Cover Sheet

SGT-600 Gas Turbine

Proposal for:
Passaic Valley Sewerage Commission (PVSC)

SIEMENS

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Date: September 19, 2018

Mr. Gregory A. Tramontozzi
Executive Director
Passaic Valley Sewerage Commission
600 Wilson Avenue
Newark, New Jersey 07105

Dear Mr. Tramontozzi:

The undersigned hereby submits the enclosed proposal for the position of **GOODS AND SPECIAL SERVICES OF POWER GENERATION SYSTEM PROCUREMENT CONTRACT**.

The undersigned hereby undertakes and promises to provide services for **GOODS AND SPECIAL SERVICES OF POWER GENERATION SYSTEM PROCUREMENT CONTRACT** and to do all work requested as appropriate and required herein as well as the contract documents concerning the same, including all written amendments and changes thereto, if any, which are incorporated herein by reference and made a part of this proposal.

SIGNATURE

Andrew Gogian
Type or Print Full Name

407-580-3981
Telephone Number

Siemens Energy, Inc.
BUSINESS NAME

Vice President North American Sales 9/19/18
Title Date

407-243-0109
Fax-Telephone Number

SIGNATURE

JULIAN ERFURTH
Type or Print Full Name

407 796 5858
Telephone Number

SIEMENS ENERGY INC.
BUSINESS NAME

SVP Commercial Sales 9/14/18
Title Date

407-243-0109
Fax-Telephone Number

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Section P-00400

PROPOSER'S QUALIFICATION FORM

THE INFORMATION SUPPLIED IN THIS DOCUMENT IS CONFIDENTIAL TO THE EXTENT PERMITTED BY LAWS AND REGULATIONS

1. **SUBMITTED BY**:

Official Name of Firm: Siemens Energy, Inc

Address: 4400 Alafaya Trail
Orlando FL 32826

2. **SUBMITTED TO**: Passaic Valley Sewerage Commission

Project Name: Power Generation System Procurement

3. **SELLER'S CONTACT INFORMATION**

Contact Person: Andrew Goggin

Title: Vice President North American Sales

Phone: 407-580-3981

Email: andrew.goggin@siemens.com

4. **TYPE OF ORGANIZATION:**

☐ SOLE PROPRIETORSHIP

Name of Owner: _____

Doing Business As: _____

Date of Organization: _____

☐ PARTNERSHIP

Date of Organization: _____

Type of Partnership: _____

Name of General Partner(s): _____

_____

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☑ CORPORATION

State of Organization: Delaware

Date of Organization: 1997

Executive Officers:

- President: Steven Conner
- Vice President(s): Florencia Gavrides
  Lonnie Ellis
- Treasurer: Heribert Stumpf
- Secretary: Ann Fairchild

☐ LIMITED LIABILITY COMPANY

State of Organization: _____

Date of Organization: _____

Members: _____

☐ JOINT VENTURE

Sate of Organization: _____

Date of Organization: _____

Form of Organization: _____

Joint Venture Managing Partner

- Name: _____
- Address: _____

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Joint Venture Managing Partner

- Name: _____

- Address: _____

_____

Joint Venture Managing Partner

- Name: _____

- Address: _____

_____

5. EXPERIENCE:

Complete the Schedule of Experience & Qualifications demonstrating experience in similar scope and size to that required under this contract.

I HEREBY CERTIFY THAT THE INFORMATION SUBMITTED HEREWITH, INCLUDING ANY ATTACHMENTS, IS TRUE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

NAME OF ORGANIZATION: Siemens Energy, Inc.

BY: _____

TITLE: Vice President North American Sales

DATED: 9.14.2018

NOTARY ATTEST:

SUBSCRIBED AND SWORN TO BEFORE ME
THIS 14th DAY OF Sept, 2018

NOTARY PUBLIC - STATE OF Florida

MY COMMISSION EXPIRES: 7.23.2021

DIANNE LOPEZ
MY COMMISSION # GG 086754
EXPIRES: July 23, 2021
Bonded Thru Notary Public Underwriters

Dianne E. Lopez

REQUIRED ATTACHMENTS

1. Schedule of Experience & Qualifications (Current Experience).
2. Evidence of authority for individuals listed in Section 6 to bind organization to an agreement.

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SCHEDULE OF EXPERIENCE & QUALIFICATIONS

Project Name	Seller's Contact Person	Description of Work	Combustion Turbine Generator Rated Capacity (MW)	Combustion Turbine Model No.	Generator Make and Model No.	Operating Frequency (Hz)	Operation Date	Hours of Operation	Currently in Service (Yes/No)
Name: Confidential Address: Singapore	Name: Confidential Telephone:	Oil and Gas, Co Gen Power Plant - Dual Fuel	25	SGT-600 GT10B1	-	50	1/1/2015	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: Indonesia	Name: Confidential Telephone:	Co Gen Power Plant - Gas Only	25	SGT-600 GT10B1	-	50	1/1/2015	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: Malaysia	Name: Confidential Telephone:	Industry, Co Gen Power Plant - Dual Fuel	25	SGT-600 GT10B2	-	50	6/1/2015	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: India	Name: Confidential Telephone:	Oil and Gas, Simple Cycle Mechanical Drive - Gas Only	23	SGT-600	N/A	50	7/1/2015	Mid Range: 2000-6000 hr/yr	Yes
Name: Confidential Address: Algeria	Name: Confidential Telephone:	Simple Cycle Mechanical Drive Gas Only	25	SGT-600	N/A	50	10/10/2014	Mid Range: 2000-6000 hr/yr	Yes
Name: Confidential Address: China	Name: Confidential Telephone:	Oil and Gas, Simple Cycle Power Gen, Off Shore	25	SGT-600	-	50	2017	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: Iraq	Name: Confidential Telephone:	Oil and Gas, Simple Cycle Mechanical Drive - Gas Only	25	SGT-600	N/A	50	2016	Base Load: 6000+ hr/yr	Yes
Name: National Institutes of Health Address: USA	Name: Constellation Energy Telephone:	Industry, Co Gen Power Plant - Gas Fuel	25	SGT-600	-	60	2004	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: Russia	Name: Confidential Telephone:	Industry, Co Gen Power Plant - Gas Fuel	33	SGT-700	-	50	2013	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: UK	Name: Confidential Telephone:	Process - Paper Plant - Gas Fuel	33	SGT-700	-	50	2016	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: China	Name: Confidential Telephone:	IPP, 2 x SGT-800 Combined Cycle	54	SGT 800	ABB	50	2016	Base Load: 6000+ hr/yr	Yes
Name: Confidential Address: China	Name: Confidential Telephone:	Utility 2 x SGT-800 Combined Cycle	56	SGT 800	ABB	50	2016	Base Load: 6000+ hr/yr	Yes
Name: Holland Board of Public Works Address: Holland, MI. USA	Name: Dan Nally Telephone:	2 x SGT-800 Combined Cycle / CHP	54	SGT 800	ABB	60	2017	Base Load: 6000+ hr/yr	Yes
Name: Roseville Electric Utility Address: Roseville, CA. USA	Name: Matt Garnet Telephone:	2 x SGT-800 Combined Cycle	54	SGT 800	ABB	60	2017	Base Load: 6000+ hr/yr	Yes
Name: Imperial Irrigation Distrct Address: El Centro, CA, USA	Name: Michael Taylor Telephone:	3 x SGT-800 Combined Cycle	55	SGT 800	ABB	60	2012	Base Load: 6000+ hr/yr	Yes
Name: Bayonne Energy Center Address: Bayonne, NJ. USA	Name: Mike Gregg Telephone:	10 x SGT-65 Simple Cycle	66	SGT-A65 WLE	Siemens	60	2012	Peaker 100-2000 hr/yr	Yes
Name: Braintree Electric Light Division Address: Braintree, MA. USA	Name:John Erik Nelson Telephone:	2 x SGT-65 Simple Cycle	58	SGT-A65 WLE	Brush	60	2009	Peaker 100-2000 hr/yr	Yes
Name: Vineland Municiple Electric Utility Address:Vineland, NJ. USA	Name: Joe Isabella Telephone:	2 x SGT-65 Simple Cycle	66	SGT-A65 WLE	Brush	60	2012	Peaker 100-2000 hr/yr	Yes
Name: Bethlehem Energy Center Address:Bethlehem, PA. USA	Name: Bob Keck Telephone:	Two, 3 x 1 SGT6-2000E Combined Cycle	117	SGT6-2000E	-	60	2002	Base Load: 6000+ hr/yr	Yes
Name: Cape Canaveral Energy Center Address: Cape Canaveral, USA	Name: Confidential Telephone:	3 x 1 SGT6-8000H Combined Cycle	305	SGT6-8000H	-	60	2013	Base Load: 6000+ hr/yr	Yes
Name: Panda Liberty Address: USA	Name: Confidential Telephone:	1 x SGT6-8000H Simple Cycle	305	SGT6-8000H	-	60	2016	Base Load: 6000+ hr/yr	Yes
Name: Duke Energy Corp Address: Rockingham, USA	Name: Confidential Telephone:	2 x 1 SGT6-5000F Simple Cycle	260	W501F-SGT6-5000F	-	60	2000	Base Load: 6000+ hr/yr	Yes
Name: Tennesse Valley Authority Address: Glasston,USA	Name: Confidential Telephone:	1 x 0 SGT6-5000F Simple Cycle	260	W501F-SGT6-5000F	-	60	2000	Base Load: 6000+ hr/yr	Yes

		Overall SGT600 Experience			
		Service introduction year	**1984**		
		Start reliability	**99.5%**)		
Units sold to date	**348**			Total fleet hours	**>10M**
Load Package hours	**>160,000**			Units F/C/MD	**144/204**

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POWER OF ATTORNEY

KNOW ALL MEN BY THESE PRESENTS, that the undersigned, Siemens Energy, Inc., ("Siemens"), a corporation duly organized and existing under and by virtue of the laws of the State of Delaware, and having an office at 4400 Alafaya Trail, Orlando, Florida 32826, does hereby make, constitute and appoint Andrew Goggin, Vice President North American Sales, and Julian Erfurth; Vice President Commercial Sales, its true and lawful attorney-in-fact for it and in its name, place and stead, to execute and deliver, on behalf of Siemens, all bid response documents for the Passaic Valley Sewerage Commission project, including any documents, notices or certificates of any kind which said attorney-in-fact may deem necessary or desirable to accomplish the foregoing.

This Power of Attorney shall continue in effect until thirty (30) days from the date hereof. The authority herein granted may not be redelegated by the attorney-in-fact to any other person.

IN WITNESS WHEREOF, the undersigned, Siemens Energy, Inc., has by the authority of its Board of Directors, caused these presents to be signed by a duly appointed officer this 12th day of September, 2018.

Siemens Energy, Inc.

By: _____

Richard J. Mould
Vice President
Siemens Energy, Inc.

UNITED STATES OF AMERICA)
STATE OF FLORIDA) ss:
COUNTY OF ORANGE)

On this 12th day of September, 2018, before me appeared Richard J. Mould, Vice President, Siemens Energy, Inc., to me personally known, who, having been duly sworn, acknowledged the execution of the foregoing Power of Attorney for and on behalf of Siemens Energy, Inc.

IN WITNESS WHEREOF, I have hereunto set my hand.

_____
Notary Public

KAREN HARMS
State of Florida-Notary Public
Commission # GG 152454
My Commission Expires
November 20, 2021

Confidential File No. Document _____

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Executive Summary:

Siemens Power Generation System for PVSC WWTF

Siemens Energy, Inc. ("Siemens") is pleased to provide The Passaic Valley Sewerage commission the enclosed technical and commercial firm bid proposal (“Firm Proposal”) in response to your request for proposal for Goods and Services for the PVSC WWTF NJEIT Project No. S340689-23, Contract No B129 to be located in Newark New Jersey.

Siemens has made every effort to address the project requirements as specified and has maintained consideration of the weighing factors detailed in the RFP while developing the attached proposal. Specifically Siemens maintained focus on Cost, Adherence to Commercial and Technical requirements, Delivery Schedule, Project Execution, Quality of Service and Installation requirements throughout this proposal development

Scope of Supply

Per the RFP, included in the scope of this offer are:

- 3 x Siemens SGT-600 Combustion Gas Turbines
- 3 x selective catalyst reduction (SCR) systems that are convertible to generate steam at a future date
- 3 x gas compressor packages for the base requirement as well as for the alternate proposal
- 2 x gas fired black start generators
- 1 x balance of plant DCS system
- Delivery to point of Destination
- Allowances for additional work as specified for cost item 14
- Allowances for PVSC Witness Test Expenses cost item 15
- Offsite Storage
- Manufacturers Training Service
- On Site Technical Direction (Technical Field Advice)

Pricing

Siemens Energy, Inc.

4400 Alafaya Trail
Orlando, FL 32826-2399

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The following pricing represents the total cost of all 33 cost items detailed in **Attachment C,** inclusive of the allowance for items 14 and 15
BASE BID Total Capital Cost (proposal forms I, II, III, IV, V): [redacted]

The following pricing represents the total cost of all 33 cost items detailed in **Attachment C1,** inclusive of the allowance for items 14 and 15
ALTERNATE BID Total Capital Cost (proposal forms I, II, III, IV, V): [redacted]

Pricing as shown is valid through January 14 2019 and may be extended as mutually agreed between buyer and seller.

Delivery

As currently outlined in the RFP all items included in the scope of supply can be delivered to project site in support of the required dates or earlier if the project should progress at an accelerated rate. Additionally as requested Siemens has included in the Capital Cost form additional pricing for storage. As a result of our extensive project experience Siemens recognizes schedules can be fluid in nature and in consideration that a construction assignee will be selected at a later date, we welcome the opportunity to further discuss and review the schedule requirements should the need arise.

Why Choose Siemens

Core Technology

At the core of this tender is the Siemens SGT-600 combustion turbine offered in consideration of the critical 17 MW requirement. The Siemens SGT-600 is part of a vast industrial, utility and mechanical drive gas turbine fleet, representing more than 6,750 installed units operating in 60 countries. This fleet also represents over 100 years of experience in gas turbine technology.

The SGT-600 Turbine specifically represents a legacy turbine frame in development since 1984, with over 348 units sold for power generation and mechanical drives. The SGT-600 has a typical, frame design with minimum number of parts and a two shaft arrangement. Modularization, few parts, long component life and easy inspection ensure a long time between overhauls and low maintenance costs. In summary, the SGT-600 offers:

- Third generation Dry Low NOx combustion technology limiting emissions to 9 PPM NOx. This superior design allows lower environmental impact and reduced operating costs
- Factory calibrated stable burners requiring no re-calibration after commissioning, and no re-calibration required for seasonal changes both leading to lower service costs
- A robust design not requiring the first major overhaul until after 60,000 equivalent operating hours

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- 24 HR Gas Generator exchange for increased availability
- A worldwide fleet start reliability of 99.5%
- A well-developed, small, economical and easily maintainable installation package

Project Execution

In addition to the advantages offered by the SGT-600, Siemens has an extensive and proven Project Execution track record. Our expertise has been developed through execution of large and small projects in the Power Industry encompassing both equipment supply only as well as full turnkey projects with responsibilities including complete plant design, construction and commissioning. This resume of experience affords Siemens an unsurpassed and proven track record of project execution in a wide range scope and markets. This experience will further allow Siemens to manage and execute the Project at PVSC with the highest level of cost efficiency and quality.

A small sample of Combustion Turbine Projects executed by Siemens includes:

- Vineland Electric Utility, NJ SC, 56MW
- City of Holland, Michigan 2 x 1 CC, DCS, HV electrical equipment, 140MW
- Bayonne Energy Center, NJ 8 x SC (2009) 512 MW, SCRs + (2017) 2 x SC SCRs
- Braintree Electric, Mass 2 x SC 116MW
- Lordstown Energy Center, Ohio 2 x 1 CS complete EPC project 940 MW

Quality of Service

After installation and throughout the life cycle of the installed equipment, Siemens offers Service support, custom tailorable to PVSC's specific needs. The core of the service network in North America begins with eight regions focusing on the local installed fleet. For the New Jersey region, support and personnel is based out of the Trenton NJ and Horsham Service Center (just north of Philadelphia) and the Malvern District Service Office (just west of Philadelphia). (all within less than a few driving hours of Newark)

The North American service network:

- Focuses on regional execution and local "first point of contact" including a full range of expertise
- Offers back up 24/7 service desk services with supplemental resources
- Maintains engineering expertise available for overall support and consultation in unusual events

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Additionally Remote diagnostic services offer:

- Immediate assistance via remote troubleshooting
- Daily monitoring if required
- Optimized maintenance based on actual operating profiles of specific units and sites
- Reduced unscheduled maintenance through advanced predictive trending

Lifetime outage support minimizes cost exposure for maintenance over the equipment lifetime through:

- Joint development of ideal outage windows in consideration of plant requirements and available resources
- Detailed outage preparation to minimize unknowns and optimize readiness for all supporting entities
- Optimized outage execution leading to minimal downtime and cost
- Formalized review and lessons learned for future benefit

Collaborative Focus

Beginning with a proposal considering Passaic Valley Sewerage Commission's requirements, continuing through project execution, delivery and installation, Siemens would like to reinforce our eagerness to support the efforts required for a successful project.

We trust this tender meets the expectation of PVSC and look forward to discussing any clarifications or changes that may be requirements at your earliest convenience.

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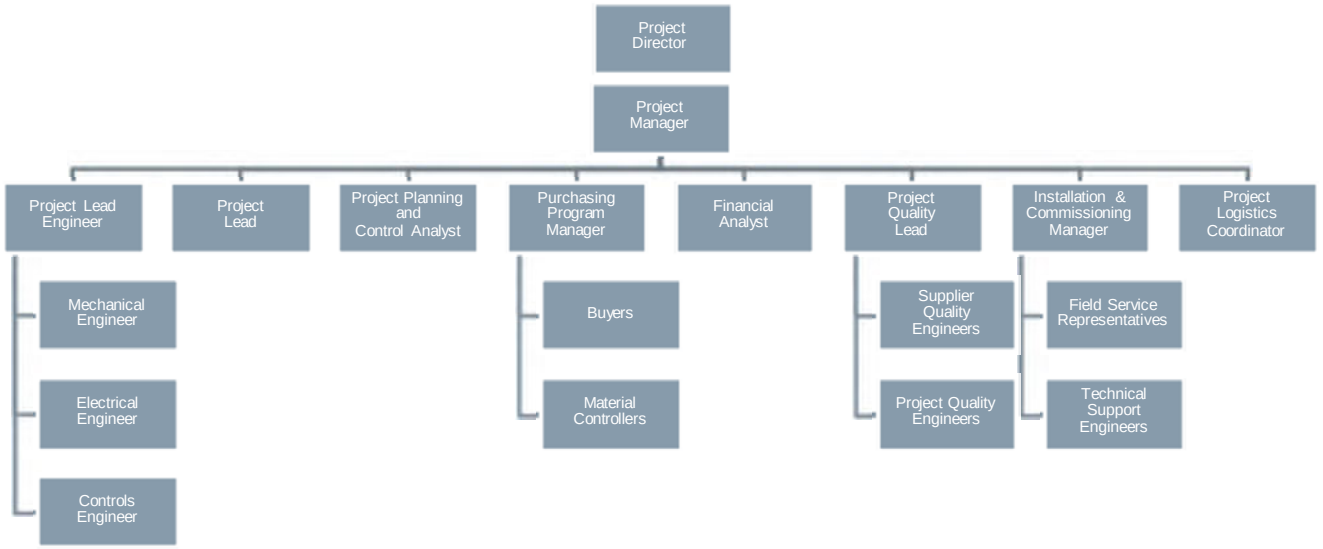
Siemens Project Team Structure



Five key roles:

- Project Lead Engineer – Responsible for the entire system integration on the project.
- Project Planning & Control Analyst – Responsible for project schedule validity and maintenance
- Purchasing Program Manager – Responsible for sub-vendor adherence to contract requirements
- Project Quality Lead – Responsible for all project inspections and quality of deliverables.
- Project Logistics Coordinator – Responsible for logistics and shipment of equipment

Other roles allocated based on specific product/project scope/complexity.
Full details and of the individuals to be provided prior to project execution.

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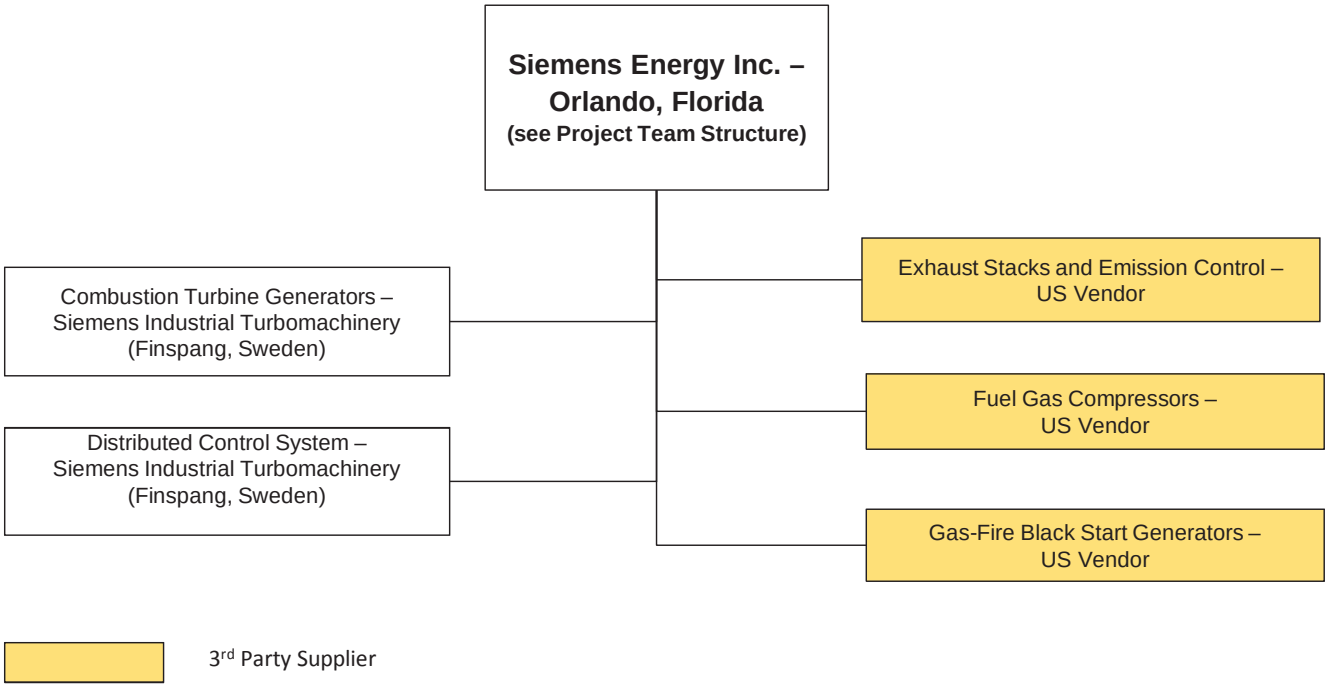
Siemens Sourcing Strategy for PVSC



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Siemens Project Approach

Cost:

In recognition of the weights applied to the 7 evaluation criteria, Siemens has closely assessed the best approach to minimize costs in the attached proposal. The proposal team evaluated internal equipment configurations and technical options and has presented the best possible solution in consideration of cost and specification compliance. In addition a rigorous approach was applied for the supply of Balance of Plant equipment. As with the internal evaluation, external vendors for BOP were evaluated for cost and specification compliance and the best combination are presented in the attached proposal.

Adherence to Terms and Conditions of Contract:

After careful review and consideration of the contract documents by Siemens Legal Department, the comments, clarifications and redlines offered represent only the most critical topics that were felt to be outside of typical industry norms. In addition, topics that may have introduced unusual risk or exposure in consideration of the application and specified equipment in this project were addressed. We have made every effort to minimize any changes in language or concepts. Should any changes or modification require additional explanation or discussion, Siemens welcomes the opportunity to discuss further in a good faith effort to arrive at a mutually agreeable solution. Details of changes and clarifications are included with this proposal.

Adherence to Technical Specifications:

Recognizing the performance requirements and critical nature of this application, Siemens has developed a solution that will deliver the required power output under the stated conditions and parameters. In addition, where required, Siemens has adjusted standard designs and supplied equipment to meet the specification as detailed. This approach was applied to the core combustion turbine, auxiliary equipment and Balance of Plant scope. Where options or alternate designs were allowable in the specification (generator rotor construction, excitation type) the best overall combination of compliance and cost was selected. The comments, exceptions and clarifications document included with this proposal represent the best evaluated combination of project requirements and cost. Should any clarification or exceptions presented warrant additional review Siemens welcomes the opportunity to discuss further in order to reach a mutually agreeable solution.

Delivery Schedule:

Siemens Energy, Inc.

4400 Alafaya Trail
Orlando, FL 32826-2399

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As currently outlined in the RFP, all items included in the scope of supply can be delivered to project site in support of the required dates, or earlier if the project should progress at an accelerated rate. Additionally as requested, Siemens has included additional pricing for storage in the Capital Cost form. As a result of our extensive project experience Siemens recognizes schedules can be fluid in nature and in consideration that an installation contractor will be selected at a later date, we welcome the opportunity to further discuss and review the schedule requirements should the need arise.

Project Execution:

Siemens has an extensive and proven Project Execution track record. Our expertise has been developed through execution of large and small projects in the Power, Chemical and Process Industries. Previous projects encompassed both equipment supply only, as well as full turnkey responsibilities including complete plant design, construction and commissioning. This resume of experience affords Siemens an unsurpassed and proven track record of project execution with a varied range of scope and markets. The combination of highly qualified project managers and a seasoned project management culture will allow Siemens to manage the Project at PVSC with the highest level of proficiency and quality. As requested we have provided a typical Project Management Organization chart for your review and consideration.

Quality of Service:

After installation and throughout the life cycle of the installed equipment, Siemens offers Service support custom tailorable to PVSC's specific needs. The core of the service network in North America begins with eight regions focusing on the local installed fleet. For the New Jersey region, support and personnel is based out of the Trenton NJ, Horsham Service Center (just north of Philadelphia) and the Malvern District Service Office (just west of Philadelphia).

The North American service network:

- Focuses on regional execution and local "first point of contact" including a full range of expertise
- Offers back up 24/7 service desk services with supplemental resources
- Maintains engineering expertise available for overall support and consultation in unusual events
- Has 69 Field Service Personnel to support the existing fleet

Available Remote diagnostic services offer:

- Immediate assistance via remote troubleshooting
- Daily monitoring if required
- Optimized maintenance based on actual operating profiles of specific units and sites
- Reduced unscheduled maintenance through advanced predictive trending

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Lifetime outage support minimizes cost exposure for maintenance over the equipment lifetime through:

- Joint development of ideal outage windows in consideration of plant requirements and available resources
- Detailed outage preparation to minimize unknowns and optimize readiness for all supporting entities
- Optimized outage execution leading to minimal downtime and cost
- Formalized review and lessons learned for future benefit

Regional Engineering Support is located in:

- Orlando, FL
- Houston, TX
- Trenton, NJ
- Mt. Vernon, OH
- Montreal, QC
- Calgary, AB

Installation Requirements:

For the PVSC project, in consideration of the requirements to reduce cost and maintain a 30 day milestone duration for each unit, Siemens has a developed the enclosed schedule (submitted with technical documentation) that offsets activities for each unit by two weeks. In our experience when multiple units are installed at the same site the most efficient and cost effective approach is to stagger repetitive activities thereby reducing the need for multiple, duplicate crews and support equipment. However once a detailed site construction plan is available Siemens recommends further review is conducted to optimize site activities.

The following narrative describes the project installation concepts and activities for the PVSC site. Note additional specifics details and drawings are located within the technical portion of this tender.

Installation
The SGT-600 installation meets stringent requirements for compactness, short erection and commissioning times and ease of maintenance. The gas turbine is mounted on a single lift skid prepared for 3 point support. The main auxiliaries are located on this skid with a few units placed off-skid.

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The gas turbine skid is built from steel beams and carries the gas turbine, speed reduction gear, auxiliary systems and starter motor. The gas turbine skid is then bolted to the generator skid and the whole package forms a single lift unit. The standard air intake and exhaust stack are supported by the gas turbine skid. A two stage disposable air filter is supplied as standard, but other options are also available depending on customer requirements. The exhaust stack can be built to site requirements as required.
The electrical and control module containing MCCs and unit control cubicles is a free standing module and can, as an option, be placed up to 500 m from the gas turbine skid. The batteries are placed in separate container close to the electrical and control module. A fully assembled standard package complete with air intake, exhaust system and control room has a “in operation” weight of approximately 190 metric tons.

Erection and commissioning
In order to reduce erection time at site, the SGT-600 comes to the job site on a skid with Most of the necessary auxiliary equipment mounted on it. Before shipment, the package is erected in the factory with all interconnecting cabling and piping. The GT package, including the control equipment (installed in the electrical and control module) is also tested up to ignition following different sequence tests up to GT ignition. Further, before shipment the gas generator (gas generator and power turbine) is separately tested in the workshop, up to full load.

Designed for ease of maintenance
The SGT-600 has a number of features that simplify maintenance and inspection.
Borescope ports are available on one side for inspection of five of the compressor stages.
At the front of the air inlet chamber, an inspection hatch is fitted allowing access to the compressor. The compressor casing is vertically split in the horizontal direction, allowing half of it to be removed for easy access to the rotor and stator parts.
The combustion chamber can be inspected from borescope access ports situated at the end of the combustion chamber. The compressors are prepared for quick exchange, by quick couplings for all media and electrical connections, and a roll-out frame can be removed from either side of the enclosure.

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100	0001649E	A	List of Content
100	0001650E	A	Check list Documents Required proposal
120	SCS22673	A	Scope of Supply SGT-600
120	J1204937E	A	Scope of work black start generators
120	J1204938E	A	Scope of work fuel gas compressors
120	J1204940E	A	Oil cooler exchanger
120	J1204941E	A	Scope of Work Future Steam Production
120	J1204939E	A	Scope of work SCR
J105010E	1CS66969	E	SGT 600-700, Sub-suppliers List
150	J150584E	A	Preliminary project time schedule SGT-600
171	J1711871E	B	PVSC Performance Guarantee
210	J2105876E	A	Nominal Degradation for extended service intervals
J210129E	1CS120411	C	Nominal performance SGT-600 Power Generation, ISO ambient matching
210	J2105874E	-	Performance Black start Generators
210	J2105873	-	Performance Runs Fuel gas compressor
W220027E	1CS26747	T	Guidelines for water and steam quality in Gas Turbine
220	J2203031E	A	Individual consumers list
220	K-1171-7	9	Lubrication oil requirements acceptance check
220	DL1171-1	10	Lubrication oil requirements delivery
220	D-MAT812109	7	Lubrication oil requirements quality
220	J2203030E	A	Start and Stop characteristics
220	J2203017E	A	Utility schedule Prelminary SGT-600
J241003E	1CS26586	W	Gaseous Fuel Requirements
W261026E	1CS103295	C	Near field nominal sound level 85 dB(A)
262	J262326E	-	SCR Performance
J300022E	1CS26598	M	Gas Generator
J300001E	1CS26597	H	General Description of the Gas Turbine Unit
300	TCS-022673P&ID19-2	A	P&ID GAS GENERATOR SYSTEM
300	TCS-022673P&ID19-1	A	P&ID GAS GENERATOR SYSTEM
300	TCS-022673P&ID01-1	A	P&ID GAS TURBINE SYSTEM
305	TCS-022673P&ID18	A	P&ID GAS TURBINE ENGINE SYSTEM
J310009E	1CS26603	F	Power Turbine

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330	TCS-022673P&ID04	A	P&ID GEAR ELECTRIC GENERATOR SYSTEM
400	TCS-022673P&ID17-2	A	P&ID LEGEND FOR SYMBOLS
400	TCS-022673P&ID17-1	A	P&ID LEGEND FOR SYMBOLS
400	J400303E	-	P&ID SCR
J400024E	1CS66559	C	Package piping specification
W401008E	1CS26757	K	Instrumentation on packaged equipment
W401010E	1CS44899	D	Valves on packaged equipment
J402003E	1CS48530	D	Cooling and sealing air system
402	TCS-022673P&ID02	A	P&ID COOLING SEALING AIR SYSTEM
J403014E	1CS103251	D	Electric starting system
403	TCS-022673P&ID03-1	A	P&ID STARTING SYSTEM
J410032E	1CS89233	E	Lubricating Oil System
410	TCS-022673P&ID08-2	A	P&ID LUBE OIL GAS TURBINE SYSTEM
410	TCS-022673P&ID08-1	A	P&ID LUBE OIL GAS TURBINE SYSTEM
410	TCS-022673PID08-1	A	PID LUBE OIL GAS TURBINE SYSTEM(2)
423	TCS-022673P&ID13	A	P&ID VENTILATION SYSTEM GAS TURBINE ENCLOSURE
J423022E	1CS86812	E	Ventilation System gas turbine enclosure
J424015E	1CS151333	A	Gas detection system
424	TCS-022673P&ID15	A	P&ID GAS DETECTION SYSTEM
425	TCS-022673P&ID16-2	A	P&ID FIRE DETECTION AND EXTINGUISHING SYSTEM H2O
425	TCS-022673P&ID16-1	A	P&ID FIRE DETECTION AND EXTINGUISHING SYSTEM H2O
431	J431277E	A	Scope of Work Fuel gas compressors
J431019E	1CS91685	B	Gas Fuel System
431	TCS-022673P&ID07	A	P&ID GAS FUEL SYSTEM
481	TCS-022673P&ID14	A	P&ID WASHING SYSTEM
482	TCS-022673P&ID10-2	A	P&ID INSTRUMENT AIR SYSTEM
J482002E	1CS26616	L	Requirements for Instrument & Operating Air
J491010E	1CS26617	M	Compressor Cleaning System GENERIC
W491021E	1CS26763	H	On line Washing
W491023E	1CS26764	T	Recommended products for compressor cleaning
500	500SET18251OD	A	Generator Overwiev Drawing
500	J500SET18251TS	A	Generator Technical specification
501	J501SET18251ITP	A	Generator Inspection &test plan
501	J501518E	A	MV Single Line Diagram
580	J580257E	-	AVR Unitrol 1020 Power System Stabilizer
W580004E	1CS26767	R	Brushless Excitation Equipment and Automatic voltage regulator

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600	J600577E	A	Load Shedding Study
620	J6201026E	A	LV Single Line Diagram
J623012E	1CS91029	A	Battery System -Pb
J624020E	1CS87550	K	Battery Charger 440VDC
W625020E	1CS92224	E	Motor Drive System
J630051E	1CS136711	C	Reliability and Availability - Simatic PCS7 Control System
W630054E	1CS176818	C	Unit Control Panel and Package System FAT
W631025E	1CS26775	P	Generator Relay Protection
W631031E	1CS93673	E	Machinery Protection Bently Nevada
W631026E	1CS26843	N	Unit Protection and Emergency shut down
J633015E	1CS73677	C	Enhanced instrumentation reliability
W635033E	1CS72331	E	GT controllers and operators interface
J636028E	1CS26641	F	Generic Turbine Governor Dual Fuel
W639009E	1CS26777	R	Synchronizing Equipment
640	J640219E	A	Control System Overview
W663003E	1CS73653	H	S7 Communication
680	E1B100002085	A	Demystifying american certification
680	J680296E	B	Electrical Installation SGT600700 US
W680010E	1CS34121	K	Principal of earthing for gas turbines
W680013E	1CS72227	H	Specification of industrial cables
W680015E	1CS72251	E	Typical Interconnecting Table
693	J693007E	US	Installation- electrical and control panels
700	J700416E	-	Genaral Layout Fuel Gas compressor
700	J700417E	-	General Layout Black Start Generator
J700024E	1CS26644	K	Layout & Terminal points power generation
700	E1B100333266	A	Preliminary Layout
J710004E	1CS157874	B	Enclosure
720	2089924	D	GT Foundation General Layout
720	J720267E	A	Preliminary Foundation loads intensity PVSC
W721003E	1CS26780	H	Foundation Design Requirements
J721010E	1CS66908	B	Gas Turbine Three-Point Supports and Auxiliary Systems Supports
W730032E	1CS128535	E	Air Intake System - Static
731	TCS-022673P&ID06	A	P&ID COMBUSTION AIR INTAKE SYSTEM
J740012E	1CS66444	C	Exhaust system

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J810028E	1CS99887	D	Preliminary shipping specification
W811005E	1CS156026	D	Packaging, Preservation and Marking
820	J8201332E	B	Preliminary Time Schedule
820	J820776E	A	Quality Control plan
W830012E	1CS33784	R	Commissioning tools
W840028E	1CS26651	P	Division of Work - Technical Advisory Services
J840029E	1CS26652	L	Installation Procedure
J840043E	1CS80303	E	Installation Tools
J852009E	1CS26653	M	Specification of Mechanical Running Test
W852044E	1CS176823	B	Witnessing of Unit Control Panel and Package System FAT
W853035E	1CS41421	E	72 Hour Reliability Run
J853017E	1CS26656	L	Commissioning procedure, Power Generation application
J853012E	1CS26655	L	Performance test procedure
W935019E	1CS26783	L	Gas Turbine Training programme - On-site training
935	1CS118959	D	Maintenance General Information
940	J9401873E	A	Back up spares PVSC
940	J9401872E	A	Operational consumables PVSC
950	1CS118959	K	Extended Maintenance Intervals
J960002E	1CS26665	E	Availability and Reliability
W980042E	1CS159505	B	Dual Tagging information and Requirements
W980041E	1CS113721	F	SDRL CDL Processes and Design Freeze Concept
980	J980878E	A	Standard Supplier Document Register List

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Standby PowerPlant 193946 . J0001650E Rev.A

SECTIONP-00350

Technical Documents Required withProposal Schedule

Reference Document	Submittal Item	Check if complete
11506	**Selective Catalytic Reduction System & Stack**	J1204939E
11506	General arrangement and elevation plans of systems furnished.	J740289E
11506	Major dimensions of major pieces of equipment.	J262326E, J740289E
11506	General description as to component or modular sizes and description ofmodifications requiredto add steamgeneratingcapability inthe future.	J400303E
11506	Predicted stack emissions for all constituents listed in Section 11506 Selective CatalyticReductionSystemSpecificationSheet	J262326E
11508	**Ammonia System**	J1204939E
11508	Equipment outline drawing	J740290E
11508	Performance data, including power requirements and ammonia consumption	J262326E
15220	**Reciprocating Fuel Gas Compressor**	J1204938E
15220	Equipment outline drawing	J700416E
15220	Compressor performance data & power requirements	J2105873E
15560	**Small Combustion Turbine/Generators**	120_SCS22673
15560	Combustion turbine generator performancedata	J210129E
15560	Preliminary/typical general arrangement Drawings showing the combustionturbine generator unit(s), inlet filter(s), exhaust stack(s), all associated compartments/enclosures/skids, starter unit, transformers, and radiators. A vertical section shall be included showing the complete installed unit including crane minimum hook height andcapacity.	E1B100333266
15560	A complete description of all equipment proposed, together with supportive data.	Technical tender file
15560	A complete description of the CTG normal start sequence and timing	J2203030E
15560	A complete description of the CTG fast start sequence and timing	J2203030E
15560	A complete description of CTG fast start degradation impacts	J2203030E
15560	Preliminary Engineering Schedule.	J150584E
15560	Preliminary Procurement/Production/Shipping Schedule.	J150584E, W811005E
15560	Shipping methods and erection criteria and requirements.	J8201332E
15560	Information on technical assistance provided during erection and commissioning.	W840028E
15560	Provide estimated hours to erect proposed combustion turbine generator unit.	J8201332E
15560	Description of all field assembly/erection required.	J840043E, 1CS26656
15560	Predicted start-up emissions	J2203030E
15910	**BlackstartGenerator**	J1204937E
15910	Engine performance data	J2105874E
15910	Preliminary arrangement drawings indicating overall dimensions, estimated weights component locations, and external connection information.	J700417E
15910	Exhaust gas emission data, maximum valves at loads of 1/2, 3/4, and full load.	J2105874E
16031	~~**Cylindrical**~~ **Salient pole type Generators**	J500SET18251TS
16031	Generator power factor correction curves for ASME PTC 6.1 acceptance test	J500SET18251TS
16031	Preliminary/typical one-line diagrams of generator electrical system, including ac and dc auxiliary electric system. One-line diagrams shall include all auxiliary load data and proposed metering and protectiverelaying.	Note: request is typical for static exciters. Rotating exciters is different see doc W580004E
16031	Preliminary/typical electrical Load List - (Provides start-up, standby, and operating electricalloads)	Note: request is for static exciters. See description of rotating exciter W580004E
16031	Detailed data describing capability of the unit to operate above and below rated speed, including minimum and maximum allowable speed versus cumulative time duration of off-normal speedoperation	J500SET18251TS
16031	Detailed information on the capability of the generator to respond to a system upset situation, where a large portion of the system load is applied to the unit and load shedding isrequired	J600577E_-_Load shedding study
16031	All generator, exciter, power system stabilizer and regulator data required to complete amathematical modelstudyofsystemstability.	J500SET18251TS, J580258E
16031	Provide a block diagram and parameter values for the significant transfer functions (representing the generator, excitation, power system stabilizer and governor) satisfactoryfortransientanddynamiccomputer studies	J500SET18251TS, J580258E, M636020E
16031	Reactive power capability versus real power capability curve	J500SET18251TS
16031	Generator performance data including reactance, resistance, time constants,inertia, damping,saturation factorsandsaturationcurves.	J500SET18251TS
16031	Reactive capability curve to indicate generator capability at various power factors.	J500SET18251TS
16031	Generator "Vee" curves.	J500SET18251TS
16031	Generator drawing with overall length, width, and height.	500SET18251OD
16031	Generator drawing with exciter or collector's overall length, width, and height.	500SET18251OD
16031	Complete description of excitation system.	W580004E
16031	Generator drawing with excitation cubicle's overall length, width, and height.	500SET18251OD
16031	Generator drawing with rotor removal clearance (straight and askew).	E1B100333266
16031	Description and listing of major generator assemblies for shipment.	J810028E
16031	Complete information on the generator supervisory instrumentation system,including a bill ofmaterial.	J501518E
16031	Detailed listing of alarm contacts available and recommended alarms for connection to DCS, includingunit pricesfor additions or deductions.	J501518E, J640219E (see layout for each scope)

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16031	Detailed listing of instrumentation furnished.	J501518E
16031	Complete description of cable requirements, including the cable constructions, for all equipmentfurnished.	Note: request is typical for static exciters. Rotating exciters is different see doc W580004E
16031	Complete description of any voltage level separation requirements for raceway or specialcableshieldingrequirements forallequipmentfurnished.	Note: request is typical for static exciters. Rotating exciters is different see doc W580004E
16031	Complete description of the lube oil piping arrangement.	410 TCS-022673PID08
16031	Complete list of other plants where the manufacturer has duplicate, or near duplicate, generators under construction or inoperation.	See reference list for SGT-600 attached in commercial part
16031	Listing of Work subcontracted to other Sellers.	To be developed durning order execution
16031	Listing of SubSellers and Sellers used.	To be developed durning order execution
16031	Proposer s preliminary engineeringschedule.	J150584E
16031	Proposer s procurement/production/shippingschedule.	J150584E
16031	Generator maximum allowable temperature of cold coolant generator temperaturerise of gas and liquid.	J500SET18251TS
16031	Generator maximum allowable temperature for armature winding, field winding core, and mechanical parts in contact with or adjacent to armature windinginsulation; and collector rings, brushes, and brushholders.	J500SET18251TS
16031	Maximum allowable temperature of cooling air and temperature rise of cooling air.	J500SET18251TS
16051	**Electrical Design andEquipment**	
16051	Bill of quantities and materials including make, manufacturer and model for allItems.	
16051	Dimensional outline drawings.	J693007E
16051	One-line diagrams showing equipment provided and equipment layout.	J6201026, J501518,
17053	**Subsystem - Programmable Logic Control System (Gas Compressors)**	
17053	Description of proposed PLC equipment, including manufacturer, model, memorytype and capacity, types and quantities of I/O modules provided, and preliminary PLC system architecture andlayout.	J1204938E
17053	Description of proposed interface to plant DCS, including communication standard, protocol, andmedia.	J640219E
17053	**Subsystem - Programmable Logic Control System (Blackstart Generators)**	J1204937E
17053	Description of proposed PLC equipment, including manufacturer, model, memorytype and capacity, types and quantities of I/O modules provided, and preliminary PLC system architecture andlayout.	J1204937E
17053	Description of proposed interface to plant DCS, including communication standard, protocol, andmedia.	J640219E
17101	**Distributed ControlSystem**	
17101	Preliminary Engineering/Production/Shipping Schedule. This schedule shall be basedon the milestone dates listed in the preliminary project schedule, and shall include the dates for database, hardware, and software cutoff, for Seller issue of each logic system configuration package for review, and for Seller issue of the graphic configuration package forreview.	J150584E
17101	System configuration drawing. The system configuration drawing shall include details on the control network, the operator work station network, and any network securitycomponents.	J640219E
17101	Proposer s listing and description of the software (graphics configurator, alarmmanager, etc.).	PCS7 system
17101	Bill of Material including the following:1) Cabinet quantity and size 2) Processor (control/link/other) quantity, manufacturer & model/series 3) Workstations quantity, manufacturer & model/series4) I/O card quantity by type and cabinet, manufacturer & model/series 5) Network hardware (switches, routers, etc.) quantity, manufacturer & model	1)doc 120_SCS22673+ J693007E 2)doc J693007E 3)120_SCS22673 + W635033E 4&5) To be defined during detailed engineering incl 20%spare

Technical DocumentScheduleP-00350

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Ingenuity for life

Project name **PVSC 3 x SGT-600 GTG**

Reference number

0061200000Xz1E1AAJ

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Scope of Supply

Project name
PVSC 3 x SGT-600 GTG

Site
Passaic Valley Sewerage Commission USA

Reference number
0061200000Xz1E1AAJ

Turbine type
SGT-600
Power Generation

This scope of supply is valid for one item of Siemens Industrial Turbomachinery AB's model SGT-600 gas turbine for power generation, designed for continuous base load operating mode.

The SGT-600 is designed to meet customer demands for highly reliable, clean and efficient power generation and mechanical drive equipment. Other customer values, such as low life cycle cost, plant compactness and short delivery time, are addressed. It is a heavy duty gas turbine, designed and developed to incorporate size and weight advantages of the aircraft derivative gas turbine while at the same time maintaining the robustness, flexibility and long life advantages of the traditional industrial gas turbine. It operates in an open cycle mode with axial air and gas flow. The complete gas turbine unit is mounted on a single foundation frame into which the lube oil tank is integrated. All the auxiliary systems such as start motor and electrically driven back-up systems are also mounted on the base frame.

Please do not hesitate to contact us regarding your requirements.

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1 Design Requirements

1.1 Design Basis

Minimum outdoor temperature: -21 ºC.
Maximum outdoor temperature: 43 ºC
Minimum lifting temperature: -15 ºC
Minimum transport temperature: -15 ºC
Altitude: <1000 meters above sea level.
Package location: Indoor.
Seismic loads according to IBC.
Acceleration short period, Ss, up to and including 1.5g.
Acceleration long period, S1, up to and including 0.625g.
Wind speed: 60 m/s according to IBC.
Non-hazardous area.
Near field sound pressure level: 85 dB(A).
Electrical utility frequency: 60 Hz.
Auxiliary voltage: 480 VAC.

1.2 General Specifications

SIL requirement assessment and SIL analysis by customer. Supplier to deliver SIL component data for protection loops interfacing with protection systems needed for overall plant safety. Customer to determine/agree with local authorities which protection loops need to be presented/verified.
KKS designation system for complete delivery with additional ISA5.1 tagging on: components, P&IDs, lists, circuit(loop) diagram, cable list, cable-connection(termination) drawing, HMI, alarm lists, fault procedure, CFC logic. If included also on Cause and Effect matrix, hook-up drawings, instrument and motor datasheets, communication signal lists. Additional ISA5.1 tag numbers provided by customer.
Welded thermowells for gas fuel system and 1/2" NPT threaded for other auxiliaries.
Rosemount pressure transmitters.
Siemens participation in HAZOP study performed by customer.
Warranty as defined in commercial terms and conditions.
Air cooled coolers for all equipment.
Surface treatment for indoor equipment according to ISO12944-2:1998, category C3 medium.
Surface treatment for outdoor equipment according to ISO 12944-2:1998, category C4 high. Enclosure internal equipment according to category C2. Galvanized carbon steel according to ISO 1461:1999.
Surface treatment for base frame according to ISO12944-2:1998, category C3.
Surface treatment for electric generator according to ISO 12944-2:1998, category C3 medium.
Enclosure exterior surface in pebble grey, RAL 7032, top coat color.
Electrical and control panels in light grey, RAL 7035.
A life cycle assessment according to ISO 14040-43 is available. It contains quantifications of the resource depletion, generation of waste and emissions to the environment caused by the manufacturing, use and disposal of the product.

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1.3 Codes and Standards

Listed international codes and standards are considered being the most relevant to gas turbine industry and is based on customer demands, Siemens experience and package standardization. Gas turbines including auxiliaries are designed, engineered, fabricated and tested according to applicable sections of the international codes & standards and Siemens internal guides, standards & specifications listed. Generally international codes & standards complies with Siemens internal guides, standards and specifications, nevertheless they have been used for guidance purposes only. Modifications (e.g. additions, revisions, editing, etc.), if any, to these listed documents, either before or after tender submittal, is subject to mutual agreement between customer and Siemens.

Equipment	Code or standard
Base frames	EN 1993 Eurocode
Control cubicles	EN IEC 61439
Couplings	API 671 with comments
Enclosures	EN 1993 Eurocode
Pressure vessels, filters and coolers	ASME VIII including U-stamp.
Units	US-units
Noise generating equipment	ISO 11204 and ISO 10494
Pipe coupling threads	NPT and/or ISO threads
Pumps	DIN and ISO standards.
Vibration measured equipment	ISO 10816-4
Vibration monitoring	API 670 with comments
Drawings	ISO 5457
Structural steel	EN 1993 Eurocode with additional compliance with IBC 2009.
Cable joints of M-type	IEC 62444
Balancing	ISO 1940-1 and ISO 11342
Bolts and nuts	ASME standards
Flanges	ANSI B16.5 on package piping and interconnecting piping.
Pipes	EN 13480 with dimensional standards according to ASME B31.3.
Air intake filter	Prefilters: EN 779:2012. High efficiency filters: EN 1822:2009.

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Equipment	Code or standard
Gas fuel system	ISO 21789
Lube Oil Unit	EN 60034 (corresponding to IEC 60034) and API 614, with exceptions and clarifications.
Electric generator	NEMA MG 1
Electric generator surface treatment	ISO 12944-2:1998 "Paints and varnishes. Corrosion protection of steel structures by protective paint systems."
Electric generator cooling ducts unit	EN779:2012
Main gear and couplings	AGMA 6011-I03
Speed reduction gear	Design according to AGMA 421
Gas detection system	IEC/EN 60079-1:2004 Explosion group IIC (zone 1)
Motor control center	EN IEC 61439
Control system	EN IEC 61439
Frequency converters	EN IEC 60204
Electrical installation	EN IEC 60204
Control cables	EN IEC 60204
Power cables	EN IEC 60204
SIL	IEC61508/IEC61511
Factory tests	ISO 3977-8
Documentation	ISO5457-1999 with designation system: KKS and ISA5.1 including P&ID symbols and designation system. Documents' structuring principles based on IEC 81346: "Classification and designation of documents for plants, systems and equipment".

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2 Equipment and Services

2.1 Gas turbine equipment

2.1.1 Gas turbine engine

Two shaft, low weight industrial type gas turbine with modular design. Horizontally split compressor casing, upper case half is lifted off for ease of maintenance.

Compressor inlet casing and inlet bellmouth casing.
All bearings of tilting pad type with directed mineral oil lubrication.
10-stage axial flow compressor with two servo motor driven variable guide vane rings, electron beam welded compressor rotor and inner stator casing with vane carriers forming air flow path.
Two-stage gas generator turbine bolted to compressor rotor.
Thrust bearing #1 combined with radial journal bearing #1, located in inlet bellmouth casing. Central casing containing radial journal bearing #2.
Two pneumatically actuated bleed valves for air bleed during startup and shutdown.
Ignition system including one removable high energy spark plug for startup burner.
Annular combustion chamber with internal thermal barrier coating.
Two optical flame detectors. One indicating the flame at startup burner at ignition and one indicating cross ignition at startup. During operation both are used as main flame detectors.
Combustion chamber primary zone bypass arrangement with a motor operating six valves for emission control at part load.
18 DLE burners of second generation for gas fuel.
Two gas fuel mainfolds: pilot and main.
Two-stage power turbine at 7700 rpm constant speed. Discs electron beam welded to shaft.
Counter clockwise rotation according to API616.
Power turbine exhaust diffuser.
Manually operated drain valves at compressor inlet plenum, bleed cavities and at combustion chamber, power turbine and exhaust casings.
Radial journal bearing #3 located in the power turbine diffuser casing. One thrust bearing combined with one radial journal bearing #4 located in power turbine diffuser casing.
Compressor bleed air used for anti-icing.
Online combustor pulsation monitoring system.
Insulation of gas turbine and exhaust casing for personnel safety and heat and noise attenuation.
Dehumidifier unit for use in non-hazardous area. For engine dry out during extended shut down periods.
12 x 1.5 mm instrument tubing in 316L stainless steel with double ferrule couplings for core engine.
Instruments with trip function during operation have the following configuration:

- 2oo3 for axial displacement, gas turbine inlet and outlet pressure, exhaust gas temperature and rotating speed.
- One accelerometer for each bearing for vibration supervision, with one spare installed at each bearing #2 and #3.
- 2oo4 for flame detection.

2.1.2 Combustion air inlet system

Air inlet system including weather protection, filters and silencer.

Single hood.
Filter house with service platform and ladder.
Single side static filter system with two filter stages, class M6 disposable prefilters and class E10 disposable high efficiency filters.
Support structure for filter house to ground level.
Hand operated hoist for filter replacement.
Anti-icing by turbine compressor bleed air.
Air intake duct in carbon steel. Length (m): 7
Bend 90 degrees in carbon steel.
Low pressure drop inlet silencer with baffles in 304 stainless steel.
Inlet plenum in glass fiber composite with inspection window.

2.1.3 Exhaust gas system

Sheet metal exhaust casing.
Exhaust bellows for connection to external exhaust system.
Bellows outlet flange in 321 stainless steel.

2.1.4 Base frame for gas turbine

Welded I-beam base frame for the gas turbine driver unit.

Pendulum, fix point and flex support between gas turbine and base frame.

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Fixed three-point support between base frame and foundation.
Bolted together with speed reduction gear and base frame for electric generator.

2.1.5 Gas turbine enclosure

Enclosure for weather and noise protection equipped with ventilation, main and emergency lighting and external stairs and walkways. The enclosure is an integral part of the machine safety concept and considered as machine equipment designed to accommodate gas turbine unit with auxiliaries.

Maintenance opening on selected side, and internal walkways for service.
Carbon steel panels.
Maintenance equipment:

- Rails for gas generator exchange.
- Maintenance overhead beams for power turbine and starter motor.
- Chain hoist for lubricating oil pumps.

Entrance doors equipped with windows.

2.1.6 Ventilation for gas turbine enclosure

Ventilation system taking air from a non-hazardous area.

2 x 100% AC driven fan creating atmospheric overpressure in gas turbine enclosure. The fans are placed outside the enclosure.
ATEX classified fans with EExde motors.
One-stage disposable barrier type air filter, class G3.
Carbon steel electric heater in the inlet. Used for operation in ambient conditions below -15°C.
Total inlet/outlet ducting length (m): 25

2.1.7 Gas fuel system

Unit located inside gas turbine enclosure close to fuel manifolds. Nitrogen purging connection for maintenance.

Simplex Y-type strainer with mesh size 200 (74 µm).
Dual quick shut off valves with intermediate bleed valve.
Motor operated control valve.
Insulation.
Total gas flow meter
Thermal insulation of pressurized piping.
Gas wetted components and piping in stainless steel 316L
Manual isolation valve and automatic isolation valve located outside building.
Gas fuel piping 100 % radiographic testing
Gas fuel ventilation connection outside gas turbine enclosure.

2.1.8 Ignition system

Ignition gas panel with shut off and ventilation valves for gas distribution to burner #6. Main gas fuel used as ignition gas. Gas wetted parts in 316/316L stainless steel.
Thermal insulation and heat tracing for pressurized Propane gas piping.

2.1.9 Starting system

Combined low voltage starting and barring motor.

Variable speed drive squirrel cage induction motor of four pole design.
Flexible coupling and SSS-type semi rigid overrunning clutch.

2.1.10 Lubricating oil system

System common for driver and driven equipment, located inside gas turbine enclosure with its components on top of tank. Designed for mineral oil fulfilling ISO VG46.

Interconnecting oil piping. Length (m): 25
Drop-in lubricating oil tank.
Three AC driven main pumps of centrifugal type, two in operation and one in standby mode. Fully automatic and bumpless switch over to standby pump. Cooling down can be made safely with a single pump in operation.
Combined high pressure and scavenge lubricating oil pump and a low pressure lubricating oil pump forming a pump group. High pressure & scavenge supplies/drains bearing #2, low pressure supplies remaining bearings.
Electrical pump and fan motors, fed via static frequency converters. DC back-up provided on all pumps by a 440V battery. In case of AC blackout, switch over to DC supply is fully automatic and bumpless.
One tank top mounted electrical heater.
2 x 100% oil filter accessible from outside of enclosure, with possibility to switch filter during operation. Filter element with 10 µm, β = 200 separation degree in multilayer metal meshed glass fiber.

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Oil mist fan with filter to obtain sub pressure.
Piping downstream filter in 316L stainless steel.
Lube oil unit filter designed according to ASME, including U-stamp
Fin fan type lubrication oil cooler.

- Capacity 1 x 100

2.1.11 Cooling and sealing air system

Cooling and sealing air for gas turbine including pipes and valves.

Air cooled seal air cooler of fin fan cooler type with tubes and headers in 316L stainless steel.

- Coolers with ducting and dampers, located indoor.

2.1.12 Washing and cleaning system

Permanently installed nozzles located upstream of gas turbine compressor. Nozzles are connected to a washing unit via high pressure hose and filter.

Compressor washing unit for offline washing with possibility for online washing.
Mobile washing unit. Locally operated.
Manually operated drain valves with piping to common drain connection point.

2.2 Electric generator equipment

2.2.1 Electric generator

Four-pole synchronous AC generator of salient pole rotor type. Brushless excitation system with rotating rectifier and PMG for excitation power supply. Lubrication oil is supplied by the gas turbine package common system. For further information refer to generator technical specification.

- 13.8kV, 60Hz, 1800RPM
- Power factor 0.85
- Generator cooling form IC3 A1, TEPV.

Anti condensation heater in main machine, exciter and medium voltage terminal box.
Separate junction boxes for instruments, excitation and heaters.
Ingress protection class: IP54.
Cooling air and stator winding temperature supervised by RTD:s.
One vibration detector of accelerometer type at each bearing.
Generator cooler material data

- Tubes: Cu90% / Ni10%, Plate fin: Aluminium
- Water box: Rilsan coated steel
- Tube and plates: Naval Brass

External stairs and platforms at electrical generator and gear box.
One-stage static disposable air filter of barrier type.
Additional ducting for air cooled electrical generator, length (m) 25

2.2.2 Automatic voltage regulator

Automatic voltage regulator integrated in the gas turbine package control system. Voltage, power factor, reactive power and manual control modes with automatic and bumpless changeover. Built in DC-chopper for field current control.

Dual channel.
Excitation current limiter with cooling air bias.
Stator current limiter with cooling air bias.
Under and over excitation limiters.
Operator interface via package HMI.
Power system stabilizer with project settings integrated in automatic voltage regulator. Required data provided by client. Site tuning and evaluation to meet grid requirements is not included.

2.2.3 Line and neutral cubicle

Terminal box for line and neutral side of generator.
Air insulated phase conductors of solid copper bar design. Connection of generator to the grid is performed via undrilled copper bus bars inside terminal box, suitable for cable or bus duct connection.

Short circuit current 55 kA/1s with 100 kA peak.
Three YN connected single phase voltage transformers on generator line side.
Three line side current transformers, 1A per phase on secondary side.
Lightning arrestors on line side, three phase-neutral and three phase-phase.
Three YN connected single phase surge capacitors.
Neutral point resistor

- Arrestor.
- Contactor.
- Current transformer.
- Resistor, 10 A, 10 s.

Connection of MV cables or bus duct at bottom of terminal box.

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2.2.4 Synchronizing equipment
Automatic and manual mode synchronization system including dead bus breaker closure by-pass switch for the generator circuit breaker.

2.2.5 Relay protection
Redundant digital multifunctional relay protection with internal hardware and software watch dog. Communication and time synchronization with gas turbine controller by PROFIBUS DP.

[51V] Inverse time over current protection.
[46] Negative sequence protection.
[87G] Differential protection.
[40] Under excitation protection.
[32R] Reverse power protection.
[27] Under voltage protection.
[59] Overvoltage protection.
[59N] 95% stator earth fault protection.
[60FL] Voltage transformer circuit supervision.
[49] Stator overload protection, realized in gas turbine control system.
[58] Rotating diode failure protection, realized in the voltage regulator.
[78] Out of step.
[50BF] Breaker failure protection.
[81] Frequency protection.
[86G] Trip lockout function.

2.2.6 Main gear and couplings
Parallel shaft gear of double helical design. White metal journal bearings with bearing temperature and vibration measurement.

String torsional and lateral analysis.
API 671 flexible disc type coupling and spark resistant coupling guard.
One vibration transducer of accelerometer type each at low speed and high speed casing side.

2.2.7 Base frame for electric generator
Base frame for the electric generator. The frame is bolted together with speed reduction gear and gas turbine base frame and forms a common three point supported unit.

2.2.8 Noise protection for electric generator
Noise reduction walls in carbon steel with service hatches.

2.2.9 Enclosure for main gear
Separate gear enclosure with common wall section with gas turbine enclosure.

2.3 Auxiliaries

2.3.1 Instrument air
Instrument air tubing in 316L stainless steel for the gas turbine package air consumers.

2.3.2 Foundation
Outline drawing of foundation with static and dynamic loads.

Embedded steel plates.

2.3.3 Gas detection system
Enclosure provided with gas detection system to detect gas fuel leakages.

All detectors connected to the gas turbine's control unit.
Gas detectors of infrared type.
Three detectors at each; two locations in the ventilation outlet from gas turbine enclosure and two locations in baseframe, in total twelve (12) detectors.

2.3.4 Fire detection and extinguishing system

2.4 Electrical and control equipment

2.4.1 Motor control center
Motor Control Center (MCC) including low voltage distribution of IEC 61439 form 4b and withdrawable unit design supplying all consumers.

Distribution panel design with cable entries at bottom and front doors with lockable handles.
Incomer with an ACB and a front panel multi-function display indicating mains parameters U, I, f and power factor.
Isc = 50kA
Single and black start diesel generator incomers without automatic transfer.
Ingress protection: IP30.
Cabinet according to Seismic loads Ss ≤ 1,5g and S1 ≤ 0.625g (IBC).
Cabinet color: RAL7035
MCCB for lube oil heater.
Voltage level: 440-480VAC, 60Hz

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2.4.2 Instrumentation

Instrumentation for gas turbine skid is fully assembled, piped and wired. Instruments and junction boxes located outdoor have minimum IP65 ingress protection. Transmitters are of two-wire 4-20 mA 24 VDC type including HART protocol for pressure transmitters. In general no gauges are used; the gas turbine package is intended for remote operation. Pressure instruments crucial for man and machine safety has 316L stainless steel shut-off valves and block and bleed-valves locked with an anti-tamper device. 1/2 x 0.083 inch instrument tubing in 316L stainless steel with double ferrule couplings for auxiliaries. Further information on instrumentation according to attached P&IDs.

2oo3 voting for all instruments (excluding vibration) with trip function during operation. Due to physical restrictions flame detectors are 2oo4.

2.4.3 Control system

Gas turbine package control system based on Siemens Simatic with PC based HMI for monitoring, control and safety with separate IEC 61508 SIL proven safety controller. Designed for operator friendliness with color process graphics, log and alarm/event displays.

Automatic startup, operation and shutdown of gas turbine and its auxiliaries.
Application software in controllers are battery backed-up for two months.
Safety system signals are failsafe and operates with 24VDC.
System programs in English.
PC based operator station of industrial rack mounted type with redundant hot-swap RAID controllers and a 19" panel mounted HMI with keyboard and mouse.

- Redundant operator station server, including one additional 24" desktop HMI client for placement in customer's premises.
- One month trending capacity for analogue signals.
- One common color laser printer.

Internal time synchronization with GPS clock between systems supplied within scope of supply.
No time synchronization of external systems included.
Operator HMI language: English.
Vibration monitoring system including key phasors and axial position.
Separate overspeed protection and monitoring system
Redundant CPUs, profibus and power supplies.
Hardwired signal interface to/from waste heat recovery unit control system for start/stop of gas turbine.
PCS7 engineering licence for control system programming included in separate desktop PC with 24" HMI, for placement in customer's premises.
Network interconnection of gas turbine packages giving access to all packages from any HMI.
Distributed I/O-modules mounted in MCC/external auxiliary system and at gas turbine/auxiliary skid.
Additional <no of> operator stations for installation by the customer. Consisting of desktop/rack computer, software, switch, patchcables and two 24" monitors.

Redundant OPC communication with external control system.

2.4.4 Cyber security system

User management included with custom users and authorities for Windows and Human machine interface, customer specific roles included.
Latest approved windows patches installed before FAT.
Virus scanning with offline scanner before shipment and at PAC.
System hardening according to Siemens specific policy.

All connections to external systems eg. Modbus, OPC, S7 and Time synchronization will be protected by firewall with Electrical Ethernet connection.
Malicious code protection:

Anti-Virus and Application control whitelisting installation.
Cyber security based on NERC:

Extended Cyber Security protection based on NERC

2.4.5 UPS and motor drives

UPS with MCB distribution board supplying uninterrupted power to instrument and control system. Automatic and bumpless switch over between mains and back-up battery by static frequency converter. UPS can be by-passed during maintenance.

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440 VDC sealed, valve regulated, lead acid battery. Capacity for ten hour emergency cooldown including UPS for one hour supply to instrument and control system. Ten years design life.
Panel mounted motor drive system for starter motor, lubricating oil pumps, oil mist fan and ventilation. Variable speed motor drives controlled by SFC's.

AC and DC power distribution boards with MCCB's. Panel ingress protection: IP21.

2.4.6 Electrical installation
Complete on-package electrical installation including main and emergency lighting, cabling with metal glands to junction boxes/remote I/O and single-phase and three-phase wall outlets. Power and instrument cables are routed on separate ladders with 90° intersections. Installation is done in workshop prior to shipping.

Industrial standard cables of halogen free, low smoke and fire classified type.
Crimp-on end sleeves on all cables and wires with a cross-section area of 6 mm2 and below.
Cable ladders in galvanized carbon steel.
Maximum cable length between package and electrical and control panel (m): 150
Interconnecting power and signal cables between package and electrical and control panels. Steel wire armoured cables of halogen free, low smoke and fire classified type. Length (m): 150

- Ladders in galvanized carbon steel. Length (m): 150

Cables between external auxiliaries and package. Steel wire armoured cables of halogen free, low smoke and fire classified type. Length (m): 25

- Ladders in galvanized carbon steel. Length [m]: 25

Cables between electrical and control panels in customer premises. Industrial standard cables of halogen free, low smoke and fire classified type. Length (m): 25

2.4.7 Black start diesel generator
Black start diesel generator set with circuit breaker, control equipment and fuel tank for 10 h operation.

Power rating: 850 kVA.

2.4.8 Remote connection
Remote connection, enabling online communication between gas turbine control system and Siemens' support center. Connection requires internet connection, provided by customer.

2.4.9 Distributed Control System
The offer includes the hardware and engineering required to provide a Distributed Control System (DCS) for control and monitoring of equipment listed in RFQ. The DCS is based on the Siemens PCS7 control system platform. This is a state of the art control system used as standard by Siemens Industrial Turbomachinery for its gas turbines. The system is used in many different control applications and market segments around the world. System knowledge is well spread and maintenance, spare parts and support can easily be found. The system is well documented and engineering, testing and troubleshooting is uncomplicated and fast.
Communication with external system is possible through a multitude of different standardized protocols. The system is provided with the following cubicles:
•10CKN11 – Power Distribution and redundant PLC for BoP/Plant Control
•10CKN12 – HW I/O Interface to plant equipment
•10CKN13 – HW I/O Interface to plant equipment and one I/O Node with safety IO.
•10CKN14 – Auxiliary network cabinet for communication with external and internal systems.
•10CWA10 – Computer rack containing plant servers and other computers as required.
The DCS will also provide the computers to be placed in the customers central control room. This will include the following:
• Redundant Operator Station Servers
• Two Operator Station Clients with single monitor.
• One Operator Station Client with Dual Monitor.
• One Combined Engineering Station and Operator Station Client with dual monitors.
• One Operator station client per GT, located in GT Unit Control Panel.
The offer also includes two operator consoles on which the supplied computers will be mounted. The computers themselves can either be placed in the operator consoles, or in the supplied computer rack

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and extended via KVM, depending on customer preferences.

2.5 Factory services

2.5.1 Packing and delivery

Delivery according to Incoterms 2010 as defined in Commercial terms and conditions.

Rental of lifting tools for transport and installation. The tools are property of Siemens and shall be returned.
Rental period for lifting tools 30 weeks from Ex-Works Finspong.
Packaging for sea transport.
Dryer for gas turbine during transport and storage. Suitable for storage up to six months

2.5.2 Factory assembly

Mechanical and electrical assembly and control system installation in workshop.

2.5.3 Factory tests

Balancing and over-speed testing of gas turbine rotor.

Electric generator routine test at the subcontractors workshop.
Gear box standard test at the subcontractors workshop.
Turbine controller FAT. HMI, software logics, sequences and trips tested with equipment simulator and project turbine controller, including communication test between HMI(s) and PLC(s).
Four hours mechanical running test of gas turbine according to API 616. Test is performed on gaseous fuel.
Performance guarantee test according to PTC 22/ISO2314 performed at workshop.
Unit workshop stationary test with contract auxiliaries and UCP. During the stationary test settings and adjustments are verified and flushing of systems carried out. Test includes unit energizing and complete starting sequence without fuel.
Workshop test with customer witness.
Fire extinguishing test release of H2O.
Witnessed FAT of turbine control system.
Witnessed mechanical running test of gas the turbine.
Witnessed balancing of gas turbine rotor. Witness includes a typical balancing and a review of balancing records for the contract rotor.
Witnessed shipment release inspection.
Witnessed electric generator routine test.

2.6 Installation and commissioning services

2.6.1 Site installation

Site installation offered on a daily rate basis.

2.6.2 Commissioning and site tests

Commissioning includes engineers to advice or perform stationary and rotating commissioning.

Stationary and rotating commissioning offered separately on a daily-rate basis.

2.7 Operation and maintenance

2.7.1 Documentation

Design phase documentation will be delivered during the project engineering phase.

- Including drawings, layouts, P&ID's, system descriptions, lists, quality plans, electrical and control documentation.

Final documentation

- Operation and Maintenance (O&M) documentation will be delivered in the As Designed and As Built delivery.
- Including O&M instructions, fault procedures, system descriptions, P&ID's, lists, drawings, layouts, sub vendor documentation, electrical and control documentation.
- Documentation language is English.
- Manufacturing record book including manufacturing and test reports, commissioning report and certificates.
- Number of Manufacturing record book copies: 1

Documentation in the design phase will be delivered according to Siemens Supplier Document Register List (SDRL).
Electronic files (PDF) are uploaded on Siemens sharepoint server according to document SDRL/CDL Processes, W980041E.

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Operation and Maintenance Documentation will be delivered according to Siemens scope, described in document Customer Documentation, W980025E.
The As Designed delivery (ExW + 16 weeks) is delivered in electronic format (3 DVD).
The As Built delivery (PAC + 14 weeks) is delivered in electronic format (3 DVD).

2.7.2 Customer training

On-site training for operation and maintenance personell.

Basic training for five days and 18 participants.
Training for electrical and instrument technicians for five days and six participants.
Training for mechanical technicians for two days and six participants.
Training for operators for three days and six participants.

2.7.3 Maintenance tools

Sets of special tools for the gas turbine package maintenance excluding normal hand tools, as listed below.

Turning of rotor and borescope inspection, excluding borescope.
Gas generator removal.
Gas generator tools.
Power turbine tools.
Roll out for maintenance.

- Left side, looking from exhaust to inlet.

Generator rotor removal tooling. Overhead crane not needed. Tool set includes:

- Rotor removal rolling tool complete.

2.7.4 Spare parts

Commissioning spare parts for core, unused parts kept by customer.

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3 Exclusions

Siemens Industrial Turbomachinery AB does not accept any responsibility for items outside this scope of supply. Equipment, works and services not listed in scope of supply are the purchaser's responsibility. Where design of the installation is to be provided by the purchaser, Siemens requests the opportunity to review and comment against the general arrangement. It is particularly important for safe and proper operation to ensure that the duct-work systems are compatible with the gas turbine.

The main exclusions from this scope of supply are:

Gas fuel ventilation pipes.
Power management system, PMS
Power system stabilizer site tuning and evaluation to meet grid requirements.
Network interconnecting cabling for control systems.
Any changes in the package's scope of supply due to SIL analysis results.
Distributed I/Os installed on package, skids or motor control center are not tested at turbine controller FAT.
Workshop test of combustion air inlet filter, ventilation and exhaust systems.
All civil works including foundations.
Counterflanges at terminal points.
Drain from terminal points.
Ducting to other locations than shown in layout drawing.
Earthing network.
Lightning protection.
External lighting.
No local equipment room supplied. Electrical and control cabinets to be installed in customer premises.
Fire detection and extinguishing for electric generator.
Generator circuit breaker.
Main power cabling from electric generator.
Instrument Air compressors
Sound and emission tests.

Following consumables and utilities:

- Auxiliary power.
- Fuel.
- Lubricating oil.
- Nitrogen.
- Washing detergent.
- Water.
- Grease.
- Instrument air.

Anything not specifically listed in the Scope of supply.

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Black Start Generator
Natural Gas Fueled

SCOPE OF WORK

Offering for the PVSC will consist of two (2) Black Start Generators systems as described below:

Two (2) Natural Gas Fueled Generators

- 4160V
- Siemens SGE-48SL (or Equal) – Lean Burn engine
- Paralleling Controls
- Winding RTDs and analog modules for temp displays
- Seismic Vibration Isolators
- No breaker (will be in gear, not provided in scope)
- Remote Radiator

  Dual Core "IEA brand" or equal

  Vertical air discharge

  Structural steel support frame and mounting holes to a concrete slab.

  Max dimensions of radiator are: 16' long by 8' wide

  480V motor with Space Heater

  Including S.S. Expansion Joints

  Booster Pump

  Thermostatic temp control

  Fan guards, Expansion tanks, 2 cooling loops

  Each loop to have its own engine driven water pump, temp and pressure indicators, flex connections.

  Connections to each radiator shall be S.S. corrugated hose with braid

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Remote Radiator protected against thermo shock or damage from cold weather.

Rust inhibitor included in initial fill.

Remote Radiator control in the generator control panel

OFF, Auto, ON

Control Power On indication

ow water level indicator light

Aftercooler

Jacket Water

Dry contacts for Motor in Auto and Running

Maximum dimensions – 7'6" width x 33'4" length

- Designed for Natural Gas supply pressure will be between 2-5 psig
- Transformer and load center (480:208V).
- CT's provided in separate box and connected
- Neutral Grounding resistor
- Voltage Surge Arrestors
- Capacitors
- Alternator Winding Strip heater
- Complete NG Fuel Skid including:

Pressure regulator,

Pressure relief valves,

Electrically operated (DC) valves, (Spring closed to shut off when gen is shutdown

Manual shutoff valves,

Excess flow control valve,

Total Valve Model 2600 or equal Strainer,

All stainless steel flexible connections,

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Flame arrestor,

Pressure taps with S.S. shutoff valves shall be installed at the inlet and outlet of the regulators.

Fuel Pressure gauge shall be installed at the inlet of the regulator.

Additional equipment needed for 2-5 PSIG NG line to be regulated down to operating gas.

- Critical Exhaust

S.S. Flex – 18”

Removable insulation Blanket

S.S. Exhaust Piping, Expansion joints, anchors, hangers, and supports for silencer.

- Nicad batteries – 24VDC
- Battery Charger for Nicad batteries – Dual Rate with full metering package
- Battery Rack and charger to be skid mounted to the gen skid.
- (2) Dry contacts for Gen Run
- Dry Contact for Remote Common Alarm
- Dry Contact for Remote Mode
- Controller Relays Required:

Over / under voltage

Reverse Power

Over/ Under Frequency

Overcurrent

- Estop

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Scope of Work

Reciprocating Fuel Gas Compressors

PVSC

Doc. No.

Rev. ind.

A

GTI No. **J1204938E**

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Reciprocating Fuel Gas Compressor

3 x 50% Design

SCOPE OF WORK

PACKAGED MOTOR DRIVE RECIPROCATING COMPRESSOR

Complete UEC reciprocating compressor package(s), each with a single compressor and driver mounted on a steel skid and containing necessary on-skid wiring, piping, and controls, as described below.

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CONDITIONS OF SERVICE

Location	New Jersey
Elevation (FASL)	12
Ambient Temperature	-5°F to 108°F

	Guarantee Case	Range
Service:	Fuel Gas	Fuel Gas
Unit Design:	3 x 50%	3 x 50%
Gas composition:	0.58	0.58
Flow rate per unit (SCFM):	6,000	3,433
Inlet pressure at skid edge (PSIG):	5	5 – 45*
Discharge pressure at skid edge (PSIG):	310	225 – 310
Suction temperature (°F):	50	50 – 120

PACKAGE STUDIES

The following package studies are typically performed by a 3rd party consulting firm:

1. Acoustical & mechanical studies (API 618 Design Approach 3a) — Included
2. Torsional analysis — Included

Acoustical studies – The outcome of this study will examine the suitability of the pulsation bottles and piping system, and determine if any changes are required. Typical changes include pulsation bottle sizing, adding of internals (choke tubes and baffles), orifice plates, main skid beam or pedestal sizes and additional pipe supports. If off-skid piping (including to suction/discharge headers, other compressor equipment, etc.) is to be included in studies, customer must supply drawings in timely manner or it will affect the delivery schedule. See the standard notes on gas compressor applications section for further details.

SE-612 83 FINSPONG, Sweden

Siemens Industrial Turbomachinery AB

Based on:
Ref.des.:
Doc. des.: / () / &

Author
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Torsional study – The outcome of this study will examine the suitability of the driver and coupling, and determine if a flywheel or others charges are required. A flywheel, if required, is not included in the compressor pricing.

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EQUIPMENT DESCRIPTION

COMPRESSOR

Reciprocating compressor, double acting, horizontally opposed as described below:

Compressor Model	6HOS4 or Equal
Rated Frame BHP	4000
Rated Frame RPM	1200
Stroke (in.)	6.00
Max Rod Load – Total	60,000

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- Force feed cylinder lubricator with divider blocks and no flow shutdown
- Meets the requirements of API 11P with supplier standard comments and exceptions
- Subject to supplier standard comments and exceptions for API 618
- 304/304L stainless steel tubing with zinc plated steel fittings
- Compressor mounted with sole plates and shims in grout box
- Compressor distance pieces mounted with Rotachock (or equal) mounts
- Compressor manufacturer's standard run test

CYLINDERS

Double acting, unlined, and lubricated cylinders as described below:

Service	Stage	Qty	Class	Bore (in.)	MAWP	Pockets	Unloaders
1	1	2	G5121	26.000	280 PSIG	VVCP	N/A
	2	1	G8767	19.000	470 PSIG	VVCP	N/A
	3	1	G8785	12.250	1050 PSIG	VVCP	N/A

VVCP – Variable volume clearance pockets for manual capacity control

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- Cylinder bodies are ductile iron unless otherwise specified
- Air cooled cylinders, water cooled packing not required on any cylinders
- Carbon steel, Ion Nitride piston rods
- Compressor manufacturer's standard cylinder hydrotest

DISTANCE PIECE, VENTS & DRAINS

- Standard (single compartment) distance piece for all throws
- Vents and drains brought to skid edge

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COMPRESSOR OIL SYSTEM

Closed loop oil system, each package, as described below:

- Shaft driven primary oil pump with suction strainer
- Simplex oil filter
- Electric pre-lube pump with check valve downstream of pump
- Crankcase immersion heater
- Direct oil cooled heat exchanger, radiator style mounted on-skid (480V)
- Thermostatic lube oil temperature control valve
- Automatic oil level make-up controller
- Compressor oil day tank not included (by others)

COMPRESSOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) vibration transmitter
- One (1) compressor oil pressure transmitter
- One (1) compressor oil pressure indicator
- One (1) compressor oil temperature element, downstream of oil cooler
- Two (2) compressor oil temperature gauges, upstream and downstream of oil cooler

COUPLING AND GUARD

- Double-flexing spacer coupling (or equal) with standard carbon steel hubs and dry type, carbon steel flex pack initially sized for a minimum 3.0 service factor.
- OSHA compliant full drive guard covering flywheel and coupling, with view port for determining unit rotation and designed for ease of removal

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MOTOR

Siemens or equal electric motor driver:

HP rating	1800
Speed	1200 RPM
Power rating	4160V/3Ph/60Hz
Enclosure Type	WPII
Air Filters	Stainless Steel
Differential Pressure Switch	Yes
Insulation Class	F
Temperature Rise	B
Service Factor	1.15
Elevation	3300 FASL
Maximum Ambient Temperature	40°C
Fixed Speed Operation	No
VFD Compatible	Yes
Starting Method	VFD

Additional features include:

- Space heater (120/240V)
- Rotachock (or equal) mounts
- Manufacturer's routine non-witnessed tests only are included
- Suitable for installation in a Class 1 Division 2 Group D hazardous area, T2B temp code (area classification and temp code to be confirmed by customer)
- Manufactured in Norwood, OH USA
- Variable Frequency Drive (VFD) manufactured by Siemens Model #6SR42020DG422AJ0-Z, shipped loose.

MOTOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) Metrix vibration transmitter
- Winding RTDs, 100 Ohm platinum, 2 per phase
- Bearing RTDs, 100 Ohm platinum, 1 per bearing
- Wired by others to customer provided MCC

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Note – Motor starter to be installed off-skid by others with power wiring between starter and main drive motor by others. Electrical design for power systems and subsystems supplying the compressor main drive motor is the responsibility of the contractor.

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PROCESS AIR COOLER

Air-X-Changers (or equivalent) box header heat exchanger for process gas cooling as described below:

- One cooler per package, 3 x 50% design
- Mounted off-skid, interconnecting piping from skid edge to cooler is by others
- Cooler driven by VFD compatible, 480V 30hp electric motor with space heater
- Murphy VS-2EX vibration switch
- Standard enamel paint with tint to match as required
- Manufactured in Tulsa, OK USA
- Fan motor starter by others, power wiring by others.

PROCESS GAS SECTION(S)

- IC section temperatures 119°F (20°F approach, based on 99°F ambient performance)
- Recycle section temperature 119°F (20°F approach, based on 99°F ambient performance)
- Fouling factor 0.001
- Corrosion allowance 0”
- Tubes SA-214 (welded carbon steel)
- Headers SA-516-70 (carbon steel)
- (3) sets automatic discharge louvers with pneumatic actuators and Kimray T12 temperature controllers, individual per stage
- Spot RT examined headers
- 1” npt thermowell connection opposite outlet nozzles
- ASME code stamp with national board registration

SUCTION SCRUBBERS

Scrubbers have been provided at the inlet of each stage of compression for removal of liquids (bulk liquid removal such as slugs has not been considered for design) as described below:

Scrubber	O.D.	S/S	MAWP	Temp.	Internals	C.A.	Material

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Stage 1	26"	100"	150 PSIG	150°F	Vane Pack	0"	Carbon Steel
Stage 2	22"	94"	215 PSIG	150°F	Vane Pack	0"	Carbon Steel
Stage 3	20"	84"	300 PSIG	150°F	Vane Pack	0"	Carbon Steel

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- Vane Mist Extractors and mesh type mist eliminators are designed to remove 99.9% of all liquid entrainment 8 microns and larger which is present in the processed gas stream, carry-over of 8 micron and larger entrained liquids will be less than 1/10 gallon per million standard cubic feet of processed gas
- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell
- Flange bolt-holes shall straddle the bottle centerline
- Located on-skid, each scrubber cascaded to previous scrubber and brought to single skid edge connection

SUCTION SCRUBBER TRIM

- Level gauge, reflex style – Penberthy RL (3/4" NPT)
- Level switch (high shutdown), electric – Murphy LS200 (2" NPT)
- Level controller, pneumatic – Murphy LS200NDVOR (2" NPT)
- Automatic dump valve, pneumatic – Murphy DVU150 (1" NPT)
- Manual drain valve – 1" NPT ball valve
- Check valve – 1" NPT piston check

PULSATION BOTTLES

Pulsation bottles have been provided at the suction and discharge of each stage of compression based on the sizing criteria of API 11P with no vessel internals with preliminary sizing as described below:

Bottle	O.D.	S/S	MAWP	Temp.	C.A.	Material

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1st Stage Suction	36"	64"	150 PSIG	150°F	0"	Carbon Steel
1st Stage Discharge	24"	64"	215 PSIG	350°F	0"	Carbon Steel
2nd Stage Suction	24"	26"	215 PSIG	150°F	0"	Carbon Steel
2nd Stage Discharge	16"	26"	300 PSIG	350°F	0"	Carbon Steel
3rd Stage Suction	16"	22"	300 PSIG	150°F	0"	Carbon Steel
3rd Stage Discharge	12.75"	22"	645 PSIG	350°F	0"	Carbon Steel

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- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping and cylinder nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell
- All suction bottles have "Vee" notch connection to the cylinder to prevent puddling of any liquids that could accidently exist
- Pulsation bottles include two inspection openings, vent, drain, pressure and temperature connections, per spec items#54 & #55
- Base price includes API 618, 5th Edition Design Approach 3a studies (formerly M2-M5)

PIPING SYSTEMS & DESIGN

All piping provided on skid shall be designed and built in accordance with below:

PROCESS PIPING

Process piping provided per preliminary sizing and general criteria as described below:

Pipe Run	Nominal Size	Flange	Material	Rating
1st Stage Suction	18" STD	150#RF	Carbon Steel	150 PSIG @ 150°F
1st Stage Discharge	12" STD	150#RF	Carbon Steel	215 PSIG @ 350°F
2nd Stage Suction	12" STD	150#RF	Carbon Steel	215 PSIG @ 150°F

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2nd Stage Discharge	8" S/40	300#RF	Carbon Steel	300 PSIG @ 350°F
3rd Stage Suction	8" S/40	300#RF	Carbon Steel	300 PSIG @ 150°F
3rd Stage Discharge	6" S/40	300#RF	Carbon Steel	645 PSIG @ 350°F
Final Discharge	6" S/40	300#RF	Carbon Steel	645 PSIG @ 350°F

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- Process Piping Code: B31.3
- Non Destructive Examination: Per Code (Radiography or Phased Array)
- Corrosion Allowance: 0.000”
- Hydrotest: 1.5 times design pressure
- Carbon Steel Material: SA-106B
- Suction Connection: Suction scrubber flange
- Discharge Connection: Skid edge

PIPING DESIGN

Design of the piping systems shall be as follows:

- The process pipe shall be sized based on a maximum gas velocity of 3000ft/min or by pressure drop calculations where applicable
- All piping greater than 2” nominal shall be buttweld and schedule STD minimum
- All piping 2” and smaller shall be socketweld or threaded and schedule 80 minimum
- All process and auxiliary gas piping 1” shall be socketweld or threaded and schedule 160
- Socketweld piping to be visually inspected, radiography not provided
- Flanges shall be raised face and rated in accordance with ANSI B16.5
- Flange gaskets shall be flexitallic and bolting studs shall be grade B7
- Pipe fittings shall be 3000 PSI for gas and auxiliary piping as a minimum, and may be socketweld or threaded
- All welded pipe is hydrotested

PROCESS INSTRUMENTATION

In addition to manufacturer’s standard instrumentation, the following additional instrumentation is included:

- Suction pressure transmitter at inlet of package
- Suction pressure gauge at inlet of package
- Discharge pressure transmitter, per stage
- Discharge pressure gauge, per stage
- Temperature element, per cylinder discharge
- Temperature gauge, per discharge of each stage

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- Please advise if additional instrumentation is required

GENERAL TUBING

General tubing, typical, as described below:

- Threaded carbon steel instrument air manifold with isolation valves for each device
- All tube fittings shall be stainless steel compression fittings
- All tubing shall be stainless steel

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CAPACITY CONTROL SYSTEMS

The following methods of capacity control have been included:

1. Variable volume clearance pockets (VVCP) on the compressor cylinder(s)
2. Automatic recycle capacity control valve
3. Motor speed turndown (VFD)

SYSTEM VALVES

System valves included in UEC scope of supply as described below:

- Suction pressure control valves – see Suction Pressure Control Valve Skid below for details
- Automatic recycle valve, 2”-300#RF Fisher V200 with Fisher DVC6200 digital positioner for capacity control and startup
- Manual blowdown valve, 1”-300#RF ball valve
- Contractor to provide inlet and outlet isolation valves in interconnecting piping.

System valves shall be provided as per the following guidelines:

- Ball valves to be full port with carbon steel body and carbon trim (ball & stem)
- Large bore (greater than 2”) ball valves to be KF or equal
- Small bore ball valves to be KF, Apollo or equal
- Small bore globe valves, check valves to be Bonney Forge or equal

RELIEF VALVES

Process relief valves as described below:

- Farris, Mercer or equal
- Thermal relief valve for suction scrubber
  - Threaded conventional spring type valve
  - Full flow relief protection sized for any upset conditions upstream of package by others
- Full flow relief valves for discharge of each stage of compression
  - Flanged conventional spring type or pilot type valve(s)
- Relief valves and blowdown manifolded and brought to single common skid edge connection

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SIEMENS

Scope of Work

Reciprocating Fuel Gas Compressors

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CONTROL PANEL & ELECTRICAL

Each compressor package shall have controls and electrical as outlined below:

CONTROL PANEL

Complete compressor logic control panel rated for Class 1, Division 2, Group D with alarm, shutdown and control items as described below:

- Allen Bradley ControlLogix – *Simplex Processor*
- PanelView Plus 19" HMI (maximum screen size available)
- Collapsible HMI Sun shield
- Ethernet switch for Modbus communications with Fiber Optic
- Enclosure built to NEMA 4 specifications
- Panel mounted and wired on-skid
- 20% spare terminal blocks for future connections
- UL698B listed assembled control panel for installation in a classified area
- Individual fuses for all PLC modules and HMI
- Notifications of alarms and shutdowns to protect compressor package
- Common relay contacts for dry contact remote start, run enabled and annunciation
- Suitable for customer-supplied primary power of 125 VDC and customer-supplied secondary power of 120 VAC. Our panel has this capability by including separate/redundant 24VDC Power Supply modules, with one accepting 125VDC and the second accepting 120VAC.
- One set of licensed software for the ControlLogix PLC & PanelView Plus HMI included for all three panels. If additional copies are required, they are available for a price adder.

INSTRUMENTATION

Instruments as described below:

- All instruments and electrical devices shall be suitable for installation in a Class 1 Group D Division 2 hazardous area
- In general, installation of pressure and temperature devices as follows:
  - Instrument connections in piping provided by thredolet unless otherwise noted
  - Pressure instrument shall be supplied with threaded instrument valve when installed in piping. Pressure gauges shall be mounted at or near the valve, pressure transmitters may be rack mounted near control panel or junction box (if provided).
    - Instrument valves to be threaded stainless steel gauge (needle) type block and bleed valve – Anderson Greenwood (M25VIS) or equal
    - Root valve provided upstream of instrument valve, socketwelded carbon steel ball valve
    - Pulsation dampeners provided for pressure instrumentation
  - Temperature instrument shall be supplied with a stainless steel threaded thermowell when installed in piping. The instrument shall be mounted at the

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thermowell. Temperature elements are to be wired directly to control system (no transmitter).

- UEC standard P&ID tagging with wire can be provided for instrumentation upon request
- Instrumentation has been provided as follows (or approved equivalent):

Instrument	Make	Model
Pressure Transmitter	Rosemount	3051T with LCD display
Pressure Indicator	Ashcroft	1279
Differential Pressure Indicator	Orange Research	1201/1203/1516
Temperature Element	Thermocouple	Type K
Temperature Indicator	Ashcroft	EL
Vibration Transmitter	Metrix	ST5484E
Vibration Switch	Murphy	VS2EX
Level Switch	Murphy	LS200
Level Control	Murphy	LS200NDVOR
Level Gauge	Penberthy	RL
Oil Controller / Gauge / Switch	Kenco	LCE
No Flow Switch	Dresser-Rand	DNFT 24 VDC

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CONDUIT AND WIRING

General conduit and wiring, typical, as described below:

- All conduit and wiring shall be installed in accordance with the NEC for installation in a Class 1 Group D Division 2 hazardous area
- Weather-tight, rigid conduit with liquid-tight, flexible conduit pigtails and THHN or MTW #14 copper stranded internal wiring
- Armored cable and cable trays available upon request for optional price adder

CONTROL TUBING

All tubing is 316L stainless steel with Parker or Swagelok 316L stainless steel compression fittings.

STRUCTURAL STEEL FRAME

Structural steel frame with preliminary dimensions as described below:

- Estimated Skid Width: 19’0”
- Estimated Skid Length: 30’0”
- Estimated Package Height: 12’6”
- Estimated Shipping Weight: 130,000 LBS

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- Frame is welded using A-36 steel in accordance with AWS D1.1
- All welders are certified and all procedures are qualified
- Pipe drawbars or lifting lugs at each end of skid
- 2" drip lip around compressor package
- (2) grounding lugs provided on opposite corners of skid

SOUND ENCLOSURE

Sound enclosure with equipment as described below:

- Single enclosure mounted on concrete around perimeter of all three compressor skids
- All equipment to be Class 1, Division 2, Group D
- Noise level outside enclosure guaranteed to be 85dBA or less at 3 feet
- Preliminary dimensions of 38'x82'x15' high
- Blow out panels
- Forced air ventilation system
- Temperature element wired to control panels to shutdown on high air temp inside building
- Electric heater
- UV Fire Detection & gas detectors
- Control panel with battery back-up for fire and gas detectors
- Control panel has a Z-purge and is mounted on the exterior of the enclosure

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PAINTING AND PREPARATION

Painting and preparation as described below:

- Standard UE Compression Type 4 paint system as follows:
  - SSPC-SP6 sandblast of non-painted items, including skids, vessels and process piping. Pre-painted items will be cleaned and top coated only. All other piping will be prepped by SSPC-SP1, 2 or 3, primed and top coated.
  - Tnemec or equal high build epoxy primer, 4-6 mils (dry).
  - Tnemec or equal Series 73 polyurethane enamel top coat, 2-3 mils (dry).
- Color: UE standard paint color gray, single monolithic color only

SHOP TESTING

Shop testing described below:

- Functional checkout of all end devices
- Leak testing of gas and pneumatic control systems
- Full shop alignment of motor and compressor
- No load run test of compressor package not provided as adequate power is not available

MATERIAL COUNTRY OF ORIGIN

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Unless otherwise agreed to, standard country of origin shall apply for all directly sourced materials. 3rd party equipment (compressor, driver, etc.) subject to vendor's standard country of origin. Standard countries: USA, Canada, Mexico, Great Britain, Spain, Germany, France, Austria, Switzerland, Portugal, Italy, Belgium, South Africa, South Korea, and Japan.

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Reciprocating Fuel Gas Compressor
3 x 50% Design

SCOPE OF WORK

PACKAGED MOTOR DRIVE RECIPROCATING COMPRESSOR

Complete UEC reciprocating compressor package(s), each with a single compressor and driver mounted on a steel skid and containing necessary on-skid wiring, piping, and controls, as described below.

CONDITIONS OF SERVICE

Location	New Jersey
Elevation (FASL)	12
Ambient Temperature	-5°F to 108°F

	Guarantee Case	Range
Service:	Fuel Gas	Fuel Gas
Unit Design:	3 x 50%	3 x 50%
Gas composition:	0.58	0.58
Flow rate per unit (SCFM):	6,000	3,433
Inlet pressure at skid edge (PSIG):	5	5 – 45*
Discharge pressure at skid edge (PSIG):	310	225 – 310
Suction temperature (°F):	50	50 – 120

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PACKAGE STUDIES

The following package studies are typically performed by a 3rd party consulting firm:

1.	Acoustical & mechanical studies (API 618 Design Approach 3a)	Included
2.	Torsional analysis	Included

Acoustical studies – The outcome of this study will examine the suitability of the pulsation bottles and piping system, and determine if any changes are required. Typical changes include pulsation bottle sizing, adding of internals (choke tubes and baffles), orifice plates, main skid beam or pedestal sizes and additional pipe supports. If off-skid piping (including to suction/discharge headers, other compressor equipment, etc.) is to be included in studies, customer must supply drawings in timely manner or it will affect the delivery schedule. See the standard notes on gas compressor applications section for further details.

Torsional study – The outcome of this study will examine the suitability of the driver and coupling, and determine if a flywheel or others charges are required. A flywheel, if required, is not included in the compressor pricing.

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EQUIPMENT DESCRIPTION

COMPRESSOR

Reciprocating compressor, double acting, horizontally opposed as described below:

Compressor Model	6HOS4 or Equal
Rated Frame BHP	4000
Rated Frame RPM	1200
Stroke (in.)	6.00
Max Rod Load – Total	60,000

- Force feed cylinder lubricator with divider blocks and no flow shutdown
- Meets the requirements of API 11P with supplier standard comments and exceptions
- Subject to supplier standard comments and exceptions for API 618
- 304/304L stainless steel tubing with zinc plated steel fittings
- Compressor mounted with sole plates and shims in grout box
- Compressor distance pieces mounted with Rotachock (or equal) mounts
- Compressor manufacturer's standard run test

CYLINDERS

Double acting, unlined, and lubricated cylinders as described below:

Service	Stage	Qty	Class	Bore (in.)	MAWP	Pockets	Unloaders
1	1	2	G5121	26.000	280 PSIG	VVCP	N/A
	2	1	G8767	19.000	470 PSIG	VVCP	N/A
	3	1	G8785	12.250	1050 PSIG	VVCP	N/A

VVCP – Variable volume clearance pockets for manual capacity control

- Cylinder bodies are ductile iron unless otherwise specified
- Air cooled cylinders, water cooled packing not required on any cylinders
- Carbon steel, Ion Nitride piston rods
- Compressor manufacturer's standard cylinder hydrotest

DISTANCE PIECE, VENTS & DRAINS

- Standard (single compartment) distance piece for all throws
- Vents and drains brought to skid edge

COMPRESSOR OIL SYSTEM

Closed loop oil system, each package, as described below:

- Shaft driven primary oil pump with suction strainer
- Simplex oil filter
- Electric pre-lube pump with check valve downstream of pump
- Crankcase immersion heater
- Direct oil cooled heat exchanger, radiator style mounted on-skid (480V)
- Thermostatic lube oil temperature control valve
- Automatic oil level make-up controller
- Compressor oil day tank not included (by others)

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COMPRESSOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) vibration transmitter
- One (1) compressor oil pressure transmitter
- One (1) compressor oil pressure indicator
- One (1) compressor oil temperature element, downstream of oil cooler
- Two (2) compressor oil temperature gauges, upstream and downstream of oil cooler

COUPLING AND GUARD

- Double-flexing spacer coupling (or equal) with standard carbon steel hubs and dry type, carbon steel flex pack initially sized for a minimum 3.0 service factor.
- OSHA compliant full drive guard covering flywheel and coupling, with view port for determining unit rotation and designed for ease of removal

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MOTOR

Siemens or equal electric motor driver:

HP rating	1800
Speed	1200 RPM
Power rating	4160V/3Ph/60Hz
Enclosure Type	WPII
Air Filters	Stainless Steel
Differential Pressure Switch	Yes
Insulation Class	F
Temperature Rise	B
Service Factor	1.15
Elevation	3300 FASL
Maximum Ambient Temperature	40°C
Fixed Speed Operation	No
VFD Compatible	Yes
Starting Method	VFD

Additional features include:

- Space heater (120/240V)
- Rotachock (or equal) mounts
- Manufacturer's routine non-witnessed tests only are included
- Suitable for installation in a Class 1 Division 2 Group D hazardous area, T2B temp code (area classification and temp code to be confirmed by customer)
- Manufactured in Norwood, OH USA
- Variable Frequency Drive (VFD) manufactured by Siemens Model #6SR42020DG422AJ0-Z, shipped loose.

MOTOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) Metrix vibration transmitter
- Winding RTDs, 100 Ohm platinum, 2 per phase

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- Bearing RTDs, 100 Ohm platinum, 1 per bearing
- Wired by others to customer provided MCC

Note – Motor starter to be installed off-skid by others with power wiring between starter and main drive motor by others. Electrical design for power systems and subsystems supplying the compressor main drive motor is the responsibility of the contractor.

PROCESS AIR COOLER

Air-X-Changers (or equivalent) box header heat exchanger for process gas cooling as described below:

- One cooler per package, 3 x 50% design
- Mounted off-skid, interconnecting piping from skid edge to cooler is by others
- Cooler driven by VFD compatible, 480V 30hp electric motor with space heater
- Murphy VS-2EX vibration switch
- Standard enamel paint with tint to match as required
- Manufactured in Tulsa, OK USA
- Fan motor starter by others, power wiring by others.

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PROCESS GAS SECTION(S)

- IC section temperatures 119°F (20°F approach, based on 99°F ambient performance)
- Recycle section temperature 119°F (20°F approach, based on 99°F ambient performance)
- Fouling factor 0.001
- Corrosion allowance 0”
- Tubes SA-214 (welded carbon steel)
- Headers SA-516-70 (carbon steel)
- (3) sets automatic discharge louvers with pneumatic actuators and Kimray T12 temperature controllers, individual per stage
- Spot RT examined headers
- 1” npt thermowell connection opposite outlet nozzles
- ASME code stamp with national board registration

SUCTION SCRUBBERS

Scrubbers have been provided at the inlet of each stage of compression for removal of liquids (bulk liquid removal such as slugs has not been considered for design) as described below:

Scrubber	O.D.	S/S	MAWP	Temp.	Internals	C.A.	Material
Stage 1	26"	100"	150 PSIG	150°F	Vane Pack	0"	Carbon Steel
Stage 2	22"	94"	215 PSIG	150°F	Vane Pack	0"	Carbon Steel
Stage 3	20"	84"	300 PSIG	150°F	Vane Pack	0"	Carbon Steel

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- Vane Mist Extractors and mesh type mist eliminators are designed to remove 99.9% of all liquid entrainment 8 microns and larger which is present in the processed gas stream, carry-over of 8 micron and larger entrained liquids will be less than 1/10 gallon per million standard cubic feet of processed gas
- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell
- Flange bolt-holes shall straddle the bottle centerline
- Located on-skid, each scrubber cascaded to previous scrubber and brought to single skid edge connection

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SUCTION SCRUBBER TRIM

- Level gauge, reflex style – Penberthy RL (3/4" NPT)
- Level switch (high shutdown), electric – Murphy LS200 (2" NPT)
- Level controller, pneumatic – Murphy LS200NDVOR (2" NPT)
- Automatic dump valve, pneumatic – Murphy DVU150 (1" NPT)
- Manual drain valve – 1" NPT ball valve
- Check valve – 1" NPT piston check

PULSATION BOTTLES

Pulsation bottles have been provided at the suction and discharge of each stage of compression based on the sizing criteria of API 11P with no vessel internals with preliminary sizing as described below:

Bottle	O.D.	S/S	MAWP	Temp.	C.A.	Material
1st Stage Suction	36"	64"	150 PSIG	150°F	0"	Carbon Steel
1st Stage Discharge	24"	64"	215 PSIG	350°F	0"	Carbon Steel
2nd Stage Suction	24"	26"	215 PSIG	150°F	0"	Carbon Steel
2nd Stage Discharge	16"	26"	300 PSIG	350°F	0"	Carbon Steel
3rd Stage Suction	16"	22"	300 PSIG	150°F	0"	Carbon Steel
3rd Stage Discharge	12.75"	22"	645 PSIG	350°F	0"	Carbon Steel

- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping and cylinder nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell

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- All suction bottles have “Vee” notch connection to the cylinder to prevent puddling of any liquids that could accidently exist
- Pulsation bottles include two inspection openings, vent, drain, pressure and temperature connections, per spec items#54 & #55
- Base price includes API 618, 5th Edition Design Approach 3a studies (formerly M2-M5)

PIPING SYSTEMS & DESIGN

All piping provided on skid shall be designed and built in accordance with below:

PROCESS PIPING

Process piping provided per preliminary sizing and general criteria as described below:

Pipe Run	Nominal Size	Flange	Material	Rating
1st Stage Suction	18" STD	150#RF	Carbon Steel	150 PSIG @ 150°F
1st Stage Discharge	12" STD	150#RF	Carbon Steel	215 PSIG @ 350°F
2nd Stage Suction	12" STD	150#RF	Carbon Steel	215 PSIG @ 150°F
2nd Stage Discharge	8" S/40	300#RF	Carbon Steel	300 PSIG @ 350°F
3rd Stage Suction	8" S/40	300#RF	Carbon Steel	300 PSIG @ 150°F
3rd Stage Discharge	6" S/40	300#RF	Carbon Steel	645 PSIG @ 350°F
Final Discharge	6" S/40	300#RF	Carbon Steel	645 PSIG @ 350°F

- Process Piping Code: B31.3
- Non Destructive Examination: Per Code (Radiography or Phased Array)
- Corrosion Allowance: 0.000”
- Hydrotest: 1.5 times design pressure
- Carbon Steel Material: SA-106B
- Suction Connection: Suction scrubber flange
- Discharge Connection: Skid edge

PIPING DESIGN

Design of the piping systems shall be as follows:

- The process pipe shall be sized based on a maximum gas velocity of 3000ft/min or by pressure drop calculations where applicable
- All piping greater than 2” nominal shall be buttweld and schedule STD minimum
- All piping 2” and smaller shall be socketweld or threaded and schedule 80 minimum
- All process and auxiliary gas piping 1” shall be socketweld or threaded and schedule 160
- Socketweld piping to be visually inspected, radiography not provided
- Flanges shall be raised face and rated in accordance with ANSI B16.5
- Flange gaskets shall be flexitallic and bolting studs shall be grade B7
- Pipe fittings shall be 3000 PSI for gas and auxiliary piping as a minimum, and may be socketweld or threaded
- All welded pipe is hydrotested

PROCESS INSTRUMENTATION

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In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- Suction pressure transmitter at inlet of package
- Suction pressure gauge at inlet of package
- Discharge pressure transmitter, per stage
- Discharge pressure gauge, per stage
- Temperature element, per cylinder discharge
- Temperature gauge, per discharge of each stage
- Please advise if additional instrumentation is required

GENERAL TUBING

General tubing, typical, as described below:

- Threaded carbon steel instrument air manifold with isolation valves for each device
- All tube fittings shall be stainless steel compression fittings
- All tubing shall be stainless steel

CAPACITY CONTROL SYSTEMS

The following methods of capacity control have been included:

1. Variable volume clearance pockets (VVCP) on the compressor cylinder(s)
2. Automatic recycle capacity control valve
3. Motor speed turndown (VFD)

SYSTEM VALVES

System valves included in UEC scope of supply as described below:

- Suction pressure control valves – see Suction Pressure Control Valve Skid below for details
- Automatic recycle valve, 2"-300#RF Fisher V200 with Fisher DVC6200 digital positioner for capacity control and startup
- Manual blowdown valve, 1"-300#RF ball valve
- Contractor to provide inlet and outlet isolation valves in interconnecting piping.

System valves shall be provided as per the following guidelines:

- Ball valves to be full port with carbon steel body and carbon trim (ball & stem)
- Large bore (greater than 2") ball valves to be KF or equal
- Small bore ball valves to be KF, Apollo or equal
- Small bore globe valves, check valves to be Bonney Forge or equal

RELIEF VALVES

Process relief valves as described below:

- Farris, Mercer or equal
- Thermal relief valve for suction scrubber
  - Threaded conventional spring type valve
  - Full flow relief protection sized for any upset conditions upstream of package by others
- Full flow relief valves for discharge of each stage of compression
  - Flanged conventional spring type or pilot type valve(s)
- Relief valves and blowdown manifolded and brought to single common skid edge connection

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CONTROL PANEL & ELECTRICAL

Each compressor package shall have controls and electrical as outlined below:

CONTROL PANEL

Complete compressor logic control panel rated for Class 1, Division 2, Group D with alarm, shutdown and control items as described below:

- Allen Bradley ControlLogix – *Simplex Processor*
- PanelView Plus 19" HMI (maximum screen size available)
- Collapsible HMI Sun shield
- Ethernet switch for Modbus communications with Fiber Optic
- Enclosure built to NEMA 4 specifications
- Panel mounted and wired on-skid
- 20% spare terminal blocks for future connections
- UL698B listed assembled control panel for installation in a classified area
- Individual fuses for all PLC modules and HMI
- Notifications of alarms and shutdowns to protect compressor package
- Common relay contacts for dry contact remote start, run enabled and annunciation
- Suitable for customer-supplied primary power of 125 VDC and customer-supplied secondary power of 120 VAC. Our panel has this capability by including separate/redundant 24VDC Power Supply modules, with one accepting 125VDC and the second accepting 120VAC.
- One set of licensed software for the ControlLogix PLC & PanelView Plus HMI included for all three panels. If additional copies are required, they are available for a price adder.

INSTRUMENTATION

Instruments as described below:

- All instruments and electrical devices shall be suitable for installation in a Class 1 Group D Division 2 hazardous area
- In general, installation of pressure and temperature devices as follows:
  - Instrument connections in piping provided by thredolet unless otherwise noted
  - Pressure instrument shall be supplied with threaded instrument valve when installed in piping. Pressure gauges shall be mounted at or near the valve, pressure transmitters may be rack mounted near control panel or junction box (if provided).
    - § Instrument valves to be threaded stainless steel gauge (needle) type block and bleed valve – Anderson Greenwood (M25VIS) or equal
    - § Root valve provided upstream of instrument valve, socketwelded carbon steel ball valve
    - § Pulsation dampeners provided for pressure instrumentation
  - Temperature instrument shall be supplied with a stainless steel threaded thermowell when installed in piping. The instrument shall be mounted at the thermowell. Temperature elements are to be wired directly to control system (no transmitter).
- UEC standard P&ID tagging with wire can be provided for instrumentation upon request
- Instrumentation has been provided as follows (or approved equivalent):

Instrument	Make	Model

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Pressure Transmitter	Rosemount	3051T with LCD display
Pressure Indicator	Ashcroft	1279
Differential Pressure Indicator	Orange Research	1201/1203/1516
Temperature Element	Thermocouple	Type K
Temperature Indicator	Ashcroft	EL
Vibration Transmitter	Metrix	ST5484E
Vibration Switch	Murphy	VS2EX
Level Switch	Murphy	LS200
Level Control	Murphy	LS200NDVOR
Level Gauge	Penberthy	RL
Oil Controller / Gauge / Switch	Kenco	LCE
No Flow Switch	Dresser-Rand	DNFT 24 VDC

CONDUIT AND WIRING

General conduit and wiring, typical, as described below:

- All conduit and wiring shall be installed in accordance with the NEC for installation in a Class 1 Group D Division 2 hazardous area
- Weather-tight, rigid conduit with liquid-tight, flexible conduit pigtails and THHN or MTW #14 copper stranded internal wiring
- Armored cable and cable trays available upon request for optional price adder

CONTROL TUBING

All tubing is 316L stainless steel with Parker or Swagelok 316L stainless steel compression fittings.

STRUCTURAL STEEL FRAME

Structural steel frame with preliminary dimensions as described below:

- Estimated Skid Width: 19'0"
- Estimated Skid Length: 30'0"
- Estimated Package Height: 12'6"
- Estimated Shipping Weight: 130,000 LBS
- Frame is welded using A-36 steel in accordance with AWS D1.1
- All welders are certified and all procedures are qualified
- Pipe drawbars or lifting lugs at each end of skid
- 2" drip lip around compressor package
- (2) grounding lugs provided on opposite corners of skid

SOUND ENCLOSURE

Sound enclosure with equipment as described below:

- Single enclosure mounted on concrete around perimeter of all three compressor skids
- All equipment to be Class 1, Division 2, Group D
- Noise level outside enclosure guaranteed to be 85dBA or less at 3 feet
- Preliminary dimensions of 38'x82'x15' high
- Blow out panels
- Forced air ventilation system
- Temperature element wired to control panels to shutdown on high air temp inside building

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- Electric heater
- UV Fire Detection & gas detectors
- Control panel with battery back-up for fire and gas detectors
- Control panel has a Z-purge and is mounted on the exterior of the enclosure

PAINTING AND PREPARATION

Painting and preparation as described below:

- Standard UE Compression Type 4 paint system as follows:
  - SSPC-SP6 sandblast of non-painted items, including skids, vessels and process piping. Pre-painted items will be cleaned and top coated only. All other piping will be prepped by SSPC-SP1, 2 or 3, primed and top coated.
  - Tnemec or equal high build epoxy primer, 4-6 mils (dry).
  - Tnemec or equal Series 73 polyurethane enamel top coat, 2-3 mils (dry).
- Color: UE standard paint color gray, single monolithic color only

SHOP TESTING

Shop testing described below:

- Functional checkout of all end devices
- Leak testing of gas and pneumatic control systems
- Full shop alignment of motor and compressor
- No load run test of compressor package not provided as adequate power is not available

MATERIAL COUNTRY OF ORIGIN

Unless otherwise agreed to, standard country of origin shall apply for all directly sourced materials. 3rd party equipment (compressor, driver, etc.) subject to vendor's standard country of origin.

Standard countries: USA, Canada, Mexico, Great Britain, Spain, Germany, France, Austria, Switzerland, Portugal, Italy, Belgium, South Africa, South Korea, and Japan.

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SIEMENS

General & Commercial

Oil cooler Exchanger

PVSC

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Rev. ind.

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Oil Cooler Exchanger

SCOPE OF WORK

Offering for the PVSC will consist of three (3) Oil Cooler Exchangers as described below:

- Air coolers are quoted to ASME Section VIII Div. 1, manufacturer's sound engineering practices, and customer specifications listed below.
- This quotation is based on Supplier's standard drawings, data, weld procedures, inspection test plan, and testing.
- Supplier proposes the GMAW (short arc) process for the root pass of single-welded joints followed with a FCAW (gas shielded) process for the filler. Supplier proposes the GMAW (short arc) process for the nozzle-to-header welds with the SMAW process for the filler. SAW is an additional welding process that could be used. All weld procedures, procedure qualifications, and weld map shall be submitted for approval prior to fabrication.
- Nozzle welds are set-on as a standard. Nozzle welds may intersect/overlap header (long seam) welds. Transition nozzles, if used, are alwaysset-on.
- Structural welding is per AWS D1.1 (2000). Structural weld procedures, procedure qualifications, and weld map are not submitted for approval prior to fabrication unless specifically requested at time of order.
- Carbon steel headers will be surface prepped per SSPC-SP5 and metalized, zinc flame spray (1 coat 3 mil thick). Headers shall be coated prior to hydrostatic testing and shall not be leaked test unless required by the customer prior to or after hydrostatic testing. Stainless steel headers shall be surface prepped per SSPC-SP7 and with no additional coating applied.
- The side frames and structure will be hand cleaned and then hot-dipped galvanized per ASTM 123.
- Mechanical equipment will be finished per manufacturer's standard.
- 9. Fins are quoted as L-Tension or Embedded type, as specified in the Air Cooled Exchanger Specification Sheet below, and will composed of our standard supply of Aluminum Alloy 1100-0 material.
- Fans quoted as Cofimco Manual Pitch or equal.

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Based on:
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- A maximum noise level guarantee is not included in the scope of supply. The cooler is designed for a calculated sound pressure of 82 DBA at 3 ft measured vertically from the fan tip for a single fan only and does not include any additional noise due to motors or drive components.
- Vibration switch quoted as Metrix 5550-121-01 Switch with Metrix ST5484E-121-0020-00 Vibration Transmitter.
- Structural steel will be standard A36 or equal material, which is taken from stock and is not traceable to specific MTRs. The plenum and drive support welds will be gapped and skip welded in order to prevent warpage during galvanizing.
- Supplier Engineering will work with the purchaser to provide the best possible design for the equipment proposed, based on the data provided with the inquiry.
- Motors quoted as electric with TEFC, CI.1, Div.2, Gr.D, Chemical Duty construction 460/3/60 Hz. Motors are quoted as single speed, 1800 RPM motors. All motors are VFD ready. Motors are mounted vertically shaft down. Motor is suitable for ± 10% of rated voltage. Please advise if true 480V motor is required since this may require special windings at additional cost and/or delivery.
- Motors shall include 120V space heaters
- Motor and fan access platform under all fans is provided.
- Motor manufacturer and frame size are preliminary and will be finalized after order to meet project requirements.
- Complete bays will ship completely assembled less columns, braces and ladders and walkways.
- Field service is not anticipated, however if requested a Supplier Representative will be available at daily rates.
- Included in our offering is Supplier's standard shop testing. This includes pressure testing of the pressure vessel by hydro-static means, one half hour motor/fan run-in test measuring the amp draw of the installed motors, and vibration measurement of the structure during the fan run-in test. Noise testing and full test erection of a single bay is available for an adder.
- Excess surface area and/or capacity has been included only if specifically indicated on the specification sheet below below.
- Unit is provided with turbulators inside the tubes to promote heat transfer. Turbulators are of stainless construction.

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- Tube bundles for “lube oil” service shall be pressure tested with oil instead of water. It is recommended that an oil flush be performed after hydro test. Supplier Standard oil flush is included in the base price above.

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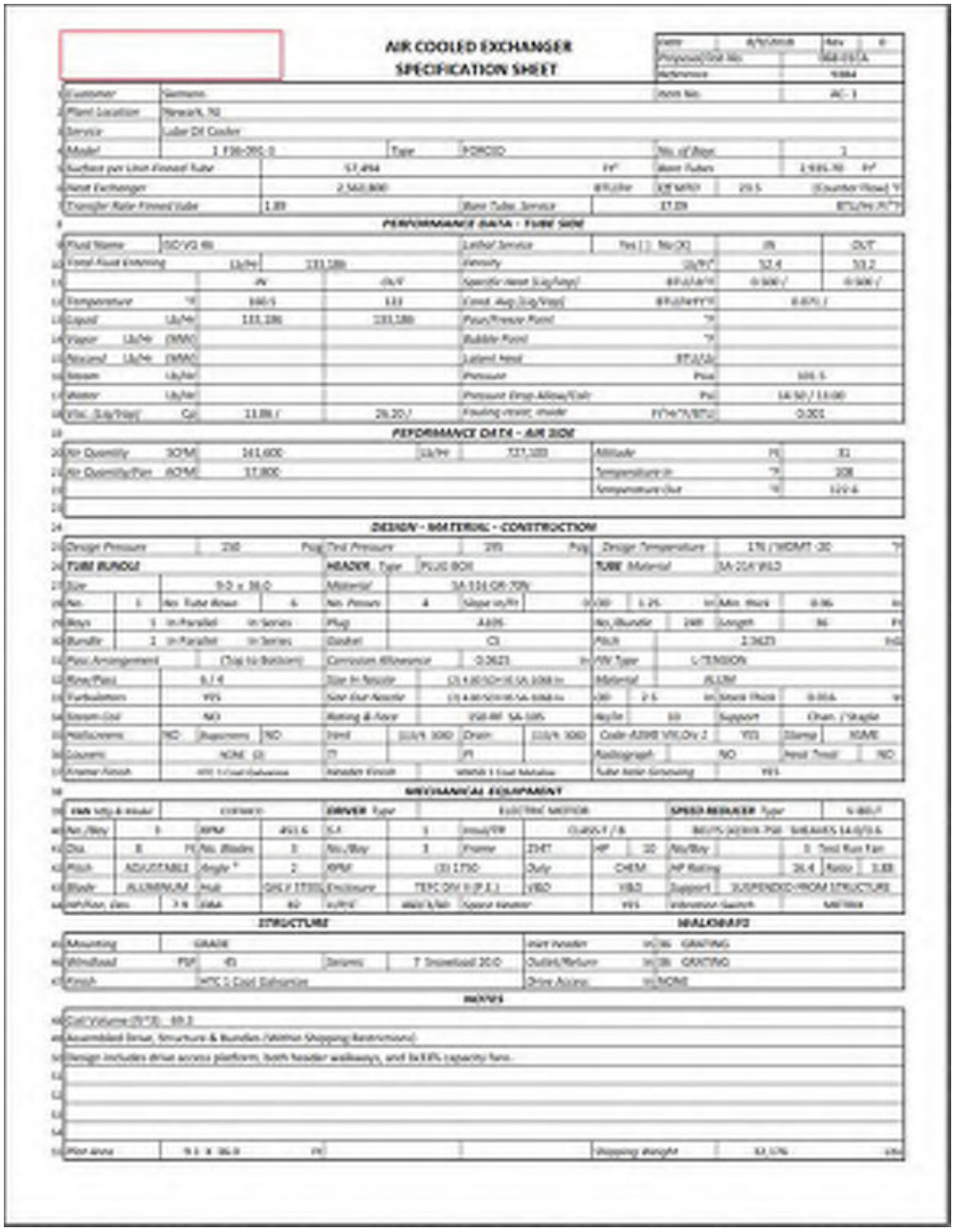

AIR COOLED EXCHANGER
SPECIFICATION SHEET

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Future Steam Production Within

The SCR Stack

SGT-600

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SCOPE OF WORK

Future Steam Offering for the PVSC will consist of:
We confirm that a steam generator section can be added in the vertical gas path that could generate steam at design conditions of 45,000 lb/hr, 825 psig, and 575 F.
Our SCR supplier has completed a preliminary design of the steam generator which would be located in the lower transition section, which would be upstream of the CO catalyst.
The steam generator would consist of a vertical gas flow superheater coil section directly above a vertical gas flow evaporator coil.
Both sections together would be approximately 12' W x 24' 6" L x 4' H. Their weight would be approximately 40-45,000 lbs. There would also be a steam drum located adjacent the SCR that would be approximately 4' dia x 12' long. It would need to be located 6' above the coils, and could be fitted into the SCR support structure.
The lower transition section would be designed with I-beams on the sides over the 24' 6" length that the coils would be positioned. The weight of the I-beams and coils would need to be considered into the design of the SCR and the steel support structure.
The specification notes that the steam generator might be a "future addition". This is possible, however we suggest the following items to be completed at time of equipment order:

1. Complete the engineering design and GA drawing for the steam generator to confirm configuration, weight, and into the SCR lower transition section.
2. Install the I beam supports now in the lower transition section. This is a relatively low cost addition compared to retrofitting in the field at a later date.
3. Design the steel support structure for the additional load of the coils and I-beams, etc. Again, this would be a relatively low cost addition compared to adding additional supports in the field at a later date.
4. By completing Items 1-3 above, the pre-designed and engineered steam generator could be a "future addition".
5. In the field the short ends of the lower transition section would be removed, and a crane would lift the 12' W x 24' 6" L x 4' H section onto the I-beam rail, and a temporary wench from the opposite site would pull the coil sections into place.

Note: If the steam generator is to be designed and added to the initial scope of supply, the added benefit is it would reduce the turbine exhaust temperature and enable us to use a lower temperature SCR catalyst and eliminate the need for the tempering air fans.

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Selective Catalytic Reduction

SCOPE OF WORK

Offering for the PVSC will consist of the design, supply, and commissioning of three (3) vertical SCR systems as described below for the three (3) SGT-600 gas turbines.

Design Conditions & Requirements

Siemens provided numerous design cases for emissions control requirements.

Table 1 shows the system outputs, applicable from 50% to 100% turbine load for temperatures from 17°F to 99°F.

Table 1 –CO / SCR System Guarantees

Parameter	Units	Guarantee
Stack NOx	ppmvd @ 15% O_2	≤2.5
Stack CO	ppmvd @ 15% O_2	≤3
VOC	ppmvd @ 15% O_2	≤4
NH_3 Slip	ppmvd @ 15% O_2	≤5
Pressure Drop	in. w.c. ≤7	

Catalyst Life of SCR Catalyst: 5,000 hours of operation or 60 calendar months after exposure to flue gas, whichever occurs first.

Overall SCR Arrangement

- The flue includes a transition to the SCR reactor from the SGT-600 exhaust. In this transition, the tempering air is added and flow distribution devices such as perforated plates are included to provide an even flow and temperature distribution at the catalyst. The SCR reactor cross section measures approximately 18 ft. x 18 ft. and is approximately 20 ft. in height.
- The CO catalyst is installed at the base (inlet) of the reactor section.
- The AIG will be located approximately 4' above the CO catalyst to allow for unobstructed access to the CO catalyst. An access door will be provided between the CO catalyst and the AIG.
- The SCR catalyst will be located above the AIG. The SCR blocks will rest on 304SS HSS support members.
- A silencer will be provided in the stack. As required by the specification, the stack elevation will be 100' above grade. A minimum distance of at least 2 diameters downstream of the silencer will be maintained to the CEM location. Ladders and

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platforms are included on the stack for access to the CEM (by others) and test ports.

- In the stack will be a "Stack Closure Damper". Because the SCR catalyst is directly below the stack, it is in line with direct exposure to the elements (rain, snow, etc.). When the unit is offline, this exposure to moisture will reduce catalyst activity and life. The damper will be closed when the unit is offline and keep the catalyst dry.
- The SCR support structure is included as shown in Appendix 3. As shown, one structure will be supplied to support all three (3) SCR reactors. A common walkway is provided, along with two (2) caged ladders from grade to the main SCR platform level. A small ladder and platform to the CO catalyst access door is included.

CO Catalyst - Catalyst Type Metallic with Pt

A CO catalyst is provided and the catalyst will be platinum-based brazed metallic designed to meet the CO and VOC requirements provided in Table 1.

Catalyst Type	Metallic with Pt
Foil Depth, in.	2
Cell Density, cpsi	220
Catalyst Block Dimensions	28.50"W x 24.50"L x 2.25"D
Block Layout	7W x 9L x 1D
Block Weight, lb.	~40
Distribution Requirements	
CO Distribution, % RMS	10
Velocity Distribution, % RMS	15
Temperature Distribution, °F	±25

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SCR Catalyst - Catalyst Type Honeycomb

- The SCR will be designed with honeycomb catalyst for NOx reduction. The catalyst will be located above the ammonia injection grid and installed on support beams. Details of the catalyst are shown in Table 3.

Catalyst Type	Honeycomb
Manufacturer	Ibiden Ceram
Catalyst Pitch, mm	2.5
Catalyst Volume, m^3	30.8
No of Layers	1
Module Layout	6W x 3D
Module Depth, ft	1.8
Catalyst Block Weight, lb.	856

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Cooling Air Fan

- Supplier will provide 1x100% tempering (cooling) air fan for each of the SGT-600 units. The fans will provide 37,800 SCFM at 16" WC and are sizing to cool exhaust temperatures from 1041°F to 840°F using ambient air. Each tempering air fan is supplied with a variable requency drive (VFD) and will be designed as follows:
  - Direct Coupled with VFD
  - NEMA 4 enclosure for VFD
  - 150 HP, 1740 RPM, 460 VAC, TEFC Motor
  - Inlet Filter Silencer Assembly
  - Discharge damper with pneumatic actuator and limit switches
  - Design Temp 99°F

Reactor and Flue Design

- The flues and reactor will be designed with the following:
  - 1/4" thick A-36 carbon steel casing and steel external stiffeners
  - 409SS internal liners
  - 4" ceramic fiber insulation
  - 304SS internal support members
  - High temperature paint on all exposed carbon steel

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Ammonia Flow Control Unit (AFCU)

- One (1) AFCU skid per unit. The AFCU will utilize ambient air and electric heat to dilute and vaporize the 19% aqueous ammonia.
- The equipment contains the following features:

• Stainless steel structural skid base with lifting lugs & grounding lugs.
• One centrifugal blowers rated at 444 SCFM @ 42"w.c. with 7.5 HP TEFC motor, 480 AC, 3 Phase, 60 Hz, 1.15 SF. The blower will be equipped with an inlet filter silencer and DP gauge.
• 4" class 150 stainless steel dilution line includes discharge expansion joints, check valves, manual isolation valves, a pressure gauge w/block and bleed, , and an annubar with a flow transmitter and manifold assembly.
• One (1) 65 kW immersion heaters, housed in separate stainless steel vessel, with type K thermocouples on each circuit. Vertical down flow; insulated and jacketed. Stainless steel piping downstream of the heater will include an expansion joint, and thermocouple/thermowell assembly with a temperature transmitter.
• One (1) upward flow, stainless steel vertical vaporizers with internal mixing element, external insulation, thermocouple w/ Thermowell & hydraulic atomizing injection nozzle. The outlet stainless steel piping will have a thermocouple/thermowell assembly and a temperature transmitter. 4", 150# RF flanged discharge connection.
• ½" class 150 class 304L Stainless Steel aqueous ammonia line includes isolation ball valves, duplex filters with a differential pressure indicator assembly, Pressure indicators, a Pressure Transmitter, Thermocouple w/ Well, inlet pressure switch, a Micro Motion coriolis mass meter, automated isolation ball valve assemblies with open/close limit switches, a Fisher/Baumann flow control valve with a globe valve bypass, and a flex line to the injection nozzle
• ½" class 150 stainless steel instrument air header with isolation ball valves, a pressure switch, and a pressure gauge w/block and bleed valve to provide actuation of pneumatic valves.
• NEMA 4 heater power panel containing components for modulated heater control, safety interlocks, and terminal blocks for instrument signals. Designed for Non-Hazardous electrical location.

- One electro-chemical sensor with a range of 0-500 ppm ammonia vapor

• NEMA 4 relay panel with Audible alarm and flashing strobe to warn of presence of ammonia in the area. Includes reset button to silence horn.
• 4-20ma and relay contacts for remote indication

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Ammonia Injection Grid

- The AIG will be designed to evenly distribute the vaporized ammonia flow utilizing computational fluid dynamics (CFD) modeling. Details on the CFD modeling are provided below.
- AIG piping (routed by others) connects at the AFCU outlet and supplies the AIG lances inside the SCR housing.
- The AIG header includes six (6) control zones. Each control zone will contain three (3) internal
  AIG pipes. The new AIG includes the following (per unit):
  • Schedule 10 304SS piping (external)
  • Schedule 40 304SS piping (internal) with mixing baffles
  • Six (6) 3" schedule 40 304SS 150# nozzle/flanges (for mounting to external casing)
  • Six (6) 3" balancing dampers
  • Six (6) 3" orifice plates and differential pressure gauges
  • Metallic bellows expansion joints, as required
- The AIG balancing dampers will be located at grade to facilitate operator access. Piping between the AFCU and SCR must be insulated with minimum 2" and aluminum lagging (by others).

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Permanent NOx Measurement Probes

- NOx sampling probes will be supplied to measure NOx and O_2 at the inlet and outlet of the SCR catalyst. The external connections will be located on the casing.

Silencer

- A silencer will be provided in the stack based on the gas turbine acoustic emissions and the Design Basis of the Near Field Noise Level parameter of 85 dBA. To ensure the proposed stack silencer will meet performance requirements, a preliminary analysis evaluation was completed using SGT-600 noise data.

Stack

- The stack will be designed per PVSC requirements. The stack internal diameter will be 9 ft. and the overall height will be 100' above grade (approximately 40 ft. above the building roof.
- Per EPA Method 1, requirements for stack measurements, a minimum 2 diameters above any flow disturbance (the silencer) is provided.
- The stack will include all ladders and test platforms per OSHA and specification requirements.
- Test ports will be provided. The stack will be 1/4" thick carbon steel casing with 409SS internal liners and 4" of ceramic fiber insulation. The casing will be shop-coated with pain as specified by PVSC.

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Stack Closure Damper

- A Stack Closure Damper will be provided in the stack. Because the SCR catalyst is directly below the stack, it is in line with direct exposure to the elements (rain, snow, etc.). When the unit is offline, this exposure to moisture will reduce catalyst activity and life. The damper will be closed when the unit is offline and keep the catalyst dry. Drains will be provided.
- The damper will be provided with the following:
  - Type: Opposed Blade Stack Damper
  - Dimensions: 108" ID Frame x 18" face to face
  - Temperature: Design 900°F
  - Frame: Rolled 3/8" Plate - ASTM-A588
  - Blade: Two (2) 1/4" Plate ASTM-A588 w/ Reinforcing Shaft:
  - Seals: ASTM-A588 Angle Seat Rain Gutter w/ Drain to Stack Outside

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Control System

The Selective Catalytic Reaction system requires ammonia as reduction agent in order to reduce the NOx. The ammonia is well mixed into the flue gas in order to reduce the NOx at a low ammonia slip level. The SCR flue system transports the flue gas in the system through the SCR reactor that contains the catalyst necessary for the NOx reduction. Critical design data for the system are the flue gas parameters: exhaust flow, ammonia flow, exhaust gas temperatures before and after tempering air, concentration of gas components as NOx and required NOx reduction over the system, and ammonia slip.

The amount of ammonia fed to the SCR system will be controlled such that the predetermined NOx concentration downstream of the SCR system always meets the emission requirements. The most common way of controlling the ammonia injection is to use a set point for the outlet NOx concentration, thus keeping the NOx emission at a constant level across the entire load range of the SCR reactor. The objective is to maintain the emission just below the required emission in order to reduce ammonia consumption at lower loads, and the lowest achievable ammonia slip.

For fast response to load changes, a feed-forward feedback control system will be utilized.
Characterizer curves will be developed for the feed forward signal based on turbine outlet NOx as a function of fuel (demand) flow rate. The outlet (stack) NOx measurements will be used for the feedback control and trim.

The control system will utilize the Opto22 SNAP PAC IO System. This system provides the most cost effective, future proof (Opto22 has a proven record of backwards

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compatibility), and open architecture system for an application of this type. The system is flexible and scalable. The Opto22 SNAP PAC 10 Systems offers:

- Peer to Peer communication between controllers
- PC Based Operator Interface to monitor, tune and control the system
- Interfacing to 3rd party system is readily available through OPC, Database linking, etc.
- Dual Ethernet Capability
- PAC Project Professional provides Logic Configuration Tools, Graphic Operator Interface, OPC Server, Database Linking, Utilities, etc.
- Flexibility and durability of the system allows the system to be taken to the IO level to reduce wiring and installation cost.

As part of our offering, Supplier will develop a Graphical Interface using PACDisplay HMI Software (included) as a means to control, monitor, troubleshoot, and tune the system. Ease of modifying "internal" parameters (a technique we have used on many systems) allows unit operational changes (i.e. startup profiles, limits, etc.) to be implemented quickly (by plant personnel) without the need to remember how to go into the control logic and find the appropriate tag names and/or sections of logic. This approach not only improves
troubleshooting and testing but eliminates the learning curve necessary every time someone has to get into the logic to make these basic changes.

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Supplied OPC Server will allow the user to interface the Plant Operator Interface directly to the Opto22 controller and we've included Modbus TCP/IP Slave Interface within our configuration for passing operational and control parameters to/from the DCS.

Scope of Supply – Three (3) SCR Control Systems:

Each Enclosure will contain the following:

- System will be developed as per the Control System Features, IO Requirements, and Customer Requirements noted above.
  - All three (3) systems will be identical.
  - Control Hardware will be Opto22 SNAP PAC based IO system
  - Hardware
    - o NEMA 4X Enclosure with necessary breakers, terminal blocks, etc.
      - § 5VDC 5A Power Supply for the IO Control Rack
      - § 24VDC 2A Power Supply for transmitters.
    - o Providing one Opto22 SNAP-PAC-R brain with IO Modules to cover IO Requirements noted above.
  - Opto22 PAC Project Professional Software will be provided
    - o PAC Control - Logic Configuration Development
    - o PAC Display - PC based Operator Interface Software
    - o OPTO22 OPC Server Software

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- Opto22 Database Linking Software
- Dual Ethernet Communications

- Operator Interface Configuration
- One (1) Operator Interface will be provided for each system:
  - Rackmount PC running Windows 10 Professional, i5/i7 Processor,500GB Hard Drive, 23" Desktop Monitor, Keyboard, and Mouse.
  - Housed inside Siemens Control Building.

Supplier will develop graphic package to monitor and control the provided system. Graphical Interface (PAC Display) will consist of the following:

- Operator Overview and Control Interactives
- Input and Output monitoring available through the graphic package.
- Trending of Process Points
- Historical Data Logging will be triggered upon Pump Activation. Data will be saved in a .csv (comma delimited) data file that can be easily imported into Excel.
- Tuning of System parameters will be accessible (password protected) via the operator interface. This eliminates the need for plant personnel to go into the logic (and relearn all the tools) while being able to easily allow modifications to curves, tuning, or system operation as necessary.

- Plant HMI / DCS Interface
- OPC Server software has been provided as part of this quote which will make interfacing to the Plant HMI system relatively easy.
- We've incorporated Modbus TCP/IP Slave logic within our configuration to allow Control and Monitoring data to/from the DCS.

Gas Flow Modeling

A computational fluid dynamics (CFD) flow model study will be performed on the SCR system to confirm and optimize the design of the AIG and SCR, assuring that the performance of the SCR will meet all flow and ammonia distribution requirements.

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Sub-suppliers list

Major sub-suppliers for the SGT-600 and SGT-700, can be found below. Selection of sub-suppliers can be subject to change without prior notice.

Gas turbine units

Gas turbine (300)

Item	Suppliers
Blade and vane material for compressor	Böhler Lemont Maskin AB Siemens Budapest La Rapida Elos Precision AB Blade Technology Ltd Segermatech
Blade and vane material for compressor turbine and power turbine	IHI-ICC Howmet Whitehall Howmet Exeter PCC Airfoils Turbocoating
Burners	AIT Goodrich
Rotor forging	Böhler Aubert & Duval Doncasters Blaenavon Frisa Aerospace
Steel castings	SAFAS GSA Doncasters PVC
Nodular iron	Pausubio
Metal hoses,	Specma Wiro AB Witzenmann
GT bearings	Orion, Waukesha, Zollern
Flame detector	BFI Automation
Bleed off valve	Gustaf Fagerberg AB
Clutch for start motor	SSS-Gears
Coupling for starter	Euroflex Transmissions
Start motor	Siemens
Vibration transducer	Brüel & Kjaer, Bently Nevada Meggitt
Speed transducer	Bently Nevada
Key phasor	Bently Nevada
Differential pressure transmitter	Siemens AG, Emerson
Ignition box	Meggitt
Pipe couplings	Parker A-lok
Quick couplings	Whalter Präzision

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Gear box & coupling (330) if applicable

Item	Suppliers
Gear box	Flender-Graffenstaden Voith Turbo BHS Getriebe Gpower Gearbox Ltd
Flexible coupling	Euroflex Transmissions
Vibration transducer, gear box	Bently Nevada

Base frame (385)

Item	Suppliers
Base frames	TP Konepajat Polska Comelf Sonstorps Mekaniska
Three point mounts	Sonstorps Mekaniska Sphere Market

Lubrication oil system (410)

Item	Suppliers
System Supplier	Fluidhouse, AEL GmbH
Temperature sensors	Siemens
Temperature indicator	WIKA
Pressure gauge	WIKA
Instrument valves	Swagelok
Non-return valves	Gestra
Temperature Control valve	Samson
Shut-off valves	KSB
Pressure relief valves	KSB
Coolers, air cooled	Specialist Heat Exchangers Ltd. GEA Batignolles Technologies Thermiques S.A.S GEA Érge-spirale et Soramat S.A.S Alfa Laval Nordic AB Jord International PTY Limited
Coolers, water cooled	Tranter International AB Alfa Laval Nordic AB
Oil mist separator	Koch International S.P.A, Scandfilter, AWS
Pumps	Allweiler
Filters	HYDAC
Motors	Siemens/RAEL Motori
Heaters	Heatex
Pipe Couplings	Swagelok
Level transmitter	Siemens Emerson
Oil System ventilation fan	Ventur/ MZ Ventilatori
Ejector	GEA
Pressure transmitter	Siemens, Emerson
Diff. pressure transmitter	Siemens, Emerson
Pressure switch	CCS
Quick Couplings	Whalter Präzision

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Fire detection and extinguishing system (422,425)

Item	Suppliers
System Supplier CO_2-system	Minimax, Det-tronics
Fire extinguishing equipment CO_2-system **(422)**	Minimax, Det-tronics
Fire extinguishing H_2O **(425)**	Det-tronics , Marioff
Fire extinguishing equipment H_2O **(425)**	Det-tronics, Semco Maritime
Fire detection panel	Minimax, Det-tronics
IR detectors	Minimax, Det-tronics
Smoke detector (AC-generator room or control room if applicable.)	Minimax, Det-tronics
Temperature detectors	Minimax, Det-tronics

Ventilation system (423)

Item	Suppliers
System Supplier	HIAK, Vokes Air, Camfil Farr Power Systems AB, AAF
Fans	Hiak Air, Brook, Crompton
Differential pressure transmitter	Siemens, Emerson
Instrument valves	Oliver
Pipe couplings	Swagelok

Gas detection system (424) if applicable

Item	Suppliers
System Supplier	Minimax / Safetech
Gas detectors	Minimax / Safetech
Gas detection panel	Minimax / Safetech

Gas fuel system (431) if applicable

Item	Suppliers
System Supplier External Filter Unit	Eltacon
System Supplier Internal Unit	Coor Servicemanagement
Filters	Eltacon
Heaters	Heatex
Strainer	Kaysafe
Gas fuel control valves	Fisher Kämmer
AC Servo Motor drivers	Siemens
Temperature indicator	WIKA
Temperature sensors	Pentronic Thermo-Electric
Limit switch	Remote Control Topworx
Flow meter	Endress+Hauser

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Item	Suppliers
Pressure guage	WIKA
Pressure transmitter	Siemens Emerson
Diff. Pressure transmitter	Siemens Emerson
Instrument valves	Oliver
Pipe couplings	Swagelok
Quick shut-off valves and isolating valve	Starline

Liquid fuel system (432) if applicable

Item	Suppliers
System Supplier	Johsjö System
Shut-off valves	Starline, Mars
Isolation valve	Pekos
Limit switch	Remote Control
Pressure safety valves	Technical
Pumps	Bucher Hydraulics
Instrument valves	Oliver
Pipe couplings	Swagelok
Liquid fuel dosage System	Johsjö System
Shut off valves	Mars
Filling Pump	Allweiler
Dosage pump	Williams
Level switch	Kübler
Level Control valve	Krombach
Pressure transmitters	Siemens Emerson
Temperature sensors	Pentronic
Filter	Parker
Heaters	Masterwatt
Motors	Siemens

Ignition system (439)

Item	Suppliers
Supplier Propane cabinet	Johsjö System AB
Supplier Ignition gas panel	Coor Servicemanagement
Flow control valves	VYC
Shut-off valve and isolating valves	Starline
Pressure control valve	VYC
Pipe couplings	Swagelok

Seal gas system (461) If applicable

Item	Suppliers
System supplier of Seal gas panel	Eagle Burgmann GmbH
Pressure transmitter	Siemens, Emerson
Diff. pressure transmitter	Siemens,Emerson
Pipe couplings	Swagelok
Instrument valves	Oliver
Filter module	Indufil / Boll & Kirsch

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Driven compressor auxilliaries (462) if applicable

Item	Suppliers
Antisurge valve	Dresser Europe Valve / Emerson Process / Mokveld

Compressor washing system (491)

Item	Suppliers
System supplier	Gas Turbine Efficiency

Driven AC generator (501) If applicable

Item	Suppliers
Generator	ABB

Driven compressor of siemens make (503) if applicable

Item	Suppliers
Forgings	Buderus AG / Böhler Edelstahl / Saarschmiede / Fomas S.P.A / Forge Monchieri / Deutsche Titan GmbH
Cast iron, Ductile cast iron	Demag Ergotech GmbH / Babcock Giesserei GmbH
Cast steel	Voest-Alpine AG / Gruppo Cividale / Schmolz & Bickenbach / Schmees Edelstahlwerke GmbH
Bearings	Sartorius GmbH / Zollern BHW Gleitlager GmbH/ Michelle Bearings
Dry Gas Seals	Flowserve / Burgmann GmbH / John Crane GmbH
Vibration transducers	Bently Nevada
Key Phasors, axial position probes	Bently Nevada
Temperature sensor, bearings	Dittmer

Electrical and control (600) if applicable

Item	Suppliers
Voltage Regulator	ABB
Neutral/Lineside Cubicle	ABB
Measuring convertors	Cewe / Tillqvist
Synchronizing system	ABB / DEIF
Relay protection	Siemens
Motor control center	Elektromontage Siemens

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Item	Suppliers
Programmable control system	Siemens
Turbine governor	Siemens
Static frequency converters	Siemens
Batteries, Pb	EXIDE
Batteries, NiCd	SAFT, Hoppeche
Battery charger	Kraft Powercon
Uninterrupted Power Supply	Kraft Powercon
Cables	Elektroskandia, DRAKA
Cables for hot areas, fire alarm	Elektroskandia, Lidalco
Distribution cubicle	Siemens
Control cubicle	ABB Elektromontage
Battery Module	Celltech
Cable glands	Elektroskandia Perfect
Cable glands, offshore	Pulsteknik Hawke
Junction boxes	Eldon Elektromontage
Junction boxes, Eex	Pulsteknik Abtech
Multipenetration seals	Fireseal
Cable marking	Weidmüller
Terminals	Phoenix, Weidmüller
Vibration montitoring	Bently Nevada Vibro-meter
Overspeed protection	Jaquet

Enclosure (710)

Item	Suppliers
Gas turbine enclosure	HIAK, FAIST, Camfil, AAF

Control room (711) If applicable

Item	Suppliers
Control room module	Jaco Fabriks

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Air intake filter (730)

Item	Suppliers
System Supplier	HIAK Camfil Farr Power Systems Donaldson, AAF
Filter media	Freudenberg Camfil Donaldson
Inlet silencer	HIAK, Camfil Farr Power Systems AB, Donaldson, FAIST, AAF
Differential pressure transmitter	Siemens Emerson
Humidity and temperature sensor	Vaisala
Instrument valves	Oliver
Pipe couplings	Swagelok

Exhaust system (740)

Item	Suppliers
System supplier	HIAK, Camfil Farr Power Systems AB, AAF Braden
Exhaust silencer	HIAK, Camfil Farr Power Systems AB, AAF Braden

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PVSC

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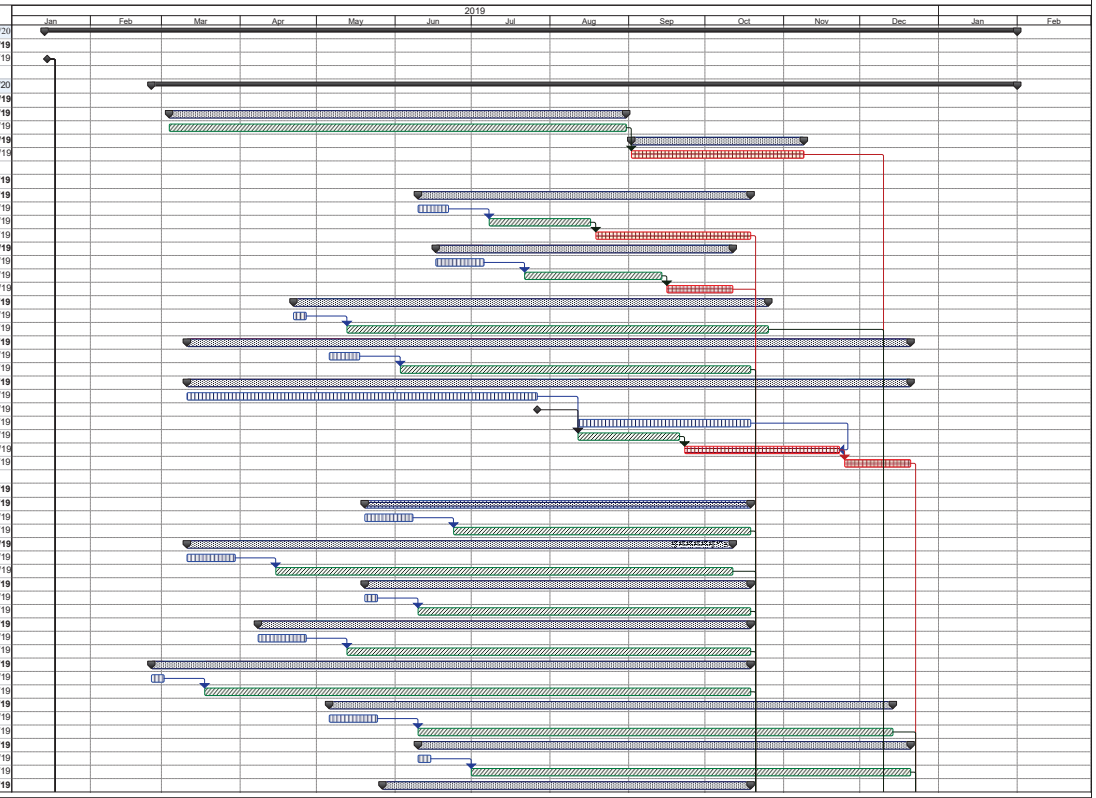
Date: 2018-09-12

ID	HG	Task Name	Start	Finish
1		**SGT-600B**	Mon 1/14/19	Fri 1/31/20
2		**Order**	**Mon 1/14/19**	**Mon 1/14/19**
3		Order date	Mon 1/14/19	Mon 1/14/19
4				
5		**Unit 1**	Mon 2/25/19	Fri 1/31/20
6		**Core Engine**	**Mon 3/4/19**	**Fri 11/8/19**
7		**Core Engine**	**Mon 3/4/19**	**Fri 8/30/19**
8		Core Engine Materials	Mon 3/4/19	Fri 8/30/19
9		**Core Engine Assembly**	**Mon 9/2/19**	**Fri 11/8/19**
10		Core engine assembly	Mon 9/2/19	Fri 11/8/19
11				
12		**Electrical**	**Mon 3/11/19**	**Fri 12/20/19**
13	6341	**Control Equipment**	**Mon 6/10/19**	**Fri 10/18/19**
14		Engineering	Mon 6/10/19	Fri 6/21/19
15		Procurement	Mon 7/8/19	Fri 8/16/19
16		Assembly	Mon 8/19/19	Fri 10/18/19
17	6381	**Junction Box**	**Mon 6/17/19**	**Fri 10/11/19**
18		Engineering	Mon 6/17/19	Fri 7/5/19
19		Procurement	Mon 7/22/19	Fri 9/13/19
20		Assembly	Mon 9/16/19	Fri 10/11/19
21	4430	**Electrical Generator**	**Mon 4/22/19**	**Fri 10/25/19**
22		Engineering	Mon 4/22/19	Fri 4/26/19
23		Procurement	Mon 5/13/19	Fri 10/25/19
24	6324	**Starter engine**	**Mon 3/11/19**	**Fri 12/20/19**
25		Engineering	Mon 5/6/19	Fri 5/17/19
26		Procurement	Mon 6/3/19	Fri 10/18/19
27	7706	**DCS**	**Mon 3/11/19**	**Fri 12/20/19**
28		Basic Engineering	Mon 3/11/19	Fri 7/26/19
29		Design Freeze	Fri 7/26/19	Fri 7/26/19
30		Detail Engineering	Mon 8/12/19	Fri 10/18/19
31		Procurement	Mon 8/12/19	Fri 9/20/19
32		Assembly	Mon 9/23/19	Fri 11/22/19
33		FAT	Mon 11/25/19	Fri 12/20/19
34				
35		**Mechanical**	**Mon 2/25/19**	**Fri 12/20/19**
36	4085	**Controll Room Building**	**Mon 5/20/19**	**Fri 10/18/19**
37		Engineering	Mon 5/20/19	Fri 6/7/19
38		Procurement	Mon 6/24/19	Fri 10/18/19
39	4011	**Assembly materials**	**Mon 3/11/19**	**Fri 10/11/19**
40		Engineering	Mon 3/11/19	Fri 3/29/19
41		Procurement	Mon 4/15/19	Fri 10/11/19
42	4102	**Base Frame GT**	**Mon 5/20/19**	**Fri 10/18/19**
43		Engineering	Mon 5/20/19	Fri 5/24/19
44		Procurement	Mon 6/10/19	Fri 10/18/19
45	4691	**Lube Oil Unit**	**Mon 4/8/19**	**Fri 10/18/19**
46		Engineering	Mon 4/8/19	Fri 4/26/19
47		Procurement	Mon 5/13/19	Fri 10/18/19
48	4980	**Gear**	**Mon 2/25/19**	**Fri 10/18/19**
49		Engineering	Mon 2/25/19	Fri 3/1/19
50		Procurement	Mon 3/18/19	Fri 10/18/19
51	6080	**Lube oil cooler, Air**	**Mon 5/6/19**	**Fri 12/13/19**
52		Engineering	Mon 5/6/19	Fri 5/24/19
53		Procurement	Mon 6/10/19	Fri 12/13/19
54	4082	**Enclosure Ventilation**	**Mon 6/10/19**	**Fri 12/20/19**
55		Engineering	Mon 6/10/19	Fri 6/14/19
56		Procurement	Mon 7/1/19	Fri 12/20/19
57	4093	**Enclosure GT**	**Mon 5/27/19**	**Fri 10/18/19**



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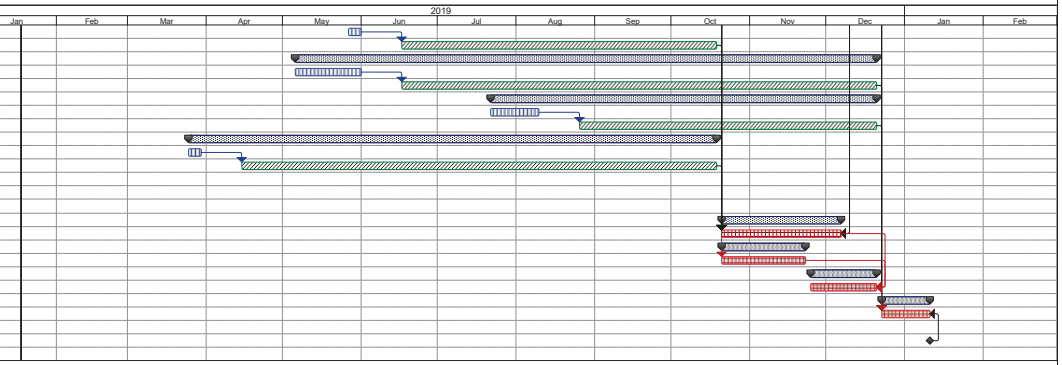
ID	HG	Task Name	Start	Finish
58		Engineering	Mon 5/27/19	Fri 5/31/19
59		Procurement	Mon 6/17/19	Fri 10/18/19
60	**5204**	**Gas Fuel Unit**	**Mon 5/6/19**	**Fri 12/20/19**
61		Engineering	Mon 5/6/19	Fri 5/31/19
62		Procurement	Mon 6/17/19	Fri 12/20/19
63	**5237**	**Fire extinguishing system**	**Mon 7/22/19**	**Fri 12/20/19**
64		Engineering	Mon 7/22/19	Fri 8/9/19
65		Procurement	Mon 8/26/19	Fri 12/20/19
66	**5950**	**Exhaust Casing**	**Mon 3/25/19**	**Fri 10/18/19**
67		Engineering	Mon 3/25/19	Fri 3/29/19
68		Procurement	Mon 4/15/19	Fri 10/18/19
69		<New Task>	Fri 1/31/20	Fri 1/31/20
70				
71		**Assembly/Packing**	**Mon 10/21/19**	**Fri 1/10/20**
72	**4012**	**Assembly GT-Unit**	**Mon 10/21/19**	**Fri 12/6/19**
73		Gasturbine assembly	Mon 10/21/19	Fri 12/6/19
74	**6300**	**Assembly El-module**	**Mon 10/21/19**	**Fri 11/22/19**
75		Electrical assembly	Mon 10/21/19	Fri 11/22/19
76	**3937**	**Workshop Stationary Test**	**Mon 11/25/19**	**Fri 12/20/19**
77		Workshop test	Mon 11/25/19	Fri 12/20/19
78	**3903**	**Packing**	**Mon 12/23/19**	**Fri 1/10/20**
79		Packning	Mon 12/23/19	Fri 1/10/20
80		**Exwork**	**Fri 1/10/20**	**Fri 1/10/20**
81		Exwork	Fri 1/10/20	Fri 1/10/20
82				



Procurement
Engineering
Assembly
%Complete
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only

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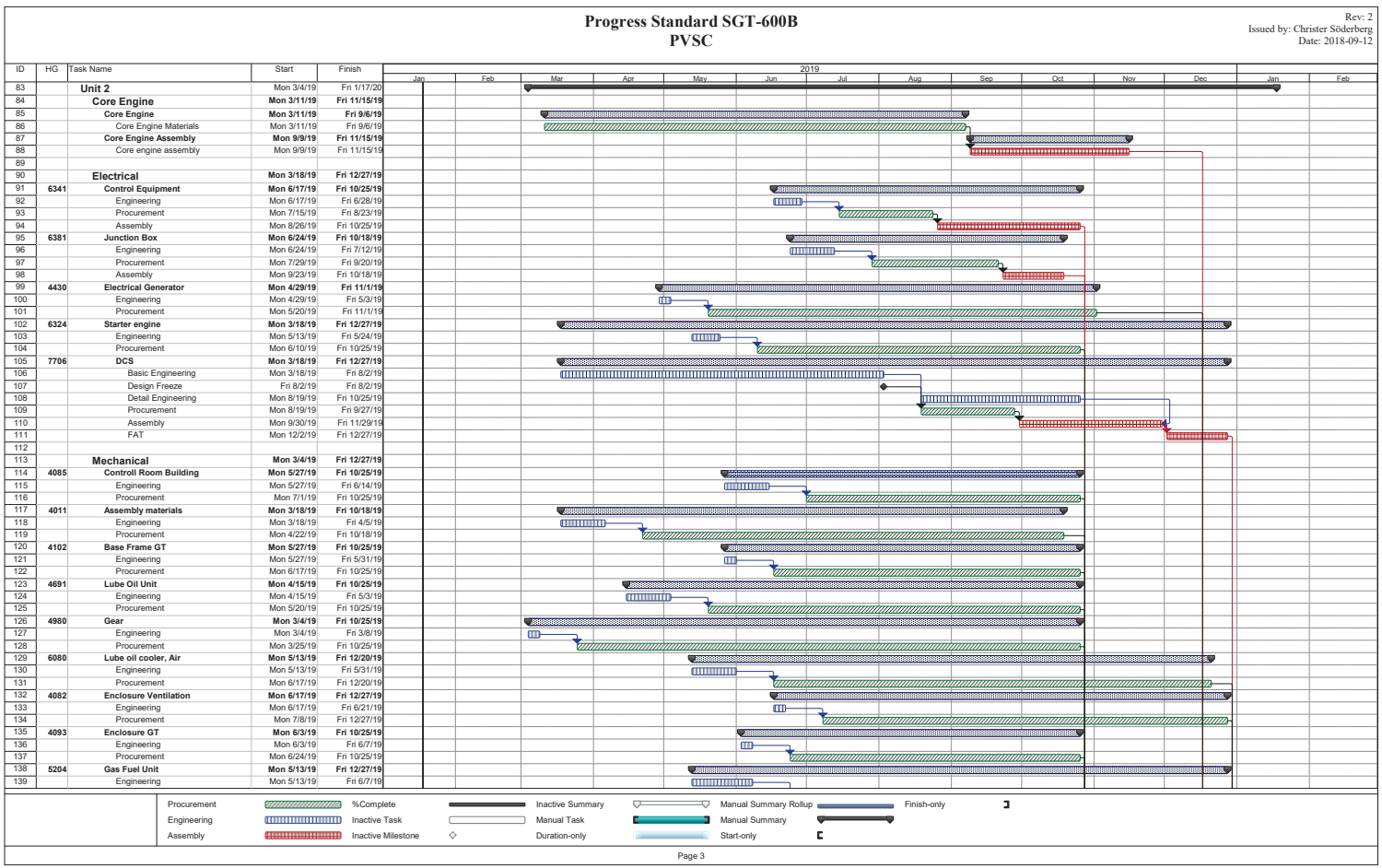
ID	HG	Task Name	Start	Finish
83		**Unit 2**	Mon 3/4/19	Fri 1/17/20
84		**Core Engine**	**Mon 3/11/19**	**Fri 11/15/19**
85		**Core Engine**	**Mon 3/11/19**	**Fri 9/6/19**
86		Core Engine Materials	Mon 3/11/19	Fri 9/6/19
87		**Core Engine Assembly**	**Mon 9/9/19**	**Fri 11/15/19**
88		Core engine assembly	Mon 9/9/19	Fri 11/15/19
89				
90		**Electrical**	**Mon 3/18/19**	**Fri 12/27/19**
91	6341	**Control Equipment**	**Mon 6/17/19**	**Fri 10/25/19**
92		Engineering	Mon 6/17/19	Fri 6/28/19
93		Procurement	Mon 7/15/19	Fri 8/23/19
94		Assembly	Mon 8/26/19	Fri 10/25/19
95	6381	**Junction Box**	**Mon 6/24/19**	**Fri 10/18/19**
96		Engineering	Mon 6/24/19	Fri 7/12/19
97		Procurement	Mon 7/29/19	Fri 9/20/19
98		Assembly	Mon 9/23/19	Fri 10/18/19
99	4430	**Electrical Generator**	**Mon 4/29/19**	**Fri 11/1/19**
100		Engineering	Mon 4/29/19	Fri 5/3/19
101		Procurement	Mon 5/20/19	Fri 11/1/19
102	6324	**Starter engine**	**Mon 3/18/19**	**Fri 12/27/19**
103		Engineering	Mon 5/13/19	Fri 5/24/19
104		Procurement	Mon 6/10/19	Fri 10/25/19
105	7706	**DCS**	**Mon 3/18/19**	**Fri 12/27/19**
106		Basic Engineering	Mon 3/18/19	Fri 8/2/19
107		Design Freeze	Fri 8/2/19	Fri 8/2/19
108		Detail Engineering	Mon 8/19/19	Fri 10/25/19
109		Procurement	Mon 8/19/19	Fri 9/27/19
110		Assembly	Mon 9/30/19	Fri 11/29/19
111		FAT	Mon 12/2/19	Fri 12/27/19
112				
113		**Mechanical**	**Mon 3/4/19**	**Fri 12/27/19**
114	4085	**Controll Room Building**	**Mon 5/27/19**	**Fri 10/25/19**
115		Engineering	Mon 5/27/19	Fri 6/14/19
116		Procurement	Mon 7/1/19	Fri 10/25/19
117	4011	**Assembly materials**	**Mon 3/18/19**	**Fri 10/18/19**
118		Engineering	Mon 3/18/19	Fri 4/5/19
119		Procurement	Mon 4/22/19	Fri 10/18/19
120	4102	**Base Frame GT**	**Mon 5/27/19**	**Fri 10/25/19**
121		Engineering	Mon 5/27/19	Fri 5/31/19
122		Procurement	Mon 6/17/19	Fri 10/25/19
123	4691	**Lube Oil Unit**	**Mon 4/15/19**	**Fri 10/25/19**
124		Engineering	Mon 4/15/19	Fri 5/3/19
125		Procurement	Mon 5/20/19	Fri 10/25/19
126	4980	**Gear**	**Mon 3/4/19**	**Fri 10/25/19**
127		Engineering	Mon 3/4/19	Fri 3/8/19
128		Procurement	Mon 3/25/19	Fri 10/25/19
129	6080	**Lube oil cooler, Air**	**Mon 5/13/19**	**Fri 12/20/19**
130		Engineering	Mon 5/13/19	Fri 5/31/19
131		Procurement	Mon 6/17/19	Fri 12/20/19
132	4082	**Enclosure Ventilation**	**Mon 6/17/19**	**Fri 12/27/19**
133		Engineering	Mon 6/17/19	Fri 6/21/19
134		Procurement	Mon 7/8/19	Fri 12/27/19
135	4093	**Enclosure GT**	**Mon 6/3/19**	**Fri 10/25/19**
136		Engineering	Mon 6/3/19	Fri 6/7/19
137		Procurement	Mon 6/24/19	Fri 10/25/19
138	5204	**Gas Fuel Unit**	**Mon 5/13/19**	**Fri 12/27/19**
139		Engineering	Mon 5/13/19	Fri 6/7/19



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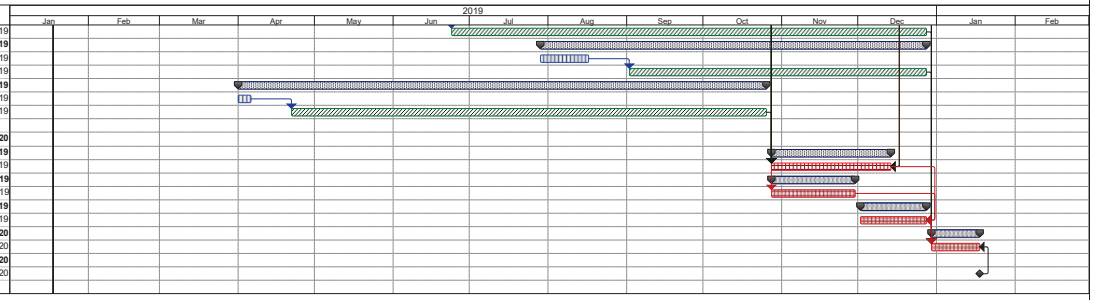
ID	HG	Task Name	Start	Finish
140		Procurement	Mon 6/24/19	Fri 12/27/19
141	5237	**Fire extinguishing system**	**Mon 7/29/19**	**Fri 12/27/19**
142		Engineering	Mon 7/29/19	Fri 8/16/19
143		Procurement	Mon 9/2/19	Fri 12/27/19
144	5950	**Exhaust Casing**	**Mon 4/1/19**	**Fri 10/25/19**
145		Engineering	Mon 4/1/19	Fri 4/5/19
146		Procurement	Mon 4/22/19	Fri 10/25/19
147				
148		**Assembly/Packing**	**Mon 10/28/19**	**Fri 1/17/20**
149	4012	**Assembly GT-Unit**	**Mon 10/28/19**	**Fri 12/13/19**
150		Gasturbine assembly	Mon 10/28/19	Fri 12/13/19
151	6300	**Assembly El-module**	**Mon 10/28/19**	**Fri 11/29/19**
152		Electrical assembly	Mon 10/28/19	Fri 11/29/19
153	3937	**Workshop Stationary Test**	**Mon 12/2/19**	**Fri 12/27/19**
154		Workshop test	Mon 12/2/19	Fri 12/27/19
155	3903	**Packing**	**Mon 12/30/19**	**Fri 1/17/20**
156		Packning	Mon 12/30/19	Fri 1/17/20
157		**Exwork**	**Fri 1/17/20**	**Fri 1/17/20**
158		Exwork	Fri 1/17/20	Fri 1/17/20
159				



Procurement
Engineering
Assembly
%Complete
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only

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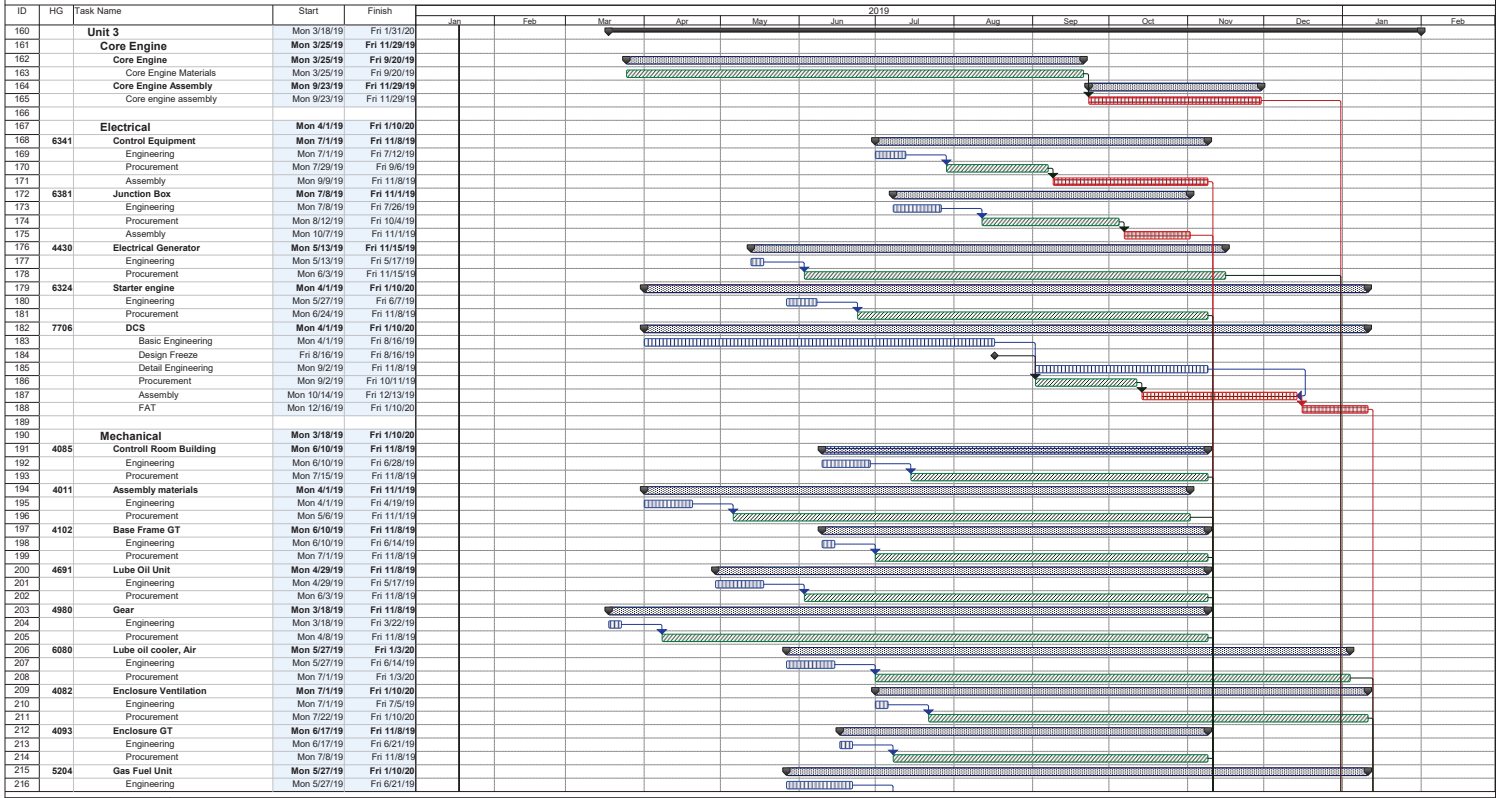
ID	HG	Task Name	Start	Finish
160		**Unit 3**	Mon 3/18/19	Fri 1/31/20
161		**Core Engine**	**Mon 3/25/19**	**Fri 11/29/19**
162		**Core Engine**	**Mon 3/25/19**	**Fri 9/20/19**
163		Core Engine Materials	Mon 3/25/19	Fri 9/20/19
164		**Core Engine Assembly**	**Mon 9/23/19**	**Fri 11/29/19**
165		Core engine assembly	Mon 9/23/19	Fri 11/29/19
166				
167		**Electrical**	**Mon 4/1/19**	**Fri 1/10/20**
168	6341	**Control Equipment**	**Mon 7/1/19**	**Fri 11/8/19**
169		Engineering	Mon 7/1/19	Fri 7/12/19
170		Procurement	Mon 7/29/19	Fri 9/6/19
171		Assembly	Mon 9/9/19	Fri 11/8/19
172	6381	**Junction Box**	**Mon 7/8/19**	**Fri 11/1/19**
173		Engineering	Mon 7/8/19	Fri 7/26/19
174		Procurement	Mon 8/12/19	Fri 10/4/19
175		Assembly	Mon 10/7/19	Fri 11/1/19
176	4430	**Electrical Generator**	**Mon 5/13/19**	**Fri 11/15/19**
177		Engineering	Mon 5/13/19	Fri 5/17/19
178		Procurement	Mon 6/3/19	Fri 11/15/19
179	6324	**Starter engine**	**Mon 4/1/19**	**Fri 1/10/20**
180		Engineering	Mon 5/27/19	Fri 6/7/19
181		Procurement	Mon 6/24/19	Fri 11/8/19
182	7706	**DCS**	**Mon 4/1/19**	**Fri 1/10/20**
183		Basic Engineering	Mon 4/1/19	Fri 8/16/19
184		Design Freeze	Fri 8/16/19	Fri 8/16/19
185		Detail Engineering	Mon 9/2/19	Fri 11/8/19
186		Procurement	Mon 9/2/19	Fri 10/11/19
187		Assembly	Mon 10/14/19	Fri 12/13/19
188		FAT	Mon 12/16/19	Fri 1/10/20
189				
190		**Mechanical**	**Mon 3/18/19**	**Fri 1/10/20**
191	4085	**Controll Room Building**	**Mon 6/10/19**	**Fri 11/8/19**
192		Engineering	Mon 6/10/19	Fri 6/28/19
193		Procurement	Mon 7/15/19	Fri 11/8/19
194	4011	**Assembly materials**	**Mon 4/1/19**	**Fri 11/1/19**
195		Engineering	Mon 4/1/19	Fri 4/19/19
196		Procurement	Mon 5/6/19	Fri 11/1/19
197	4102	**Base Frame GT**	**Mon 6/10/19**	**Fri 11/8/19**
198		Engineering	Mon 6/10/19	Fri 6/14/19
199		Procurement	Mon 7/1/19	Fri 11/8/19
200	4691	**Lube Oil Unit**	**Mon 4/29/19**	**Fri 11/8/19**
201		Engineering	Mon 4/29/19	Fri 5/17/19
202		Procurement	Mon 6/3/19	Fri 11/8/19
203	4980	**Gear**	**Mon 3/18/19**	**Fri 11/8/19**
204		Engineering	Mon 3/18/19	Fri 3/22/19
205		Procurement	Mon 4/8/19	Fri 11/8/19
206	6080	**Lube oil cooler, Air**	**Mon 5/27/19**	**Fri 1/3/20**
207		Engineering	Mon 5/27/19	Fri 6/14/19
208		Procurement	Mon 7/1/19	Fri 1/3/20
209	4082	**Enclosure Ventilation**	**Mon 7/1/19**	**Fri 1/10/20**
210		Engineering	Mon 7/1/19	Fri 7/5/19
211		Procurement	Mon 7/22/19	Fri 1/10/20
212	4093	**Enclosure GT**	**Mon 6/17/19**	**Fri 11/8/19**
213		Engineering	Mon 6/17/19	Fri 6/21/19
214		Procurement	Mon 7/8/19	Fri 11/8/19
215	5204	**Gas Fuel Unit**	**Mon 5/27/19**	**Fri 1/10/20**
216		Engineering	Mon 5/27/19	Fri 6/21/19



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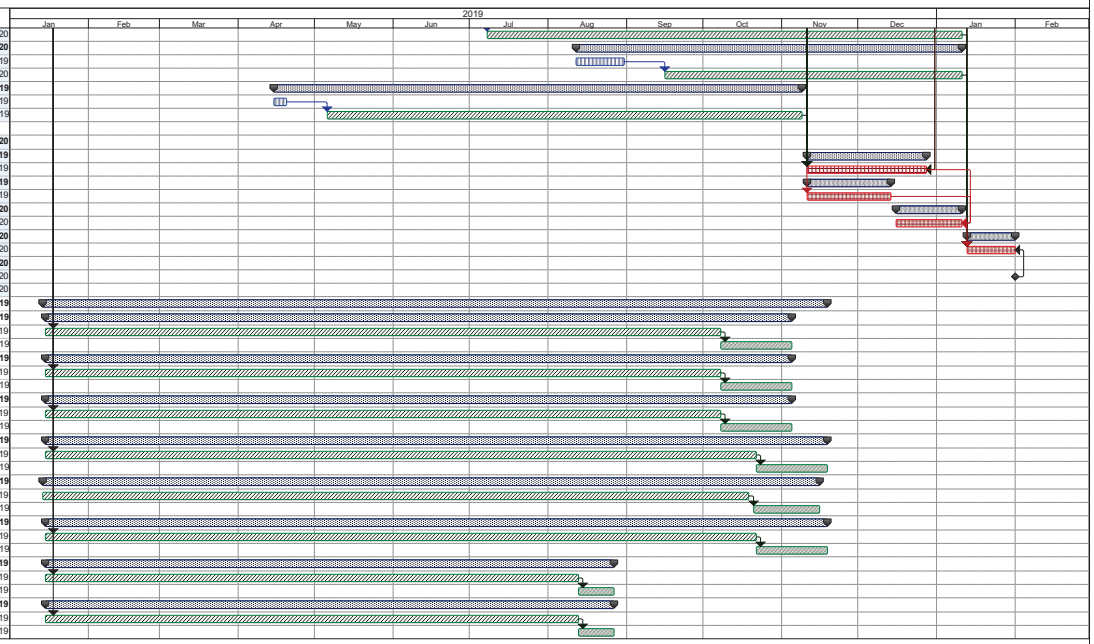
Progress Standard SGT-600B
PVSC

Rev: 2
Issued by: Christer Söderberg
Date: 2018-09-12

ID	HG	Task Name	Start	Finish
217		Procurement	Mon 7/8/19	Fri 1/10/20
218	5237	**Fire extinguishing system**	**Mon 8/12/19**	**Fri 1/10/20**
219		Engineering	Mon 8/12/19	Fri 8/30/19
220		Procurement	Mon 9/16/19	Fri 1/10/20
221	5950	**Exhaust Casing**	**Mon 4/15/19**	**Fri 11/8/19**
222		Engineering	Mon 4/15/19	Fri 4/19/19
223		Procurement	Mon 5/6/19	Fri 11/8/19
224				
225		**Assembly/Packing**	**Mon 11/11/19**	**Fri 1/31/20**
226	4012	**Assembly GT-Unit**	**Mon 11/11/19**	**Fri 12/27/19**
227		Gasturbine assembly	Mon 11/11/19	Fri 12/27/19
228	6300	**Assembly El-module**	**Mon 11/11/19**	**Fri 12/13/19**
229		Electrical assembly	Mon 11/11/19	Fri 12/13/19
230	3937	**Workshop Stationary Test**	**Mon 12/16/19**	**Fri 1/10/20**
231		Workshop test	Mon 12/16/19	Fri 1/10/20
232	3903	**Packing**	**Mon 1/13/20**	**Fri 1/31/20**
233		Packing	Mon 1/13/20	Fri 1/31/20
234		**Exwork**	**Fri 1/31/20**	**Fri 1/31/20**
235		Exwork	Fri 1/31/20	Fri 1/31/20
236		<New Task>	Fri 1/31/20	Fri 1/31/20
237		**BOP**	**Mon 1/14/19**	**Mon 11/18/19**
238		**Fuel Gas Compressor Unit 1**	**Tue 1/15/19**	**Mon 11/4/19**
239		Lead Time	Tue 1/15/19	Mon 10/7/19
240		Site Delivery	Tue 10/8/19	Mon 11/4/19
241		**Fuel Gas Compressor Unit 2**	**Tue 1/15/19**	**Mon 11/4/19**
242		Lead Time	Tue 1/15/19	Mon 10/7/19
243		Site Delivery	Tue 10/8/19	Mon 11/4/19
244		**Fuel Gas Compressor Unit 3**	**Tue 1/15/19**	**Mon 11/4/19**
245		Lead Time	Tue 1/15/19	Mon 10/7/19
246		Site Delivery	Tue 10/8/19	Mon 11/4/19
247		**SCR Unit 1**	**Tue 1/15/19**	**Mon 11/18/19**
248		Lead Time	Tue 1/15/19	Mon 10/21/19
249		Site Delivery	Tue 10/22/19	Mon 11/18/19
250		**SCR Unit 2**	**Mon 1/14/19**	**Fri 11/15/19**
251		Lead Time	Mon 1/14/19	Fri 10/18/19
252		Site Delivery	Mon 10/21/19	Fri 11/15/19
253		**SCR Unit 3**	**Tue 1/15/19**	**Mon 11/18/19**
254		Lead Time	Tue 1/15/19	Mon 10/21/19
255		Site Delivery	Tue 10/22/19	Mon 11/18/19
256		**Black Start Generator Unit 1**	**Tue 1/15/19**	**Mon 8/26/19**
257		Lead Time	Tue 1/15/19	Mon 8/12/19
258		Site Delivery	Tue 8/13/19	Mon 8/26/19
259		**Black Start Generator Unit 2**	**Tue 1/15/19**	**Mon 8/26/19**
260		Lead Time	Tue 1/15/19	Mon 8/12/19
261		Site Delivery	Tue 8/13/19	Mon 8/26/19



Procurement
Engineering
Assembly
%Complete
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only

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		Document number			
		Revision	A	Page	1

Nominal degradation for extended service intervals, SGT-600 3rd generation DLE

The nominal unrecoverable degradation is shown in comparison with new and clean engine. Data is based on assumption that the compressor is clean and that the unit has operated in accordance with operation & maintenance manuals.

The degradation graph is for general information only. Replacements/refurbishments are according to maintenance general information SGT-600 3rd generation DLE, 1CS137073.

The base load curves are applicable when running the gas turbine at 100% load.

The "Heat rate @ constant power" curves are applicable when the gas turbine runs at constant power output irrespective of ambient conditions, i.e. to be used for part load applications.

Gas

Equivalent operating hours after maintenance (EOH)	Power output degradation (%)	Heat rate @ base load degradation (%)	Heat rate @ constant power degradation (%)	Exhaust temperature @ base load degradation (% of °C)	Exhaust flow @ base load degradation (%)	Exhaust temperature @ constant power degradation (% of °C)	Exhaust flow @ constant power degradation (%)
After 34 000	-2.1	0.9	0.6	0.5	-1.2	1.1	-0.6
After 68 000	-2.1	1.0	0.6	0.6	-1.3	1.2	-0.7
After 102 000	-3.2	1.6	1.1	0.9	-2.0	1.8	-1.0

BU / SGT-600(PG B, PG Ex B, MD B)/&EC102

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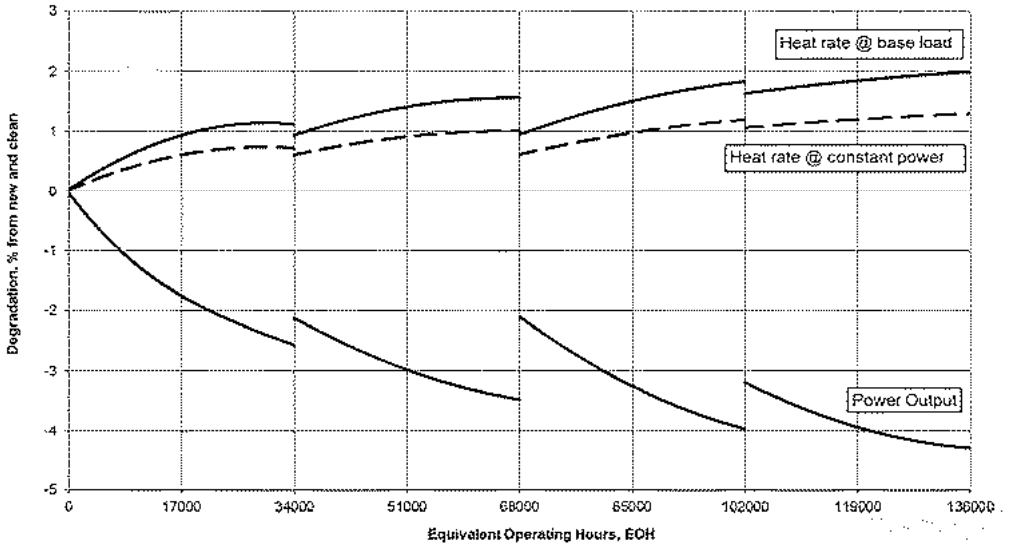
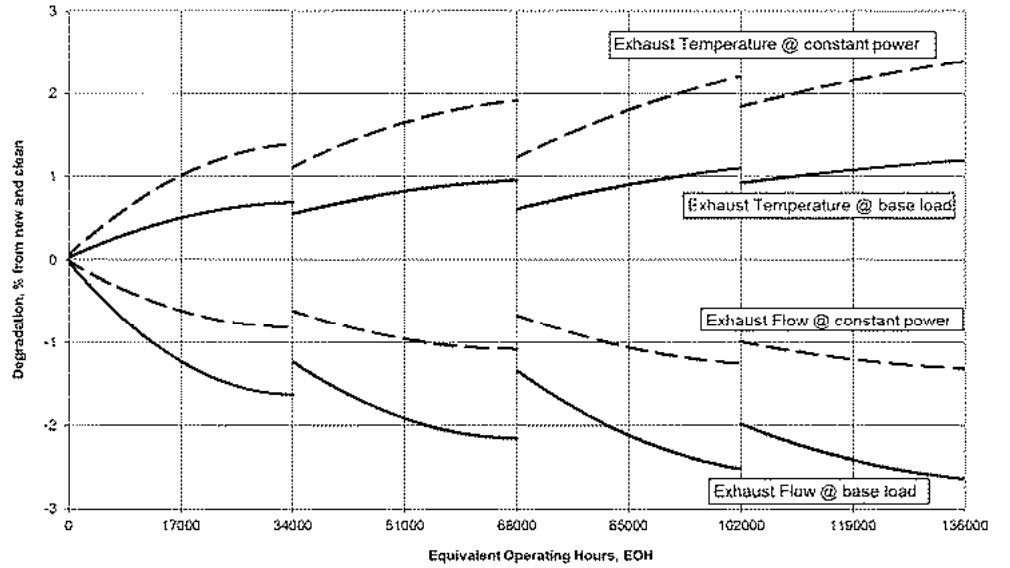
		Document number			
		Revision	A	Page	2

SGT-600 Power Output and Heat Rate degradation in case TBO 34' EOH, gas fuel operation



SGT-600 Exhaust Flow and Exhaust Temperature degradation in case TBO 34' EOH, gas fuel operation



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Nominal performance SGT-600 Power Generation, ISO ambient matching

This document presents the nominal performance curves for a gas turbine of type SGT-600 in power generation application, ISO ambient matching.

The first two diagrams present performance data expressed in SI-units, the last two diagrams contain the same information converted to imperial units.

Within the two diagrams with the same units (SI or US), the first is for gaseous fuel and the second is for liquid fuel.

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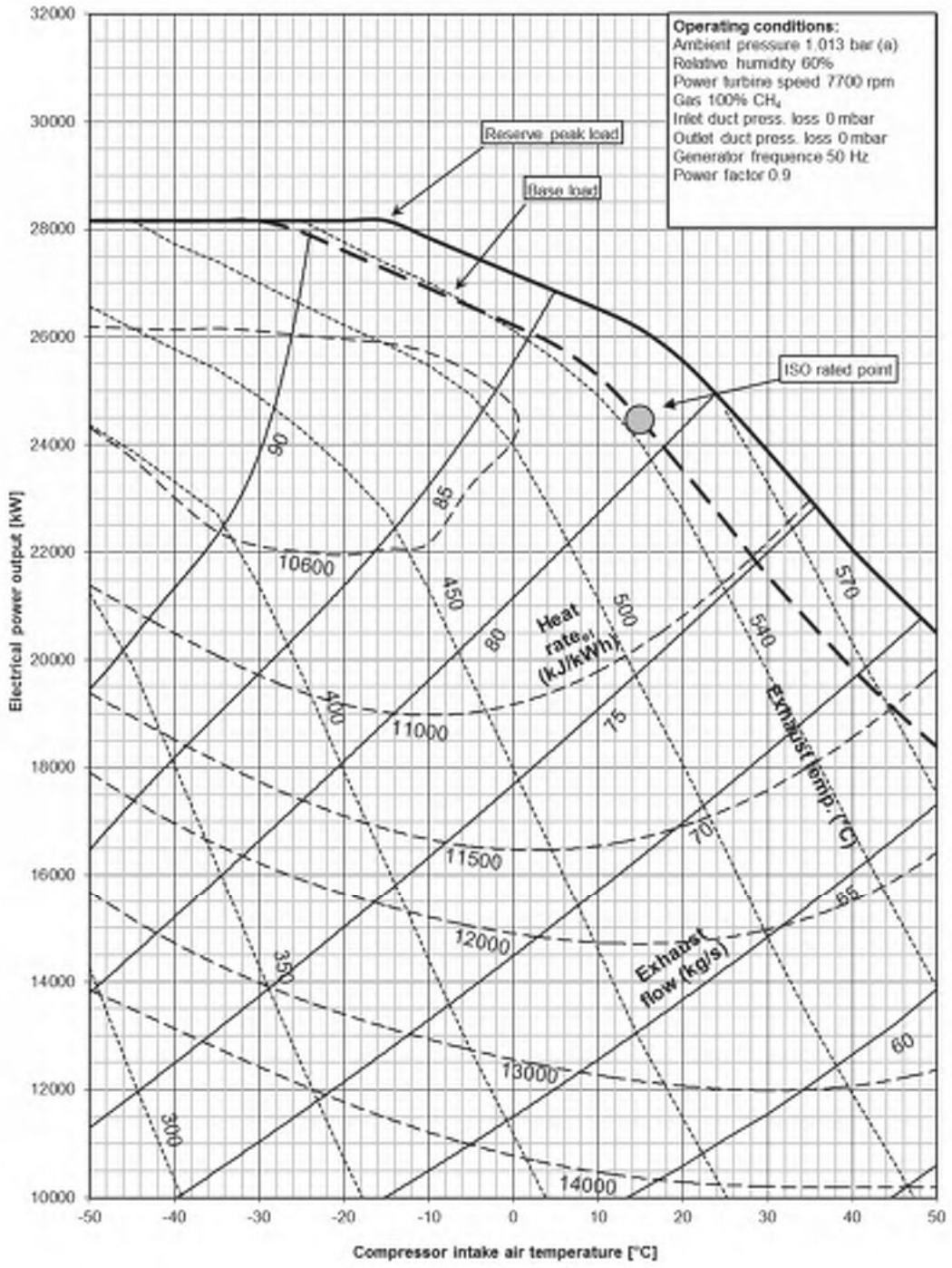
Nominal performance SGT-600 Power Generation
ISO ambient matching, Gaseous fuel



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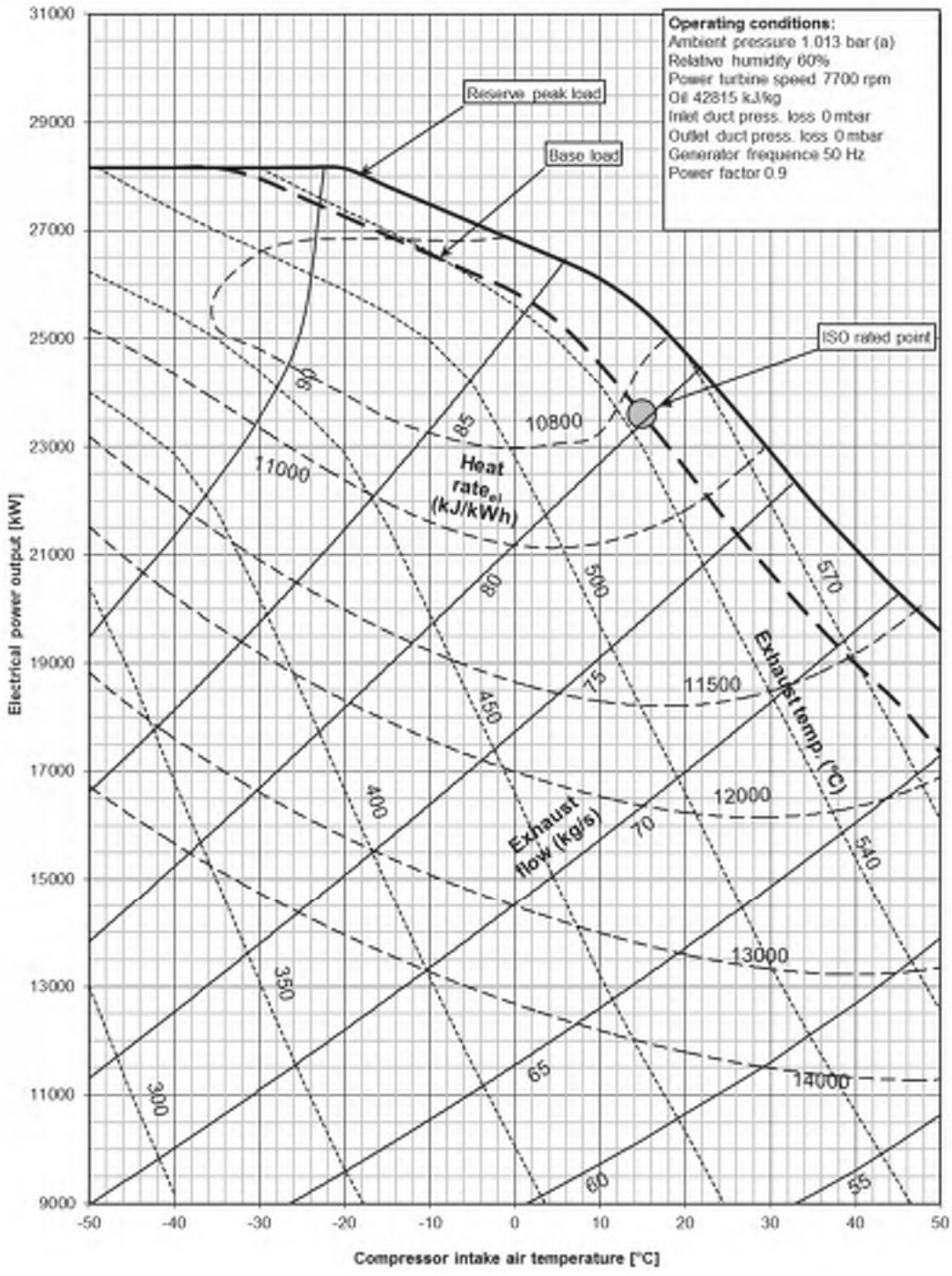
Nominal performance SGT-600 Power Generation
ISO ambient matching, Liquid fuel



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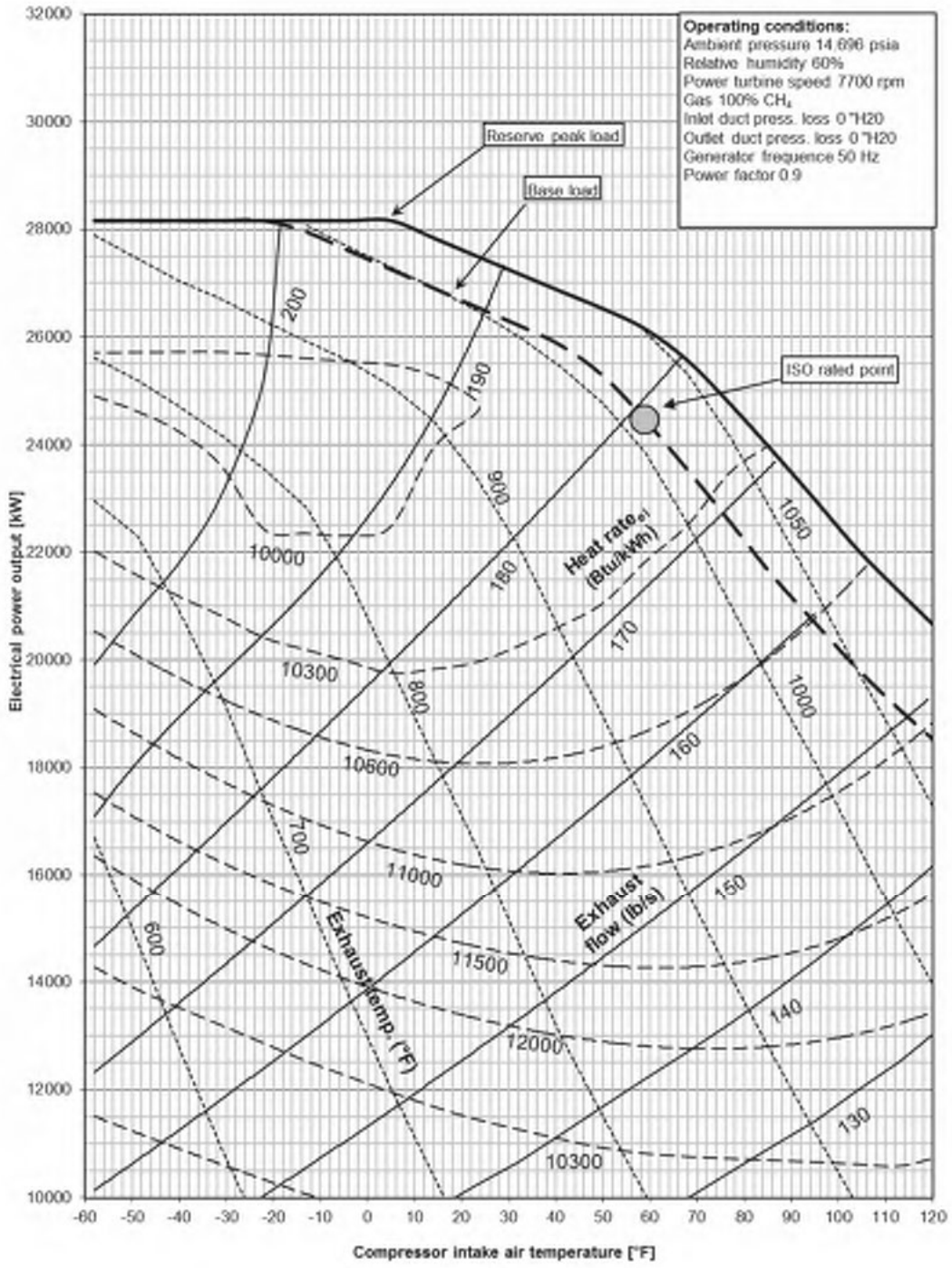
Nominal performance SGT-600 Power Generation
ISO ambient matching, Gaseous fuel



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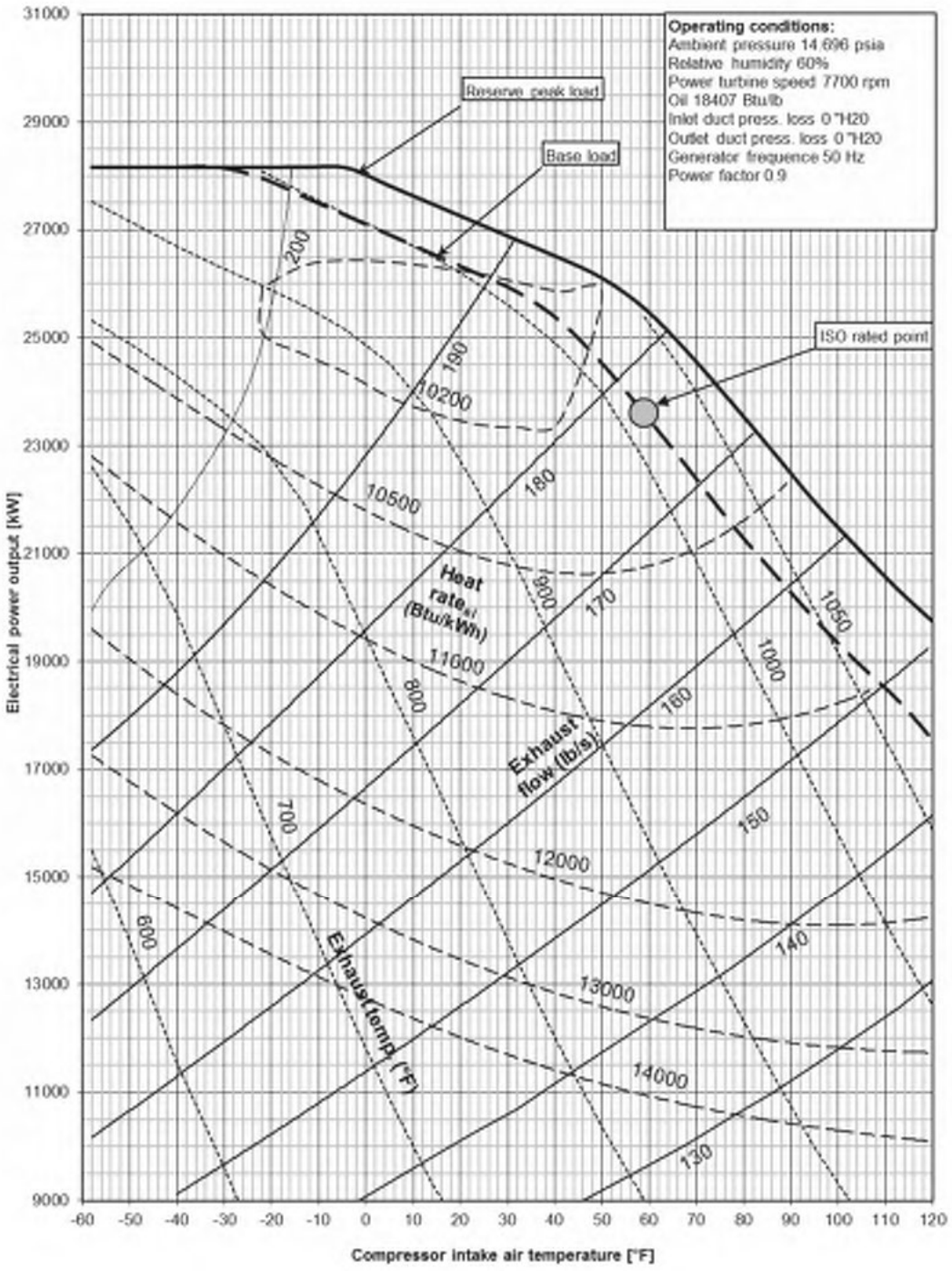
Nominal performance SGT-600 Power Generation
ISO ambient matching, Liquid fuel



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		Document number		1CS26747	
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Guidelines for water and steam quality

Combustion Chamber

Depending on gas turbine model and choice of burner type, water and steam injection is available or not. See list below.

SGT-600

Steam injection is applicable for the conventional burner option.

Water injection is applicable for conventional and DLE burner operating on liquid fuel, as well as conventional burner operating on gaseous fuel. For DLE burner operating on gaseous fuel, please contact SGT-600 product manager.

SGT-700

Water and steam injection is not applicable.

SGT-750

Water injection is applicable for dual fuel burner option.

SGT-800

Water and steam injection is not applicable.

FO / SGT-600(MD B, PG B, PG EX B) SGT-700(MD B, PG B, PG EX B) SGT-800(PG B, PG B2, PG Ex B2, PG B LS) / &EC102,SGT-750	

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TABLE 1 - Chemistry guidelines for steam and water injection

Parameter	Units	Steam	Water
Cation conductivity of steam or boiler feed water (measured online after strongly acid cation exchanger)	µS/cm	< 0.3	< 0.3
Specific conductivity (measured online at outlet of water treatment plant),	µS/cm	-	< 0.2
Sodium, Na (To be checked if cation or specific conductivity exceeds the levels specified above)	mg/kg (ppm)	< 0.01	< 0.01
Total dissolved solids	mg/kg (ppm)	< 0.1	< 0.1
Silica, SiO_2	mg/kg (ppm)	< 0.02	< 0.02
Iron, Fe	mg/kg (ppm)	< 0.02	< 0.02
Oil	mg/kg (ppm)	Not detectable	Not detectable
pH		5-10	5-10

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TABLE 2 – System properties for steam injection

	Steam injection SGT-500		Steam injection SGT-600	
Steam to fuel ratio [a] Maximum allowed steam flow is 2.0 kg/s (4.4 lb/s)	<2.0		<1.5	
Pressure Min	25 bar(a) [b]	363 psi(a) [b]	25 bar(a) [c]	363 psi(a) [c]
Max	50 bar(a) [b]	725 psi(a) [b]	80 bar(a) [c]	1160 psi(a) [c]
Pressure variation, max	±5 %		±5 %	
Pressure variation rate	<0.5 %/s		<0.5 %/s	
Temperature, Min	Dry, superheated >20°C	Dry, superheated >36°F	Dry, superheated >20°C	Dry, superheated >36°F
Max	400 °C	752 °F	400 °C	752 °F
Temperature variation, Max	±10 °C	±18 °F	±10 °C	±18 °F
Temperature variation rate, Max	1 °C/s	1.8 °F/s	1 °C/s	1.8 °F/s

[a] May vary depending on fuel heating value.
[b] Required pressure to achieve max mass flow 2 kg/s (4.4 lb/s) is 41 bar (a) (595 psi (a))
[c] Required pressure to achieve max mass flow 2 kg/s (4.4 lb/s) is (TBA)

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TABLE 3 – System properties for water injection

	Water injection SGT-500		Water injection SGT-600		Water injection SGT-750	
Pressure, Min	2 bar(a)	29 psi(a)	3 bar(a)	43,5 psi(a)	3 bar(a)	43,5 psi(a)
Max	10 bar(a)	145 psi(a)	15 bar(a)	217,6 psi(a)	15 bar(a)	217,6 psi(a)
Temperature, Min	5°C	41 °F	5°C	41 °F	5°C	41 °F
Max	40 °C	104 °F	45 °C	113 °F	45 °C	113 °F
Temperature variation, max	N/A		N/A		N/A	
Temperature variation rate, max	N/A		N/A		N/A	
Water to fuel ratio [a)]	<1.1		<1.1		<1.5	
Filtration requirement	10 micron absolute β > 5000		10 micron absolute β > 5000		10 micron absolute β > 5000	

[a)] May vary depending on fuel heating value.

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Compressor turbine

TABLE 4 - Steam quality requirements for compressor turbine

	Steam injection SGT-600	
Steam to fuel ratio [a] Maximum allowed steam flow is 2.0 kg/s (4.4 lb/s)	<1.5	
Pressure, Min	17 bar(a)	247 psi(a)
Max	80 bar(a)	1160 psi(a)
Pressure variation, max	±5 %	
Pressure variation rate	<0.5 %/s	
Temperature, Min	Dry, superheated >20 °C	Dry, superheated >36 °F
Max	350 °C	662 °F
Temperature variation, max	±10 °C	±18 °F
Temperature variation rate, max	1 °C/s	1.8 °F/s
Cation conductivity (online) or **Specific conductivity** (grab sample), µS/cm	<0.2 or <1.5 [b]	
Sodium and Potassium, Na+ K, mg/kg (ppm)	<0.01	
Total dissolved solids, TDS, mg/kg (ppm)	<0.1	
Silica, SiO_2, mg/kg (ppm)	<0.02	
Iron, Fe, mg/kg (ppm)	<0.02	
Copper, Cu, mg/kg (ppm)	<0.003	
Oil and Grease, mg/kg (ppm)	Not Detectable	
pH	5-10	

[a] May vary depending on fuel heating value.
[b] Specific conductivity before any addition of alkalising agents

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Water for evaporative coolers

TABLE 5 - Properties for water used for evaporative coolers

Parameter	Units	Recommended quality of recirculating water with salt containing make-up water	Recommended quality of salt containing make-up water assuming a concentration factor of 4	Guidelines for operation with demineralised or RO make-up water (suitable tap water or well water unavailable)
Ca hardness	mg/kg $CaCO_3$ (ppm $CaCO_3$)	50 – 400	30 [a] – 100	Operate without blowdown while supervising water chemistry and fouling until the first of the parameters for the recirculating water approaches the upper limit. After that, operate with low blow down, approximately 5% or less of evaporation rate, while supervising chemistry (conductivity) and fouling.
Total Alkalinity	mg/kg $CaCO_3$ (ppm $CaCO_3$)	50 – 400	30 [a] – 150 [b]	
Conductivity	µS/cm	< 3000	50 – 750	
pH		7-9	6.0-8.5	
Practical Scaling Index [c] (PSI)		6.0-7.0	-	
Silica, SiO_2	mg/kg (ppm)	< 100	< 25	
Sodium and Potassium, Na + K	mg/kg (ppm)	< 200	< 50	
Chlorides, Cl^-	mg/kg (ppm)	< 200	< 50	
Sulphate, SO_4^{2-}	mg/kg (ppm)	< 300	< 75	
Oil and Grease	mg/kg (ppm)	< 10	< 2	
Suspended Solids	mg/kg (ppm)	< 30	< 5	
Iron, Fe	mg/kg (ppm)	< 0.5	< 0.1	

[a] Higher concentration factor should be used when allowed by the remaining parameters
[b] Number of cycles to be multiplied with 0.67 for total alkalinity
[c] Calculated from temperature, conductivity, Ca hardness and total alkalinity

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Compressor washing

Off-line washing is the recommended method.
For conditions for on-line washing Siemens Industrial Turbomachinery AB shall be consulted.

TABLE 6 - Water quality for compressor washing

	Units	Water for off-line washing		Water for on-line washing	
Temperature, Min		10 °C	50 °F	10 °C	50 °F
Max		50 °C	122 °F	60 °C	140 °F
Cation Conductivity (online) or **Specific Conductivity** (grab sample)	µS/cm	- -		<0.2 or <1.5 [a)]	
Sodium and Potassium, Na + K	mg/kg (ppm)	<200		<0.01	
Total Dissolved Solids, TDS	mg/kg (ppm)	<1000		<0.1	
Hardness	mg/kg $CaCO_3$ (ppm $CaCO_3$)	<500		-	
Turbidity		<1 NTU		-	
Silica, SiO_2	mg/kg (ppm)	-		<0.02	
Iron, Fe	mg/kg (ppm)	<0.3		<0.02	
Copper, Cu	mg/kg (ppm)	<1.0		<0.003	
Oil and Grease	mg/kg (ppm)	-		Not detectable	
$KMnO_4$-consumption	mg/kg (ppm)	-		<5	
pH		5-9		5-9	

[a)] Specific conductivity before any addition of alkalising agents

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		Document number		1CS26747	
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Water quality for standard fuel separators

Water soluble contaminants in distillate fuels such as sodium (Na) and potassium (K) can usually be reduced to acceptable level by washing in separators.

The feed water to separator must be of sufficient quality to clean the fuel until it fulfils the required fuel specification. The required feed water quality shall be specified by the supplier of the separator.

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WATER FOR STANDARD LUBE OIL COOLERS

Table 7 - Cooling water guideline for 316 (L)

Parameter*	**Unit**	**"316 (L)"** (For example, 2343XX, 2353XX)
Temperature out	°C	< 50
pH	-	> 5.0
Conductivity	mS/cm	-
Chloride, Cl^-	mg/l	< 500
Sulphide, S^{2-}	mg/l	-
Ammonia, NH3	mg/l	-
Bicarbonate, HCO_3^-	mg/l	-
Suspended solids	mg/l	< 1000
Water velocity	m/s	≥ 1.0[1)]
HCO_3^-/SO_4^{2-}	ppm/ppm	-
HCO_3^-/Cl^-	ppm/ppm	-

*) Additional information regarding Ca content (ppm) and total alkalinity

(as ppm CaCO3) is needed if the risk for scaling is to be established

[1)] Preferably > 1.8 m/s

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		Document number			
		Revision	A	Page	1

Typical individual consumers list (preliminary)

This document describes the typical auxiliary power consumption of the individual main consumers for a SGT-600 gas fuel gas turbine unit (air cooled lubrication oil, seal air coolers) for power generation and with air cooled generator.

Description	Normal start (kW)	Normal operation (kW)	Cooling down (kW)	Stand still (kW)	Rated power (kW) @ 40°C	Rated Volt AC	Rated Volt DC	Remarks
Starting system								
Starter motor	225	-	6	-	150	400		SFC drive / Short time rated
Cooling sealing air system								
Seal/purge air cooler MTR 1	1.1	1.1	1.1	-	1.5	400		SFC drive
Seal/purge air cooler MTR 2	1.1	1.1	1.1	-	1.5	400		SFC drive
Lubrication oil system								
Lube oil heater	30	-	-	30	30	480		DOL
Lube oil mist fan motor 1	2.2	2.2	2.2	-	4	270		SFC drive
Lube oil pump motor 1	10	10	10	-	30	270		SFC drive
Lube oil pump motor 2	10	10	10	-	30	270		SFC drive
Lube oil pump motor 3	-	-	-	-	30	270		SFC drive/Standby
Lube oil boost pump motor 1	2.2	2.2	2.2	-	4	270		SFC drive
Lube oil boost pump motor 2	2.2	2.2	2.2	-	4	270		SFC drive
Lube oil boost pump motor 3	-	-	-	-	4	270		SFC drive/Standby
Lube oil cooler fan motor 1	7.5	7.5	7.5	-	7.5	460		DOL drive
Lube oil cooler fan motor 2	7.5	7.5	7.5	-	7.5	460		DOL drive
Lube oil cooler fan motor 3	7.5	7.5	7.5	-	7.5	460		DOL drive
Ventilation system								
GT room vent motor 1	15	15	15	-	30	400		SFC drive
GT room vent motor 2	-	-	-	-	30	400		SFC drive/Standby
Gas fuel system								
Control valve , main	1.5	1.5	-	-	3.2	148		SFC drive
Control valve , pilot	1.5	1.5	-	-	3.2	148		SFC drive
Gas fuel compressor								
Compressor Drive Motor 1	-	1865	-		1865	4160		SFC Drive
Process air cooler motor 1	-	22.5	-		22.5	460		SFC Drive
Compressor control panel	1.2	1.2	-		1.2	120		
Power distribution panel	1.0	1.0	-		1.0	480		
Building ventilation fan 1	-	112	-		112	460		DOL
Building ventilation Standby fan	-	112	-		112	460		DOL

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SIEMENS	Performance & Technical Information SGT-600	GTI number		J2203031E	
		Document number			
		Revision	A	Page	2

Description	Normal start (kW)	Normal operation (kW)	Cooling down (kW)	Stand still (kW)	Rated power (kW) @ 40°C	Rated Volt AC	Rated Volt DC	Remarks
Compressor wash system								
Electrical heater 1	-	-	-	4.5	4.5	480		
Electrical heater 2	-	-	-	4.5	4.5	480		
Comp. washing pump motor	-	-	-	2.7	3	480		
Forst guard heater	0.2	0.2	0.2	0.2	0.2	480		
Generator								
Standstill heaters - stator	-	-	-	4.8	4.8	480		
Standstill heater - MV encl.	-	-	-	0.87	0.87	480		
Standstill heater - exciter	-	-	-	0.45	0.45	480		
Exhaust system								
CEMS	-	-	-	-	-	480		
Ammonia skid blower 1	-	5.5	-	-	5.5	460		DOL
Ammonia skid blower 2	-	5.5	-	-	5.5	460		DOL
Ammonia skid heater	-	65	-	-	65	460		
Ammonia opto 22 control	0.8	0.8	-	-	0.8	460		
SCR Dilution fan motor	-	5.5	-	-	5.5	460		DOL
SCR Tempering fan motor		112			112	460		DOL
SCR Tempering Standby fan		-			112	460		DOL
Miscellaneous								
Battery charger	0.1	0.1	0.1	8	10	480	460	Float charging
Compt/skid light & sockets	2	2	2	3	3	230		
UPS loads	3	3	3	2	3.5	230		
Single phase loads	6.5	6.5	4	3	6.5	230		
Three phase loads	15	15	15	12	15	480		
Combustion system								
Bypass valve servo	-	1.0	-	-	1.6		565	SFC drive
Guide vane ADJ. servo	0.8	0.8	-	-	1.1		565	SFC drive
Black start charger 1		1.0			1.0	120		Per site
Black start charger 2		1.0			1.0	120		Per site

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K-standard
K-standard

Issued by dept	Release date	Classification	Category	Language	Document number	Revision	Page
RGM	2018-08	Restricted		sv en	**K-1171-7**	**9**	**1 (3)**

Replaces: K-1171-7, ed. 8, 18-02

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ID:K-1171-7_Name:Lubricating oil_Rev:9_Protection:Restricted_IP:R00,S00
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Titel
Mottagningskontroll av turbinolja

Title
Receiving inspection of lubricating oil

Innehåll

1 Allmänt
2 Referenser
3 Mottagning av leverans
4 Provtagningsansvar
5 Provtagningsmetod
6 Provhantering
7 Analys av prov
8 Kvalitetsförordringar

Contents

1 General
2 References
3 Delivery acceptance
4 Sampling responsibility
5 Sampling method
6 Sample handling
7 Analysis of samples
8 Quality demands

1 Allmänt

Denna standard skall tillämpas vid mottagningskontroll av smörjolja för ång- och gasturbiner. Den gäller vid oljeleveranser både till SIT Finspång och till utemontageplatser.

1 General

This standard shall be used for delivery control of lubricating oil for steam and gas turbines. It is valid for deliveries both to SIT Finspong and to erection sites.

2 Referenser

011-04884
"Fuel, lubricant, water and deposit sampling and transportation"

DL 1171-1
Smörjolja för ång- och gasturbiner

2 References

011-04884
Fuel, lubricant, water and deposit sampling and transportation

DL 1171-1
Lubricating oil for steam- and gas turbines

3 Mottagning av leverans

Lossning av en leverans måste ske i enlighet med direktiven från SIT:s representant.
Viktig information för leverantören är t.ex. erforderlig slanglängd för att nå tankens påfyllningsstuds.

Lossning skall alltid ske genom ett filter med maskvidden max 10µm (β_{10}=75).

Innan lossning påbörjas skall leverantören överlämna analysintyg och lastningsprov(er), för varje batch, i enlighet med DL 1171-1

Analysintyg för varje lastningsprov skickas av SIT representant till chemlab.energy@siemens.com för utvärdering.

Företrädelsevis skall en batch användas till en turbin.

Köparens representant äger rätt att vägra mottaga leverans av en batch om:
- Analysintyg saknas.
- Om analysintyget visar att oljan inte uppfyller kraven i den gällande materialspecifikationen.

3 Delivery acceptance

Unloading of a delivery must be in accordance with the directives from SIT:s representative.
Important information for the supplier is e.g. necessary hose length in order to reach the filling connection piece of the tank.

Unloading shall always be made through a filter with a mesh size of max 10µm (β_{10}=75, 0.39 mils).

Before unloading is started the supplier shall hand over analysis certificate and loading sample(s), for each batch, in accordance with DL 1171-1

Analysis certificates for each loading sample is sent by SIT's representative to chemlab.energy@siemens.com for evaluation.

Preferably a single batch for each turbine shall be used.

The purchaser's representative owns the right to reject deliver of a batch if:
- If the analysis certificate is missing
- The analysis certificate shows that the oil does not comply with requirements in the valid material specification.

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4 Provtagningsansvar

- **Lastningsprov:** se DL 1171-1
- **Leveranssprov:** SIT:s representant är ansvarig för provtagningen vid lossning.
- **Tankprov:** SIT:s representant är ansvarig för provtagningen från tanken efter fyllning.

5 Provtagningsmetod

All provtagning ska utföras i enlighet med "Work instruction" 011-04884.

5.1 Leveransprov

5.1.1 Bulkleverans

När lossningen börjar skall två prov tas direkt från påfyllningsslangen.

5.1.2 Fat- eller IBC-leverans

För varje levererad batch ska ett provpar (d.v.s. två prov) tas för varje påbörjad 3 m^3 olja.
- Varje provpar ska vara taget från samma fat eller IBC.
- Olika provpar ska tas från olika fat eller IBC.

5.1.3 Exempel

Två batcher olja är levererade. 2 m^3 från Batch A i två behållare (IBC) och 8 m^3 från Batch B i åtta behållare.
- Batch A: Ett provpar tas från samma behållare
- Batch B: Tre provpar tas från tre olika behållare.

- Totalt åtta prover från fyra behållare (två från Batch A och sex från Batch B).

10 m^3 olja har levererats från samma batch i fat.
- Fyra provpar tas från fyra olika fat.
- Totalt åtta prover från fyra olika fat.

5.2 Tankprov

Efter att smörjoljetanken är påfylld, **men före cirkulering av oljan är påbörjad,** skall ett prov tas direkt från turbinens smörjoljetanken.

6 Provhantering

Oljeprover ska inte utsättas för solljus och skall lagras svalt och mörkt.

6.1 Lastningsprov

Se DL 1171-1

Lastningsprovet som överlämnas av oljeleverantören lagras tills vidare.

6.2 Leveransprov

Lagras tills vidare.

4 Sampling responsibility

- **Loading sample:** see DL 1171-1.
- **Delivery sample:** SIT representative is responsible for sampling at delivery
- **After-filling sample:** SIT representative is responsible for sampling after filling tank.

5 Sampling method

All sampling shall be done in accordance with Work instruction 011-04884.

5.1 Delivery sample

5.1.1 Bulk delivery

When unloading starts two samples shall be taken directly from the discharge hose.

5.1.2 Barrel or IBC delivery

For each delivered batch, take one pair of samples for every 3 m^3 of delivered oil.
- Each pair shall be taken from the same barrel or IBC
- Every different pair shall be sampled from different barrels of IBC

5.1.3 Examples

Two oil batches are delivered. 2 m^3 from Batch A in two containers (IBC) and 8 m^3 from Batch B in eight containers.
- Batch A: One pair of samples from the same container.
- Batch B: Three pairs of samples from three different containers.
- In total eight samples from four different containers. (two from Batch A and six from Batch B).

10 m^3 of oil is delivered in one batch in barrels.
- Four pairs of samples is taken from four different barrels.
- In total eight samples from four different containers.

5.2 After-filling sample

After completed unloading, **but before oil circulation is started,** a sample shall be taken directly from the turbine lube oil tank.

6 Sample handling

Oil samples shall not be exposed to sunlight and shall be stored in a dark and cool environment.

6.1 Loading sample

See DL 1171-1

The loading sample which is handed over by oil supplier is stored until further notice.

6.2 Delivery samples

Stored until further notice.

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6.3 Tankprov

Det ena provet från varje provpar skickas av SIT representant till SIT, Finspång för analys och utvärdering. Det andra provet från varje provpar lagras tills vidare.

6.3 After-filling samples

One sample from each pair is sent by SIT representative to SIT, Finspång for analysis and evaluation. The other sample is stored until further notice.

7 Analys av prov

Avd. Materialteknik och Kemi SIT, Finspång kontrollerar att fordringarna i materialspecifikationen är uppfyllda i leverantörens analysintyg som vid analys av tankprovet. Om så är fallet lämnas övriga prov utan åtgärd.

Om analysintyget eller tankprovets analysresultat avviker från materialspecifikationen, så ska SIT utföra analys och utvärdering av lastnings- och leveransproverna.

Prov analyseras enligt Tabell 1 nedan.

7 Analysis of samples

Dept. Materials technology and Chemistry SIT, checks that the suppliers analysis certificate and the tank sample fulfil the requirements in the lube oil specification stipulated in the purchase order.
If that is the case, other tests will be canceled.

If the supplier analysis certificate or the tank sample analysis results deviate from the material specification, SIT shall perform analysis and evaluation of the loading and delivery samples.

Samples are analyzed according to Table 1 below.

Tabell 1. Analyser för fyllningsprov och leveransprov

Table 1. Analysis for after filling sample and delivery sample

Parameter	Parameter	Standardmetod / Standard method	
Föroreningar	Impurities	ISO 4406	
Metallinnehåll	Elemental content	ICP-AES	
Viskositet vid 40°C	Viscosity at 40°C	ISO 3104	ASTM D 445

Table 2. Kompletterande analyser

Table 2. Additional analyzes

Parameter	Parameter	Standardmetod / Standard method	
Skumning	Foaming	ISO 6247	ASTM D 892
Luftavskiljning vid 50°C	Air release at 50°C	ISO 9120	ASTM D 3427
Vattenseparationsförmåga	Demulsibility	ISO 6614	ASTM D 1401

8 Kvalitetsfordringar

Om metaller som normalt inte ingår i oljans additivpaket detekteras, så betraktas dessa som organometalliska föroreningar.

8.1 Riktlinjer

Riktlinjer för metallinnehåll i tankprovet:
- Metallföroreningar < 1 mg/kg är acceptabla

Metalliska föroreningar kan påverka oljans fysikaliska egenskaper negativt, speciellt med avseende på Zn, Ca, Mg, Ba etc. Om värdet ovan överskrids så ska oljans analyseras i enlighet med Tabell 2. Resultaten ska utvärderas mot materialspecifikationen, för att säkerställa säker turbindrift

Om analysresultaten för tankprovet avviker från kraven i materialspecifikationen, så ska lastnings- och leveransproven analyseras i enlighet med Tabell 1. Resultaten ska utvärderas mot materialspecifikationen och leverantörens analysintyg.

8 Quality demands

If metals that are not part of the oils additive package are detected, these will be considered as organometallic contaminants.

8.1 Guidelines

Guidelines for metallic content in after-filling sample:
- Metalllic contaminants < 1.0 mg/kg are acceptable.

Metallic contaminants can affect the physical properties of the oil negatively, especially Zn, Ca, Mg, Ba etc. If the value above is exceed the oil shall be analyzed in accordance with Table 2. The results shall be evaluated against the material specification, to ensure safe gas turbine operation.

If the analysis result of the after-filling sample deviates from the requirements in the material specification, the loading and delivery samples shall be analyzed in accordance with Table 1. The results shall be evaluated against the materialspecification and the supplier’s analysis certificate.

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SIEMENS

Tekniska leveransbestämmelser
Technical delivery terms

Document number	Revision	Page
DL 1171-1	**10**	**1 (2)**

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Titel
Smörjolja för ång- och gasturbiner

Title
Lubricating oil for steam- and gas turbines

Innehåll

1 Giltighet
2 Kvalitetsfordringar
3 Leveranskontroll
4 Leverans av olja
5 Metod
6 Dokumentation
7 Märkning

Contents

1 Validity
2 Quality requirements
3 Delivery inspection
4 Delivery of oil
5 Method
6 Documentation
7 Marking

1 Giltighet

Dessa leveransbestämmelser gäller tillsammans med övriga dokument som åberopas i inköpsordern. Krav och leveransvillkor angivna i inköpsordern gäller alltid oberoende av vad som anges i åberopade dokument.

Leveransbestämmelserna gäller för smörjolja till ång- och gasturbiner

Den levererade oljan bör vara från så få batcher som möjligt.

Kompletterande köpdokument:
- Materialspecifikation för smörjolja (MAT81210X).

1 Validity

These delivery terms apply together with the other documents referred to in the purchase order. Demands and delivery terms stipulated in the purchase order always apply independent of what is stipulated in referred documents.

The delivery terms are valid for lubricating oil for steam and gas turbines.

The delivered oil should be from as few batches as possible.

Supplementary purchase document:
- Material specification for lubricating oils (MAT81210X).

2 Kvalitetsfordringar

Oljan skall vid både lastning och lossning uppfylla fordringarna enligt materialspecifikationen, som är angiven i inköpsordern.

Om metaller som normalt inte ingår i oljans additivpaket detekteras, så betraktas dessa som organometalliska föroreningar.

2 Quality requirements

The oil must at both loading and unloading fulfill the requirements in the material specification, stated in the purchase order.

If metals that are not part of the oils additive package are detected, these will be considered as organometallic contaminants.

3 Leveranskontroll

Vid lastning av bulkleverans och fyllning av fat/IBC, så ska två representativa lastningsprov tas från varje batch.

3.1 Hantering av första provet (från varje batch)

Det första lastningsprovet skall analyseras av leverantören gentemot köparens materialspecifikation och ett analysintyg ska skapas.

3 Delivery inspection

When loading of bulk delivery or filling of barrels/IBC, two representative loading samples shall be taken from each batch.

3.1 Handling of the first sample (from each batch)

The first loading sample shall be analysed by the supplier against the purchaser's material specification and an analysis certificate shall be created.

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Analysintyget ska minst innehålla följande information:

- Provtagningsdatum
- Analysdatum
- Batchnummer
- Kinematisk viskositet
- Luftavskiljning
- Syratal
- Vatteninnehåll
- Skumning
- Vattenseparationsförmåga
- Partikelräkning
- Kalcium-, zink och fosforinnehåll

3.2 Hantering av andra provet (från varje batch)

Det andra lastningsprovet ska överlämnas till köparens representant vid leverans.

4 Leverans av olja

Lossning av en leverans måste ske i enlighet med direktiven från köparens representant.

Lossning skall alltid ske genom ett filter med maskvidden max 10µm (β_{10}=75).

I samband med lossning ska lastningsprov(er) överlämnas till köparens representant. Se avsnitt 3.2.

Köparens representant äger rätt att vägra mottaga leverans av en batch om:
- Analysintyg saknas.
- Analysintyget visar att oljan inte uppfyller kraven i den gällande materialspecifikationen.

5 Metod

All provtagning ska vara utförd i enlighet med leverantörens gottfinnande.

6 Dokumentation

All dokumentation ska vara skriven på engelska.
Enheter ska vara angivna i enlighet med SI-systemet.
All dokumentation ska vara entydig och tydligt läsbar.

Oljeleverantören ska, före och i samband med leveransen, överlämna följande till köparens representant:

- Analysintyg för varje levererad batch i enlighet med avsnitt 3.1.

7 Märkning

Alla lastningsprov ska vara märkta med:
- Provtagningsdatum
- Typ av olja
- Batchnummer

The analysis certificate shall at least contain the following information:
- Date of sampling
- Date of analysis
- Batch no.
- Kinematic viscosity
- Air release value
- Total acid number
- Water content
- Foaming
- Demulsibility
- Particle count
- Calcium, zinc and phosphorus content

3.2 Handling of the second sample (from each batch)

The second loading sample shall be handed over to the purchaser's representative at delivery.

4 Delivery of oil

Unloading of a delivery must be in accordance with the directives from the purchaser's representative.

Unloading shall always be made through a filter with a mesh size of max 10µm (β_{10}=75, 0.39 mils).

In connection with unloading the loading sample(s) shall be handed over to the purchaser's representative. See section 3.2.

The purchaser's representative owns the right to reject deliver of a batch if:
- The analysis certificate is missing
- The analysis certificate shows that the oil does not comply with requirements in the valid material specification.

5 Method

All sampling shall be performed in accordance with the supplier's discretion.

6 Documentation

All documentation shall be written in English
Units shall be given in accordance with the SI system.
All documentation shall be unambiguous and readable.

The oil supplier shall, before and in conjunction with the delivery, hand over the following to the purchaser's representative:
- Analysis certificate for each delivered batch in accordance with section 3.1.

7 Marking

All loading samples shall be marked with:
- Date of sampling
- Type of oil
- Batch number

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Materialspecifikation
Material specification

Doc No. **MAT812109**

Based on | Replaces MAT812109 rev 6 | Lang. sv en (82) | Rev. ind. 7 | Page 1 (2)

Author Martina Domonkos | 2015-07-02 | Resp. dept. REK | Sec. level Restricted

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Titel
Fordringar gällande smörjolja

Title
Requirements for lubricating oil

Referenser till andra dokument
DL1171-1

References to other documents
DL1171-1

1 Allmänt

Denna materialspecifikation gäller vid anskaffning av smörjolja avsedd för växlade applikationer med höga drifttemperaturer som är konstruerade för ISO VG 46.

1 General

This material specification is valid for procuring turbine oil that may be used for geared applications with high operation temperatures that are designed for ISO VG 46.

2 Egenskaper

Turbinolja är vanligtvis en paraffinbaserad mineralolja bestående av en blandning med mättade kolväten och additiv som förbättrar oljans egenskaper, exempelvis termisk stabilitet. Blandningen av basolja och additiv skall inte ha någon negativ påverkan på material eller öka risken för svåra beläggningar i oljesystemet.

Utöver de fordringar som nämns i tabell 1 skall oljan inte innehålla organometalliska föreningar eller ha en zinkhalt >5 mg/kg.

2.1 Termisk stabilitet

Turbinoljan skall motstå höga temperaturer utan att oljans egenskaper förändras anmärkningsvärt. Den maximala oljetemperaturen i kontakt med komponenter i systemet (exempelvis lager, växel osv.) är 120°C och den maximala oljetemperaturen i oljetanken är 80°C.

2.2 Kompabilitet

Oljan skall vara blandbar med rester av turbinolja (*max. 4 volym %*) utan att förändra egenskaperna hos den nya oljan.

2 Properties

Turbine oil is usually paraffin based mineral oil consisting of a mixture of saturated hydrocarbons with additives to improve properties such as thermal stability. The admixture of base oil and additives must not have any negative effects on materials or increase the risk for excessive amounts of deposits in the oil system.

In addition to the requirements listed in table 1 the turbine oil must not contain additives with organometallic compounds or a zinc content >5 mg/kg.

2.1 Thermal stability

The turbine oil must be capable of withstanding high temperatures without excessive deterioration of the oil properties. The maximum oil temperature when in contact with components in the system (*e.g. bearings, gearboxes etc.*) is 120°C and the maximum oil temperature in the oil tank is 80°C.

2.2 Compatibility

The oil must be miscible with remaining quantities (*max. 4% by volume*) of turbine oil without changing the properties of the new oil.

3 Tekniska leveransbestämmelser

Tekniska leveransbestämmelser angivna i DL1171-1 och i inköpsordern gäller tillsammans med denna specifikation.

3 Technical delivery terms

Technical delivery terms stated in DL1171-1 and in the purchase order apply together with this specification.

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Template Tekniskt stddok

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SIEMENS **Materialspecifikation** / **Material specification** Doc No. **MAT812109**

Based on Replaces MAT812109 rev 6 Lang. sv en (82) Rev. ind. 7 Page 2 (2)

Tabell 1 / Table 1: Fordringar / Requirements

FORDRINGAR Requirements			**Testmetod Test method**	
ISO VG 46	Unit	Limit	ISO	ASTM D
Viskositet vid 40°C Viscosity at 40°C	mm^2/s	41.4 - 50.6	3104	445
Viskositetsindex Viscosity index		> 90	2909	2270
Densitet vid 15°C Density at 15°C	kg/m^3	Report [1)]	3675	1298
Flampunkt (Cleveland Open Cup) Flash point	°C (°F)	> 200 (> 392)	2592	92
Lägsta flyttemperatur Pour point	°C (°F)	< -6 (< 21) Om inget annat specificerats [2)] Unless otherwise specified [2)]	3016	97
Syratal, färdigprodukt Total Acid Number, finished product	mgKOH/g	< 0.3	6618	974
Korrosionsskydd Rust preventing characteristics		Godkänt B Pass B	7120	665
Kopparkorrosion Copper corrosion		Nivå 2 Level 2	2160	130
Vattenseparationsförmåga Demulsibility	min	< 30	6614	1401
Luftavskiljning vid 50°C Air release at 50°C	min	≤ 4	9120	3427
Skumning vid 24°C Foaming at 24°C	ml	≤ 450/0	6247 (Seq. I)	892 (Seq. I)
Vattenhalt Water content	mg/kg	< 200	Karl Fischer	1744
Oxidationsstabilitet (TOST [3)]) Oxidation stability	h	≥ 3000	4263	943
Oxidationsstabilitet (RPVOT [4)]) Oxidation stability	min	≥ 750		2272
Föroreningar [5)] Impurities	ISO code NAS	20/17/14 Class 8	4406	
Lastbärande förmåga Load carrying capacity	FZG	≥ 8		5182

1) Skall anges av oljeleverantören.
Shall be stated by the oil supplier.
2) Om särskilda krav på flyttemperatur finns, är dessa detaljerade i projektspecifik smörjmedelslista.
If special requirements on pour point exists, these are detailed in the project specific Lubricant List.
3) TOST = Turbine Oxidation Stability Test.
4) RPVOT = Rotating Pressure Vessel Oxidation Test.
5) Vid leverans.
At delivery.

SE-612 83 FINSPONG, Sweden Siemens Industrial Turbomachinery AB

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SIEMENS	Performance & Technical Information SGT-600	GTI number		J2203030E	
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Typical start, stop and trip characteristics SGT-600 PG, 3rd Gen DLE

Reference conditions

Barometric pressure	1.013 bar(a) / 14.693 psi(a)
Relative humidity	60%
Ambient temperature	15 °C / 59°F
Duct pressure losses:	
Inlet	8 mbar / 3.2 in H_2O
Outlet	5 mbar / 2.0 in H_2O
Fuel	Gaseous fuel acc. to Siemens fuel specification LHV: 46 808 kJ/kg / 20124 Btu/lb

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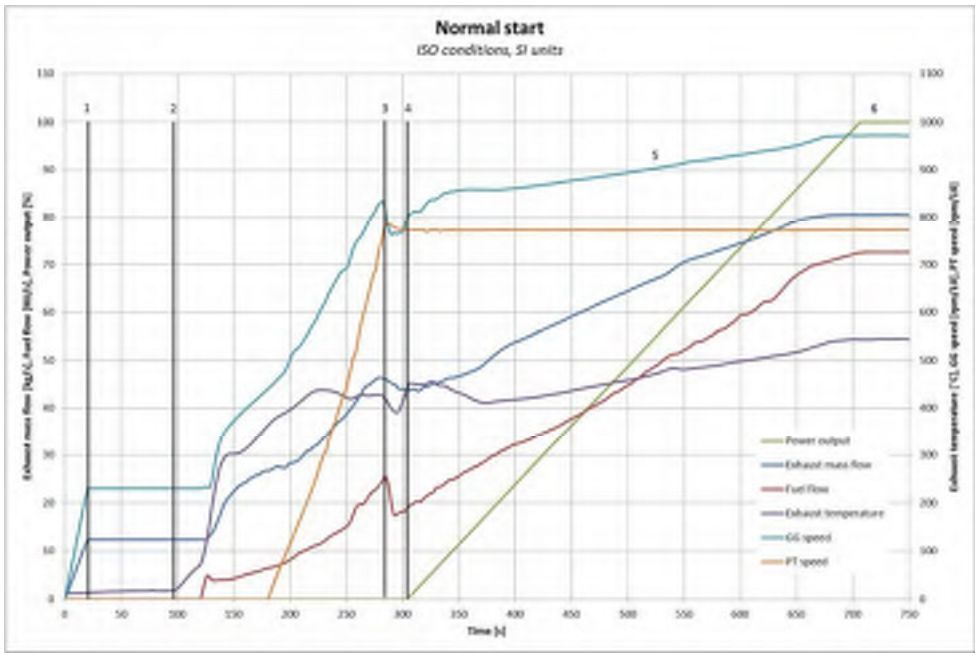
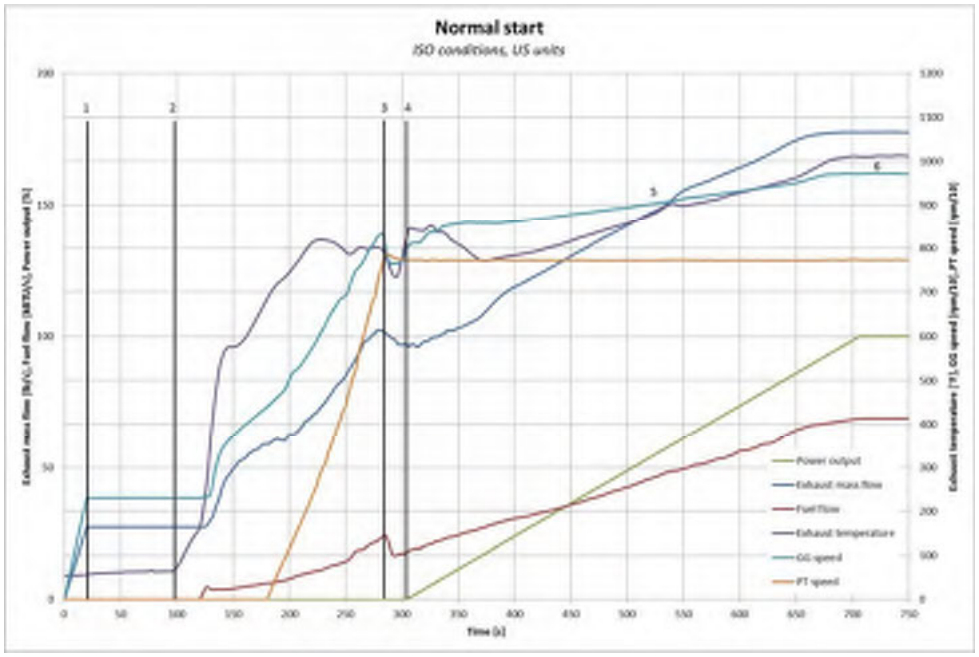
Start characteristics





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1) Purging

Reaches purge speed, 2300 rpm, after » 20 seconds. Purging will be carried out for at least 75 s but can be prolonged depending on boiler, stack, exhaust duct design or to fulfil certain standards, for example NFPA 85. If purge credit is available the purging time can be excluded, which will reduce the starting time approximately 75 s.

2) Ignition

Ignition at 2300 rpm.

3) Idle

Reaches idle after » 280 s.

4) Synchronisation

The time needed for synchronisation is mainly depending on the stability of the grid. Time from ignition to synchronization is approximately 210 s.

5) Loading

The loading will normally be carried out by 60 kW/s.

When reaching full load the gas turbine will require additional 5-10 minutes until full efficiency, and hereby also full power output, can be obtained.

6) Full load

Reaching full load after approximately 12 minutes.

Fuel consumption for a normal start at ISO conditions:
0-50% load: $7.80 \cdot 10^3$ MJ / $7.40 \cdot 10^6$ BTU
0-100% load: $2.07 \cdot 10^4$ MJ / $1.96 \cdot 10^7$ BTU

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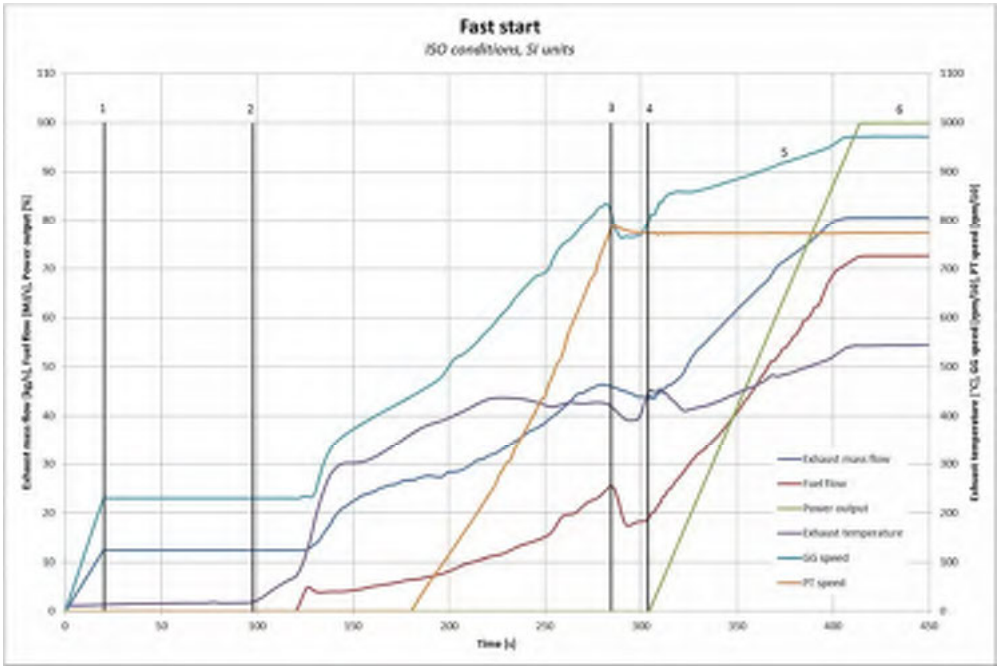
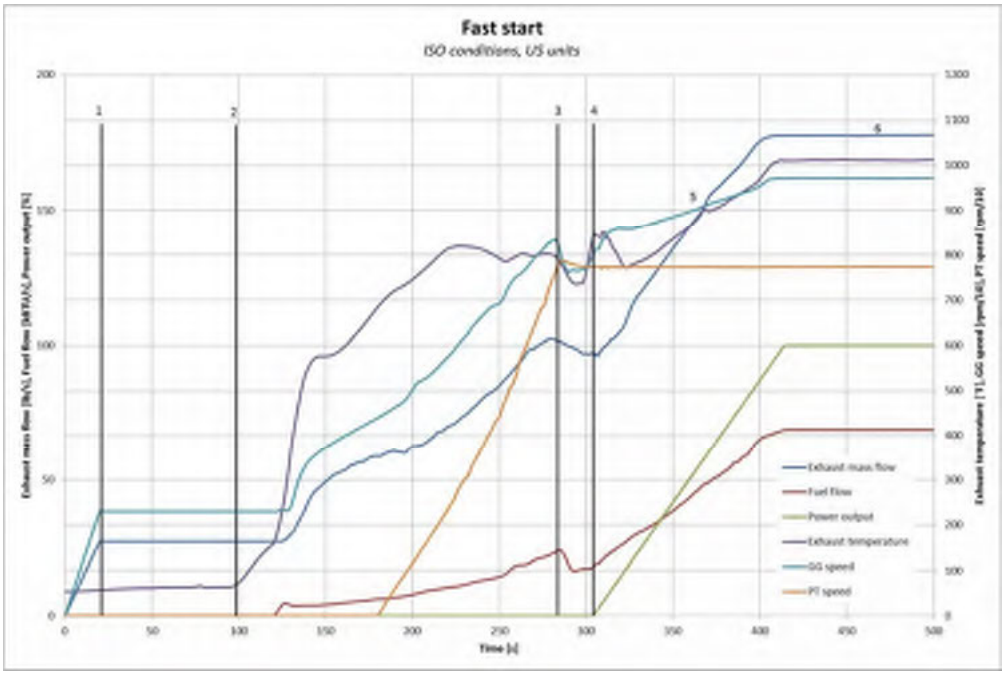
Fast start characteristics





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1) Purging

Reaches purge speed, 2300 rpm, after » 20 seconds. Purging will be carried out for at least 75 s but can be prolonged depending on boiler, stack, exhaust duct design or to fulfil certain standards, for example NFPA 85. If purge credit is available the purging time can be excluded, which will reduce the starting time approximately 75 s.

2) Ignition

Ignition at 2300 rpm.

3) Idle

Reaches idle after » 280 s.

4) Synchronisation

The time needed for synchronisation is mainly depending on the stability of the grid. Time from ignition to synchronization is approximately 210 s.

5) Loading

The loading will be carried out by a 220 kW/s load ramp.

When reaching full load the gas turbine will require additional 5-10 minutes until full efficiency, and hereby also full power output, can be obtained.

6) Full load

Reaching full load after approximately 7 minutes.

The gas turbine is assumed to be in stand-by mode with lube oil system and enclosure ventilation running.

Fuel consumption for a normal start at ISO conditions:
0-50% load: $3.65 \cdot 10^3$ MJ / $3.46 \cdot 10^6$ BTU
0-100% load: $7.19 \cdot 10^3$ MJ / $6.82 \cdot 10^6$ BTU

7) Fast start factor CX

Fast start factor Cx = 4

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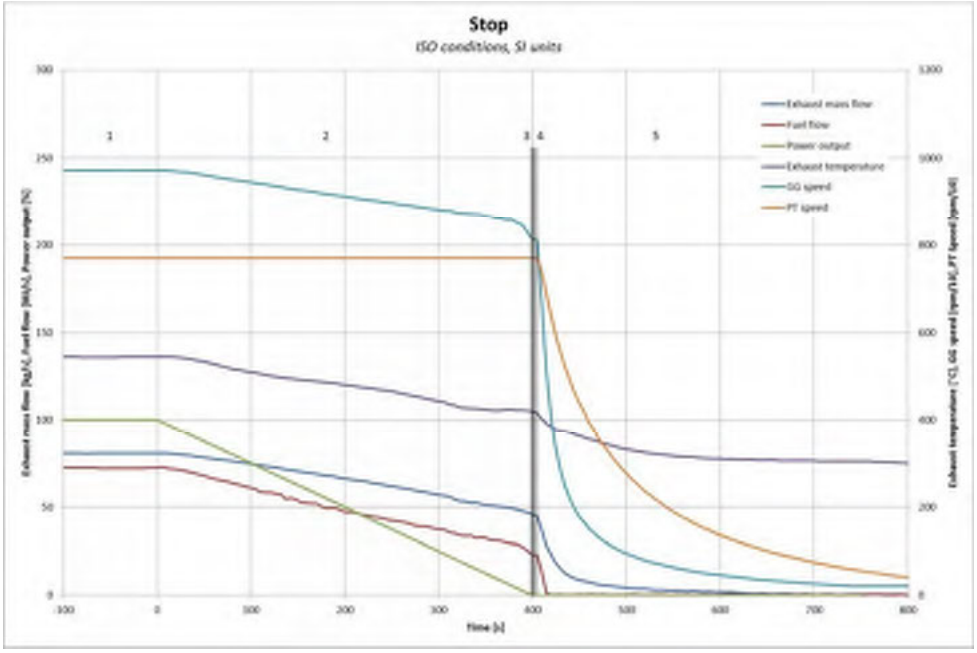
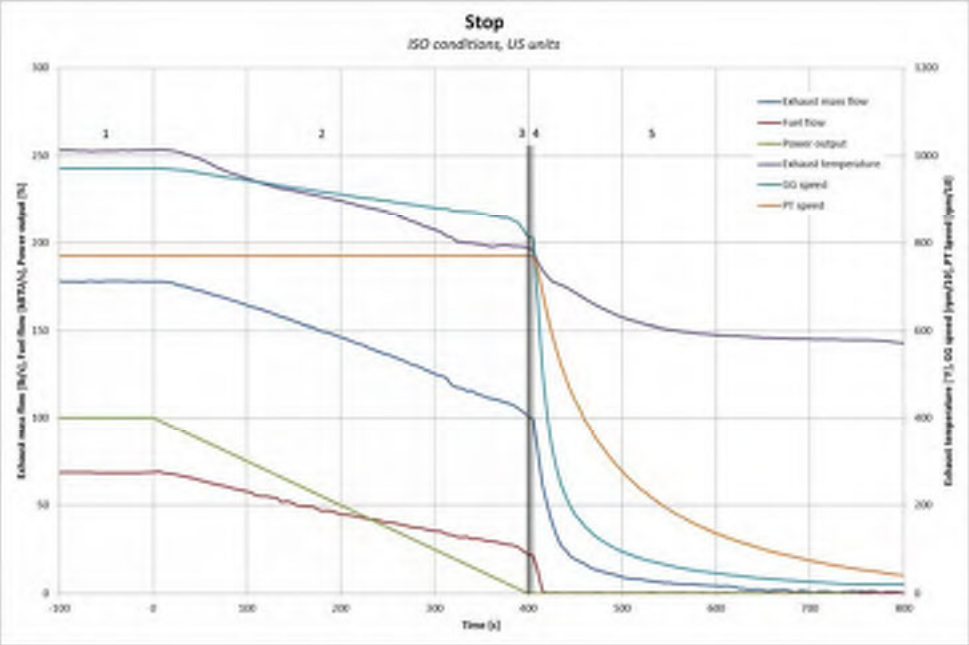
Stop characteristics





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1) Full load

2) Unloading

The unloading will be carried out by a 60 kW/s load ramp.

3) Idle

Reaches idle after » 400 s.

4) Fuel flow is shut off

5) Run down

The run down starts immediately after the fuel flow is shut off.

During the cooling period of 10 hours the gas turbine shall be on turning gear at 200 rpm. It is possible to restart the gas turbine at any time during the cooling period. If the power supply fails during the cooling period and the turbine speed goes below 180 rpm for 10 minutes the turbine will be interlocked for the rest of the cooling period.

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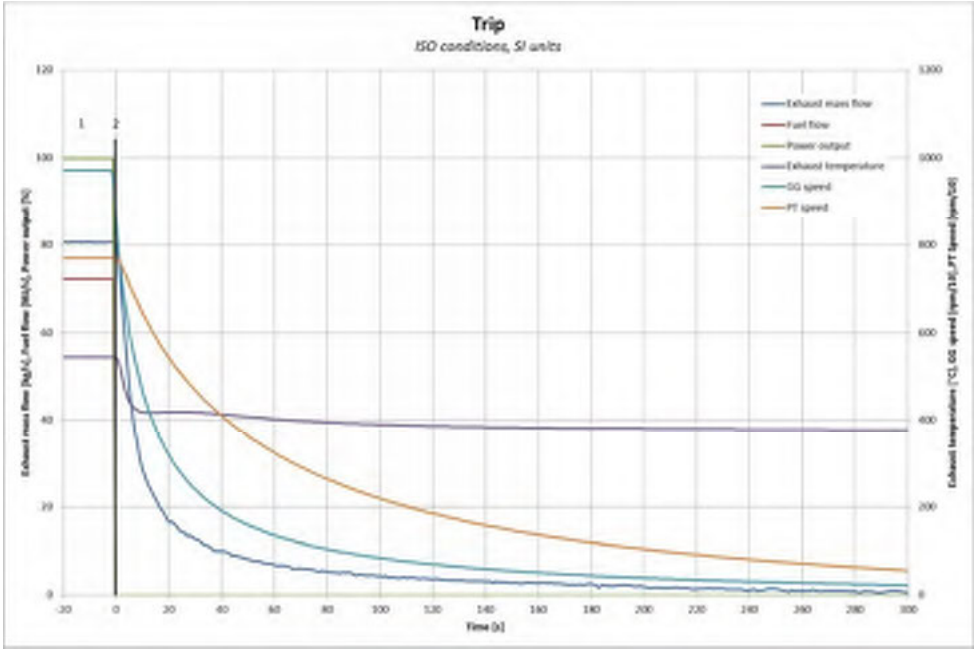
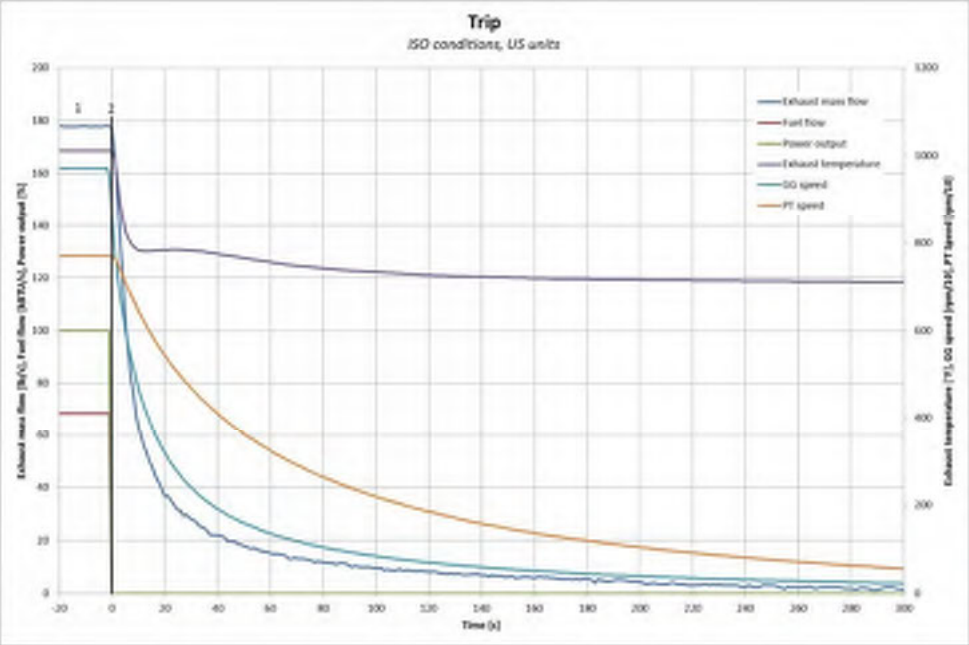
Trip characteristics





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1) Full load

2) Trip

3) Run down

The run down starts immediately after the trip is initiated and the fuel flow is shut off.

During the cooling period of 10 hours the gas turbine shall be on turning gear at 200 rpm. It is possible to restart the gas turbine at any time during the cooling period. If the power supply fails during the cooling period and the turbine speed goes below 180 rpm for 10 minutes the turbine will be interlocked for the rest of the cooling period.

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Start up emissions

Predictive start up emissions (no guarantee) due to start time depends on site criteria and conditions

Ignition - idle

0.07 kg/event (0.165 lb/event) NOx

2.0 kg/event (4.4 lb/event) CO

idle-100% load

2.0 kg/event (4.4 lb/event) NOx

11.0 kg/event (24.0 lb/event) CO

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SIEMENS	Performance & Technical Information SGT-600	GTI number		J241003E	
		Document number		1CS26586	
		Revision	W	Page	1

Specification for gaseous fuels, SGT-600 2nd generation DLE combustion system

The purpose of this specification is to define the properties of gaseous fuels acceptable for use in the SGT-600. The SGT-600, with 2nd generation DLE combustion system, is capable of burning all common natural gases and a number of other gases such as ethane, propane and hydrocarbon fuels rich in inert compounds, heavy hydrocarbons, hydrogen, etc. Tables 1-3 show the general allowable ranges for properties, constituents and contaminants valid for gaseous fuels in the SGT-600. The specification is valid at the terminal point of the gas turbine internal fuel system. Gas treatment options are available if required.

The contaminants listed are those most commonly found in natural gas fuels. If a fuel contains a contaminant or constituent for which a limit has not been included, or in cases where there are deviations from the requirements, Siemens must be consulted. A chemical analysis of the fuel must be submitted to Siemens for review and approval prior to operation of the gas turbine. Variations in gas composition and properties must also be reported and reviewed. Ultimately, only those fuels stipulated in the supply contract shall be permissible for operation.

Auxiliary systems and turbine governor will be adapted for the specific project gases and requirements and may not apply to all gases within this specification. The levels of certain constituents or properties may influence the design of the fuel system, enclosure ventilation, gas detection, area classification, materials selection, maintenance plan etc.

For definitions, see Appendix.

Table1: Gas fuel constituents		**Max**	**Min**
Methane, CH_4	mole %(1)	100	0
Ethane, C_2H_6	mole %(1)	100	0
Propane, C_3H_8	mole %(1)	100	0
Butanes and heavier alkanes, C_{4+}	mole %(1)	15(3)	0
Hydrogen, H_2	mole %(1)	10(3)	0
Inerts, N_2/CO_2	mole %(2)	30/25(4)	0
Hydrogen sulfide, H_2S	mole %(1)	3	0
Others (carbon monoxide, alkenes, etc)		Report	0

(1) % of reactant species (i.e. inerts not included)

(2) % of total (inerts + reactants)

(3) May be restricted to lower levels depending on the other gas constituents.

(4) Fuels with high inert content may require a separate fuel for ignition and start-up

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Table 2: Gas fuel properties	Unit	Max	Min
Wobbe index, WI^0	MJ/Nm^3	75	30
WI^T variation for start-up gas	%	±5	-
WI^T variation rate	$MJ/m^3/s$	±0.1	-
Gas temperature	°C	120(5)	-15
Temperature above dew point(6)	°C	-	20
Gas pressure set value(7)	bar(a)	28	-
Pressure variation from set value	bar	±0.5(8)	-
Pressure variation rate	bar/s	±0.1(9)	-

(5) May be restricted to lower temperatures for gases with low Wobbe index.
(6) Includes all substances, e.g. hydrocarbons, water and elemental sulfur, that could form liquids or solids in the fuel supply system
(7) This will be project specific depending on e.g. gas composition, gas temperature and ambient temperature. Typical value is 21-23 bar(a) for natural gas.
(8) <1.5 bar for transients, such as start-ups, sudden load steps or load rejections
(9) No periodic cycling of gas pressure is permitted

Table 3: Contaminants	Unit	Max	Min
Particulates < 5 µm	ppmw	5	-
Particulates > 5 µm	ppbw	5	-
Na, K	ppmw	0.1	-
Other metals		Report	-
Lube oil	ppmw	0.5	-
Other impurities		Report	-

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Appendix

Wobbe index

The fuel gas Wobbe index, WI^0, is defined as the lower heating value, LHV (volumetric) divided by the square root of the relative density.

$$WI^0 = \frac{LHV}{\sqrt{\rho_{rel}}} \qquad (\rho_{rel} = \frac{\rho_{gas}}{\rho_{air}})$$

Nm3 (normal cubic meter) at 101.325 kPa and 273 K (0°C).

To evaluate the suitability of a gas with varying properties or several gases with different properties, the temperature corrected Wobbe index, WIT, is introduced.

$$WI^T = WI^0 * \sqrt{\frac{273}{T_{Fuel}}}$$

$T_{Fuel} = \text{Fuel temperature at gas fuel system terminal point, K}$

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SIEMENS	Performance & Technical Information SGT-600, SGT-700, SGT-750	GTI number		W261026E	
		Document number		1CS103295	
		Revision	C	Page	1

Near field nominal sound level, 85 dB(A)

Background

Gas turbines are a source of sound. The sound level is a significant characteristic, as high sound levels create an unpleasant environment and cause hearing injuries. It is important to be able to quantify sound levels in order to keep them at an acceptable level.

Applicable standard

ISO11204 "Acoustics- Noise emitted by machinery and equipment- measurement of emission sound pressure levels at workstation and at other specified positions- Method requiring environmental correction".

Definitions

In general all definitions follow ISO 11204, some clarifications are made below.

Near field

The area close to the delivered equipment. (As opposed to far field which is usually several hundred meters away.)

Working area

Working area is defined as 1 m from the delivered equipment and 1.5 m above ground. When a horizontal exhaust is supplied, the area within 3m of the exhaust bellows is excluded from the working area. The areas inside the sound enclosures are also excluded from the working area. If several units are installed, and the distance between them is less than 20m (centre line to centre line), then the area between GTs is excluded from the working area. See figure 1.

Frequency of interest

The frequency range of interest includes octave bands with centre frequencies from 63 Hz to 8 kHz

Free field

A field in which reflections at the boundaries are negligible over the frequency range of interest.

Background sound near field

Background sound is defined as the sound pressure level measured when all the equipment in the scope of supply is silent. Examples of background sound are wind noise, other equipment and traffic. The background sound shall be at least 6 dB, but preferably 15 dB less than the sound of interest to avoid use of the correction procedure.

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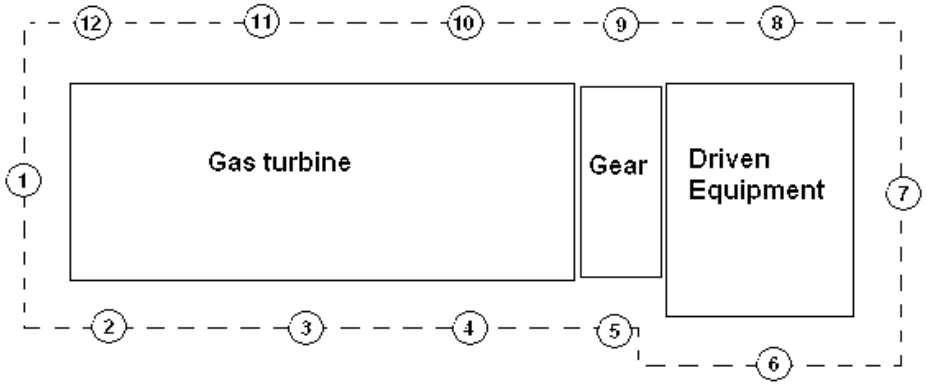

Fig 1: Working area with typical measurement positions marked.

Testing

Measurement positions

The measurement positions are evenly distributed 1m from delivered equipment and 1,5 m above ground for near field sound as per the example in figure 1.

Operation of the gas turbine under test

The sound level measurements will be made during normal operation conditions at base load.

Measurement time and equipment

The sound levels are measured for 30-60 s at each measurement position for near field sound. Instruments will fulfil class 1, in accordance with IEC 651.

Sound levels

Sound pressure levels in free field conditions fulfil the table below.

Two different options are available:

- Surface sound pressure level
- Equivalent sound pressure level at any point 1m from equipment

Surface sound pressure level [$\bar{L}_{pA}$][1]	≤ 85 dB(A)
Equivalent sound pressure level [L_{eqA}][2]	≤ 85 dB(A)

[1] $\bar{L}_{pA}$: The A-weighted surface sound pressure level, averaged over all used microphone positions in the working area, 1m from equipment and 1.5 meter above ground.

[2] L_{eqA}: The A-weighted equivalent sound pressure level in the microphone positions in the working area, 1m from equipment and 1.5 meter above ground.

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Corrections

Measuring the sound levels of a gas turbine involves dealing with certain practical difficulties, e.g. background noise, reflected noise, etc. If measurements are not taken in free field conditions, corrections for reflections and background noise will be made according to ISO 11204.

If the difference between the background sound and the sound of interest is less than 6 dB, but the measured noise level at base load is less than the specified level, the sound level specification will be considered as fulfilled.

No measurements can be done if the background noise is more than the specified level and the sound specification will then be considered as fulfilled.

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SIEMENS	Gas Turbine SGT-600	GTI number		J300022E	
		Document number		1CS26598	
		Revision	M	Page	1

Gas generator

Purpose

The gas generator generates a flow of pressurised hot gas, driving the power turbine.

General description

The SGT-600 gas turbine operates in an open cycle mode with axial air and gas flow through the turbine. It can be divided into two main sections, the gas generator and the power turbine. The two main sections are not mechanically interconnected, so the gas generator speed is determined by the output of the unit, which allows a wider control range at sustained efficiency.

The gas generator comprises of the compressor, the combustion chamber and the compressor turbine.

Inlet housing

The inlet housing consists of a plenum, which smoothly directs the incoming air to the compressor inlet and inlet casing. The inner part of the inlet casing contains bearing housing #1 and a shaft with a coupling, connecting the starting motor to the gas generator rotor.

The inner and the outer part of the casing is connected via four load-taking hollow struts, which also contain lubrication oil lines to the bearings as well as electric cables for the speed and vibration transducers. They are also used to convey seal and waste air.

Compressor

The compressor has 10 stages. Guide vanes of the first two stages are variable, actuated by a control mechanism and a variable speed electrical motor.

There are slots for bleeding off air downstream the second stage (bleed valve #1) and the fifth stage (bleed valve #2). The two bleed valves are located on the upper casing half. The bleed valves open at low load to prevent the compressor from surging and also at rapid load loss. Bleed off air is redirected into the air inlet plenum.

The compressor casing, covering the whole compressor section, is horizontally split to facilitate servicing and replacement of components. The casing carries the vane segments and variable vanes.

The compressor rotor is built up from a number of fully electron beam welded discs, onto which the intermediate shaft is also welded. The first rotor blade is made from titanium alloy (uncoated) for its high strength and low weight. Rotating blades, stages #2 to #10, are coated for corrosion protection (SSA12 Chromalloy) and improved compressor performance. Any blade can easily be replaced because of its attachment to the disc.

A diffuser section, at the compressor discharge, decelerates the flow and directs the air into the combustion chamber.

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SIEMENS	Gas Turbine SGT-600	GTI number		J300022E	
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Combustion chamber

The SGT-600 is designed for two different Combustion chambers, the conventional combustion chamber (CCC) and the 2nd generation Dry Low No_x Emission (DLE).

In the combustion chamber, which is of the annular type (covering the whole circumfe-rence), fuel is injected into 18 burners. (applicable for both types).

Ignition takes place by means of a spark plug. One burner is used as a start up burner. The spark plug is placed at the start up burner, which is supplied with ignition gas from the ignition gas system.

There are two flame detectors in the combustion chamber. One is indicating the flame in the start up burner at ignition, and during operation it is used as main flame detector. The other flame detector indicates cross ignition during start up, and during operation it is also used as main flame detector.

Dry low no_x emission (DLE)

When operating on gaseous fuels, the DLE burners are working according to the lean premixed combustion principle. This principle will ensure a low flame temperature and the formation of small amount of thermal NO_x. A variable bypass air system reduces the CO emissions during part load.

When operating on liquid fuel, the burners form a conventional diffusion flame. NO_x-reduction can be achieved by injecting water (option).

Conventional combustion chamber (CCC)

The conventional burner is recommended for single liquid fuel operation or dual fuel design when the liquid fuel will be used as main fuel

One further advantage for the CCC is that the burners are easy accessible for maintenance and overhaul

When operating on liquid fuel, NO_x-reduction can be achieved by injecting water (option).

Compressor turbine

The two-stage compressor turbine comprises the stator, carrying the guide vanes, and the rotor assembly bolted to the compressor rotor.

The blades and vanes are cooled by internal convective cooling.

The stator surfaces are provided with abradable (rubb off) honeycomb seals to withstand a slight blade tip rubbing. This also minimise the interstage gas leakage, which increases the efficiency.

The rotor blades as well as the guide vanes are precision cast. All surfaces are coated with anti oxidation coating.

While the compressor casing is of horizontal split design, the other casings of the unit make use of vertically split, single piece, circular casings. By this, the casing circularity can be maintained in the hot section and the turbine running clearances and aerodynamic losses be kept at a minimum.

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Bearings

Two bearings, #1 and #2, numbered from the inlet to the exhaust, carries the gas generator rotor. While the bearing housing of the cold bearing #1 is kept sub-atmospheric, the housing of bearing #2 is pressurised as it is located next to the compressor discharge. This permits size reduction and reduces the use of intricate labyrinth seals.

Bearing #1 is a combined thrust and journal bearing. Bearing #2 is a journal bearing. The bearings are of tilting pad type.

The bearings are equipped with temperature sensors and accelerometer type vibration pick-ups, the latter being vertically fitted on the outside of the bearing housings.

During operation, oil is continuously supplied to the bearings. Return oil from the bearing casings is led back to the lubrication oil tank by gravity and oil mist by a fan.

Cooling and sealing air

At a number of positions along the casings air is extracted for cooling and sealing purposes. The air is, dependent of use, taken from the different bleed cavities or from the compressor discharge.

Cooling air is used for cooling the compressor turbine rotor, vanes and blades. Sealing air is used to prevent hot gases from entering the bearing housing or oil mist from leaking out from the bearing housings.

Function

Start up

During start up, combustor ignition and unit acceleration is performed up to self-sustaining speed with the bleed valves open and the variable inlet guide vanes in closed position.

Bleed valve #1 has a simple open-close function and is open only during start and stop operation. At start the bleed valve #1 is kept open up to ~6900 rpm NGG * and is then closed.

Bleed valve #2 is open up to ~7800 rpm NGG* and is the closing as a variable function of the gas generator speed between ~7800 and ~8600 rpm NGG.

The start up is finalised when the minimum continuous speed/load is obtained.

NGG* = normalised gas generator speed = $N\sqrt{\frac{288}{T2}}$

N = actual gas generator speed (rpm)

T2 = actual compressor inlet air temperature (K)

Continuous operation

The gas generator speed varies dependant of load and ambient air conditions, however upwards limited to the maximum gas generator speed.

The bleed valve #2 opening is variable as a function of the gas generator speed, between ~7800 to ~8600 rpm NGG*, and above ~8600 rpm NGG* it will be fully closed unless bleed valve #2 is used for emission control on low loads.

The variable inlet guide vanes are in closed position until ~8600 rpm and opens as a function of the gas generator speed until they reach the open position at ~9800 rpm.

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Shut down

After load reduction the fuel flow is reduced to zero and the fuel shut off valves are closed. At shutdown the bleed valve #1 is opened when the speed has decreased to ~6800 rpm NGG* and the valve is closed again when the gas turbine has reached barring speed, (~200 rpm NGG*). Barring shall be started within 10 minutes after a shutdown (performed by the electrical starting motor). Barring is then continued for 10 hours until the gas turbine is cooled down. After this, the starting motor is stopped and the gas generator brought to stand still. During the barring period, normal start up is possible.

Instrumentation and control system

The ambient air conditions are input data for running the gas generator at its best performance. The gas generator speed is operated from the control system by means of the amount of fuel entering the combustion chamber and position of the variable inlet guide vanes.

The activation of the bleed off valves, the variable inlet guide vanes and the ignition system are affected from the start/stop automation and the protection section of the control system.

Several transducers along the gas generator detect stator and rotor vibrations, caused by a failure, during operation. The signals are read by the control system and displayed in a clear manner. Different alarm and trip levels are predefined to prevent and protect the gas generator if they are exceeded during operation.

Installation

The gas generator, as well as the gas turbine unit as a whole, is mounted with its supports on a single foundation frame into which the lubrication oil tank is inserted.

As the different sections of the gas generator is built up as removable modules, this also permits easy access and fast simple maintenance.

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SIEMENS	Gas Turbine SGT-600	GTI number		J300001E	
		Document number		1CS26597	
		Revision	H	Page	1

General description of the gas turbine unit

The SGT-600 is a low weight industrial gas turbine designed and developed to incorporate size and weight advantages of the aircraft derivative gas turbine while at the same time maintaining the robustness, flexibility and long life advantages of the traditional heavy duty industrial gas turbine. The unit combines a series of well tried and proven materials, components and design principles to form the most modern and fuel efficient unit of this type.

The gas generator section consists of a ten stage axial air compressor which is built up from a number of fully electron beam welded discs and onto which the intermediate shaft also is welded. The two gas generator turbine discs are bolted onto the intermediate shaft.

The low pressure section of the compressor and intermediate shaft are manufactured in low alloy steel. Inconel 718 is used for the discs in the high pressure section of the compressor.

The cooled gas generator turbine stator and rotor blades are precision cast.

While the compressor section is of conventional horizontally split design, the remainder of the unit makes use of vertically split, single piece, circular stator components. By this means the loss of circularity experienced with split casings is eliminated, hence running clearances and, thereby aerodynamic losses can be reduced to a minimum.

These sections can be removed as modules which permits easy access and fast simple maintenance.

The combustion chamber is of straight through annular design and suitable for both liquid and gaseous fuels.

The complete gas turbine unit is mounted on a single foundation frame into which the lubrication oil tank is inserted. All the auxiliary systems such as starting motor and electrically driven back-up systems are also mounted on the base frame.

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SIEMENS	Gas Turbine SGT-600	GTI number		J310009E	
		Document number		1CS26603	
		Revision	F	Page	1

Power turbine

Purpose

The power turbine converts the pressurised hot gas flow from the gas generator to mechanical energy, driving a generator via a gear.

General description

The power turbine is a two stage axial-flow turbine. It is not mechanically but hydro-dynamically connected to the gas generator.

The nominal turbine speed is 7700 rpm and the direction of shaft rotation is anti-clockwise looking counterflow. In MD application, the turbine speed range is 50 – 105 % of the nominal.

Rotor

The two rotor stages of the turbine is built up by two rotor discs, which are electron-beam welded to each other and to the rotor shaft, which in its turn is flanged to the gear box. A portion of the rotor between the two bearings has a significantly enlarged diameter to increase the rotational inertia.

The rotor blades are fitted to the discs in firtree shaped slots. The blades are provided with abradable sealing strips towards the stator, which minimise the blade tip clearance.

Stator

The stator supports two guide vane rings. The inner rings are provided with honeycomb seals. The first row of guide vanes is hollow to transport air to the turbine discs of the first stage.

Casings

The turbine casing houses the power turbine stages as well as the compressor turbine stages and the combustor of the gas generator. The casing is a non-split welded structure.

The turbine casing is mounted to the diffusor casing. The diffusor casing contains the diffusor, the purpose of which is to retard velocity and gain static pressure, thereby increasing the pressure ratio across the power turbine. The bearing housings are attached to the diffusor casing.

The exhaust casing surrounds the diffusor casing and connects to the outlet duct.

Bearings

The power turbine rotor is carried by two bearings, number three and four, numbered from the inlet to the exhaust. Bearing number three is a journal bearing and number four is a combined thrust bearing and journal bearing. Both bearings are of tilting pad type.

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Cooling and sealing air

At a number of locations, air from the cooling and sealing air system is used for cooling and sealing purposes. The air is, dependent of use, taken from the different bleed cavities or from the compressor delivery.

The first row of guide vanes is cooled by air taken from the high-pressure cavity of the compressor. The air is led via an external pipe into a manifold. From there, air is distributed via flexible hoses to each individual hollowed guide vane. Exit air is further used to cool the surface of the first rotor disc before entering the gas path.

A part of the supplied air is also tapped from the manifold to form a heat barrier between the stator and the surrounding turbine casing. This air partly enters the turbine gas path and partly leaks off to the outlet casing.

Sealing air is used to prevent hot gases from entering the bearing housing or oil mist from leaking out from the bearing housings.

Function

Start up

During start up, which is after purging period and combustor ignition, the power turbine accelerates to nominal speed. The start up is finalised when the generator is synchronised and/or minimum continuos load is obtained.

Continuos operation

The speed is constant during normal operation. The power output is determined by the characteristics of gas flow entering the power turbine.

Shut down

As the gas generator is shut down, the power turbine output is decreased and the generator is disconnected from the grid at minimum load. Then the power turbine is coasting down.

During the subsequent gas generator cooling down period, when the gas generator is turned by the electrical starting motor, the power turbine may indirectly also be a part of the time by the hydrodynamic forces working onto the power turbine.

The standstill occurs when the cooling down period is finalised and the starting motor is shut off.

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SIEMENS	Gas Turbine SGT-600, SGT-700	GTI number		J330015E	
		Document number		1CS26606	
		Revision	E	Page	1

Load gear box and couplings

The Load Gear is a parallel shaft gear of double helical design. The pinion shaft on the high-speed side is connected to the power turbine via a flexible coupling of laminated metallic disc type.

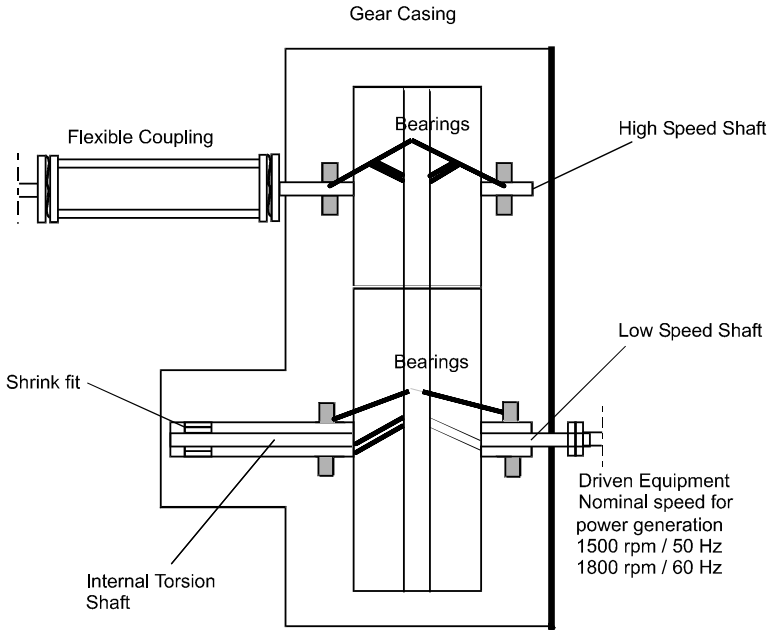
The outgoing power from the low speed side is transmitted through an internal torsional shaft of the driven equipment by a stiff flange coupling.

The gear has 4 journal bearings of sleeve type but no thrust bearing.

From Power Turbine

Nominal speed from Power Generation:

SGT-600 / 7700 rpm



FO / SGT-600(PG B, PG EX B), SGT-700(PG B, PG EX B)/&DF101

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SIEMENS	Auxiliary Systems SGT-600, SGT-700	GTI number		J400024E	
		Document number		1CS66559	
		Revision	C	Page	1

Package piping specification

1. General design

Piping used within the gas turbine package and its auxiliaries are installed in a protected area. They are not subject to the extreme pressures and/or pressure-peaks that may occur in process equipment. The piping is divided in to two main areas package piping and core engine piping, The core engine piping is categorized as machinery equipment.

2. Design of package piping

The package equipment piping is designed in accordance with EN 13480 and verified with ASME B31.3. The turbine piping nozzles are designed in accordance with EN 13480 with additional design criteria for the turbine design. Manufacturing and testing is performed in accordance with EN 13480 with additional requirements of any applicable classification society. The codes and standards applicable for SGT-600/-700 piping installation are listed in codes and standards, summary below.

All piping material is generally of ASTM A312-TP316/316L quality. Piping dimensions are 1" to 8" and rated 150 lbs to 2500 lbs. For detailed information about piping and fittings concerning material, dimensions, codes, gaskets, bolting etc refer to appendix 1. Piping clamps in hot-dip galvanized up to 200 °C and above 200°C in TP304/316. Tubing clamps in PP up to 90°C, above 90°C to 300°C in AL. Above 300°C in TP304/316. The project P&ID will be marked with material code and pipe code in project to identify the auxiliary piping according to appendix 1. (except from core engine pipes.). Branches and weld in connections in the piping system are performed according to appendix.2.

Couplings for tubing are of Swagelock type whit NPT thread and the tubing are of ASTM A-312-TP316 material quality. The dimensions for small bore pipes are OD 1/4" , 3/8" thickness 0,065" , OD ½ -¾" thickness 0.083", OD 1" thickness 0,126" depending on application.

The piping system has metal hoses installed where necessary. The hoses are installed to handle thermal movements between the piping and core engine.

The metallic hoses are designed according to EN 13480-4.

If option "quick turbine (gas generator) exchange" is selected, the piping system has quick couplings installed where necessary.

BU/SGT-600(PGB, Ex B, MD B) SGT-700(PGB, Ex B, MD B) /&DF101	

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SIEMENS	Auxiliary Systems SGT-600, SGT-700	GTI number		J400024E	
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Figure 1. Metallic hose

The quick couplings are designed according to DNV-OS-E201

Figure 2. Typical pipe quick coupling (Option)

Figure 3. Typical pipe coupling for lube oil system.

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The gaskets in the piping are of spiral wound with centering/support ring type or of fibre reinforced type depending on application. The gaskets are designed according to ANSI B16.20 and ANSI B16.21.

Pipe threads are taper threads (NPT) in accordance with ASME B1.20.1. Thread engagement requirements for each thread size are according to the requirements given in that specification. Threaded connections have not less than four (4) full threads engaged after being tightened by hand only.

Thermowells are of weld in design for gas fuel system. On all other systems the thermowells are threaded. The instrument connection is ½"NPT female.

Figure 4. Thermowell

For valves in the piping refer to separate document GTI W401010E

For Instrument installation refer to separate document GTI W401008E/W401009E

2.1 Manufacturing of package piping

Package auxiliary piping is manufactured in accordance with EN 13480-4.All welding of package piping is performed and inspected by operators qualified to EN 287-1 and with procedures qualified in accordance with EN ISO 15609-1.

2.2 Testing of package piping

Package auxiliary piping is inspected in accordance with EN13480-5 and other evant codes as specified below.

2.2.1 Pressure testing

Pressure testing is performed according to EN 13480-5 and requirements from actual classification society.

2.2.2 Radiography

Radiography testing is performed in accordance with EN 1435, or other national standard as applicable for the scope of supply.

Acceptance criteria for radiography testing of the equipment are in accordance with EN 12517 and applicable SIT AB standards and pressure vessel codes.

Acceptance criteria for piping are in accordance with EN 13480-5.

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2.2.3 Ultrasonic inspection

Ultrasonic testing is performed in accordance with EN 1714, or other national standard as applicable for the scope of supply.

Acceptance criteria for ultrasonic testing of the equipment are in accordance with EN 1712 and applicable SIT AB standards and pressure vessel codes.

Acceptance criteria for piping are in accordance with EN 1712 level 2.

2.2.4 Magnetic particle inspection

Magnetic particle examination is performed in accordance with EN 1290, or other national standard as applicable for the scope of supply.

Acceptance criteria for magnetic particle examination of the equipment are in accordance with EN 1291 and applicable SIT AB standards and pressure vessel codes.

Acceptance criteria for piping are in accordance with EN 1291 level 1.

2.2.5 Liquid penetrant inspection

Liquid penetrant examination in accordance with EN 571 or other national standard as applicable for the scope of supply.

Acceptance criteria for liquid penetrant examination of the equipment are in accordance with EN 1289 and applicable SIT AB standards and pressure vessel codes.

Acceptance criteria for piping are in accordance with EN 1289 level 1.

2.3 Summary of codes and standards for package piping

2.3.1 Design

ASME B.31.3	Process piping
ASME B1.20.1	Pipe threads, General purpose
ASME B16.5	Pipe flanges and flanged fittings
ASME B16.9	Factory-made wrought buttwelding fittings
ASME B18.2.1	Square and hex bolts and screws-inch series
ASME B18.2.2	Square and Hex Nuts (Inch Series)
ASME B16.21	Non-metallic Flat Gaskets for Pipe Flanges
ASME B16.20	Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed
ASME B16.34	Valves – Flanged, Threaded and Welding End
DNV-OS-E201	Det Norske Veritas
DIN	Flanges connected to core engine are generally according to DIN standards
EN 13480-3	Metallic Industrial Piping - Design and calculation

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Materials

Pipes	ASTM A312 Grade TP316/316L
Bends, cones,	
T-shaped pipes	ASTM A403 Grade TP316/316L
Flanges	ASTM A182 Grade TP316/316L

2.3.2 Manufacturing

EN13480-4	Metallic industrial piping
EN 287	Approval testing of welders
EN 15609-1	Specification and qualification of welding procedures for metallic materials.

2.3.3 Testing

EN 12517	Non-destructive examination of welds
EN 1289	Non-destructive examination of welds - Penetrant testing of welds
EN 1290	Non-destructive examination of welds - Magnetic particle examination of weldsEN 1291. Non-destructive examination of welds - Magnetic particle testing of welds - Acceptance levels
EN 1435	Non-destructive examination of welds – Radiographic examination of welded joints
EN 1712	Non-destructive examination of welds – Ultrasonic examination of welded joints - Acceptance levels
EN 1714	Non-destructive examination of welds - Ultrasonic examination of welded joints
EN 571	Non-destructive testing - Penetrant testing
EN 13480-5	Metallic Industrial Piping - Inspection and Testing

3. Core engine piping

Piping and tubing on the core engine is according to SIT AB standard and categorized as machinery equipment. The piping on the core engine is not subject to any changes.

3.1 Core engine piping design and manufacturing

Piping is designed and manufactured according to EN13480. All welding of turbine equipment installation is performed and inspected by operators qualified to

EN 287-1 and with procedures qualified in accordance with EN ISO 15609-1.

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3.1.1 Core engine piping materials for SGT600

Pipes	Materials according to European standards (EN). The European materials are comparable to material ASTM A312 TP 304,316,316L,321
Bends, cones,	Material quality which corresponds to material
T-shaped pipes,	quality for pipes as above
Flanges	

3.1.2 Core engine piping materials for SGT700

Pipes	Materials according to European standards (EN). The European materials are comparable to material ASTM A312 TP 304,316,316L,316HT
Bends, cones,	Material quality which corresponds to material
T-shaped pipes,	quality for pipes as above.
Flanges	

3.2 Testing of core engine piping

Testing of core engine is performed according to SIT AB standards. These standards are based on international piping standards such as;

EN 12517	Non-destructive examinations of welds
EN 1289	Non-destructive examination of welds - Penetrant testing of welds
EN 1290	Non-destructive examination of welds - Magnetic particle examination of welds
EN 1291	Non-destructive examination of welds - Magnetic particle testing of welds - Acceptance levels
EN 1435	Non-destructive examination of welds - Radiographic examination of welded joints
EN 1712	Non-destructive examination of welds - Ultrasonic examination of welded joints - Acceptance levels
EN 1714	Non-destructive examination of welds - Ultrasonic examination of welded joints
EN 571	Non-destructive testing - Penetrant testing
EN 13480-5	Metallic industrial piping, press

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SIEMENS	Auxiliary Systems SGT-600, SGT-700	GTI number	J400024E		
		Document number	1CS66559		
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Appendix I, Pipe specification matrix

MATERIAL CODE	TEMP. RANGE	TYPES OF MATERIAL	PIPES - ALL SEAMLESS		FITTINGS - ALL SEAMLESS (6)		FLANGES/UNIONS (7)		NOTES
			MATERIALS	DIMENSIONS	MATERIALS	DIMENSIONS	MATERIALS	DIMENSIONS OF FLANGES	
ASMAB1	0-775 (F) -18-413 (°C)	UNALLOYED CARBON STEEL	ASTM A106-B	ANSI B36.10	ASTM A234-WPB	ANSI B16.9	ASTM A105	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMAA1	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	MSS SP-43 (3) ANSI B16.9	ASTM A182-F316L	LAPPED FLANGE TO ANSI B16.5 STUB-END TO MSS SP 43 TYPE A, SCH 10S	(7) (8)
ASMAA2	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	MSS SP-43 (3) ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMBA1, ASMBA2	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMBA3	-20-1000 (F) -29-538 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316	ANSI B36.19	ASTM A403-WP316	ANSI B16.9	ASTM A182-F316	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMCA1	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMDA1, ASMDA3	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMDA2	-20-1000 (F) -29-538 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316	ANSI B36.19	ASTM A403-WP316	ANSI B16.9	ASTM A182-F316	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMEA1, ASMFA1 ASMGA1	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)

BOLTING AND GASKETS

OBJECT	RATING LB	MATERIAL	DIMENSION
STUD BOLTS FOR ASMAB1	150	CS: ASTM A193-B7 CL. 2A	ANSI B16.2.1
STUD BOLTS FOR OTHER CODES	150 - 2500	SS: ASTM A193-B8M CL. 2A	
HEXAGON HEAD NUTS FOR ASMAB1	150	CS: ASTM A194-7 CL. 2B	ANSI B16.2.2
HEX. HEAD NUTS FOR OTHER CODES	150 - 2500	SS: ASTM A194-8M CL. 2B	
FLAT GASKETS	150 - 300	1 MM EXP. GRAPHITE (NOTE 4)	ANSI B16.21
SPIRAL WOUND GASKETS WITH CENTERING/SUPPORT RINGS	400 - 2500	4.5 MM EXP. GRAPHITE / 316L	ANSI B16.20

NOTES FOR SHEET 1 AND 2

(1) SEE REPORT SIEMENS 2080071 FOR THE COMPLETE PRESSURE/TEMPERATURE RELATIONS.
[2]
(3) FOR THIN WALL RUN PIPE OF SCH 10S WITH PIPE SIZES 5" - 8" [DN 125 - DN 200] AND 150 LB, USE BUTT WELDING FITTINGS TO MSS SP-43/SCH 10S, SEAMLESS.
(4) IN LUBE OIL SYSTEM, PIPE CODE ASMAA1, USE FLAT GASKETS MADE FROM RUBBER-BOUND ARAMIDE FIBRE (TYPE SPECIMA DIXO 4000), WITH THICKNESS 1.5 MM. DIMENSIONS TO ANSI B16.21/150 LBS. MAX TEMPERATURE 120 °C.
(5) C = CORROSION OR EROSION ALLOWANCE
(6) SEE PIPING BRANCH SPECIFIC. 2071376 SHEET 5 FOR DETAILS ON T-PIECES AND WELDOLETS.
(7) AS ALTERNATIVE TO FLANGES IN PRESSURE RATINGS 150 - 1500, AND IN SIZES 1" - 1 1/2", USE UNIONS OF CLASS 3000 TO ANSI B16.11 WITH BUTT WELDING ENDS TO ANSI B 16.25, AND SCH 10 OR 40 ACCORDING TO PIPE CODE
(8) THERMOWELL IN PIPE LINE NOM. SIZE ≥ 3" ACC. TO DRAWING SIEMENS 2080083.

2071376 SHEET 1, ISSUE 2008-10-01 (SEAMLESS)

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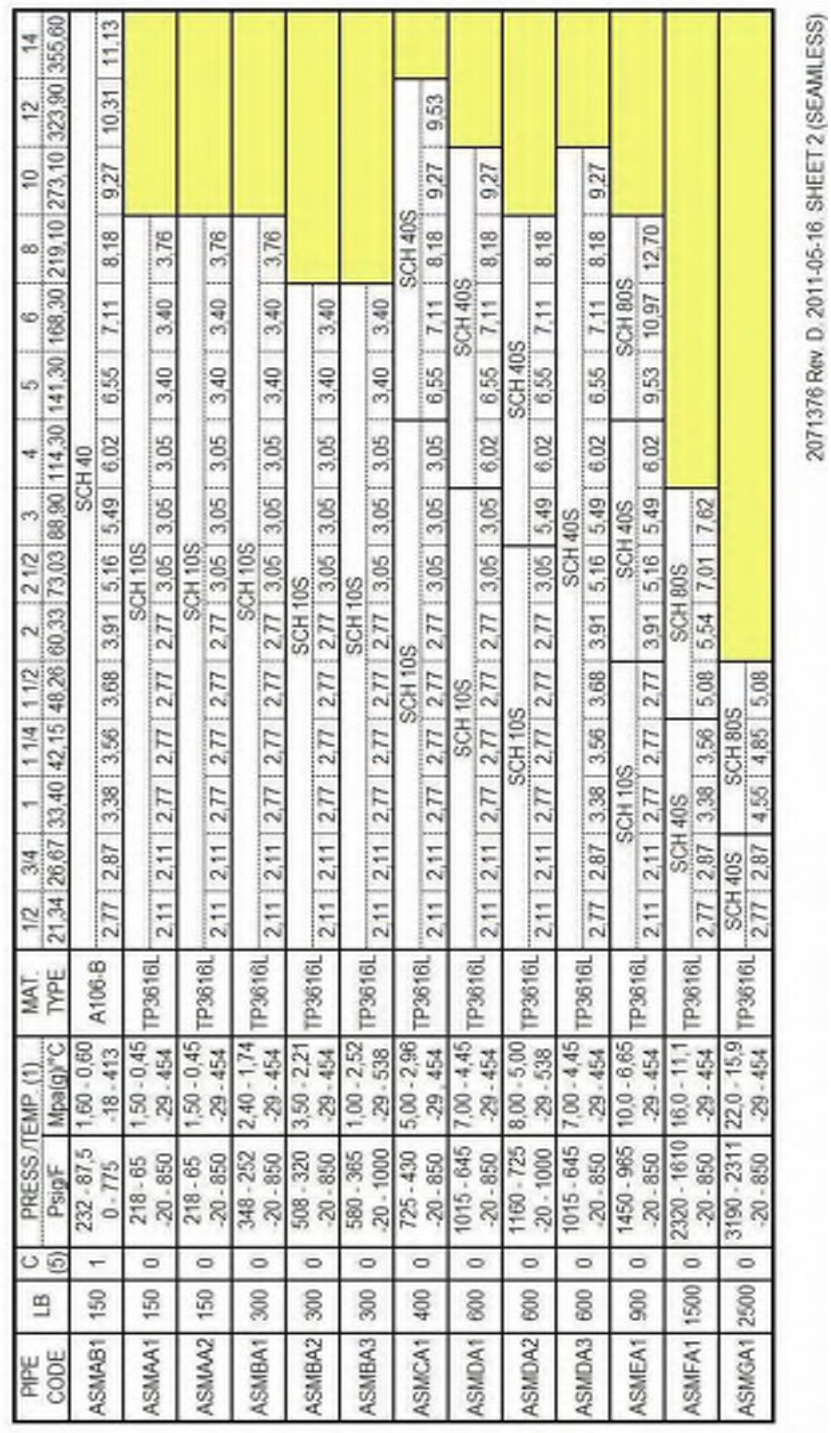

PIPE CODE	LB	C (5)	PRESS./TEMP. (1) Psig/F	PRESS./TEMP. (1) Mpa(g)/°C	MAT. TYPE	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10	12	14
						21,34	26,67	33,40	42,15	48,26	60,33	73,03	88,90	114,30	141,30	168,30	219,10	273,10	323,90	355,60
ASMAB1	150	1	232 - 87,5 0 - 775	1,60 - 0,60 -18 - 413	A106-B	SCH 40														
						2,77	2,87	3,38	3,56	3,68	3,91	5,16	5,49	6,02	6,55	7,11	8,18	9,27	10,31	11,13
ASMAA1	150	0	218 - 65 -20 - 850	1,50 - 0,45 -29 - 454	TP3616L	SCH 10S														
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40	3,76			
ASMAA2	150	0	218 - 65 -20 - 850	1,50 - 0,45 -29 - 454	TP3616L	SCH 10S														
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40	3,76			
ASMBA1	300	0	348 - 252 -20 - 850	2,40 - 1,74 -29 - 454	TP3616L	SCH 10S														
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40	3,76			
ASMBA2	300	0	508 - 320 -20 - 850	3,50 - 2,21 -29 - 454	TP3616L	SCH 10S														
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40				
ASMBA3	300	0	580 - 365 -20 - 1000	1,00 - 2,52 -29 - 538	TP3616L	SCH 10S														
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40				
ASMCA1	400	0	725 - 430 -20 - 850	5,00 - 2,96 -29 - 454	TP3616L	SCH 10S									SCH 40S					
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	6,55	7,11	8,18	9,27	9,53	
ASMDA1	600	0	1015 - 645 -20 - 850	7,00 - 4,45 -29 - 454	TP3616L	SCH 10S									SCH 40S					
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	6,02	6,55	7,11	8,18	9,27		
ASMDA2	600	0	1160 - 725 -20 - 1000	8,00 - 5,00 -29 - 538	TP3616L	SCH 10S									SCH 40S					
						2,11	2,11	2,77	2,77	2,77	2,77	3,05	5,49	6,02	6,55	7,11	8,18			
ASMDA3	600	0	1015 - 645 -20 - 850	7,00 - 4,45 -29 - 454	TP3616L	SCH 40S														
						2,77	2,87	3,38	3,56	3,68	3,91	5,16	5,49	6,02	6,55	7,11	8,18	9,27		
ASMEA1	900	0	1450 - 965 -20 - 850	10,0 - 6,65 -29 - 454	TP3616L	SCH 10S						SCH 40S			SCH 80S					
						2,11	2,11	2,77	2,77	2,77	3,91	5,16	5,49	6,02	9,53	10,97	12,70			
ASMFA1	1500	0	2320 - 1610 -20 - 850	16,0 - 11,1 -29 - 454	TP3616L	SCH 40S				SCH 80S										
						2,77	2,87	3,38	3,56	5,08	5,54	7,01	7,62							
ASMGA1	2500	0	3190 - 2311 -20 - 850	22,0 - 15,9 -29 - 454	TP3616L	SCH 40S		SCH 80S												
						2,77	2,87	4,55	4,85	5,08										

2071376 Rev. D. 2011-05-16. SHEET 2 (SEAMLESS)

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		Document number		1CS66559	
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MATERIAL CODE	TEMP. RANGE	TYPES OF MATERIAL	PIPES - ALL WELDED		FITTINGS - WELDED OR SEAMLESS (6)		FLANGES/UNIONS (7)		NOTES
			MATERIALS	DIMENSIONS	MATERIALS	DIMENSIONS	MATERIALS	DIMENSIONS OF FLANGES	
ASMAA3	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	MSS SP-43 (3) ANSI B16.9	ASTM A182-F316L	LAPPED FLANGE TO ANSI B16.5 STUB-END TO MSS SP 43 TYPE A, SCH 10S	(7) (8)
ASMAA4	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	MSS SP-43 (3) ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMBA4, ASMBA5	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMBA6	-20-1000 (F) -29-538 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316	ANSI B36.19	ASTM A403-WP316	ANSI B16.9	ASTM A182-F316	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMCA2	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMDA4	-20-850 (F) -29-454 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316L	ANSI B36.19	ASTM A403-WP316L	ANSI B16.9	ASTM A182-F316L	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)
ASMDA5	-20-1000 (F) -29-538 (°C)	ACID RESISTANT STAINLESS STEEL	ASTM A312-TP316	ANSI B36.19	ASTM A403-WP316	ANSI B16.9	ASTM A182-F316	ANSI B16.5 WELDING NECK, RAISED FACE	(7) (8)

BOLTING AND GASKETS

OBJECT	RATING LB	MATERIAL	DIMENSION
STUD BOLTS	150 - 600	ASTM A193-B8M CL. 2A	ANSI B18.2.1
HEX. HEAD NUTS	150 - 600	ASTM A194-8M CL. 2B	ANSI B18.2.2
FLAT GASKETS	150 - 300	1 MM EXP. GRAPHITE	ANSI B16.21
SPIRAL WOUND GASKETS WITH CENTERING/SUPPORT RINGS	400 - 600	4.5 MM EXP. GRAPHITE / 316L	ANSI B16.20

NOTES FOR SHEET 3 AND 4

(1) SEE REPORT SIEMENS 2080071 FOR THE COMPLETE PRESSURE/TEMPERATURE RELATIONS.

(3) FOR THIN WALL RUN PIPE OF SCH 10S WITH PIPE SIZES 5" - 24" (DN125 - DN 600) AND 150 LB, USE BUTT WELDING FITTINGS TO MSS SP-43/SCH 10S.

(5) C = CORROSION OR EROSION ALLOWANCE.

(6) SEE PIPING BRANCH SPECIFICATION 2071376 SHEET 5 FOR DETAILS ON T-PIECES AND WELDOLETS.

(7) AS ALTERNATIVE TO FLANGES IN PRESSURE RATINGS 150 - 600, AND IN SIZES 1", 1 1/2", USE UNIONS OF CLASS 3000 TO ANSI B16.11 WITH BUTT WELDING ENDS TO ANSI B 16.25, AND SCH 10 ACCORDING TO PIPE CODE.

(8) THERMOWELL IN PIPE LINE NOM. SIZE ≥ 3" ACC. TO DRAWING SIEMENS 2080083.

2071376 SHEET 3, ISSUE 2008-10-01 (WELDED)

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PIPE CODE	LB	C (5)	PRESS./TEMP. (1) Psig/F	PRESS./TEMP. (1) MPa(g)/°C	MAT. TYPE	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10	12	14	16	18	20	24
						21,34	26,67	33,40	42,15	48,26	60,33	73,03	88,90	114,3	141,3	168,3	219,1	273,1	323,9	355,6	406,4	457,2	508,0	609,6
ASMAA3	150	0	218 - 65 -20 - 850	1,50 - 0,45 -29 - 454	TP316L	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40	3,76	4,19	4,57	4,78	4,78	4,78		
ASMAA4	150	0	218 - 65 -20 - 850	1,50 - 0,45 -29 - 454	TP316L	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40	3,76	4,19	4,57	4,78	4,78	4,78	5,54	6,35
ASMBA4	300	0	348 - 252 -20 - 850	2,40 - 1,74 -29 - 454	TP316L	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40	3,76	4,19	4,57					
ASMBA5	300	0	508 - 320 -20 - 850	3,50 - 2,21 -29 - 454	TP316L	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40	3,40								
ASMBA6	300	0	580 - 365 -20 - 1000	4,00 - 2,52 -29 - 538	TP316	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05	3,40									
ASMCA2	400	0	725 - 430 -20 - 850	5,00 - 2,96 -29 - 454	TP316L	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05	3,05										
ASMDA4	600	0	1015 - 645 -20 - 850	7,00 - 4,45 -29 - 454	TP316L	2,11	2,11	2,77	2,77	2,77	2,77	3,05	3,05											
ASMDA5	600	0	1160 - 725 -20 - 1000	8,00 - 5,00 -29 - 538	TP316	2,11	2,11	2,77	2,77	2,77	2,77	3,05												

2071376 SHEET 4, ISSUE 2008-02-18 (WELDED)

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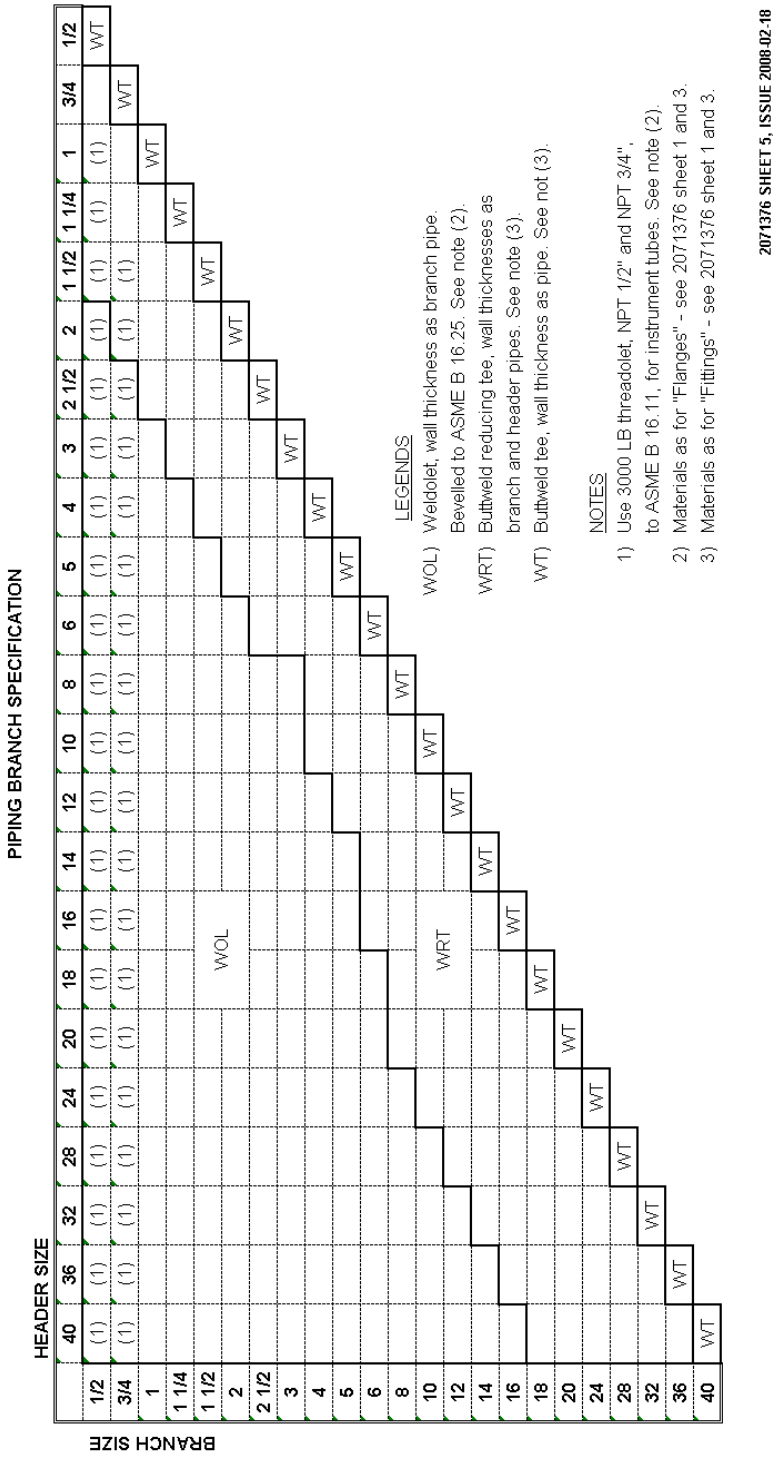

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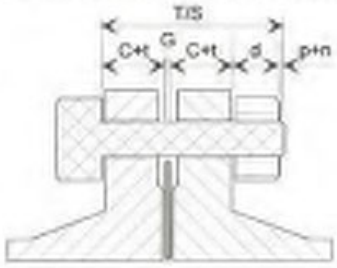
Appendix II, Bolting for flange acc. to pipe standard

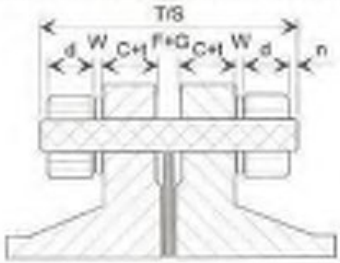
FLANGE JOINT ARRANGEMENTS. ENCLOSURE 1 TO SIEMENS 506785
PAGE 1/1, 2007-10-11

FIGURE 1 - FLANGE RATING 150 AND 300 LB



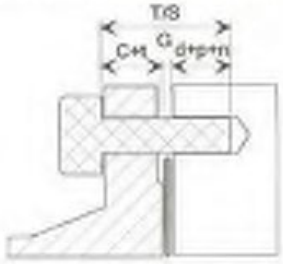
FLANGE STANDARD:	ANSI B16.5
MACHINE BOLT	ANSI B18.2.1
NUT:	ANSI B18.2.2
GASKET:	ANSI B16.21

FIGURE 2 - FLANGE RATING 150 - 2500 LB



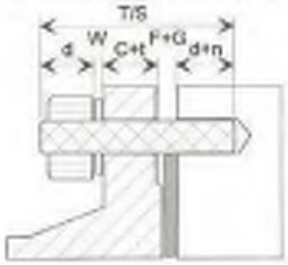
FLANGE STANDARD:	ANSI B16.5
STUD BOLT:	ANSI B18.2.1
NUT:	ANSI B18.2.2
GASKET 150 - 300 LB:	ANSI B16.21
GASKET > 300 LB:	ANSI B16.20
(spiral wound with centering/support rings)	
WASHERS:	ANSI B18.22.1
(not for Piping Standard Siemens 2071376)	

FIGURE 3 - FLANGE RATING 150 AND 300 LB



FLANGE STANDARD:	ANSI B16.5
MACHINE BOLT	ANSI B18.2.1
NUT:	ANSI B18.2.2
GASKET:	ANSI B16.21

FIGURE 4 - FLANGE RATING 150 - 2500 LB



FLANGE STANDARD:	ANSI B16.5
STUD BOLT:	ANSI B18.2.1
NUT:	ANSI B18.2.2
GASKET 150 - 300 LB:	ANSI B16.21
GASKET > 300:	ANSI B16.20
(spiral wound with centering/support rings)	
WASHERS:	ANSI B18.22.1
(not for Piping Standard Siemens 2071376)	

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Bolting for flange to flange acc. to Piping Standard SIEMENS 506793 and 2071376

BOLT LENGTHS CALCULATED ACCORDING TO ANSI B16.5 ANNEX F.

TABLE 8/9 (Figure 1)

150 LB - Hex. head bolt with nut (no washers)

Pipe code: ICCA, IH1A

Pipe Size	C	t	d	G	F	p	n	T inch	S inch	S mm	Bolts qty
1/2	0,44	0,12	1/2	0,04	0,00	0,12	0,12	1,90	2	51	4
3/4	0,50	0,12	1/2	0,04	0,00	0,12	0,12	2,02	2	51	4
1	0,56	0,12	1/2	0,04	0,00	0,12	0,12	2,14	2 1/4	57	4
1 1/2	0,69	0,12	1/2	0,04	0,00	0,12	0,12	2,40	2 1/2	64	4
2	0,75	0,12	5/8	0,04	0,00	0,14	0,25	2,79	2 3/4	70	4
2 1/2	0,88	0,12	5/8	0,04	0,00	0,14	0,25	3,05	3	76	4
3	0,94	0,12	5/8	0,04	0,00	0,14	0,25	3,17	3 1/4	83	4
4	0,94	0,12	5/8	0,04	0,00	0,14	0,25	3,17	3 1/4	83	8
5	0,94	0,12	3/4	0,04	0,00	0,15	0,25	3,31	3 1/2	89	8
6	1,00	0,12	3/4	0,04	0,00	0,15	0,25	3,43	3 1/2	89	8
8	1,12	0,12	3/4	0,04	0,00	0,15	0,25	3,67	4	102	8
10	1,19	0,12	7/8	0,04	0,00	0,17	0,25	3,95	4	102	12
12	1,25	0,12	7/8	0,04	0,00	0,17	0,25	4,07	4	102	12
14	1,38	0,12	1	0,04	0,00	0,19	0,25	4,48	4 1/2	114	12
16	1,44	0,12	1	0,04	0,00	0,19	0,25	4,60	4 1/2	114	16
18	1,56	0,12	1 1/8	0,04	0,00	0,21	0,25	4,99	5	127	16
20	1,69	0,19	1 1/8	0,04	0,00	0,21	0,25	5,39	5 1/2	140	20
24	1,88	0,19	1 1/4	0,04	0,00	0,21	0,25	5,89	6	152	20
26	2,81	0,19	1 1/4	0,04	0,00	0,21	0,25	7,75	8	203	38
32	3,18	0,19	1 1/2	0,04	0,00	0,25	0,25	8,78	9	229	36
36	3,56	0,19	1 1/2	0,04	0,00	0,25	0,25	9,54	10	254	32
40	3,56	0,19	1 1/2	0,04	0,00	0,25	0,25	9,54	10	254	36

TABLE 11/12 (Figure 1)

300 LB - Hex. head bolt with nut (no washers)

Pipe code: MCCA, MC5A, MH1A, MH2A

Pipe Size	C	t	d	G	F	p	n	T inch	S inch	S mm	Bolts qty
1/2	0,56	0,12	1/2	0,04	0,00	0,12	0,12	2,14	2 1/4	57	4
3/4	0,62	0,12	5/8	0,04	0,00	0,14	0,25	2,53	2 1/2	64	4
1	0,69	0,12	5/8	0,04	0,00	0,14	0,25	2,67	2 3/4	70	4
1 1/2	0,81	0,12	3/4	0,04	0,00	0,15	0,25	3,05	3	76	4
2	0,88	0,12	5/8	0,04	0,00	0,14	0,25	3,05	3	76	8
2 1/2	1,00	0,12	3/4	0,04	0,00	0,15	0,25	3,43	3 1/2	89	8
3	1,12	0,12	3/4	0,04	0,00	0,15	0,25	3,67	4	102	8
4	1,25	0,12	3/4	0,04	0,00	0,15	0,25	3,83	4	102	8
5	1,38	0,12	3/4	0,04	0,00	0,15	0,25	4,19	4 1/2	114	8
6	1,44	0,12	3/4	0,04	0,00	0,15	0,25	4,31	4 1/2	114	12
8	1,62	0,12	7/8	0,04	0,00	0,17	0,25	4,81	5	127	12
10	1,88	0,12	1	0,04	0,00	0,19	0,25	5,48	5 1/2	140	16
12	2,00	0,12	1 1/8	0,04	0,00	0,21	0,25	5,87	6	152	16
14	2,12	0,12	1 1/8	0,04	0,00	0,21	0,25	6,11	6 1/2	165	20
16	2,25	0,12	1 1/4	0,04	0,00	0,21	0,25	6,49	6 1/2	165	20
18	2,38	0,12	1 1/4	0,04	0,00	0,21	0,25	6,75	7	178	24
20	2,50	0,19	1 1/4	0,04	0,00	0,21	0,25	7,13	8	203	24
24	2,75	0,19	1 1/2	0,04	0,00	0,25	0,25	7,92	8	203	24
26	3,38	0,19	1 5/8	0,04	0,00	0,30	0,25	9,36	10	254	38
32	3,88	0,19	1 7/8	0,04	0,00	0,33	0,25	10,64	11	279	38
36	4,12	0,19	2	0,04	0,00	0,33	0,25	11,24	12	305	32
40	4,50	0,19	1 5/8	0,04	0,00	0,30	0,25	11,68	12	305	32

TABLE 8/9 (Figure 2)

150 LB - Stud bolt with nuts (no washers)

Pipe code: ASMAB1, ASMAA1, ASMAA2, ASMAA3, ASMAA4

Pipe Size	C	t	d	G	F	W	n	I inch	S inch	S mm	Bolts qty
1/2	0,44	0,12	1/2	0,04	0,00	0	0,12	2,28	2 1/2	64	4
3/4	0,50	0,12	1/2	0,04	0,00	0	0,12	2,40	2 1/2	64	4
1	0,56	0,12	1/2	0,04	0,00	0	0,12	2,52	2 1/2	64	4
1 1/2	0,69	0,12	1/2	0,04	0,00	0	0,12	2,76	3	76	4
2	0,75	0,12	5/8	0,04	0,00	0	0,25	3,20	3 1/2	89	4
2 1/2	0,88	0,12	5/8	0,04	0,00	0	0,25	3,54	3 1/2	89	4
3	0,94	0,12	5/8	0,04	0,00	0	0,25	3,66	4	102	4
4	0,94	0,12	5/8	0,04	0,00	0	0,25	3,66	4	102	8
5	0,94	0,12	3/4	0,04	0,00	0	0,25	3,91	4	102	8
6	1,00	0,12	3/4	0,04	0,00	0	0,25	4,03	4	102	8
8	1,12	0,12	3/4	0,04	0,00	0	0,25	4,27	4 1/2	114	8
10	1,19	0,12	7/8	0,04	0,00	0	0,25	4,66	5	127	12
12	1,25	0,12	7/8	0,04	0,00	0	0,25	4,78	5	127	12
14	1,38	0,12	1	0,04	0,00	0	0,25	5,29	5 1/2	140	12
16	1,44	0,12	1	0,04	0,00	0	0,25	5,41	5 1/2	140	16
18	1,56	0,12	1 1/8	0,04	0,00	0	0,25	5,90	6	152	16
20	1,69	0,19	1 1/8	0,04	0,00	0	0,25	6,30	6 1/2	165	20
24	1,88	0,19	1 1/4	0,04	0,00	0	0,25	6,93	7	178	20
26	2,81	0,19	1 1/4	0,04	0,00	0	0,25	8,79	9	229	28
32	3,18	0,19	1 1/2	0,04	0,00	0	0,25	10,03	10	254	28
36	3,56	0,19	1 1/2	0,04	0,00	0	0,25	10,79	11	279	32
40	3,56	0,19	1 1/2	0,04	0,00	0	0,25	10,79	11	279	36

TABLE 11/12 (Figure 2)

300 LB - Stud bolt with nuts (no washers)

Pipe code: ASMBA1, ASMBA2, ASMBA3, ASMBA4, ASMBA5, ASMBA6

Pipe Size	C	t	d	G	F	W	n	I inch	S inch	S mm	Bolts qty
1/2	0,56	0,12	1/2	0,04	0,00	0	0,12	2,52	2 1/2	64	4
3/4	0,62	0,12	5/8	0,04	0,00	0	0,25	3,02	3	76	4
1	0,69	0,12	5/8	0,04	0,00	0	0,25	3,16	3 1/2	89	4
1 1/2	0,81	0,12	3/4	0,04	0,00	0	0,25	3,66	4	102	4
2	0,88	0,12	5/8	0,04	0,00	0	0,25	3,54	4	102	8
2 1/2	1,00	0,12	3/4	0,04	0,00	0	0,25	4,01	4	102	8
3	1,12	0,12	3/4	0,04	0,00	0	0,25	4,27	4 1/2	114	8
4	1,25	0,12	3/4	0,04	0,00	0	0,25	4,51	4 1/2	114	8
5	1,38	0,12	3/4	0,04	0,00	0	0,25	4,79	5	127	8
6	1,44	0,12	3/4	0,04	0,00	0	0,25	4,91	5	127	12
8	1,62	0,12	7/8	0,04	0,00	0	0,25	5,52	5 1/2	140	12
10	1,88	0,12	1	0,04	0,00	0	0,25	6,29	6 1/2	165	16
12	2,00	0,12	1 1/8	0,04	0,00	0	0,25	6,78	7	178	16
14	2,12	0,12	1 1/8	0,04	0,00	0	0,25	7,02	7	178	20
16	2,25	0,12	1 1/4	0,04	0,00	0	0,25	7,53	7 1/2	191	20
18	2,38	0,12	1 1/4	0,04	0,00	0	0,25	7,79	8	203	24
20	2,50	0,19	1 3/8	0,04	0,00	0	0,25	8,17	8	229	24
24	2,75	0,19	1 1/2	0,04	0,00	0	0,25	9,17	10	254	24
26	3,38	0,19	1 5/8	0,04	0,00	0	0,25	10,68	11	279	28
32	3,88	0,19	1 7/8	0,04	0,00	0	0,25	12,38	13	330	28
36	4,12	0,19	2	0,04	0,00	0	0,25	12,91	13	330	32
40	4,50	0,19	1 5/8	0,04	0,00	0	0,25	12,92	13	330	32

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TABLE 14/15 (Figure 2)

600 LB - Stud bolt with nuts and (possible) washers

Pipe code: NC5A, NH2A and ASMCA1, ASMCA2

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
USE CLASS 600 DIMENSIONS											
4	1,38	0,12	7/8	0,12	0,50	0,134	0,06	5,70	6	152	8
5	1,50	0,12	7/8	0,12	0,50	0,134	0,06	5,94	6	152	8
6	1,62	0,12	7/8	0,12	0,50	0,134	0,06	6,38	6 1/2	165	12
8	1,88	0,12	1	0,12	0,50	0,134	0,06	6,95	7	178	12
10	2,12	0,12	1 1/8	0,12	0,50	0,134	0,06	7,83	8	203	16
12	2,25	0,12	1 1/4	0,12	0,50	0,165	0,06	8,25	9	229	16
14	2,38	0,12	1 1/4	0,12	0,50	0,165	0,06	8,51	9	229	20
16	2,50	0,12	1 3/8	0,12	0,50	0,165	0,06	9,00	9	229	20
18	2,62	0,12	1 3/8	0,12	0,50	0,165	0,06	9,24	10	254	24
20	2,75	0,19	1 1/2	0,12	0,50	0,165	0,06	9,83	10	254	24
24	3,00	0,19	1 3/4	0,12	0,50	0,180	0,06	10,92	11	279	24
26	3,75	0,19	1 7/8	0,12	0,50	0,180	0,06	12,67	13	330	28
32	4,25	0,19	2	0,12	0,50	0,180	0,06	13,92	14	356	28

TABLE 17/18 (Figure 2)

600 LB - Stud bolt with nuts and (possible) washers

Pipe code: PC5A, PH2A, ASMDA1, ASMDA2, ASMDA3, ASMDA4, ASMDA5

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
1/2	0,56	0,12	1/2	0,12	0,50	0,095	0,06	3,23	3 1/4	83	4
3/4	0,62	0,12	5/8	0,12	0,50	0,095	0,06	3,60	4	102	4
1	0,69	0,12	5/8	0,12	0,50	0,095	0,06	3,74	4	102	4
1 1/2	0,88	0,12	3/4	0,12	0,50	0,134	0,06	4,45	4 1/2	114	4
2	1,00	0,12	5/8	0,12	0,50	0,095	0,06	4,96	4 1/2	114	8
2 1/2	1,12	0,12	3/4	0,12	0,50	0,134	0,06	4,93	5	127	8
3	1,25	0,12	3/4	0,12	0,50	0,134	0,06	5,19	5 1/2	140	8
4	1,50	0,12	7/8	0,12	0,50	0,134	0,06	5,94	6	152	8
5	1,75	0,12	1	0,12	0,50	0,134	0,06	6,69	7	178	8
6	1,88	0,12	1	0,12	0,50	0,134	0,06	6,95	7	178	12
8	2,19	0,12	1 1/8	0,12	0,50	0,134	0,06	7,62	8	203	12
10	2,50	0,12	1 1/4	0,12	0,50	0,165	0,06	8,75	9	229	16
12	2,62	0,12	1 1/4	0,12	0,50	0,165	0,06	8,99	9	229	20
14	2,75	0,12	1 3/8	0,12	0,50	0,165	0,06	9,50	10	254	20
16	3,00	0,12	1 1/2	0,12	0,50	0,165	0,06	10,25	11	279	20
18	3,25	0,12	1 5/8	0,12	0,50	0,180	0,06	11,03	11	279	20
20	3,50	0,19	1 5/8	0,12	0,50	0,180	0,06	11,62	12	305	24
24	4,00	0,19	1 7/8	0,12	0,50	0,180	0,12	13,23	14	356	24

TABLE 20/21 (Figure 2)

900 LB - Stud bolt with nuts and (possible) washers

Pipe code: RC3A, RH4A and ASMEA1

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
USE CLASS 1500 DIMENSIONS											
3	1,50	0,12	7/8	0,12	0,50	0,134	0,06	5,94	6	152	8
4	1,75	0,12	1 1/8	0,12	0,50	0,134	0,06	6,94	7	178	8
6	2,00	0,12	1 3/4	0,12	0,50	0,165	0,06	7,75	8	203	8
8	2,19	0,12	1 3/8	0,12	0,50	0,165	0,06	7,82	8	203	12
8	2,50	0,12	1 3/8	0,12	0,50	0,165	0,06	9,00	9	229	12
10	2,75	0,12	1 3/8	0,12	0,50	0,165	0,06	9,50	10	254	16
12	3,12	0,12	1 3/8	0,12	0,50	0,165	0,06	10,24	11	279	20
14	3,00	0,12	1 1/2	0,12	0,50	0,165	0,06	11,07	11	279	20
16	3,50	0,12	1 5/8	0,12	0,50	0,180	0,06	11,63	12	305	20
18	4,00	0,12	1 7/8	0,12	0,50	0,180	0,12	13,09	14	356	20

TABLE 23/24 (Figure 2)

1500 LB - Stud bolt with nuts and (possible) washers

Pipe code: TC3A, TH4A and ASMFA1

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
1/2	0,88	0,12	3/4	0,12	0,50	0,134	0,06	4,45	4 1/2	114	4
3/4	1,00	0,12	3/4	0,12	0,50	0,134	0,06	4,69	5	127	4
1	1,12	0,12	7/8	0,12	0,50	0,134	0,06	5,19	5 1/2	140	8
1 1/2	1,25	0,12	1	0,12	0,50	0,134	0,06	5,69	6	152	8
2	1,50	0,12	7/8	0,12	0,50	0,134	0,06	5,94	6	152	8
2 1/2	1,62	0,12	1	0,12	0,50	0,134	0,06	6,43	6 1/2	165	8
3	1,88	0,12	1 1/8	0,12	0,50	0,134	0,06	7,20	8	203	8
4	2,12	0,12	1 1/4	0,12	0,50	0,165	0,06	7,99	8	203	8
6	2,88	0,12	1 1/2	0,12	0,50	0,185	0,06	10,01	10	254	8
6	3,25	0,12	1 3/8	0,12	0,50	0,185	0,06	10,09	11	279	12
8	3,62	0,12	1 5/8	0,12	0,50	0,180	0,06	11,77	12	305	12
10	4,25	0,12	1 7/8	0,12	0,50	0,180	0,12	13,59	14	356	12
12	4,88	0,12	2	0,12	0,50	0,180	0,12	15,16	16	406	16
14	5,25	0,12	2 1/4	0,12	0,50	0,220	0,12	16,42	18	457	16
16	5,75	0,12	2 1/2	0,12	0,50	0,238	0,12	17,96	18	457	16
18	6,38	0,12	2 3/4	0,12	0,50	0,259	0,12	19,78	20	508	16

TABLE 26/27 (Figure 2)

2500 LB - Stud bolt with nuts and (possible) washers

Pipe code: VC3A, VH4A and ASMGA1

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
1/2	1,19	0,12	3/4	0,12	0,50	0,134	0,06	5,07	5 1/2	140	4
3/4	1,25	0,12	3/4	0,12	0,50	0,134	0,06	5,19	5 1/2	140	4
1	1,38	0,12	7/8	0,12	0,50	0,134	0,06	5,70	6	152	4
1 1/2	1,75	0,12	1 1/8	0,12	0,50	0,134	0,06	6,94	7	178	8
2	2,06	0,12	1	0,12	0,50	0,134	0,06	7,19	8	203	8
2 1/2	2,25	0,12	1 1/8	0,12	0,50	0,134	0,06	7,94	8	203	8
3	2,62	0,12	1 1/4	0,12	0,50	0,165	0,06	8,99	9	229	8
4	3,00	0,12	1 1/2	0,12	0,50	0,165	0,06	10,25	11	279	8
6	3,62	0,12	1 3/4	0,12	0,50	0,180	0,06	12,02	12	305	8
6	4,25	0,12	2	0,12	0,50	0,180	0,12	13,84	14	356	8
8	5,00	0,12	2	0,12	0,50	0,180	0,12	15,34	16	406	12
10	5,50	0,12	2 1/2	0,12	0,50	0,238	0,12	18,46	20	508	12
12	7,25	0,12	2 3/4	0,12	0,50	0,259	0,12	21,50	22	559	12
14	Not available										

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BOLT LENGTHS CALCULATED ACCORDING TO ANSI B16.5 ANNEX F.

TABLE 8/9 (Figure 3)

150 LB - Hex. head bolt without nut (no washers)

Pipe code: ICCA, IH1A

Pipe Size	C	t	d	G	F	p	n	T inch	T inch	S mm	Bolts qty
1/2	0,44	0,12	1/2	0,04	0,00	0,12	0,12	1,34	1 1/2	38	4
3/4	0,50	0,12	1/2	0,04	0,00	0,12	0,12	1,40	1 1/2	38	4
1	0,56	0,12	1/2	0,04	0,00	0,12	0,12	1,46	1 1/2	38	4
1 1/2	0,69	0,12	1/2	0,04	0,00	0,12	0,12	1,59	1 3/4	44	4
2	0,75	0,12	5/8	0,04	0,00	0,14	0,25	1,92	2	51	8
2 1/2	0,88	0,12	5/8	0,04	0,00	0,14	0,25	2,05	2	51	8
3	0,94	0,12	5/8	0,04	0,00	0,14	0,25	2,11	2 1/4	57	8
4	0,94	0,12	5/8	0,04	0,00	0,14	0,25	2,11	2 1/4	57	8
5	0,94	0,12	3/4	0,04	0,00	0,15	0,25	2,25	2 1/2	57	8
6	1,00	0,12	3/4	0,04	0,00	0,15	0,25	2,31	2 1/2	63	8
8	1,12	0,12	3/4	0,04	0,00	0,15	0,25	2,43	2 1/2	64	8
10	1,19	0,12	7/8	0,04	0,00	0,17	0,25	2,64	2 3/4	70	12
12	1,25	0,12	7/8	0,04	0,00	0,17	0,25	2,70	2 3/4	70	12
14	1,38	0,12	1	0,04	0,00	0,19	0,25	2,96	3	76	12
16	1,44	0,12	1	0,04	0,00	0,19	0,25	3,09	3	76	16
18	1,56	0,12	1 1/8	0,04	0,00	0,21	0,25	3,31	3 1/2	89	16
20	1,69	0,19	1 1/8	0,04	0,00	0,21	0,25	3,51	3 1/2	89	20
24	1,88	0,19	1 1/4	0,04	0,00	0,21	0,25	3,82	4	102	20
26	2,81	0,19	1 1/4	0,04	0,00	0,21	0,25	4,75	5	127	28
32	3,16	0,19	1 1/2	0,04	0,00	0,25	0,25	5,41	5 1/2	146	28
36	3,56	0,19	1 1/2	0,04	0,00	0,25	0,25	5,79	6	152	32
40	3,56	0,19	1 1/2	0,04	0,00	0,25	0,25	5,79	6	152	36

TABLE 11/12 (Figure 3)

300 LB - Hex. head bolt without nut (no washers)

Pipe code: MCCA, MCSA, MH1A, MHZA

Pipe Size	C	t	d	G	F	p	n	T inch	T inch	S mm	Bolts qty
1/2	0,56	0,12	1/2	0,04	0,00	0,12	0,12	1,46	1 1/2	38	4
3/4	0,62	0,12	5/8	0,04	0,00	0,14	0,25	1,79	1 3/4	44	4
1	0,69	0,12	5/8	0,04	0,00	0,14	0,25	1,86	2	51	4
1 1/2	0,81	0,12	3/4	0,04	0,00	0,15	0,25	2,13	2 1/4	57	4
2	0,88	0,12	5/8	0,04	0,00	0,14	0,25	2,05	2 1/4	57	8
2 1/2	1,00	0,12	3/4	0,04	0,00	0,15	0,25	2,31	2 1/2	64	8
3	1,12	0,12	3/4	0,04	0,00	0,15	0,25	2,43	2 1/2	64	8
4	1,25	0,12	3/4	0,04	0,00	0,15	0,25	2,56	2 1/2	64	8
5	1,38	0,12	3/4	0,04	0,00	0,15	0,25	2,69	2 3/4	70	8
6	1,44	0,12	3/4	0,04	0,00	0,15	0,25	2,75	2 3/4	70	12
8	1,62	0,12	7/8	0,04	0,00	0,17	0,25	3,07	3	76	12
10	1,88	0,12	1	0,04	0,00	0,19	0,25	3,48	3 1/2	89	16
12	2,00	0,12	1 1/8	0,04	0,00	0,21	0,25	3,75	4	102	16
14	2,12	0,12	1 1/8	0,04	0,00	0,21	0,25	3,87	4	102	20
16	2,25	0,12	1 1/4	0,04	0,00	0,21	0,25	4,12	4 1/2	114	20
18	2,38	0,12	1 1/4	0,04	0,00	0,21	0,25	4,25	4 1/2	114	24
20	2,50	0,19	1 1/4	0,04	0,00	0,21	0,25	4,44	4 1/2	114	24
24	2,75	0,19	1 1/2	0,04	0,00	0,25	0,25	4,88	5	127	24
26	3,38	0,19	1 5/8	0,04	0,00	0,31	0,25	5,79	6	152	28
32	3,88	0,19	1 7/8	0,04	0,00	0,33	0,25	6,57	7	178	28
36	4,12	0,19	2	0,04	0,00	0,33	0,25	6,83	7	178	32
40	4,50	0,19	1 5/8	0,04	0,00	0,50	0,25	6,81	7	178	32

TABLE 8/9 (Figure 4)

150 LB - Stud bolt with nut (no washers)

Pipe code: ASMAB1, ASMAA1, ASMAA2, ASMAA3, ASMAA4

Pipe Size	C	t	d	G	F	W	n	T inch	T inch	S mm	Bolts qty
1/2	0,44	0,12	1/2	0,04	0,00	0	0,12	1,34	2	51	4
3/4	0,50	0,12	1/2	0,04	0,00	0	0,12	1,40	2	51	4
1	0,56	0,12	1/2	0,04	0,00	0	0,12	1,46	2	51	4
1 1/2	0,69	0,12	1/2	0,04	0,00	0	0,12	1,59	2 1/4	57	4
2	0,75	0,12	5/8	0,04	0,00	0	0,25	2,53	3 1/2	64	4
2 1/2	0,88	0,12	5/8	0,04	0,00	0	0,25	2,66	3 1/2	76	4
3	0,94	0,12	5/8	0,04	0,00	0	0,25	2,72	3 3/4	76	4
4	0,94	0,12	5/8	0,04	0,00	0	0,25	2,72	3 3/4	76	8
5	0,94	0,12	3/4	0,04	0,00	0	0,25	2,97	3	76	8
6	1,00	0,12	3/4	0,04	0,00	0	0,25	3,03	3	76	8
8	1,12	0,12	3/4	0,04	0,00	0	0,25	3,15	3 1/2	89	8
10	1,19	0,12	7/8	0,04	0,00	0	0,25	3,47	3 1/2	89	12
12	1,25	0,12	7/8	0,04	0,00	0	0,25	3,53	3 1/2	89	12
14	1,38	0,12	1	0,04	0,00	0	0,25	3,91	4	102	12
16	1,44	0,12	1	0,04	0,00	0	0,25	3,97	4	102	16
18	1,56	0,12	1 1/8	0,04	0,00	0	0,25	4,34	4 1/2	114	16
20	1,69	0,19	1 1/8	0,04	0,00	0	0,25	4,53	4 1/2	114	20
24	1,88	0,19	1 1/4	0,04	0,00	0	0,25	4,88	5	127	20
26	2,81	0,19	1 1/4	0,04	0,00	0	0,25	5,81	6	152	28
32	3,16	0,19	1 1/2	0,04	0,00	0	0,25	6,79	7	178	28
36	3,56	0,19	1 1/2	0,04	0,00	0	0,25	7,16	8	203	32
40	3,56	0,19	1 1/2	0,04	0,00	0	0,25	7,16	8	203	36

TABLE 11/12 (Figure 4)

300 LB - Stud bolt with nut (no washers)

Pipe code: ASMBA1, ASMBA2, ASMBA3, ASMBA4, ASMBA5, ASMBA6

Pipe Size	C	t	d	G	F	W	n	T inch	T inch	S mm	Bolts qty
1/2	0,56	0,12	1/2	0,04	0,00	0	0,12	1,46	2	51	4
3/4	0,62	0,12	5/8	0,04	0,00	0	0,25	2,41	2 1/2	64	4
1	0,69	0,12	5/8	0,04	0,00	0	0,25	2,47	2 1/2	64	4
1 1/2	0,81	0,12	3/4	0,04	0,00	0	0,25	2,84	3	76	4
2	0,88	0,12	5/8	0,04	0,00	0	0,25	2,66	3	76	8
2 1/2	1,00	0,12	3/4	0,04	0,00	0	0,25	3,03	3	76	8
3	1,12	0,12	3/4	0,04	0,00	0	0,25	3,15	3 1/2	89	8
4	1,25	0,12	3/4	0,04	0,00	0	0,25	3,28	3 1/2	89	8
5	1,38	0,12	3/4	0,04	0,00	0	0,25	3,41	3 1/2	89	8
6	1,44	0,12	3/4	0,04	0,00	0	0,25	3,47	3 1/2	89	12
8	1,62	0,12	7/8	0,04	0,00	0	0,25	3,80	4	102	12
10	1,88	0,12	1	0,04	0,00	0	0,25	4,41	4 1/2	114	16
12	2,00	0,12	1 1/8	0,04	0,00	0	0,25	4,75	5	127	16
14	2,12	0,12	1 1/8	0,04	0,00	0	0,25	4,80	5	127	20
16	2,25	0,12	1 1/4	0,04	0,00	0	0,25	5,22	5 1/2	140	20
18	2,38	0,12	1 1/4	0,04	0,00	0	0,25	5,41	5 1/2	140	24
20	2,50	0,19	1 1/4	0,04	0,00	0	0,25	5,60	6	152	24
24	2,75	0,19	1 1/2	0,04	0,00	0	0,25	6,35	7	178	24
26	3,38	0,19	1 5/8	0,04	0,00	0	0,25	7,23	8	203	28
32	3,88	0,19	1 7/8	0,04	0,00	0	0,25	8,22	9	229	28
36	4,12	0,19	2	0,04	0,00	0	0,25	8,72	9	229	32
40	4,50	0,19	1 5/8	0,04	0,00	0	0,25	8,35	9	229	32

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TABLE 14/15 (Figure 4)

400 LB - Stud bolt with nut and (possible) washer

Pipe code: NC5A, NH2A and ASMCA1, ASMCA2

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
USE CLASS 600 DIMENSIONS											
4	1.38	0.12	7/8	0.12	0.50	0.134	0.06	4.06	4 1/2	114	8
5	1.50	0.12	7/8	0.12	0.50	0.134	0.06	4.18	4 1/2	114	8
6	1.62	0.12	7/8	0.12	0.50	0.134	0.06	4.30	4 1/2	114	12
8	1.88	0.12	1	0.12	0.50	0.134	0.06	4.81	5	127	12
10	2.12	0.12	1 1/8	0.12	0.50	0.134	0.06	5.38	5 1/2	140	16
12	2.25	0.12	1 1/8	0.12	0.50	0.165	0.06	5.72	6	152	16
14	2.38	0.12	1 1/8	0.12	0.50	0.165	0.06	5.86	6	152	20
16	2.50	0.12	1 3/8	0.12	0.50	0.165	0.06	6.22	6 1/2	165	20
18	2.62	0.12	1 3/8	0.12	0.50	0.165	0.06	6.34	6 1/2	165	24
20	2.75	0.18	1 1/2	0.12	0.50	0.165	0.06	6.70	7	178	24
24	3.00	0.19	1 3/4	0.12	0.50	0.180	0.06	7.56	8	203	24
28	3.25	0.19	1 7/8	0.12	0.50	0.180	0.06	8.56	9	229	28
32	4.25	0.19	2	0.12	0.50	0.180	0.06	9.30	10	254	28

TABLE 17/18 (Figure 4)

600 LB - Stud bolt with nut and (possible) washer

Pipe code: PC6A, PH2A, ASMDA1, ASMDA2, ASMDA3, ASMDA4, ASMDA5

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
1/2	0.88	0.12	1/2	0.12	0.50	0.095	0.06	2.46	2 1/2	64	4
3/4	0.93	0.12	5/8	0.12	0.50	0.095	0.06	2.71	2 3/4	70	4
1	1.06	0.12	5/8	0.12	0.50	0.095	0.06	2.84	3	76	4
1 1/2	0.88	0.12	3/4	0.12	0.50	0.134	0.06	3.31	3 1/2	89	4
2	1.00	0.12	5/8	0.12	0.50	0.095	0.06	3.45	3 1/2	89	8
2 1/2	1.12	0.12	3/4	0.12	0.50	0.134	0.06	3.95	4	102	8
3	1.25	0.12	3/4	0.12	0.50	0.134	0.06	4.08	4	102	8
4	1.50	0.12	7/8	0.12	0.50	0.134	0.06	4.18	4 1/2	114	8
5	1.75	0.12	1	0.12	0.50	0.134	0.06	4.68	5	127	8
6	1.88	0.12	1	0.12	0.50	0.134	0.06	4.81	5	127	12
8	2.12	0.12	1 1/8	0.12	0.50	0.134	0.06	5.32	5 1/2	140	12
10	2.50	0.12	1 1/4	0.12	0.50	0.165	0.06	6.42	6	152	16
12	2.62	0.12	1 1/4	0.12	0.50	0.165	0.06	6.54	6 1/2	165	20
14	2.75	0.12	1 3/8	0.12	0.50	0.165	0.06	6.67	6 1/2	165	20
16	3.00	0.12	1 1/2	0.12	0.50	0.165	0.06	6.98	7	178	20
18	3.25	0.12	1 5/8	0.12	0.50	0.165	0.06	7.48	8	203	20
20	3.50	0.19	1 5/8	0.12	0.50	0.165	0.06	7.89	8	203	24
24	4.00	0.19	1 7/8	0.12	0.50	0.180	0.12	8.85	9	229	24

TABLE 20/21 (Figure 4)

900 LB - Stud bolt with nut and (possible) washer

Pipe code: RC3A, RH4A and ASMEA1

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
USE CLASS 1500 DIMENSIONS											
3	1.50	0.12	7/8	0.12	0.50	0.134	0.06	4.18	4 1/2	114	8
4	1.75	0.12	1 1/8	0.12	0.50	0.134	0.06	4.93	5	127	8
5	2.00	0.12	1 1/4	0.12	0.50	0.165	0.06	5.47	5 1/2	140	8
6	2.15	0.12	1 3/8	0.12	0.50	0.165	0.06	5.61	5 1/2	140	12
8	2.50	0.12	1 3/4	0.12	0.50	0.165	0.06	6.22	6 1/2	165	12
10	2.75	0.12	1 3/4	0.12	0.50	0.165	0.06	6.47	6 1/2	165	16
12	3.12	0.12	1 3/4	0.12	0.50	0.165	0.06	6.84	7	178	20
14	3.38	0.12	1 7/8	0.12	0.50	0.165	0.06	7.35	8	203	20
16	3.50	0.12	1 7/8	0.12	0.50	0.165	0.06	7.73	8	203	20
18	4.00	0.12	1 7/8	0.12	0.50	0.180	0.12	8.79	9	229	20

TABLE 23/24 (Figure 4)

1500 LB - Stud bolt with nuts and (possible) washer

Pipe code: TC3A, TH4A and ASMFA1

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
1/2	0.88	0.12	3/4	0.12	0.50	0.134	0.06	3.31	3 1/2	89	4
3/4	1.00	0.12	3/4	0.12	0.50	0.134	0.06	3.45	3 1/2	89	4
1	1.12	0.12	7/8	0.12	0.50	0.134	0.06	3.95	4	102	4
1 1/2	1.25	0.12	1	0.12	0.50	0.134	0.06	4.18	4 1/2	114	8
2	1.62	0.12	1	0.12	0.50	0.134	0.06	4.55	5	127	8
3	1.88	0.12	1 1/8	0.12	0.50	0.134	0.06	5.06	5 1/2	140	8
4	2.12	0.12	1 1/4	0.12	0.50	0.165	0.06	5.59	6	152	8
6	2.88	0.12	1 1/2	0.12	0.50	0.165	0.06	6.25	7	178	8
8	3.25	0.12	1 3/4	0.12	0.50	0.165	0.06	6.97	7	178	12
10	3.62	0.12	1 7/8	0.12	0.50	0.180	0.06	7.85	8	203	12
12	4.25	0.12	2	0.12	0.50	0.180	0.12	9.04	9	229	12
14	4.88	0.12	2	0.12	0.50	0.180	0.12	9.60	10	254	16
16	5.25	0.12	2 1/2	0.12	0.50	0.220	0.12	10.83	11	279	16
18	5.75	0.12	2 1/2	0.12	0.50	0.245	0.12	11.66	12	305	16
20	6.38	0.12	2 3/4	0.12	0.50	0.259	0.12	13.00	13	330	16

TABLE 26/27 (Figure 4)

2500 LB - Stud bolt with nut and (possible) washer

Pipe code: VC3A, VH4A and ASMGA1

Pipe Size	C	t	d	G	F	W	n	T inch	S inch	S mm	Bolts qty
1/2	1.19	0.12	3/4	0.12	0.50	0.134	0.06	3.62	4	102	4
3/4	1.25	0.12	3/4	0.12	0.50	0.134	0.06	3.68	4	102	4
1	1.38	0.12	7/8	0.12	0.50	0.134	0.06	4.06	4 1/2	114	4
1 1/2	1.75	0.12	1 1/8	0.12	0.50	0.134	0.06	4.45	5	127	4
2	2.00	0.12	1	0.12	0.50	0.134	0.06	4.45	5	127	8
2 1/2	2.25	0.12	1 1/4	0.12	0.50	0.134	0.06	5.45	5 1/2	140	8
3	2.62	0.12	1 1/2	0.12	0.50	0.165	0.06	5.84	6 1/2	165	8
4	2.88	0.12	1 3/4	0.12	0.50	0.165	0.06	6.47	7	178	8
5	3.62	0.12	1 3/4	0.12	0.50	0.180	0.06	8.19	9	229	8
6	4.25	0.12	2	0.12	0.50	0.180	0.12	9.29	10	254	8
8	5.00	0.12	2	0.12	0.50	0.180	0.12	10.84	10	254	12
10	6.50	0.12	2 1/2	0.12	0.50	0.236	0.12	13.00	13	330	12
12	7.25	0.12	2 3/4	0.12	0.50	0.250	0.12	13.87	14	356	12
14	Not available										

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TABLE A - APPLICABLE DIMENSIONS FOR HEX. HEAD BOLTS IN 150 - 300 LB

FIGURE	S inch	S mm	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2			
	1 1/4	32	X															
	1 1/2	38	X															
	1 3/4	44	X	X														
	2	51	X	X														
	2 1/4	57	X	X	X													
	2 1/2	64	X	X	X													
	2 3/4	70	X	X	X	X												
	3	76	X	X	X	X	X											
	3 1/4	83	X	X	X	X	X	X										
	3 1/2	89	X	X	X	X	X	X	X									
1	4	102	X	X	X	X	X	X	X									
	4 1/2	114	X	X	X	X	X	X	X		X							
AND	5	127	X	X	X	X	X	X	X		X	X						
	5 1/2	140	X	X	X	X	X	X	X		X	X						
3	6	152	X	X	X	X	X	X	X		X	X		X				
	6 1/2	165	X	X	X	X	X	X	X		X	X		X	X			
	7	178	X	X	X	X	X	X	X		X	X		X	X			
	8	203	X	X	X	X	X	X	X		X	X		X	X			
	9	229		X	X	X	X	X	X		X	X		X	X			
	10	254			X	X	X	X	X		X	X		X	X			
	11	279				X	X	X	X		X	X		X	X			
	12	305					X	X	X		X	X		X	X			
	13	330						X	X		X	X		X	X			
	14	356							X		X	X		X	X			
	15	381									X	X		X	X			
	16	406									X	X		X	X			
	18	457										X		X	X			
	20	508												X	X			
	22	559												X	X			

TABLE B - APPLICABLE DIMENSIONS FOR STUD BOLTS IN 150 - 2500 LB

FIGURE		S	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4
	2 1/4	57	X															
	2 1/2	64	X															
	2 3/4	70	X	X														
	3	76	X	X														
	3 1/4	83	X	X	X													
	3 1/2	89	X	X	X	X												
	4	102	X	X	X	X	X											
	4 1/2	114	X	X	X	X	X	X										
	5	127	X	X	X	X	X	X	X									
	5 1/2	140	X	X	X	X	X	X	X	X								
2	6	152	X	X	X	X	X	X	X	X	X							
	6 1/2	165	X	X	X	X	X	X	X	X	X	X						
AND	7	178	X	X	X	X	X	X	X	X	X	X	X					
	8	203	X	X	X	X	X	X	X	X	X	X	X	X				
4	9	229		X	X	X	X	X	X	X	X	X	X	X	X			
	10	254			X	X	X	X	X	X	X	X	X	X	X	X		
	11	279				X	X	X	X	X	X	X	X	X	X	X	X	
	12	305					X	X	X	X	X	X	X	X	X	X	X	X
	13	330						X	X	X	X	X	X	X	X	X	X	X
	14	356							X	X	X	X	X	X	X	X	X	X
	15	381								X	X	X	X	X	X	X	X	X
	16	406									X	X	X	X	X	X	X	X
	18	457										X	X	X	X	X	X	X
	20	508											X	X	X	X	X	X
	22	559												X	X	X	X	X
	24	610													X	X	X	X
	26	660														X	X	X
	28	711															X	X

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Instrumentation on packaged equipment

This specification describes gas turbine package instrumentation. Applications are Mechanical Drive (MD) and Power Generation (PG), both onshore and offshore installations. It is a standardised package design, i.e. types, installation, manufacturers, and design praxis et cetera are of a well-proven design and provided with a fully functional guarantee. The entire Instrumentation and Control system is fully assembled with piping and wiring for the whole package when delivered. External skids, e.g. external gas fuel unit and fire module must be interconnected at site. The complete package is tested in Siemens workshop with its project control equipment up to ignition point.

BU / SGT-600(MD B, PG B, PG Ex B) SGT-700(MD B, PG B, PG Ex B) / &EC102	

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1. General

1.1 Abbreviations

API	American Petroleum Institute
BS	British Standard
CMS	Condition Monitoring System
DCS	Distributed Control Systems
DIN	Deutsche Institute fur Normung
EN	Euronorm
HART	Highway Addressable Remote Transducer
HHT	Hand Held Terminal
I&C	Instrument & Control
IEC	International Electrotechnical Commission
I/O	Input/Output
IS	Intrinsically Safe
ISA	Instrumentation Systems and Automation
ISA RP	ISA Recommended Practice
ISO	International Organisation for Standardisation
KKS	Kraftwerk Kennzeichnen System (Designation System)
MD	Mechanical Drive
NACE	National Association of Corrosion Engineers
OSP	Overspeed Protection
P&ID	Process & Instrument Diagram
PG	Power Generation
RTD	Resistance Temperature Detector
RVDT	Rotary Variable Displacement Transducer
SI	System International
SIL	Safety Integrity Level
SPDT	Single Point Double Throw
SPST	Single Point Single Throw
UCP	Unit Control Panel

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2. General requirements for design

Package instrumentation and control is designed in conformity with relevant laws and normative references specified in this document. All I&C is well made with excellent craftsmanship.

2.1 Normative references

Listed here are normative references where applicable parts are followed in this standardised package design.

API607	Fire Test for Soft-Seated Quarter-Turn Valves
API670	Machinery Protection Systems
API6FA	Fire Test for Valves
API-RP-551	Process Measurement Instrumentation
BS6739	Code of practice for instrumentation in process control systems: installation design and practice
DIN19227	Symbols for Point of Measure
DIN2481	Graphic symbols for P&ID
DIN EN10204	Metallic products – Types of inspection documents
IEC60584	Thermocouples
IEC60079	Electrical apparatus for explosive gas atmospheres
IEC60529	Degrees of protection provided by enclosures (IP Code)
IEC60751	Industrial platinum resistance thermometer sensors
ISO2954	Mechanical vibration of rotating and reciprocating machinery – requirements for instruments for measuring vibration severity
ISO5167	Measurement of fluid flow by means of pressure differential devices
KKS	Power Station Designation System
NACE MR0175	Standard material requirements. Sulphide stress cracking resistance metallic materials for oilfield equipment

2.2 Measurement units

Measurement units are in conformity with SI system (Système International d'Unités) except for temperature where degrees Celsius (°C) is used. Some of the SI units used are:

Pascal for pressure	Pa (kPa, MPa)
Litre or cubic meter for volume	l or m3
Meter for length width distance	m
Kilogram or metric ton for mass or weight	kg or t
Square meter for area	m2
Kilogram per cubic meter for density	kg/m3

On request (optional) it is possible to display US units (such as Fahrenheit and PSI) or switch from Pascal to Bar. Refer to scope of supply for included units.

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2.3 Graphic symbols and tag numbering

Designation system is based on KKS, a power station designation system.

In conjunction with the KKS system, following standards are used:

"*Symbols for Point of Measure*": according to DIN 19227.

"*Graphic symbols for P&ID*": generally according to DIN 2481.

For a more detailed description of the KKS system see separate document where parts of DIN 19227 and DIN 2481 also are described.

As the KKS designation system is an essential base for design of the package, a change to other designation system would influence the overall design of control, electrical and mechanical systems and documentation, also altering control system programming.

Special demands for other designation systems can be implemented to different extents. In its simplest form it is a translation table between KKS and customer designation system in order to allow personnel to identify components. Information supplied on a bus link as well as hardwired signals does not carry tag number information, leaving possibility for the customer to configure these signals at the DCS according to their desired designation system.

3. Instrumentation system design

3.1 General

Basic criteria for instrumentation used for measurement, supervision, control, protection and safety are defined according to following aspects:

- Safety, man and machine
- Reliability
- Environmental conditions
- Ease of control and maintenance
- Possibility of future package expansions
- Conformity throughout whole package unit and, if required, auxiliary systems

Installation of instruments in general complies with API RP 551 and BS6739, Siemens standards and other standards of similar kind. Due to package unit measures there are some exceptional cases. All excepted measurement points are of a field-proven design and provided with a functional guarantee.

Instruments are located as close as possible to the measurement point and are installed, as far as possible, with special regard to provide a good overview and enabling staff/technicians to check and maintain equipment. All instruments can, if need occurs, be removed without disturbing adjacent equipment, piping or tubing. Electrical equipment, junction boxes, fittings, etc. are unobstructed by other installed equipment and accessible for maintenance.

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3.2 Degree of protection, environmental conditions

All instruments inside enclosure are of at least ingress protection class IP54, normally IP65. Externally located instruments have at least IP65 ingress protection.

Instrumentation on the package is, in general, designed for environmental conditions ranging from -40°C to +85°C temperature, i.e. ambient conditions ranging from -40°C to +55°C, and to withstand such diverse conditions as offshore platforms, deserts, arctic and tropical climate.

Core engine internal instrumentation is designed for engine internal extreme conditions.

All instrumentation components are made of materials suitable for these environmental conditions, avoiding formation of fouling and mildew.

An instrument exposed to direct sunlight and therefore reaching exceptional high temperatures, i.e. mounted outdoors on sites with high ambient temperatures, has sunshades.

3.3 Hazardous area classifications

Package instrumentation for use in hazardous areas is certified for use in 'Zone 1', 'Device group IIB' and 'Temperature class T3 to T6' according to CENELEC. Where applicable all package instrumentation also has certification according to ATEX 94/9/EC for 'Equipment group II', 'Equipment category 2' and 'Type of explosive atmosphere G'.

Instrumentation is of EEx(i) intrinsic safe type. This decision is based on availability and serviceability. Distributed I/O with built in barriers uses as few components as explosion proof technology and will result in a higher availability.

Intrinsically safe isolators with galvanic separation and zener barriers are used in those cases the I/O is not equipped with built in barriers, i.e. vibration and combustion dynamic pressure measurement.

In special cases, e.g. impossibility in obtaining EEx(i) certification, instruments are of EEx(d) and EEx(de) type, i.e. pressure switches.

3.4 Instrumentation type

Instrumentation for measurement and control is of electronic type without mechanical counter-reaction. Instruments are connected to the control system via a 2-wire system, 4-20mA signal @ 24 V DC power supply or via instrument bus.

On all possible positions, instruments utilising HART protocol are used.

Electric circuits for on-off instruments such as pressure switches etc are fed by 24 VDC power supply.

3.5 Sub suppliers

Instrumentation is an integral part of the gas turbine package and all sub suppliers are evaluated on basis of quality. Changes of suppliers would affect the quality control organisation effort to assure a safe and reliable product.

Refer to separate document "Sub-suppliers list" for a list of approved instrument sub suppliers.

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4. Supply systems

4.1 Electrical power supply

To provide an uninterrupted AC power supply for control system equipment, an UPS system is included.

On customer request (optional) redundant UPS or customer fed in single or redundant configuration are possible.

4.2 Instrument & operating air

Terminal point for instrument air supply is located at skid edge. Internal AISI316L air supply distribution line is divided into branches for different areas of the package. Air filter and block valve at terminal point and for external units is included in the supply.

It is not possible to use process natural gas as instrument and operating air supply. Requirements for air supply by customer are to be found in technical file.

On customer request (optional) an air supply system can be included.

5. Alarm and protection systems

Emergency shutdown instruments are hooked-up fail-safe i.e. if an internal fault or e.g. a cable break occurs; the package is put into safe mode.

A SIL proven protection PLC performs the unit protection. The unit protection system works with tripping scheme 1oo1 and 1oo2, or upon request 2oo3 (optional). Some dedicated hardwired equipment is also provided e.g. fire extinguishing system with dedicated controls and an associated DC-power supply.

5.1 Alarm systems

Both visual and acoustic alarm systems are used. Alarm lists on the operator screen display alarms with time stamps.

5.2 ESD

Instruments used for shutdown purposes are not dedicated to and used solely for emergency shut down purposes, e.g. thermocouples used for measurement of GT exhaust temperature, pressure transmitters for compressor discharge pressure and hall effect probes for speed measurement are used both for control and shutdown functions. Only hard wired connected instruments are used in the ESD system.

6. Package control system

The package is equipped with an industrial type control system built up around standard microcomputer based products of integrated and distributed control systems for industrial automation. The system is very rugged and fulfils applicable standards for resistance to interference. It is used in all types of applications.

As main medium for man-machine interface high-resolution colour graphic display is used.

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7. Condition monitoring system

CMS is an optional tool for collecting, presenting, analysing and storing process data for extended periods. Data is presented in various graphs and reports. The system is built around a standard PC with Microsoft Windows operating system. For a full description of CMS and its different modules refer to separate document.

7.1 Remote connection

Remote connection enables an online connection between customers control system and Siemens. Remote connection requires an internet connection (DSL or similar) provided by customer.

8. Earthing systems

The package is internally earthed and provided with lugs for external earthing by others. In order to reduce risk for common mode voltage between instrument earth (IE) and protective earth (PE) the two earth systems are always interconnected for the package control equipment.

8.1 Protection earth

Control cable screens are only connected to ground in control panel end. Screen is continuously wired from ground point in cabinet to attached equipment where it is isolated.

8.2 Instrument earth

Instrumentation cable screens are only connected to ground in control panel end. Screen is continuously wired from ground point in cabinet to attached equipment where it is isolated. Instrument earth and protection earth is connected together in the UCP.

8.2.1 Noise and interference

Where applicable, double screened signal cables are used in order to suppress noise and interference. Inner screens are earthed in cabinet end and open in instrument end to suppress interferences from frequencies lower than 10 kHz. Outer screen is earthed in both ends to suppress interferences from frequencies higher than 10 kHz.

8.3 Intrinsically safe (IS) earth

A separate IS earth is required for intrinsically safe instrument circuits using barriers instead of isolators. A separate IS earth bar is included in the UCP for use together with loops utilising zener barriers. This separate IS earth bar shall be connected by customer to site IS earth system.

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9. Safety integrity level, instruments

Where applicable and necessary SIL-certified instruments/transmitters and transducers with safety data are used.

SIL-certification is for instruments/transmitters/systems with internal diagnostic possibilities such as pressure transmitters, overspeed protection system and vibration monitoring system.

Safety data is used for transducers without possibility of internal diagnostic such as accelerometers, thermocouples and dynamic pressure sensors where the monitoring system is supervising/monitoring the transducers.

Protection loops are engineered with safety as first consideration, only instruments of documented high quality are chosen.

SIL verification can be supplied on customer request (optional), refer to scope of supply for details.

10. Instruments and equipment

Instrument casings are generally made of epoxy-coated low copper die-cast aluminium alloy or stainless steel and are suitable for a petrochemical plant type as well as an offshore salt-laden, humid and corrosive type of environmental atmosphere. Instruments mounted outside of enclosure in offshore applications have casings of AISI316L stainless steel.

All instrument casings in stainless steel are optional.

When sulphide stress cracking resistance is required conventional austenitic stainless steels in contact with fuel containing hydrogen sulphide are selected in accordance with NACE MR0175/ISO 15156 part 3, table A.6.

Electrical connections are in general millimetre threads, according to EN50262, for hazardous and safe area installations.

All measuring ranges are according to package standard, covering the needs for safe and reliable operation of the gas turbine.

10.1 Temperature instruments

Auxiliary system temperature instruments are installed in thermowells. They are replaceable without disturbing the process or interfere with the process connections.

Flanged process connections are not used due to space restrictions.

Core engine instruments are installed in probe assemblies except for bearing temperatures which are installed in the bearing pads.

To increase availability and response times are both RTD's and thermocouples connected directly to temperature specific I/Os i.e. no converters/transmitters introducing an extra source of error are used.

10.1.1 Thermowells

Thermowells are designed with safety and quick response time as first considerations. Thermowells used throughout the package are robust and spare parts are not in general necessary.

Thermowells used throughout the package are according to DIN 43763 form B and form D but are designed for quicker response times.

Thermowells are delivered with AISI316L stainless steel quality.

Process connection is threaded ½"-NPT and welding for the gas system.

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10.1.2 Thermometers

Thermometers are of the bimetallic type having a dial face that is white with black and red markings and a nominal diameter of 100 mm.

Instrument casing is made of stainless steel.

Dual gradation scale, °F/°C.

Connection thread is G1/2".

10.1.3 RTD

RTD's are of platinum wire wounded Class 'A' PT100 type in accordance with IEC60751. They are connected to the control system dedicated RTD I/O.

Sensors utilise a four-wire connection for compensating cable length and to minimize influence of divergence in cable resistance.

10.1.4 Thermocouples

Thermocouples are used for core engine hot section measurements e.g. exhaust and burner temperatures not in the auxiliary systems.

They are of type N, except for compressor discharge temperature which is of type K, tolerance class 1, in accordance with IEC60584, due to its excellent characteristics avoiding green root and with low influence of short range ordering. They are connected to the control system dedicated thermocouple I/O and cold junction compensation is carried out in the I/O.

Thermocouples have an isolated measurement tip.

10.1.5 Temperature transmitters

Are not used.

10.1.6 Temperature switches

Are not used.

10.2 Pressure instruments

Pressure instruments are attached to manifolds, not to surrounding structures, enabling removal of instrument for calibration and service without disturbing the manifold, support brackets and piping.

Pressure instruments have shut-off valves and block-and-bleed valves with T-style handles, not lockable.

Some instruments share a common process tapping-point though having individual shut-off and block-and-bleed valves.

Flanged process connections are not used due to space restrictions.

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10.2.1 Pressure gauge

Pressure gauge dial face is white with black and red markings. They are glycerine-filled for damping purposes. Wetted parts of gauges are of stainless steel and window is of laminated safety glass.

Diameter is nominally 100 mm.

Connection is G1/2" parallel threads, bottom connection.

Accuracy class 1.0.

Dual gradation scale, Pa/psi.

10.2.2 Differential pressure gauge

Differential pressure gauge dial face is white with black and red markings. They are glycerine-filled for damping purposes. Wetted parts of gauges are of stainless steel and window is of laminated safety glass.

Diameter is nominal 100 mm.

Connection is G1/4" parallel threads, bottom connection.

Accuracy class 1.6.

Dual gradation scale, Pa/psi.

10.2.3 Pressure transmitter

Pressure transmitters with a piezo resistive silicon chip sensor are of smart type with HART protocol, exceptions are transmitters used for surge protection where quick response times are required. Total error, including linearity, hysteresis and repeatability, is less than ±0.35%. Signal interface to control system is via 4-20mA signal.

Wetted parts of the instrument are of AISI316L stainless steel.

Instrument casings are made of epoxy-coated low copper die-cast aluminium alloy or stainless steel and are suitable for a petrochemical plant type as well as an offshore salt-laden, humid and corrosive type of environmental atmosphere. Instruments mounted exterior to the enclosure in offshore applications have casings of AISI316L stainless steel.

All instrument casings in stainless steel are optional; refer to scope of supply for included material.

Pressure transmitters are equipped with an integral display showing measured value in Pascal. Displays are facing walkways etc as far as possible. Displays are only for indication.

10.2.4 Differential pressure transmitter

Differential pressure transmitters with a piezo resistive silicon chip sensor are of smart type with HART protocol. Total error, including linearity, hysteresis and repeatability, is less than ±0.45%. Signal interface to control system is via 4-20mA signal.

Wetted parts of the instrument are of AISI316L stainless steel.

Instrument casings are made of epoxy-coated low copper die-cast aluminium alloy or stainless steel and are suitable for a petrochemical plant type as well as an offshore salt-laden, humid and corrosive type of environmental atmosphere. Instruments mounted exterior to the enclosure in offshore applications have casings of AISI316L stainless steel.

All instrument casings in stainless steel are optional; refer to scope of supply for included material.

Pressure transmitters are equipped with an integral display showing measured value in Pascal. Displays are facing walkways etc as far as possible. Displays are only for indication.

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10.2.5 Pressure switch

Use of pressure switches is generally avoided.

Switches are used in the lubrication oil system and are monitoring the discharge pressure after the lubrication oil pumps (for pump switch-over initiation).

Switches have hermetically sealed electrical assembly with SPDT potential-free contact and field adjustable set point.

Switches are of very rugged design utilising disc-spring design making them relatively impervious to surge and ripple.

Wetted parts of switches are in AISI316 stainless steel.

10.2.6 Differential pressure switch

Use of differential pressure switches is generally avoided.

Differential pressure switch is only used for the liquid fuel filters in order to initiate a notification when change of filter is necessary. The switch is an integral part of the filter assembly.

Wetted parts of the switch are in AISI316 stainless steel.

10.3. Flow instruments

Flow is measured and calculated using two pressure transmitters (see chapter 0 for information regarding pressure transmitters). Pressures are measured upstream and downstream the control valve.

Flow meters are, however, used for performance testing, and can be supplied on request (optional) as per items below.

10.3.1 Positive displacement flow meter (optional)

Used for optional liquid fuel flow measurement; refer to scope of supply for included equipment.

The flow meter is a turbine type flow meter with pulse output connected directly to the control system. Instrument bearings are of rolling bearings type and wetted parts are steel nitrated. Maximum inaccuracy is 0.5%.

10.3.2 Coriolis flow meter (optional)

Used for optional gas fuel measurement; refer to scope of supply for included equipment.

The instrument is of smart type with HART protocol interfacing the control system via a 4-20mA signal. Wetted parts of instrument are of AISI316 stainless steel. Maximum inaccuracy is 1.0% for gas service.

10.4 Level instruments

10.4.1 Level transmitter

Instrument used in liquid application is of smart guided wave radar type with protected coaxial rod. The instrument is equipped with integral display and interfaces the control system via a 4-20mA signal. Wetted parts are of AISI316 stainless steel. Electronics enclosure is made of aluminium and has M20x1.5 electrical connection. Process connection is G¾".

Stainless steel housing can be supplied on request (optional).

Accuracy is better than ±3 mm

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10.4.2 Level switch

10.4.2.1 Magnet operated switch

Level switches of magnet-operated float type are of stainless steel material and mounted internally in the vessel. Process connection is G2".

Contacts are SPST potential-free.

Electronics housing is made of aluminium.

Stainless steel housing can be supplied on request (optional).

10.4.2.2 Vibrating fork switch

Level switches of vibrating fork type are designed for use in liquids using the principle of a tuning fork. Piezo-electric technique is used to oscillate the forks and fork frequencies are continuously monitored. Process connection is ½" NPT and electrical connection is M20x1.5.

Contacts are SPDT potential-free.

Wetted parts are of AISI316L stainless steel material and instrument housing is of stainless steel.

10.5 Vibration transducers

Vibration monitoring equipment is rack mounted in the control panel and connected to the package control system. The system is used for alarm, shut down and analyses/balancing purposes.

10.5.1 Bearing and casing vibration

Accelerometers are used for machine supervision and shutdown purposes. They are located on or adjacent to the bearing housings. In general are the output integrated to velocity. Together with a phase reference on each shaft they are also used for balancing and machinery diagnostics of the gas turbine.

Casings are made of stainless steel, hermetically welded and equipped with integral cable protected by a flexible stainless steel hose welded to the case.

Accelerometers have differential output and are of symmetrical shear type. They are connected to charge amplifiers with housings/casings made of extruded aluminium.

When included in Siemens scope of supply, accelerometers are also used on gearbox and generator.

10.5.2 Shaft vibration (optional)

Shaft vibration is not for supervision or shutdown purposes, only for indication. Shaft vibration is measured with the eddy current principle based on a non-contact transducer and a conditioner forming a calibrated proximity system. The proximity system is temperature compensated and fully short circuit protected.

Transducer tip is made of polyphenylene sulfide and transducer body of AISI 304 stainless steel. Signal conditioner housing/casing is made of aluminium. Connectors are of gold-plated brass material.

Probe pairs are installed with a 90° separation.

Shaft vibration measurement is optional; refer to scope of supply for included equipment.

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10.6 Pulsation transducers

Combustion humming, or combustion dynamic measurement, is measured with piezo-electric acceleration compensated transducers. The transducer is mounted in a probe assembly and is using wave guide technique to measure the dynamic pressure. The wave guide is purged and has additional tubing downstream in order to reduce influence from reflections. Transducers are connected to charge amplifiers.

The transducer is of stainless steel material and is hermetically sealed.

The transducers are used for supervision, controls and shutdown purposes. Transducers are connected to a combustion dynamic monitoring system and signal interchange with the control system is via 4-20 mA signal.

10.7 Position sensors

10.7.1 Axial displacement

Axial displacement is measured with the eddy current principle based on a non-contact transducer and a conditioner forming a calibrated temperature compensated and fully short circuit protected proximity system.

Transducer tip is made of Torlon and transducer body of stainless steel. Signal conditioner housing/casing is made of extruded aluminium.

Refer to scope of supply for included equipment.

10.7.2 Phase reference

A phase reference, of same type as for optional shaft vibration, is used for vibration phase angle reference measurement and for machinery diagnostics.

10.7.3 Limit switches

Valve limit switches are of mechanical type, micro switches. The switches are of different brands depending on valve brand. They all have SPDT potential-free contacts.

10.7.4 Angular position

RVDT is a rugged position sensor used for angular position sensing.

RVDTs are accurate with linearity error less than ±0,5% and are used for the variable guide vane angle measurements.

10.8 Speed sensors

Speed is measured with the hall-effect principle based on a differential non-contact transducer with integrated electronics. Differential hall-effect transducers have excellent characteristics making it impervious to target vibrations and external magnetic fields without fading signal at low speed. Sensors are reading equally spaced grooves in a tooth wheel. Sensors are connected to an IEC 61508 SIL proven overspeed protection system.

Speed sensors for controls and overspeed protection are shared due to space restrictions. Three sensors per shaft are supplied i.e. 2oo3 for overspeed protection.

Transducer housing is of stainless steel material.

Refer to scope of supply for included equipment.

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10.9 Analyzers

When optional water or steam injection is used, an analyser is used to measure water or steam conductivity.

10.10 Humidity

For humidity a combination instrument is used, measuring humidity and temperature. It is a microprocessor-based transmitter with a humidity sensor of capacitive thin-film type and a built-in Pt100 Class B type RTD temperature sensor. Typical accuracy of analogue output is ±0.05% of full scale at +20°C. Interface to the control system is via a 4-20 mA signal.

10.11 Fire detection

Heat and flame detectors are used to detect fire inside the GT enclosure. Heat detectors are activated when a fixed temperature level is exceeded or when a predetermined temperature gradient is exceeded. Flame detectors react to the infrared light and movements from flames.

The fire detectors are wired to the fire panel via skid-edge junction boxes. The fire panel is installed at the UCP and connected to the control system.

Supply of detectors only, wired to skid-edge junction boxes, for connection to general site fire detection and extinguishing system, is also possible.

Additional detectors that can be installed on an optional basis are optical smoke detectors for the local control room and for the battery compartment.

10.12 Gas detection

Gas detectors are of IR-type and have two setting values, alarm and trip.

The gas detectors are wired to skid-edge junction boxes and connected to the control system.

Supply of detectors only, wired to skid-edge junction boxes, for connection to general site gas detection system is also possible.

Additional detectors can be installed on optional basis.

10.13 Combustion flame detection

Combustion flame detection uses fiber optic technology allowing monitoring and supervision in high temperature areas. Both IR and UV are monitored. Fiber optic cable is kept as short as possible in order not to lose radiation intensity.

2 fiber optic probes are monitoring the flame together with 2 flame scanners. The flame scanners are connected to 2 flame amplifiers with periodically internal self test procedure.

On request 2oo4 voting can be supplied (optional).

Self-monitoring for fail-safe function control is according to EN 230 and EN 298

The fiber optic cable is of silicon insulated flexible steel armouring type.

10.14 Solenoid valves

Connection size of the valve is dependent on the operated valve air demands. Operating power is 24VDC with a maximum consumption of 25W. Valve body is generally made of brass or aluminium. Solenoids have continuous service rating with class F insulation according to IEC 60085.

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10.15 Instrument shut-off valves and block-and-bleed valves

Block and bleed valves, manifolds, for pressure measurements are of two-valve execution. They have 1/2"NPT threads for process and instrument connection and 1/4"NPT threads for test and calibration outlet.

Block and bleed valves, manifolds, for differential pressure are of five-valve execution. They have 1/2"NPT threads for process, instrument connection and for test and calibration outlet.

Test and calibration outlets are equipped with quick couplings intended for calibration of the instrument and for process value reading, all quick couplings throughout the package are of same size.

Shut-off valves and manifolds are made of AISI316L material.

10.16 Junction boxes

Junction boxes are of RAL7032 silicon grey painted carbon steel material. JB's of stainless steel material can be supplied on request (optional). Suitable access and working space is provided for, in order to facilitate safe operation and maintenance. All fittings, junction boxes and device enclosures have gaskets or O-rings to prevent entrance of water. Ingress protection is IP66 for hazardous area installations and at least IP65 for non-hazardous area indoor installations. Cable entries are at bottom of JB. By way of exception JB's can have side cable entries due to package made measures. Cable glands and multicore quick connectors are used depending on location and service of the JB.

JB's for hazardous area installation are delivered in two categories; EEx(e) and EEx(d). EEx(d) is used only for a certain extent, e.g. for ignition coil assembly, flame detector and power supplies.

Delicate signals e.g. vibration, speeds et cetera are routed according to manufacturer recommendations.

Stainless steel vents and drains for junction boxes located outdoors are optional.

Each junction box has a tag plate on the front and is named in accordance with KKS-system. As a general figure the number of spare terminals and DIN rails is 15% in each case, it depends on number of included options. Total number of JB's depends on type of installation and included options.

10.17 unit control panel

For a description of the package control system and cabinets refer to separate documents.

10.18 Recording instrumentation

Recording instrumentation is not used. The control system has trending capacity. For detailed description refer to separate documents.

10.19 Impulse piping and fittings

Auxiliary impulse piping dimensions are ½x0,083 inch. Fittings are of compression type with a double ferrule design. Instrument impulse piping and compression fittings are of AISI316 stainless steel material.

11. Inspection, calibration and testing of instruments

Full inspection, calibration and testing of all instrumentation are carried out. All records are furnished according to ISO 9001 standards.

12. Tag plates

Instrument identification tags are made of stainless steel. Tags are showing KKS tag number.

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13. Certificates

Calibration certificates are included in the Commissioning report.

EC declaration of conformity with reference to applicable design standard and test standard is provided for inline-instrument pressure containing parts in piping of hazardous class I to III, in accordance with EN13480-5. Non-pressure containing parts are supplied with Ex Type Test Certificate if needed for the periodical survey of the equipment.

Test certificates for piping, piping components and pressure containing parts in-line instruments in non-hazardous piping (EN 13480 category 0) and atmospheric piping is optional and only included upon request.

13.1 Calculations

Calculations for valves, cabling and instrumentation are not obtainable except when special needs occur.

14. Spare parts

Commissioning spares, which are included for and replaced by the gas turbine supplier at no cost, are limited to equipment broken and/or malfunctioning during erection and commissioning.

Defined sets of commissioning and/or operational spares can be offered on an optional basis.

Spare parts scope depends on for instance numbers of gas turbines, service, and site accessibility etceteras. Due to the highly standardised package design the number of different spare parts needed is kept to a minimum.

15. Instrument loop testing

All loops are tested from sensor up to and including HMI. Calibration equipment is traceable to ISO 9001 standards. Auxiliary systems built by Siemens sub-suppliers have its equipment calibrated and tested by respective sub-supplier. For included tests refer to separate documentation.

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16. Documentation

The following documents regarding instrumentation are included in the package;

- P&ID with legend sheet
- Instrument list
- Setting list
- Cable list
- Loop diagrams
- Typical hook-up drawings
- Instrument manufacturer manuals/datasheets
- Certificates

giving all information needed for safe operation and maintenance of package.

ISA, or any other form, instrument datasheets are only submitted on optional basis. Instrument calculations are replaced by prototype test procedures. All information is found in manufacturer's manuals and in instrument lists.

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SIEMENS	Auxiliary systems SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W401010E	
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Valves on packaged equipment

General

Control valve types used are ball valves for fuel gases and butterfly valves for bleed air applications.

Valve design, in order to conform to other standards than mentioned in this specification or by any other reason, is not subject to redesign in this standardised package.

When needed extension bonnets are used.

Pressure ratings of all valves are according to the rating of respectively system, see separate document P&ID's.

Nameplates are according to valve/actuator/positioner manufacturer standard.

Control valves

The main and pilot control valves used for gas fuel supply are v-shaped conventional ball valves or eccentric plug type. With flanged or wafer connections.

The main and pilot gas fuel control valves are made of the following materials.

Seat	CF3M or CG8M
Body	CF3M or CG8M

The central gas control valve for SGT700/800 and RPL valve for SGT750 is of globe valve type with threaded connections.

The central gas control valve is made of the following materials.

Seat	1.4571
Body	CF3M/1.4408

For control of liquid fuel flow a variable speed pump and a SFC is used.

A butterfly type control valve is used for the compressor bleed-off.

Control valves are sized in accordance with Siemens demands, i.e. for the rates of flow and pressure drops under design conditions, and manufacturer's recommendations. Sizing according to ISA 75.01 or ISA 75.02 has not been considered.

Seat leakage is according to ANSI/FCI70-2-1991.

On/Off valves

Valves sizes are ½", ¾", 1", 2", 3" and 4" and of floating ball mainly soft-seated.

Valve body connection is welded, flanged or NPT-threaded.

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Shutdown valve

Valves are reset manually from operator station prior to re-activation to service.

Shutdown valves and fuel system shut off valve, located outside package enclosure, has fire test approvals according to BS6755 part 2: 1997, API607 and API6FA.

Valve body connection in the gas and liquid fuel systems are flanged, threaded or welded.

Pressure relief valves

Pressure relief valve sizing and set pressure are in accordance with Siemens demands, manufacturer's recommendations, API RP520 and EN ISO 4126-1. Sizing according to API RP 526 and tightness according to API RP 527 only on special requests.

Wetted parts are of SS316.

Valve body connections are of flanged and threaded type.

Relief valves fitted purely for relief of thermal expansion of liquids in blocked-in lines are not used on the package.

Bursting discs are not used.

Lifting levers and exposed spring type valves are not used.

Solenoid valves

Connection size of the valve is dependent on the operated valve air demands. Operating power is maximum 24VDC with a maximum consumption of 25W. Valve body is generally made of brass or aluminum. Solenoids have continuous service rating with class F insulation according to IEC 60085. Solenoids are mounted on the valves with namur interface or mounted in line.

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SIEMENS	Auxiliary systems SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W401010E	
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Actuators

Control valves

Control valves in gas fuel applications use brushless AC servomotor drives as actuating device.

Central gas control valve is of pneumatic type with an I/P-positioner. The positioner is mounted on the valve.

Actuator for bleed valve applications is of pneumatic type with an I/P-positioner. The positioner is mounted on or close to the valve.

Positioners do not utilise HART protocol.

All control valve actuators/positioners utilises local position readout

The action of each valve on failure of its control signal or acting medium is to a fail-safe condition.

On/Off valves

Pneumatic actuators operate the on/off valves. Actuators are single acting scotch-yoke or rack and pinion type, with spring return. The material of the actuators is in general anodized aluminium. For instrument air pressure range see separate document. The action of each valve on failure of its control signal or acting medium is to a fail-safe condition.

Shutdown valves

Shutdown valves are operated by pneumatic scotch-yoke actuators, fail-safe and spring return.

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SIEMENS	Auxiliary Systems SGT-700	GTI number		J402003E	
		Document number		1CS48530	
		Revision	D	Page	1

Cooling and sealing air system

Ref: Attached P&ID

General description of the system

In order to prevent the gas turbine from oil and gas leakage and cool the hot parts, the gas turbine is equipped with a cooling and sealing air system (See page 2 for schematic).

The eleven-stage compressor has slots for bleed-off air after the second and sixth stages. The air flows through the slots into two cavities, the low pressure (LP) and the high pressure (HP) bleed cavities, between the inner stator blade carrier and the outer compressor casing.

Sealing air

Sealing air to bearing No 1 is supplied from the LP bleed cavity. The major part of the air flows via the bearing casing to the oil tank, where it is blown off via the oil mist fan. The remaining air of the air flows via a labyrinth into the compressor airflow path.

Sealing air to bearing No 3 and No 4 is also taken from the LP bleed cavity and is fed to the bearing via an external pipe. Some of the air flows from the bearing out into the exhaust gas flow path and the remainder flows with the return oil to the oil tank.

Sealing and cooling air to bearing No 2 is taken from the compressor delivery. This air is hot and has to be cooled down in an external sealing air cooler.

Cooling air

Turbine stages 1 and 2 are cooled by air from the compressor. Both the guide vanes and the blades are hollowed to allow the cooling air to flow inside.

Cooling air to the power turbine is taken from the HP bleed cavity. The cooling air is fed via an external pipe to a ring manifold. From this manifold, individual flexible hoses supply through the third stage guide vanes with air for disc cooling.

Picture on page 2 shows a typical Sealing and Cooling Air System with single, water cooled cooler.
The system can also be equipped with air cooled cooler or double coolers.

FO/ SGT-700(PG B, PG Ex B) / &DF101	

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SIEMENS	Auxiliary Systems SGT-700	GTI number		J402003E	
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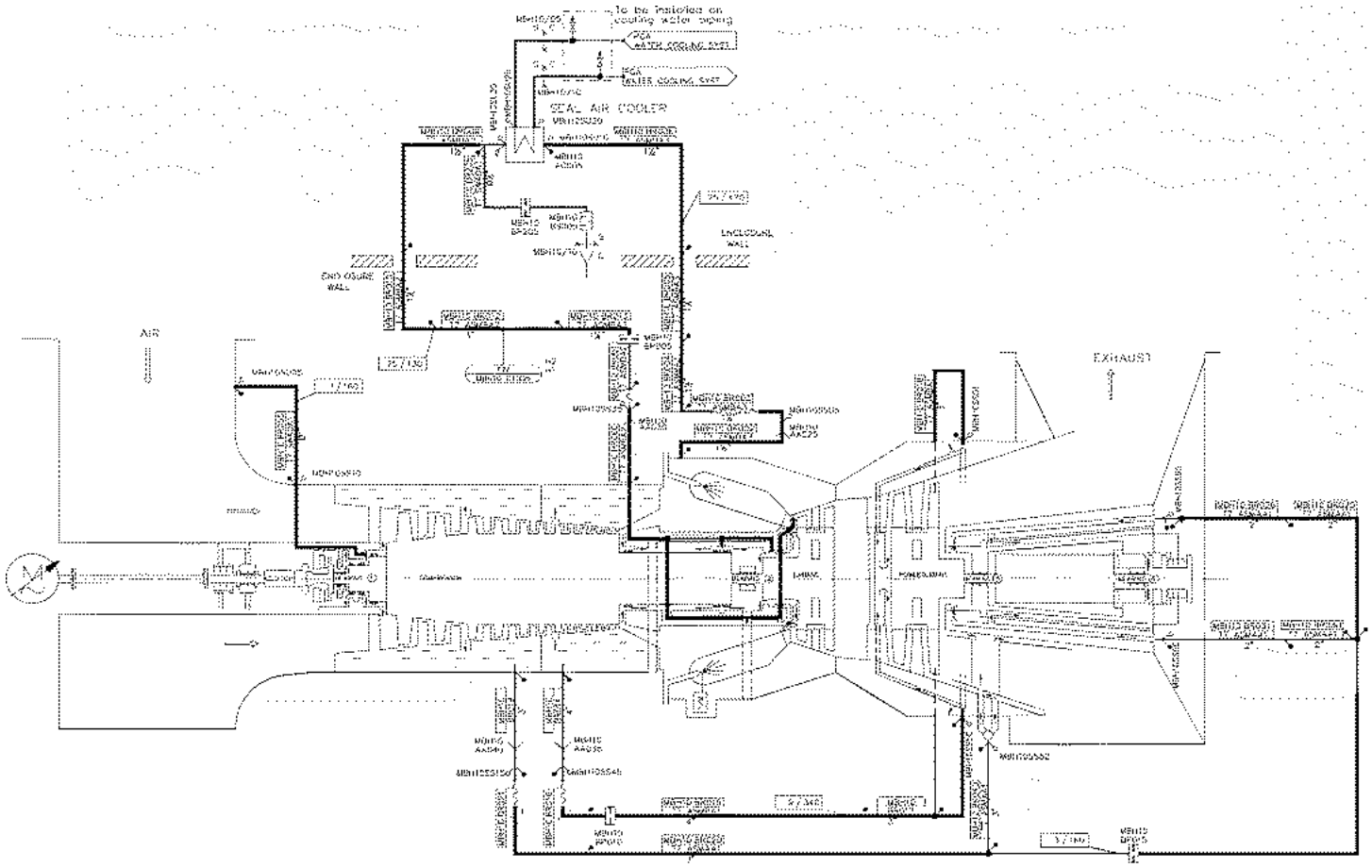

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SIEMENS	Auxiliary systems SGT-600, SGT-700	GTI number		J403014E	
		Document number		1CS103251	
		Revision	D	Page	1

Electric starting system

Ref.: Attached P&ID

Components

- Electric AC motor, 4-pole design. Motor mounted on piedestal in front of the gas generator.
- Intermediate shaft with SSS type clutch between electric motor and gas generator shaft.
- Static Frequency Converter (SFC) controlled by GT control system, fed from GT MCC.
- Turbine control system, supervisory and controlling functions.

Main system data

Motor rating:	150 kW
Rated voltage at 50 Hz:	400 VAC
Absorbed PF:	~ 1,0
Max. inrush current:	Rated motor current
No. of consecutive starts:	6

Time between two consecutive starts depends on rolling out time:

For Mechanical Drive:	4-8 minutes depending on driven equipment
For Power Generation:	15 minutes

Function

Start

At a GT start the starting system is given a predetermined speed reference. This speed reference corresponds to the purging speed of the gas turbine, which is approx. 2300 rpm.

The purging continues for a time sufficient to ventilate the gas turbine and the complete exhaust system. When the purging time has elapsed fuel is injected and the gas turbine is ignited. When the GT accelerates beyond the self-sustaining speed the SSS clutch will disengage and the SFC is switched off.

Stop and cool down

When the GT is stopped or at shutdown, the starting system is engaged and given a speed reference equal to the barring speed of the gas generator, which is 215 rpm. When the gas generator rotor speed comes down to the set speed of the SFC, the SSS clutch will engage and thereby the gas generator rotor will be driven by the starting system.

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Manual turning of compressor rotor

The start system is provided with a manually operated withdrawable crankshaft.
The crankshaft can be used to exactly position the rotor, for example during boroscope inspection.

Number of starts consecutive

The start motor is protected for over-temperature by an integrated thermistor, hardwired to the SFC for alarm at high temperature.

The start system is designed for short time operation, a maximum number of 6 start attempts can be made until the maximum temperature in the start motor is reached.

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SIEMENS	Auxiliary Systems SGT-600, SGT-700	GTI number		J410032E	
		Document number		1CS89233	
		Revision	E	Page	1

Lubricating oil system

Ref: Attached P&ID

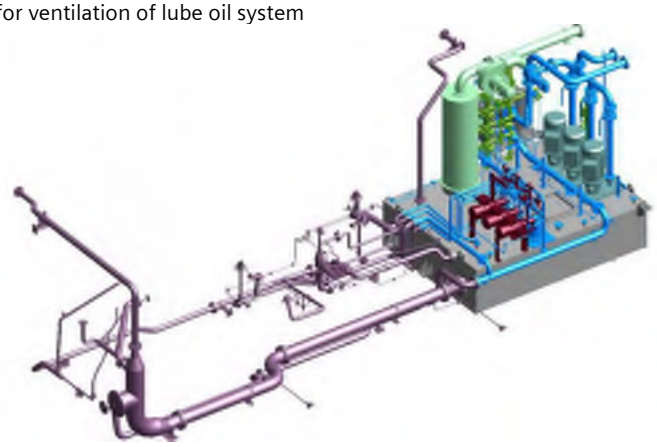
The lubricating oil system is designed to supply oil, at a controlled pressure and temperature, to lubricate and cool the turbine thrust and journal bearings, gearbox (if any) and driven equipment.

The lubricating oil system comprises of an oil tank and an oil supply system.

The oil tank is a reservoir of the drop in type, located in the package base-frame. The gas turbine oil tank capacity is 8 800 litres run-down level (2300 US gallons).

The oil system is comprised of:

- Tank
- Heater
- Pumps
- Filters
- Cooler
- Temperature regulating valve
- Pipe work
- Ejector/ fan for ventilation of lube oil system



Also provided are devices for protection against low pressure and high temperature conditions.

The turbine uses mineral oil in the lubrication system. Use of this oil has the following advantages:

- It is considerably less expensive then synthetic oils
- It is more readily available then synthetic oils
- It needs less monitoring then synthetic oils
- It is less toxic then synthetic oils

FO / SGT-600 (MD B, PG B),SGT-700(MD B, PG B,) /&DB101	

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The use of flame retardant oils in gas turbines is generally not recommended. Some oils require special seals to be used in systems and can also react with metals used in some types of bearings. If the customer has a specific requirement for use of this type of oil, as a supplier we will be pleased to review the specification of the oil proposed and establish any specific impact on the gas turbine or it's associated systems. In most cases special attention also has to be given to handling and disposal of flame-retardant oils and specific breather emissions, etc.

Oil consumption can vary between engines, but as a guide it consumes about 0,4 litres per day (about 0,1 US gallon per day).

Siemens specifications gives details of the lubricating oil requirements needed for use in the lubrication oil system. In general, ISO VG 46 oils from the majority of international manufacturers will meet the requirements.

- Lubricating oil requirements quality MAT 812109

It is nevertheless important that the oil fully comply with Siemens requirements to ensure that lubrication characteristics are satisfied and additives and other composition limits are complied with.

Lubricating oil system components

Oil tank

The lubricating oil tank of the drop in type is made of either carbon steel or stainless steel, according to Scope of Supply Document. It is located in the package base-frame. All pipes used in the lubricating oil system are made of stainless steel.

Lubrication oil heaters

The minimum lubricating oil temperature for engine starting is 25°C. A 30kW electric immersion heater in the lubricating oil tank, operate to raise the temperature of the oil to the minimum requirement for engine starting. The heater is top-mounted and can be removed without emptying the tank.

Level transmitter

The oil level transmitter provides warnings if the oil tank contents are below predetermined level.

Oil mist system

The lube oil mist system allows the fumes, which are generated during package operation, to vent to atmosphere. A fan, operating via SFC (Static Frequency Converter) to raise a sub atmospheric pressure in the tank and return piping, to prevent oil fumes leakage at bearings during start-up and coast down. When the turbine is in full operation the sub-atmospheric pressure is kept by an ejector, driven by air from bearing#2. The ventilated oil mixed air passes through an oil mist filter before it enters the atmosphere at a safe location. A high degree of the oil is separated and drained back to the tank.

Lubricating oil filters

The filters are installed downstream of the temperature regulating valve in the main line lubricating oil flow. The filters are of duplex type (two elements, one in each filter vessel) which allows change over during operation. The filtration degree is 10-micron at β>200. The cartridges are of the disposable type.

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Lubricating oil pumps

The lubricating oil system has two main circuits:

One low-pressure circuit feeding all bearings (except bearing #2) of the gas turbine as well as the driven equipment with 3x50% vertical mounted submerged centrifugal pumps. The pressure is derived from the pressure of the centrifugal pumps.

One high-pressure circuit feeding pressure controlled oil to GT bearing #2 with 3x50% gear pumps. The pressure is regulated by the SFC´s to a pressure 1.5-1.8 bar above the bearing compartment pressure. Each HP-pump is combined with a scavenge pump to ensure draining of bearing #2.

The system runs with 2x50% LP pumps and 2x50% HP pumps in normal operation. In case of a pump or motor failure on a pump in operation, the standby pump will automatically start without tripping the GT. Due to the characteristics of a centrifugal pump, with increasing flow when pressure is decreasing, one pump in operation during change over period is sufficient.

The pumps are AC-powered via SFC's (Static Frequency Converters). The power supply to the pumps is continuous in case of AC supply failure via an emergency battery system that is connected directly on the SFC's DC side.

The pump motors are supplied via the battery bank for 10 minutes after AC failure. After 10 minutes, when the GT is tripped, the frequency will be decreased in steps to save battery during the cooling down period.

The advantages of the AC/DC system are:

- Always one pump in spare
- Broken pump shaft will not cause turbine trip
- Less moving parts than gear driven pumps
- No pressure drop at pump switch-over

There are three different lube oil systems available:

- normal, for all power generation and for mechanical drive units with a flow level of ≤ 700 litres per minute for driven equipment
- extended, for mechanical drive units with a flow level of ≤ 1100 litres per minute for driven equipment[1]
- reduced, for mechanical drive units with a flow level of 200 litres per minute for driven equipment

Pump flow	Total flow (l/min) [SGT-600 /SGT-700]	Flow to driven object (l/min)	Pressure at flange for driven object (bar)	Retention time in oil tank
Reduced	700 / 750	200	1.5-1.8	8.5 min
Normal	1200 / 1250	700	1.5-1.8	5.3 min
Extended	1600 / 1650	1100	1.5-1.8	4.0 min

Oil coolers

[1] The flow is calculated for min 4 minutes retention time (depending on application). If higher flows, additional lube oil tank is required (maybe also an optional lube oil system).

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The oil cooler can be air or water-cooled according to Scope of Supply Document. The temperature control valve controls flow through the cooler.

The typical package includes a plate type water-cooled oil cooler. This type of cooler are suitable for use with Temper (synthetic glycol-free liquid) or as an alternative with fresh water with 40 % ethylene glycol at an inlet temperature of up to 40°C.

Air cooled lube oil coolers, for installation off-package, can be supplied as an option.

The recommended orientation of these units is for vertical airflow.

Temperature control valve

The three-way temperature control valve mixes cold lube oil from the cooler with warm oil from the tank in order to achieve correct oil temperature to the consumers.

The valve is equipped with a manual override function in order to operate the valve in case of temperature closed loop control malfunction. The nominal mixing temperature is set depending on site conditions.

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SIEMENS	Auxiliary Systems SGT-600, SGT-700	GTI number		J423022E	
		Document number		1CS86812	
		Revision	E	Page	1

Ventilation system gas turbine enclosure

Ref: Attached P&ID

General description of the system

The gas turbine room ventilation system is designed to supply the gas turbine room with air needed for cooling and ventilation ensure that it is a non-hazardous area.

That is to say:

- To keep a slight overpressure in the GT room.
- To ensure that there are at least 90 air changes / hour.
- The shut-off dampers close when the fire-fighting system is activated.
- Ventilation air taken from a safe area.

System description:

The system is installed with 1x100% or redundant 2x100% fans.

The fans are controlled by frequency converters. The fan delivers a pre-set flow depending of the ambient temperature. This reduces the need of preheating in cold conditions.

If one of the fans is out of order the other fan will automatically start up, to manage the needed flow.

The ventilation system is always in operation when the gas turbine is running. The gas turbine start-up sequence begins by starting the ventilation fans. The ventilations system continues for at least 3 hours after shut down to cool the gas turbine. To stop the ventilation the gas supply system has to be shut off and purged.

Ventilation with overpressure in the GT room is used for all applications and the ventilation air is taken from a safe area.

The shut-off dampers are maintaining the CO_2 concentration in case of fire. If the fire-fighting system is activated, the shut-off dampers are closed and the fan is stopped automatically.

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		Document number		1CS151333	
		Revision	A	Page	1

Gas detection system

The gas detection system is a failsafe SIL 2 certified system according to IEC 61508 with detectors hardwired to failsafe inputs. The system is active during standstill, shutdown, and all operation modes of the gas turbine package. Detectors (except for combustion air inlet or ventilation air inlet, if included) are part of the explosion resistant design, using dilution ventilation for the gas turbine enclosure.

Detectors of infrared type are used to monitor the presence of gas fuel in the gas turbine enclosure.

Placement of gas detectors:

- two detector in gas turbine enclosure ventilation outlet
- one detector in the base frame

The detectors are of flame proof design (EN 60079-1), approved for explosion group IIC for use in zone 1 (ATEX directive 2014/34/EU) and have ingress protection IP65 (IEC 60529).

Detectors are certified as "stand-alone gas detection apparatus" (IEC-60079-29-1) with linear output 4-20 mA for 0-100% LEL (Lower Explosive Limit).

If one of the detectors senses HIGH gas concentration, 5% LEL, an alarm is initiated. If one of the gas detectors senses HIGH-HIGH gas concentration, 8% LEL, an emergency shutdown is initiated.

• ISO 21789	Gas turbine applications – Safety
• IEC 61508	Functional safety of electrical / electronic / programmable electronic safety – related systems
• EN 60079-1	Standard for Explosive Atmospheres – Part 1 Equipment Protection by Flameproof Enclosures
• IEC 60529	Degrees of protection provided by enclosures (IP code)
• IEC 60079-29-1	Gas detectors – Performance requirements of detectors for flammable gases
• ATEX Directive 2014/34/EU	Equipment and protective systems intended for use in potentially explosive atmospheres

Additional equipment available, refer to the scope of supply for inclusion.

- Two out of three (2oo3) voting, consisting of three gas detectors in each detection position
- Extended gas detection, adds one detector in combustion air inlet and one detector ventilation air inlet

SGT-600(MD B, PG B, PG Ex B), SGT-700(MD B, PG B, PG Ex B)	

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Reciprocating Fuel Gas Compressor
3 x 50% Design

SCOPE OF WORK

PACKAGED MOTOR DRIVE RECIPROCATING COMPRESSOR

Complete UEC reciprocating compressor package(s), each with a single compressor and driver mounted on a steel skid and containing necessary on-skid wiring, piping, and controls, as described below.

CONDITIONS OF SERVICE

Location	New Jersey
Elevation (FASL)	12
Ambient Temperature	-5°F to 108°F

	Guarantee Case	Range
Service:	Fuel Gas	Fuel Gas
Unit Design:	3 x 50%	3 x 50%
Gas composition:	0.58	0.58
Flow rate per unit (SCFM):	6,000	3,433
Inlet pressure at skid edge (PSIG):	5	5 – 45*
Discharge pressure at skid edge (PSIG):	310	225 – 310
Suction temperature (°F):	50	50 – 120

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PACKAGE STUDIES

The following package studies are typically performed by a 3rd party consulting firm:

1.	Acoustical & mechanical studies (API 618 Design Approach 3a)	Included
2.	Torsional analysis	Included

Acoustical studies – The outcome of this study will examine the suitability of the pulsation bottles and piping system, and determine if any changes are required. Typical changes include pulsation bottle sizing, adding of internals (choke tubes and baffles), orifice plates, main skid beam or pedestal sizes and additional pipe supports. If off-skid piping (including to suction/discharge headers, other compressor equipment, etc.) is to be included in studies, customer must supply drawings in timely manner or it will affect the delivery schedule. See the standard notes on gas compressor applications section for further details.

Torsional study – The outcome of this study will examine the suitability of the driver and coupling, and determine if a flywheel or others charges are required. A flywheel, if required, is not included in the compressor pricing.

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EQUIPMENT DESCRIPTION

COMPRESSOR

Reciprocating compressor, double acting, horizontally opposed as described below:

Compressor Model	6HOS4 or Equal
Rated Frame BHP	4000
Rated Frame RPM	1200
Stroke (in.)	6.00
Max Rod Load – Total	60,000

- Force feed cylinder lubricator with divider blocks and no flow shutdown
- Meets the requirements of API 11P with supplier standard comments and exceptions
- Subject to supplier standard comments and exceptions for API 618
- 304/304L stainless steel tubing with zinc plated steel fittings
- Compressor mounted with sole plates and shims in grout box
- Compressor distance pieces mounted with Rotachock (or equal) mounts
- Compressor manufacturer's standard run test

CYLINDERS

Double acting, unlined, and lubricated cylinders as described below:

Service	Stage	Qty	Class	Bore (in.)	MAWP	Pockets	Unloaders
1	1	2	G5121	26.000	280 PSIG	VVCP	N/A
	2	1	G8767	19.000	470 PSIG	VVCP	N/A
	3	1	G8785	12.250	1050 PSIG	VVCP	N/A

VVCP – Variable volume clearance pockets for manual capacity control

- Cylinder bodies are ductile iron unless otherwise specified
- Air cooled cylinders, water cooled packing not required on any cylinders
- Carbon steel, Ion Nitride piston rods
- Compressor manufacturer's standard cylinder hydrotest

DISTANCE PIECE, VENTS & DRAINS

- Standard (single compartment) distance piece for all throws
- Vents and drains brought to skid edge

COMPRESSOR OIL SYSTEM

Closed loop oil system, each package, as described below:

- Shaft driven primary oil pump with suction strainer
- Simplex oil filter
- Electric pre-lube pump with check valve downstream of pump
- Crankcase immersion heater
- Direct oil cooled heat exchanger, radiator style mounted on-skid (480V)
- Thermostatic lube oil temperature control valve
- Automatic oil level make-up controller
- Compressor oil day tank not included (by others)

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COMPRESSOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) vibration transmitter
- One (1) compressor oil pressure transmitter
- One (1) compressor oil pressure indicator
- One (1) compressor oil temperature element, downstream of oil cooler
- Two (2) compressor oil temperature gauges, upstream and downstream of oil cooler

COUPLING AND GUARD

- Double-flexing spacer coupling (or equal) with standard carbon steel hubs and dry type, carbon steel flex pack initially sized for a minimum 3.0 service factor.
- OSHA compliant full drive guard covering flywheel and coupling, with view port for determining unit rotation and designed for ease of removal

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MOTOR

Siemens or equal electric motor driver:

HP rating	1800
Speed	1200 RPM
Power rating	4160V/3Ph/60Hz
Enclosure Type	WPII
Air Filters	Stainless Steel
Differential Pressure Switch	Yes
Insulation Class	F
Temperature Rise	B
Service Factor	1.15
Elevation	3300 FASL
Maximum Ambient Temperature	40°C
Fixed Speed Operation	No
VFD Compatible	Yes
Starting Method	VFD

Additional features include:

- Space heater (120/240V)
- Rotachock (or equal) mounts
- Manufacturer's routine non-witnessed tests only are included
- Suitable for installation in a Class 1 Division 2 Group D hazardous area, T2B temp code (area classification and temp code to be confirmed by customer)
- Manufactured in Norwood, OH USA
- Variable Frequency Drive (VFD) manufactured by Siemens Model #6SR42020DG422AJ0-Z, shipped loose.

MOTOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) Metrix vibration transmitter
- Winding RTDs, 100 Ohm platinum, 2 per phase

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- Bearing RTDs, 100 Ohm platinum, 1 per bearing
- Wired by others to customer provided MCC

Note – Motor starter to be installed off-skid by others with power wiring between starter and main drive motor by others. Electrical design for power systems and subsystems supplying the compressor main drive motor is the responsibility of the contractor.

PROCESS AIR COOLER

Air-X-Changers (or equivalent) box header heat exchanger for process gas cooling as described below:

- One cooler per package, 3 x 50% design
- Mounted off-skid, interconnecting piping from skid edge to cooler is by others
- Cooler driven by VFD compatible, 480V 30hp electric motor with space heater
- Murphy VS-2EX vibration switch
- Standard enamel paint with tint to match as required
- Manufactured in Tulsa, OK USA
- Fan motor starter by others, power wiring by others.

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PROCESS GAS SECTION(S)

- IC section temperatures 119°F (20°F approach, based on 99°F ambient performance)
- Recycle section temperature 119°F (20°F approach, based on 99°F ambient performance)
- Fouling factor 0.001
- Corrosion allowance 0”
- Tubes SA-214 (welded carbon steel)
- Headers SA-516-70 (carbon steel)
- (3) sets automatic discharge louvers with pneumatic actuators and Kimray T12 temperature controllers, individual per stage
- Spot RT examined headers
- 1” npt thermowell connection opposite outlet nozzles
- ASME code stamp with national board registration

SUCTION SCRUBBERS

Scrubbers have been provided at the inlet of each stage of compression for removal of liquids (bulk liquid removal such as slugs has not been considered for design) as described below:

Scrubber	O.D.	S/S	MAWP	Temp.	Internals	C.A.	Material
Stage 1	26"	100"	150 PSIG	150°F	Vane Pack	0"	Carbon Steel
Stage 2	22"	94"	215 PSIG	150°F	Vane Pack	0"	Carbon Steel
Stage 3	20"	84"	300 PSIG	150°F	Vane Pack	0"	Carbon Steel

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- Vane Mist Extractors and mesh type mist eliminators are designed to remove 99.9% of all liquid entrainment 8 microns and larger which is present in the processed gas stream, carry-over of 8 micron and larger entrained liquids will be less than 1/10 gallon per million standard cubic feet of processed gas
- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell
- Flange bolt-holes shall straddle the bottle centerline
- Located on-skid, each scrubber cascaded to previous scrubber and brought to single skid edge connection

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SUCTION SCRUBBER TRIM

- Level gauge, reflex style – Penberthy RL (3/4" NPT)
- Level switch (high shutdown), electric – Murphy LS200 (2" NPT)
- Level controller, pneumatic – Murphy LS200NDVOR (2" NPT)
- Automatic dump valve, pneumatic – Murphy DVU150 (1" NPT)
- Manual drain valve – 1" NPT ball valve
- Check valve – 1" NPT piston check

PULSATION BOTTLES

Pulsation bottles have been provided at the suction and discharge of each stage of compression based on the sizing criteria of API 11P with no vessel internals with preliminary sizing as described below:

Bottle	O.D.	S/S	MAWP	Temp.	C.A.	Material
1st Stage Suction	36"	64"	150 PSIG	150°F	0"	Carbon Steel
1st Stage Discharge	24"	64"	215 PSIG	350°F	0"	Carbon Steel
2nd Stage Suction	24"	26"	215 PSIG	150°F	0"	Carbon Steel
2nd Stage Discharge	16"	26"	300 PSIG	350°F	0"	Carbon Steel
3rd Stage Suction	16"	22"	300 PSIG	150°F	0"	Carbon Steel
3rd Stage Discharge	12.75"	22"	645 PSIG	350°F	0"	Carbon Steel

- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping and cylinder nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell

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- All suction bottles have “Vee” notch connection to the cylinder to prevent puddling of any liquids that could accidently exist
- Pulsation bottles include two inspection openings, vent, drain, pressure and temperature connections, per spec items#54 & #55
- Base price includes API 618, 5th Edition Design Approach 3a studies (formerly M2-M5)

PIPING SYSTEMS & DESIGN

All piping provided on skid shall be designed and built in accordance with below:

PROCESS PIPING

Process piping provided per preliminary sizing and general criteria as described below:

Pipe Run	Nominal Size	Flange	Material	Rating
1st Stage Suction	18" STD	150#RF	Carbon Steel	150 PSIG @ 150°F
1st Stage Discharge	12" STD	150#RF	Carbon Steel	215 PSIG @ 350°F
2nd Stage Suction	12" STD	150#RF	Carbon Steel	215 PSIG @ 150°F
2nd Stage Discharge	8" S/40	300#RF	Carbon Steel	300 PSIG @ 350°F
3rd Stage Suction	8" S/40	300#RF	Carbon Steel	300 PSIG @ 150°F
3rd Stage Discharge	6" S/40	300#RF	Carbon Steel	645 PSIG @ 350°F
Final Discharge	6" S/40	300#RF	Carbon Steel	645 PSIG @ 350°F

- Process Piping Code: B31.3
- Non Destructive Examination: Per Code (Radiography or Phased Array)
- Corrosion Allowance: 0.000”
- Hydrotest: 1.5 times design pressure
- Carbon Steel Material: SA-106B
- Suction Connection: Suction scrubber flange
- Discharge Connection: Skid edge

PIPING DESIGN

Design of the piping systems shall be as follows:

- The process pipe shall be sized based on a maximum gas velocity of 3000ft/min or by pressure drop calculations where applicable
- All piping greater than 2” nominal shall be buttweld and schedule STD minimum
- All piping 2” and smaller shall be socketweld or threaded and schedule 80 minimum
- All process and auxiliary gas piping 1” shall be socketweld or threaded and schedule 160
- Socketweld piping to be visually inspected, radiography not provided
- Flanges shall be raised face and rated in accordance with ANSI B16.5
- Flange gaskets shall be flexitallic and bolting studs shall be grade B7
- Pipe fittings shall be 3000 PSI for gas and auxiliary piping as a minimum, and may be socketweld or threaded
- All welded pipe is hydrotested

PROCESS INSTRUMENTATION

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In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- Suction pressure transmitter at inlet of package
- Suction pressure gauge at inlet of package
- Discharge pressure transmitter, per stage
- Discharge pressure gauge, per stage
- Temperature element, per cylinder discharge
- Temperature gauge, per discharge of each stage
- Please advise if additional instrumentation is required

GENERAL TUBING

General tubing, typical, as described below:

- Threaded carbon steel instrument air manifold with isolation valves for each device
- All tube fittings shall be stainless steel compression fittings
- All tubing shall be stainless steel

CAPACITY CONTROL SYSTEMS

The following methods of capacity control have been included:

1. Variable volume clearance pockets (VVCP) on the compressor cylinder(s)
2. Automatic recycle capacity control valve
3. Motor speed turndown (VFD)

SYSTEM VALVES

System valves included in UEC scope of supply as described below:

- Suction pressure control valves – see Suction Pressure Control Valve Skid below for details
- Automatic recycle valve, 2"-300#RF Fisher V200 with Fisher DVC6200 digital positioner for capacity control and startup
- Manual blowdown valve, 1"-300#RF ball valve
- Contractor to provide inlet and outlet isolation valves in interconnecting piping.

System valves shall be provided as per the following guidelines:

- Ball valves to be full port with carbon steel body and carbon trim (ball & stem)
- Large bore (greater than 2") ball valves to be KF or equal
- Small bore ball valves to be KF, Apollo or equal
- Small bore globe valves, check valves to be Bonney Forge or equal

RELIEF VALVES

Process relief valves as described below:

- Farris, Mercer or equal
- Thermal relief valve for suction scrubber
  - Threaded conventional spring type valve
  - Full flow relief protection sized for any upset conditions upstream of package by others
- Full flow relief valves for discharge of each stage of compression
  - Flanged conventional spring type or pilot type valve(s)
- Relief valves and blowdown manifolded and brought to single common skid edge connection

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CONTROL PANEL & ELECTRICAL

Each compressor package shall have controls and electrical as outlined below:

CONTROL PANEL

Complete compressor logic control panel rated for Class 1, Division 2, Group D with alarm, shutdown and control items as described below:

- Allen Bradley ControlLogix – *Simplex Processor*
- PanelView Plus 19" HMI (maximum screen size available)
- Collapsible HMI Sun shield
- Ethernet switch for Modbus communications with Fiber Optic
- Enclosure built to NEMA 4 specifications
- Panel mounted and wired on-skid
- 20% spare terminal blocks for future connections
- UL698B listed assembled control panel for installation in a classified area
- Individual fuses for all PLC modules and HMI
- Notifications of alarms and shutdowns to protect compressor package
- Common relay contacts for dry contact remote start, run enabled and annunciation
- Suitable for customer-supplied primary power of 125 VDC and customer-supplied secondary power of 120 VAC. Our panel has this capability by including separate/redundant 24VDC Power Supply modules, with one accepting 125VDC and the second accepting 120VAC.
- One set of licensed software for the ControlLogix PLC & PanelView Plus HMI included for all three panels. If additional copies are required, they are available for a price adder.

INSTRUMENTATION

Instruments as described below:

- All instruments and electrical devices shall be suitable for installation in a Class 1 Group D Division 2 hazardous area
- In general, installation of pressure and temperature devices as follows:
  - Instrument connections in piping provided by thredolet unless otherwise noted
  - Pressure instrument shall be supplied with threaded instrument valve when installed in piping. Pressure gauges shall be mounted at or near the valve, pressure transmitters may be rack mounted near control panel or junction box (if provided).
    - § Instrument valves to be threaded stainless steel gauge (needle) type block and bleed valve – Anderson Greenwood (M25VIS) or equal
    - § Root valve provided upstream of instrument valve, socketwelded carbon steel ball valve
    - § Pulsation dampeners provided for pressure instrumentation
  - Temperature instrument shall be supplied with a stainless steel threaded thermowell when installed in piping. The instrument shall be mounted at the thermowell. Temperature elements are to be wired directly to control system (no transmitter).
- UEC standard P&ID tagging with wire can be provided for instrumentation upon request
- Instrumentation has been provided as follows (or approved equivalent):

Instrument	Make	Model

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Pressure Transmitter	Rosemount	3051T with LCD display
Pressure Indicator	Ashcroft	1279
Differential Pressure Indicator	Orange Research	1201/1203/1516
Temperature Element	Thermocouple	Type K
Temperature Indicator	Ashcroft	EL
Vibration Transmitter	Metrix	ST5484E
Vibration Switch	Murphy	VS2EX
Level Switch	Murphy	LS200
Level Control	Murphy	LS200NDVOR
Level Gauge	Penberthy	RL
Oil Controller / Gauge / Switch	Kenco	LCE
No Flow Switch	Dresser-Rand	DNFT 24 VDC

CONDUIT AND WIRING

General conduit and wiring, typical, as described below:

- All conduit and wiring shall be installed in accordance with the NEC for installation in a Class 1 Group D Division 2 hazardous area
- Weather-tight, rigid conduit with liquid-tight, flexible conduit pigtails and THHN or MTW #14 copper stranded internal wiring
- Armored cable and cable trays available upon request for optional price adder

CONTROL TUBING

All tubing is 316L stainless steel with Parker or Swagelok 316L stainless steel compression fittings.

STRUCTURAL STEEL FRAME

Structural steel frame with preliminary dimensions as described below:

- Estimated Skid Width: 19'0"
- Estimated Skid Length: 30'0"
- Estimated Package Height: 12'6"
- Estimated Shipping Weight: 130,000 LBS
- Frame is welded using A-36 steel in accordance with AWS D1.1
- All welders are certified and all procedures are qualified
- Pipe drawbars or lifting lugs at each end of skid
- 2" drip lip around compressor package
- (2) grounding lugs provided on opposite corners of skid

SOUND ENCLOSURE

Sound enclosure with equipment as described below:

- Single enclosure mounted on concrete around perimeter of all three compressor skids
- All equipment to be Class 1, Division 2, Group D
- Noise level outside enclosure guaranteed to be 85dBA or less at 3 feet
- Preliminary dimensions of 38'x82'x15' high
- Blow out panels
- Forced air ventilation system
- Temperature element wired to control panels to shutdown on high air temp inside building

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- Electric heater
- UV Fire Detection & gas detectors
- Control panel with battery back-up for fire and gas detectors
- Control panel has a Z-purge and is mounted on the exterior of the enclosure

PAINTING AND PREPARATION

Painting and preparation as described below:

- Standard UE Compression Type 4 paint system as follows:
  - SSPC-SP6 sandblast of non-painted items, including skids, vessels and process piping. Pre-painted items will be cleaned and top coated only. All other piping will be prepped by SSPC-SP1, 2 or 3, primed and top coated.
  - Tnemec or equal high build epoxy primer, 4-6 mils (dry).
  - Tnemec or equal Series 73 polyurethane enamel top coat, 2-3 mils (dry).
- Color: UE standard paint color gray, single monolithic color only

SHOP TESTING

Shop testing described below:

- Functional checkout of all end devices
- Leak testing of gas and pneumatic control systems
- Full shop alignment of motor and compressor
- No load run test of compressor package not provided as adequate power is not available

MATERIAL COUNTRY OF ORIGIN

Unless otherwise agreed to, standard country of origin shall apply for all directly sourced materials. 3rd party equipment (compressor, driver, etc.) subject to vendor's standard country of origin.

Standard countries: USA, Canada, Mexico, Great Britain, Spain, Germany, France, Austria, Switzerland, Portugal, Italy, Belgium, South Africa, South Korea, and Japan.

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Gas fuel system

Ref: Attached P&ID

General description of the system

The gas fuel system supplies the gas turbine combustor with a controlled flow of gaseous fuel.

The system receives gas from the customer gas fuel supply. The gas fuel system is installed inside the GT package except for isolation valves installed just outside the GT enclosure wall. If an external gas fuel unit is included (optional supply from Siemens), this unit is installed separately outside the GT package.

The gas is passing the isolation valves, the strainer, two quick shut off valves and is then distributed to the pilot- and main gas manifolds that supplies the fuel nozzles. Separate control valves control the flow to their respective manifolds.

A small portion of gas is also distributed separately to burner No.6 to establish an ignition flame during start up. A spark plug is therefore located close to this burner.

Gas fuel supply temperature and pressure are supervised by instruments in the system.

In order to avoid corrosion/erosion, stainless steel gas fuel supply piping is always used downstream the strainer. The gas piping in the GT package is seamless and generally acc. to ASTM A312-TP 316/316L quality, imperial dimensions.

The gas manifolds are connected to the purge air system. If the gas turbine is operated on liquid fuel, the gas nozzles are continuously purged with air.

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Function

Start up

When starting, the isolation valve is opened and the vent valves are closed. When the automatic leakage test of the quick shut off valves is completed and the ignition flame for burner No.6 is detected, the quick shut off valves open. The pilot gas control valve regulates the gas flow injected for main ignition. When main ignition is completed, the gas supply for burner No.6 is switched from the ignition gas line to the normal gas supply from the pilot manifold. At increasing load, main gas is introduced through the main gas control valve.

If the turbine is provided with a liquid fuel system, then LPG/Propane is used for ignition of burner No.6. A small cabinet with 2 x 100% LPG/Propane bottles is therefore installed outside the GT package, together with the liquid fuel skid. Each bottle will last for approximately 30 starts.

Continuous operation

Gas is injected to the combustor via the manifolds and through the nozzles. The gas flow is regulated by the gas control valves. At full load operation, main part of the fuel is distributed to the main gas nozzles, only a minor part of the fuel is distributed to the pilot gas nozzles.

Shut down

During turbine stop the load/speed of the turbine is ramped down. When the load/speed has reached a pre-set value, the turbine is stopped. Thereby the fuel quick shut-off valves close and the control valves are set to minimum position. Simultaneously, the isolation valve closes, the ventilation valve between the quick shut off valves opens and blows off the trapped gas between the shut-off valves to the atmosphere.

Standstill

The isolation valve and the quick shut off valves are closed. The vent valve between the quick shut off valve is in open position. Control valves are in minimum position.

In case of emergency shut down, fire, gas detection or GT ventilation failure/stop, the vent valve between the isolation valve and the quick shut off valves opens to blow off the gas. This is done to ensure no gas is entering the GT package during these conditions.

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Instrument & operating air system

Ref: Attached P&ID

General

Reliable instrument air is required during all modes of operation. Normally the external air system is provided by the customer, but the supply system can be offered as an option item.

Consumption

Instrument air consumption at different stages[1]:

	Start and operation of gas turbine Nm³/h (scf/h)	Stop of gas turbine up to 30 min. Nm³/h (scf/h)	Compressor washing (offline) for 30s of nozzle and pipes clean blowing Nm³/h (scf/h)
Fuel application			
Gas fuel only	**1,5 (53)**	**1,5 (53)**	**13 (459)**
Dual / Liquid fuel	**1,5 (53)**	**81 (2860)**	**13 (459)**

[1] If a pulse clean filter is used, the consumption will be increased with 44 Nm3/h / 1554 scf/h. The pulse sequence is normally active during 15 to 30 minutes after initiation, or continuously in case of extreme environmental conditions. Final air consumption is decided during project engineering.

FO / SGT-600(PG B, MD B, PG Ex B)/&DB101

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Data

Design pressure:	10 bar(g)
Required pressure: (with PCAIF)	7.5 ±0.5 bar(g) / 109 ±7.25 psi(g)
Minimum pressure for operation: (with PCAIF)	6.0 bar(g) / 87 psi(g)
Required pressure: (without PCAIF)	6.0 ±0.5 bar(g) / 87 ±7.25 psi(g)
Minimum pressure for operation: (without PCAIF)	5.5 bar(g) / 80 psi(g)
Dew point[2,3]	20°C/36°F below minimum ambient temperature
Maximum particle size[2]	1 µm / 0.04 mils
Maximum oil content[2]	0,1 mg / Nm³ / 6.25 x 10e-9 lb/ft
Maximum temperature	70°C / 158°F
Minimum temperature[4]	-30°C / -22°F
Normal consumption during operation:	< 1,5 Nm³/h / 53 scf/h
Maximum consumption during operation for Gas fuel only:	1,5 Nm³/h / 53 scf/h
Maximum consumption Liquid fuel only and Dual fuel:	81 Nm³/h / 2860 scf/h (for 30 minutes of clean blowing phase and cooling manifolds during standstill)
Compressor washing (off-line):	13 Nm³/h /459 scf/h (for 30 seconds of nozzle and pipes clean blowing)
PCAIF consumption:	Add 44 Nm³/h /1554 scf/h

Note: PCAIF = Pulse Clean Air Intake Filter.

[2] Requirements of compressed air purity typically apply to ISO 8573-1 Class 2/1 - 3/2 (Particle Size / Dew Point / Oil Content).
[3] The temperature value mentioned against dew point is the marginal temperature value. (For example: If the minimum ambient temperature of site is +5° C then customer has to design the dew point to -15° C or below.)
[4] Minimum temperature specified in this document applies to components like valves, actuators, solenoids & filters in the instrument air system (not for pipes). If the instrument air temperature is below -30°C, there are other options to protect these components.

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SIEMENS	Auxiliary systems SGT-600, SGT-700	GTI number		J491010E	
		Document number		1CS26617	
		Revision	M	Page	1

Compressor washing system

On-line and off-line mobile washing unit for compressor washing including on-package fixed piping and permanently installed nozzles. Washing unit includes instrumentation, make-up and drain valves, flexible hoses and power cabling. Draining is included on gas turbine package. Washing is operated locally on package, on condition washing enabled from unit control panel/human machine interface. Off-line washing is not allowed during standstill, start-up and on-load operation of gas turbine.

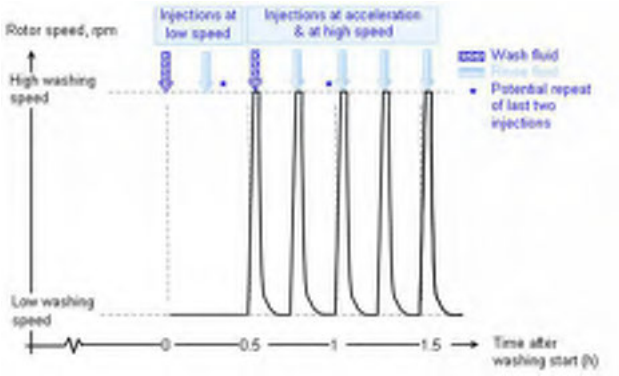
Washing is restricted to temperatures above -10°C (14°F). Anti-freeze agents shall be used below water temperatures of +5°C (41°F) for off-line washing, and +12°C (53.6°F) for on-line washing.

Pollution deposits from ambient air may, over a period of time, result in fouling, reduced flow capacity and loss of compressor efficiency. Severe fouling can even cause surging or rotating stall. Following the recommended washing instructions will optimize gas turbine performance, efficiency and exhaust emission levels.

Preparations for off-line washing

- Cool down to maximum 100°C (212°F) in the air/gas path before washing, 4 hours.

Washing cycle off-line



FO / SGT-600(MD B, PG B, PG Ex B) SGT-700(MD B, PG B, PG Ex B) / &DB101	

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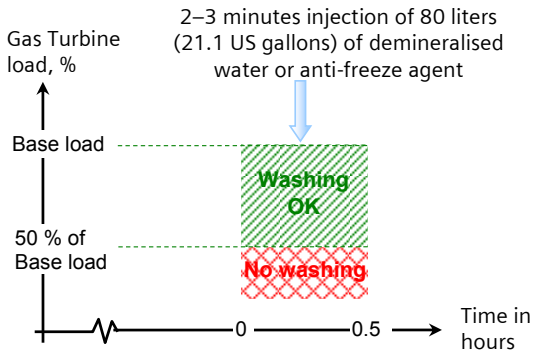
Recommended intervals for on-line washing; recommended to be performed every 24 hours of operation.



Technical data

Washing unit	
Tank/s	Plastic (polyethylene) Tank/s with a total capacity of 95-100 liters (25.1-26.4 US gallons)
Wheels	Four with inflatable rubber tires.
Ingress protection (Electrical Components)	≥IP55
Power supply	3 Phase, 16A fuse
Flow rate	21 liters/min
Pipes and hoses	Pipe material: SS316 Stainless steel; Suction and drain hoses material: reinforced PVC.
Flexible hose and power cable	Length: 10 meters each
Injection pressure	50-60bar(g) / 725-870Psi(g)
Cleaning agents Water quality	W491023E "Recommended products for compressor cleaning" W220027E "Guidelines for water and steam quality in gas turbine"
Electrical connection	Receptacle on gas turbine package
Fluid amounts, complete wash cycle	200 liters of water 80 liters of cleaning agent

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Equipment on the package	
Nozzles	Four nozzles. Material : SS316 stainless steel
Nozzle filter	125 µm mesh size brass

Additional equipment available, refer to the scope of supply for inclusion.	
External drain tank	1200 liters (317 US gallons) holding drainage from 30 injections of 40 liters to complete washing cycles. Material: UV stabilized polyethylene. All metal parts made of SS304 stainless steel. EPDM rubber gaskets. Local level indicator clock-type Ø 70 mm. Air operated diaphragm type drain pump with operating pressure 2-3bar(g). Material: aluminum with nitrile butadiene rubber diaphragm and nitrile butadiene rubber ball valve.
ATEX	Approved Zone 2 Application with electrical ATEX approved Zone 1 material, T3, Gas Group IIB (II 3G Ex IIB T3), IP56

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SIEMENS	Auxiliary Systems SGT-600, SGT-700	GTI number		W491021E	
		Document number		1CS26763	
		Revision	H	Page	1

On- line washing

The overall benefit of using on- line washing has been widely questioned by both Users and Suppliers. This is mainly due to an apparent increase of maintenance cost on units utilising on-line systems and subsequent lower availability due to need for more maintenance (more long term deterioration), which can offset the gain in revenue from the temporarily better output power from the gas turbine.

As a gas turbine supplier Siemens supports the market's opinion and Siemens recommendation is firstly to prevent dirt entering the engine as far as possible, by high efficient combustion air intake filters and thus extending the time between washings. Secondly, when washing is necessary, off-line washing is the preferred method. With off-line washing the dirt is drained out from the engine at the position it builds up.

On-line washing can give a long-term degradation of the engine, as dirt is likely to be transferred from the first stages to both the rear stages of the compressor and to the turbine stages. On-line washing is only suggested in combination with very good air filtration and when cost for shut down for off-line washing is very high.

Siemens do not recommend using detergent at on- line washing, only clean water and alcohol type anti freezes additive when required. Due to the relative high velocity in the compressor inlet and hence temperature depression, the static temperature in the inlet is significantly lower than the ambient temperature. On- line washing without anti freeze mixture must then not be performed below a certain ambient temperature level. Otherwise ice formation may occur in the compressor inlet (e.g. on the bell mouth or the IGV) during on- line washing, possibly causing impact damage to the compressor blading.

If on-line washing is to be used to prolong the intervals between off-line washings, the effect of carrying out the on-line washing has to be carefully evaluated in each specific case.

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SIEMENS	Auxiliary Systems SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W491023E	
		Document number		1CS26764	
		Revision	T	Page	1

Recommended products for compressor cleaning.

The following products fulfil the requirements in MAT900001 and are recommended for compressor cleaning in SGT-600, SGT-700, SGT-750 and SGT-800 gas turbines.

Cleaning agents

The cleaning agents in table 1 are recommended for off-line and on-line cleaning in accordance with relevant operation and maintenance instructions. The cleaning agents in table 1 are suggestions and should not be viewed as a single option. Siemens Industrial Turbomachinery AB recommends that only demineralised water is used for on-line cleaning. Only for persistent deposits, a cleaning agent may be applied.

Solvent-based cleaning agents shall not be used for gas turbines operating at arctic conditions (-50°C to +40°C) since these have O-rings made of hydrogenated nitrile rubber (HNBR). Solvent-based cleaning agents compromise the structural integrity of the O-rings.

Table 1. Cleaning agents.

Cleaning agents	Manufacturer
Turbotect 927, solvent based	Turbotect AG, Postfach 1411, Badstrasse 15 (Mäderhof), CH-5401 Baden, Switzerland Tel. +41 56 200 50 20, Fax +41 56 200 50 22 http://www.turbotect.com
Turbotect 950, water based	
Turbotect 2020, water based	
ZOK 27, water based	Airworthy Ltd., Elsted, Midhurst, W. Sussex, GU29 0JT, England Tel. +44 1730 811920, Fax +44 1730 811930 http://www.zok.com
Fyrewash F1, solvent based	Rochem Technical Services (Europe) Ldt., 11 Sun Valley Business Park, Winnell Close, Winchester, Hampshire SO23 0LB Tel. +44 1962 890089, Fax +44 1962 890090 http://www.rochem.net
Fyrewash F3, water based	
Turbo-K, water based	FP Turbomachinery Consultants GmbH, Wiesenstrasse 57, 79312 Emmendingon, Germany Tel. +49 7641 55346, Fax +49 7641 55319 http://www.turbo-k.co.uk/
Conntect 5000, water based	Conntect Inc., 332 Federal Road, Brookfield, CT/USA Tel. +1 203-775-8445, Fax +1 203-775-9339 http://www.conntect.com
Protoklenz GT, water based	Minco UK Ltd, Mr. Bob Gronski, 6 Castle Rise, London Road, Stroud GLOS GL5 2 AW, England , Tel. +44 1453 764 149, Fax +44 1453 764 008 http://www.minco.org

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Anti-freeze agents

The recommended anti-freeze agent can be used down to –10°C (14 °F) and it is compatible with both water and solvent based cleaning agents in table 1. Anti-freeze agents have to fulfil the same requirements concerning purity as the cleaning agents according to MAT900001.

The anti-freeze agent in table 2 may be used both for off-line and on-line washing.

Table 2. Anti-freeze agent.

Anti-freeze agent	Manufacturer
Turbotect ARF-301,	Turbotect AG, Postfach 1411, Badstrasse 15 (Mäderhof), CH-5401 Baden, Switzerland Tel. +41 56 200 50 20, Fax +41 56 200 50 22 http://www.turbotect.com

Table 3. Anti-freeze agent.

Anti-freeze agent	Manufacturer
GTC Frostex	Skyline Technologies BV, Mient 201, 2564KL, Den Haag, Netherlands Tel. +31 70 3232060, Fax +31 70 3232635

The anti-freeze agent in Table 3 is recommended only for off-line washing. The anti-freeze agent is a "ready-to-use" mixture of water, cleaning agent (ZOK 27), and anti-freeze. The anti-freeze agent can be used down to –10°C (14 °F) and it is compatible with ZOK 27.

If organic solvents are used as anti-freeze like alcohol's (methanol, ethanol or isopropanol), it is important to adhere to local regulations concerning operational security.

General information and recommendations

The recommendation of products must not be considered as an acknowledgement of the products ability to efficiently clean the compressor blading, but is a statement of its compliance with requirements regarding purity and operability.

SIT AB reserves the right to withdraw any product from the above given lists, in case of quality failure of commercial deliveries (which are considered out-of-specification), deviations from submitted and approved specifications or adverse effect on gas turbine operation.

SIT AB recommends using water based products. Only for persistent organic deposits, a solvent-based product may be applied. The recommendations of the cleaning agent supplier for proper concentration of the product and waste treatment shall be followed.

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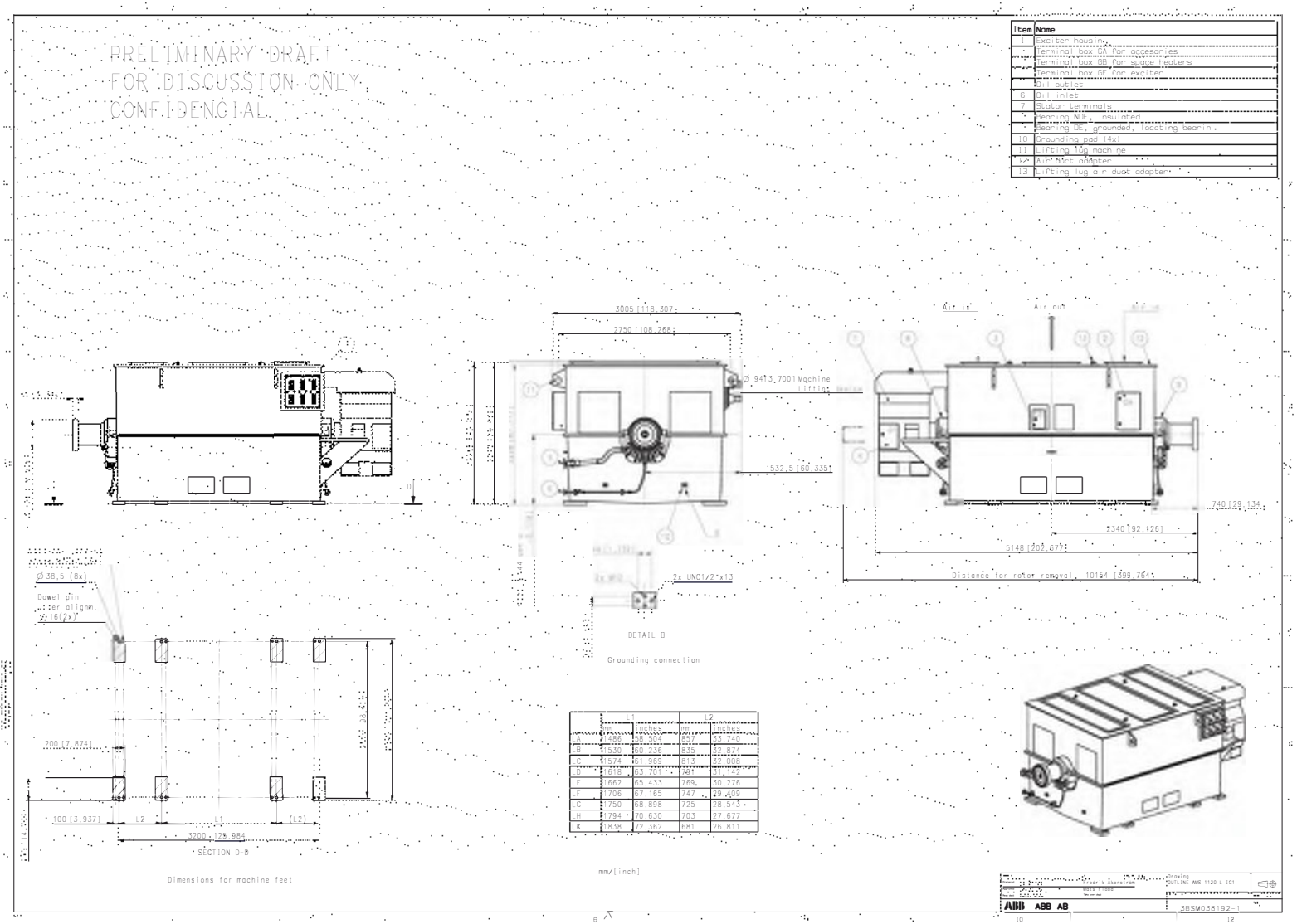

	L1		L2	
	mm	inches	mm	inches
LA	1486	58.504	857	33.740
LB	1630	60.236	835	32.874
LC	1574	61.969	813	32.008
LD	1618	63.701	781	31.142
LE	1662	65.433	769	30.276
LF	1706	67.165	747	29.409
LG	1750	68.898	725	28.543
LH	1794	70.630	703	27.677
LK	1838	72.362	681	26.811

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TECHNICAL SPECIFICATION FOR BRUSHLESS SYNCHRONOUS GENERATOR

CLIENT	**:**	**Siemens Industrial Turbomachinery AB**
PROJECT	**:**	**PVSC**
TYPE	**:**	**AMS 1120LA 4P BS**
OUR REFERENCE	**:**	**SET18251-01**
DRIVEN EQUIPMENT	**:**	**Gas turbine**
DATE	**:**	**2018-09-10**

INDEX

1. Technical Specification
2. Included accessories
3. Position notes, Specification comments and Validation notes
4. Documentation
5. Tests and Certificates
6 A. Rated data
6 B. Standards
6 C. Other performance data
6 D. Site conditions
6 E. Starting characteristics
6 F. Installation data
7 Short Circuit Equations
8 Curves" "

Prep.	Carl Regnstrom 2018-09-10	Project	PVSC			
Appr.		Client	Siemens Industrial Turbomachinery AB			
Title	Technical Specification Synchronous Machine	Our reference	SET18251-01			
		Resp. dept	DMMG / MHS Status Draft			
ABB	ABB AB	Doc. no.	XYK210045-XXX	Lang. en	Rev. ind. A	Page 1 / No. of p. 20

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1. Technical Specification

ABB type AMS 1120LA 4P BS brushless synchronous Generator rated
Power =25882 kVA,
PF =0.85 (Overexcited),
PF =0.9 (Underexcited),
Voltage =13800 V,
Frequency =60 Hz,
Speed =1800 rpm,
for installation in safe area.Designed for Gas Turbine.
Designed according to NEMA MG1.

2. Included accessories

2.1 Standards and Site Conditions

- IBC level 2 (Ss ≤ 1,5g and S1 ≤ 0.625g)

2.2 Main Mechanical Data

- Cooling arrangement: IC3 A1. Inlet and outlet duct through base or above from the surrounding, self circulation.
- Counter clockwise direction of rotation at drive end, facing shaft end.
- Protection of machine IP00. IP54 with duct and filter connected. Final IP degree depending on final duct and filter design
- Temperature rise, rotor within class B
- Temperature rise, stator within class B

2.3 Excitation

- Main brushless exciter type GLB 600C for DC excitation complete with diode bridge, thyristors, RC-circuits and control box.
- Mini circuit breaker - PMG over current protection.
- PMG

2.4 Shaft Extensions

- Flange diameter 548 mm
- Flanged shaft end with internal spigot in DE

2.5 Bearings

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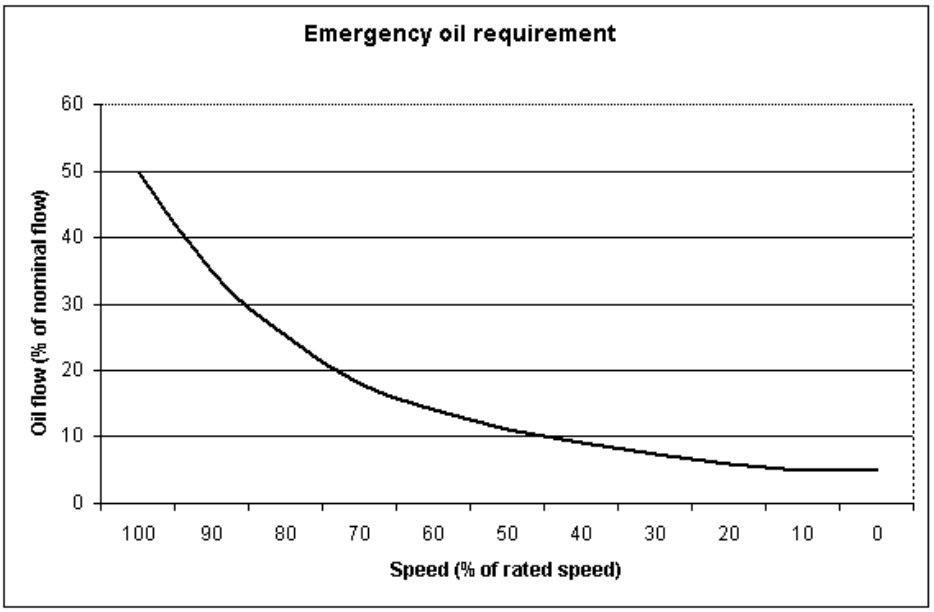
- Bearing size GL315
- Complete bearing oil connection system to common point, stainless in- and outlet, ANSI
- Forced lubricated sleeve bearing.
- Oil connection at left side of machine seen from DE, location at DE.
- Oil inlet flange: ANSI 3/4" Cl 150
- Oil outlet flange: ANSI 2½" Cl 150
- Orifice in fitting for reduction of oil pressure
- The lube oil drain pressure must be less than or equal to the machine ambient pressure. An oil drain pressure of 200-1000 Pa lower than the bearing ambient is recommended.

Bearings not equipped with oil ring



2.6 Main Terminal Boxes and Related Accessories

- Heaters in main terminal box, safe area, 120 V single phase supply
- Main terminal box located on the left side, seen from DE
- MainTerminal Box supply cable entry from below. Gland plate is removable, undrilled and of non magnetic material.
- Standard large air insulated Main Terminal Box
- The main terminal box is delivered as a loose item, assembly on site is not included in ABB's scope of supply.
- The main terminal box needs to be supported from beneath. Supports are not included in ABB's scope of supply.

2.6.1 Line side

- 3 Current Transformers, 3 cores, 2000/1-1-1A, class 0.3 B-0.5 / C200 / C200
- 3 Surge Arrestors

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- 3 Surge Capacitors single phase
- 3 Voltage Transformers
- Earting device 3-phase ball bolt including earthing equipment.

2.6.2 Neutral side

- 3 Current Transformers, 4 cores, 2000/1-1-1-1A, class 0.3 B-0.5 / C200 / C200 / C200

2.6.3 Neutral point

- 1 Current Transformer, 2 cores (included in MTB)
- MV contactor (included in MTB)
- NGR (400 A, 10 s) in separate enclosure (IP23)

2.7 Monitoring and Protection Accessories

RTD's according to IEC 60751, class B
- 1x RTD in warm machine air, duplex (Pt100), 3 wire, unshielded.
- 1x RTD per Bearing Shell, duplex (Pt100), 3 wire, unshielded
- 2x RTD in cold machine air, duplex (Pt100), 3 wire, unshielded (mounted at NDE + DE)
- 12 x RTD's in stator windings, single (Pt100), 3 wire, unshielded, safe and hazardous area
- Heaters in both main machine and exciter, safe area, 120 VAC 1 phase supply. The heaters should always be connected during stand still to avoid condensation.

- Anticondensation heaters in the main machine	V, ph, W :	120, 1, 5200
- Anticondensation heater in the exciter	V, ph, W :	120, 1, 650

- Painted carbon steel junction boxes with glands. Located at right side of machine facing DE.
- Prepared for bonding
- Shaft earthing brush mounted at DE.
- Vibration control, velocity type BN 330500 (3 probes(2oo3) in horizontal direction per bearing), safe area.

2.8 Special Design and Accessories

- Varnish of rotor coils
- Vibration level according to ABB standard (MDD 3AAM100425)

2.9 Painting and corrosion protection

- Standard gray colour (RAL 7032)
- Standard industrial coating acc. to ISO 12944 C3

2.10 Packing and Transportation

- Shrink film packing.

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2.11 Special components

3. Position notes, Specification comments and Validation notes

- Note! Heating is required for flange and shaft end when ambient temperature is below 0 °C

4. Documentation

- Installation and maintenance manual in English language. (one covering all identical units)
- Standard documents for Machine according to MDD 3AAM100439
- User's manual on CD, (1 copies) (one covering all identical units)

5. Tests and Certificates

- 2 weeks advance notice are given for FAT
- 1 weeks advance notice are given for work shop test and inspections (prior to FAT)
- Witnessed Routine and Type test according to ABB standard procedure

5.1 Routine tests

- Air gap measurement, unwitnessed
- Bearing heat run, witnessed
- Dielectric test, witnessed
- Magnetic neutral pos., axial play in bearing and distance shaft-end to footplate, witnessed
- Measurement of insulation resistance before and after dielectric test, witnessed
- No-load characteristics, witnessed
- Overspeed test, witnessed
- Phase sequence and terminal marking, witnessed
- Resistance measurement, unwitnessed
- Settings list for machine protection, unwitnessed
- Short-circuit characteristics, witnessed
- Vibration measurement during retardation or acceleration, witnessed
- Vibration measurements, witnessed
- Visual inspection of complete machine, witnessed

5.2 Type tests

- Determination of efficiency at rated P.F. and 100, 75, 50 and 25% load, unwitnessed
- Determination of rated excitation current, unwitnessed
- Determination of reactance Xd, Xd', Xd" and time-constant Ta, Td', Td", witnessed
- Determination of timeconstant (Td0'), unwitnessed (one covering all identical units)
- Heat run at P.F. = 0, witnessed (one covering all identical units)
- Sudden three -phase short-circuit test, witnessed
- Waveform analys TIF, witnessed (one covering all identical units)

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5.3 Special tests

- Adjustment of pressure reducing valve/orifice plate, unwitnessed
- Balancing of rotor complete, unwitnessed
- Control of seismic vibration units, unwitnessed
- Core ring test stacked stator, witnessed
- Dissipation factor (tan delta) measurement on complete winding, unwitnessed
- PMG, Output voltage and frequency, unwitnessed
- Radial bearing clearance, unwitnessed
- Test of main terminal box, unwitnessed
- Voltage and current balance, unwitnessed

5.4 Certificates

- Calibration certificate for all PT 100 elements
- Material check of blank for rotorbody
- Material check of blank to pole tips

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A. Rated data

at cooling air temperature 40 °C/ 104 F		
Machine type		AMS 1120LA 4P BS
Output	kVA	25882
Power factor (overexcited)		0.85
Voltage	V (±5.0 %)	13800
Frequency	Hz (±2.0 %)	60
Speed	rpm	1800
Current	A	1083
Exciter type		GLB 600C
Excitation	V / A	82 / 9
Power factor (underexcited)		0.90
Output (underexcited)	kVA	24444
Active output (underexcited)	kW	22000
Current (underexcited)	A	1023
PMG ratings:		
- Voltage AC	V	166
- Power factor		0.6
- Current	A	11.0
- Frequency	Hz	300
- Poles		20
- Phases		3

B. Standards

Applicable standards		NEMA
Insulation class stator and exciter		F
Insulation class main rotor		H
Temperature rise, stator within class		B
Temperature rise, rotor within class		B
Increased safety, Standards/Form		

C. Other performance data

Guaranteed efficiency at P.F. 0.85 and		
100 / 75 / 50 / 25 % load	%	97.96 97.67 96.94 94.40
Guaranteed efficiency at P.F. 1.0 and		
100 / 75 / 50 / 25 % load	%	98.34 98.09 97.46 95.27
Reactances:		
- X_d	(±15) %	134.7
- X_d' unsat/sat	" %	22.0 / 18.9
- X_d'' unsat/sat	" %	14.0 / 12.3
- X_q unsat/sat	" %	67.3 / 62.1
- X_q'' unsat/sat	" %	20.9 / 18.4
- X_0	%	6.0
- X_2	%	15.1
- X_L	%	10.4
Time constants:		
- T_d'	s	0.845
- T_d''	s	0.022
- T_{d0}'	s	6.067
- T_{q0}''	s	0.107
- Ta	s	0.150
Sub-transient short circuit current Ik''	(±15) %	814.5
Generator inertia constant		

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- H	s	1.30
Excitation main machine:		
- voltage no load	V	35
- voltage full load	V	71
- current no load	A	379
- current full load	A	776
Excitation exciter:		
- voltage no load	V	40
- voltage full load	V	82
- current no load	A	4
- current full load	A	9
Sudden short circuit current (peak)	kA	25
Short circuit ratio	%	80
Max. field forcing for 10 seconds	%	160
Sustained short circuit, stator current for 10 seconds at symmetrical conditions	%	263
Max. permissible overspeed (<2 min)	rpm	2250
Max. continuous negative sequence current	%	10
Fault condition capability $(I_2/I_N)^2t$	s	40
Voltage regulation acc. to IEEE 100, seventh edition		
- Regulation = (Et - E) / E	%	134
Overcurrent capability (I^2 - 1) t	s	37.5
this relationship shall apply for values of t between	s	10 - 60

Allowed current harmonic content, with base 25880 kVA

Harmonic	Amplitude [p.u]
5	0.02
7	0.017
11	0.012
13	0.011
17	0.01
19	0.01
23	0.009
25	0.006

If the current harmonic content is higher than above values, the temperature of the machine may rise above the specified limits

Permissible output at diff. temp.				
Cooling air temperature	°C/F	-20/-4	15/59	43/109
Output	kVA	35000	31400	23295
Power factor		0.85	0.85	0.85
Stator current	A	1464	1314	975
Exciter output	kVA	82	70	48
Exciter excitation	V / A	100 / 11	93 / 10	77 / 8
Efficiency at				
100 % load	%	98.10	98.07	97.87
75 % load	%	97.97	97.88	97.51
50 % load	%	97.52	97.33	96.68
25 % load	%	95.69	95.27	93.85

D. Site conditions

Ambient temperature range	°C	-20 - 43	F	-4 - 104

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Altitude	m a.s.l.	1000	ft.a.s.l.	3281
Hazardous area classification		Non hazardous area		
Seismic zone		Acc. to UBC, Zone 4		

F. Installation data

Protection form/cooling form		IP00 TEPV		
Cooling air:				
- Max external pressure drop in cooling ducts	Pa	600		
- Min cooling air flow	m³/s	11.2		
Heat losses:				
- Cooling air	kW	403		
- Lubrication oil at 65 °C	kW	21.3		
Arrangement form		IM 1005		
Shaft end according to drawing				
Sleeve bearings:				
- Max. permissible axial play towards D-end	mm	15.0	in.	0.591
- Max. permissible axial play towards N-end	mm	15.0	in.	0.591
- Max. permissible axial thrust	kN	0	lbf	0
- Min. barring speed	rpm	30		
- Rotor break away torque	Nm	5991		
- Required oil flow to bearings (Total)	l/min	45	gpm	11.9
- Oil temperature range to bearings	°C	40 - 65	F	104 - 149
- Required oil pressure at 65 °C	kPa	175	psi	25
- Supply oil pressure		To be advised by customer*)		
*)For setting of pressure reduction valve/orifice				
Default oil pressure*)	kPa	210	psi	30.5
*)Used if no value received from customer before FAT				
- Max supply oil pressure	kPa	500	psi	72.5
- Type of oil		ISO VG 46		
- Degree of purity for oil		17/15/12 acc. to ISO 4406:1999		
Weights (estimated):				
- Total (complete machine, excluding terminal box)	kg	41800	lb	92200
- Stator	kg	19600	lb	43100
- Rotor	kg	15600	lb	34200
Rotor inertia ($J=m*r_m^2$)	kgm²	1891	lb-ft²	44866
First bending lateral critical speed	rpm	>2070		
Direction of rotation (at drive end, facing shaft end)		Counter-clockwise		
Noise level (based on totally enclosed machine, at 1m, rated speed and no load acc.to ISO 3744)	dB(A)	85 dB(A)		

Forces on the foundation per stator side			
Static	Rated torque	2-phase short circuit	3-phase short circuit

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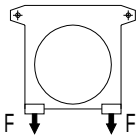	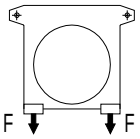	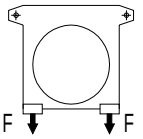	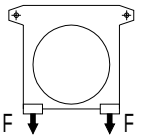
F = 205 kN F = 46075 lbf	F = 205 kN ± 47.6 kN F = 46075 lbf ± 10703 lbf	F = 205 kN ± 540.6 kN F = 46075 lbf ± 121536 lbf	F = 205 kN ± 497.6 kN F = 46075 lbf ± 111862 lbf
Forces on each inner foot (2 inner feet/side)*)			
F = 51.2 kN F = 11519 lbf	F = 51.2 kN ± 23.8 kN F = 11519 lbf ± 5352 lbf	F = 51.2 kN ± 270.3 kN F = 11519 lbf ± 60768 lbf	F = 51.2 kN ± 248.8 kN F = 11519 lbf ± 55931 lbf
Forces on each outer foot (2 outer feet/side)*)			
F = 51.2 kN F = 11519 lbf	F = 51.2 kN F = 11519 lbf	F = 51.2 kN F = 11519 lbf	F = 51.2 kN F = 11519 lbf
*)The foundation shall be dimensioned to withstand the maximum force at all feet positions.			

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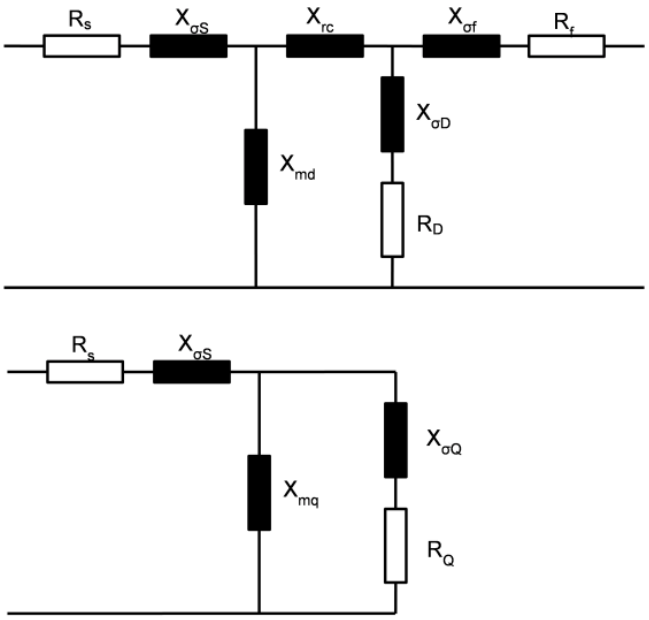
Generator type code: AMS 1120LA 4P BS
Equivalent circuit between phase and neutral (equivalent star)



REMARKS:
- All parameters have been calculated from design data. The stated values of the armature to rotor mutual inductances correspond to unsaturated operating conditions.
- The model is suitable only for dynamic simulations where the rotor speed remains close to synchronous speed at all times.

Stator resistance R_s	p.u.	0.0026
d-axis stator leakage reactance $X_{\sigma S}$	p.u.	0.1038
Canay reactance X_{rc}	p.u.	-0.0567
Field winding leakage reactance $X_{\sigma f}$	p.u.	0.2171
Field winding resistance R_f	p.u.	0.0007
d-axis main reactance X_{md}	p.u.	1.2432
d-axis leakage reactance of damper winding $X_{\sigma D}$	p.u.	0.1882
d-axis damper winding resistance R_D	p.u.	0.0780
Stator resistance R_s	p.u.	0.0026
q-axis stator leakage reactance $X_{\sigma S}$	p.u.	0.1038
q-axis leakage reactance of damper winding $X_{\sigma Q}$	p.u.	0.0313
q-axis main reactance X_{mq}	p.u.	0.5690
q-axis damper winding resistance R_Q	p.u.	0.0447

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Airgap torque equation - 3-phase short circuit

$T_e(t) = M_0 \, e^{-t/t_0} \sin wt + M_1 \, e^{-t/t_1}$

$M_0 = 9.09$; $M_1 = 1.78$; $t_0 = 0.107$ s ; $t_1 = 0.0978$ s ; $w = 377$ rad/s

Maximum value of torque $10.5 * T_N$, when t = 4.08 ms

Airgap torque equation - 2-phase short circuit

$T_e(t) = M_0 \, e^{-t/t_0} \sin wt - M_1 \, e^{-t/t_1} \sin 2wt + M_2 \, e^{-t/t_2}$

$M_0 = 7.48$; $M_1 = 3.76$; $M_2 = 1.9$; $t_0 = 0.168$ s ; $t_1 = 0.523$ s ; $t_2 = 0.288$; $w = 377$ rad/s

Maximum value of torque $11.4 * T_N$, when t = 5.55 ms

Rated torque $T_N = 119$ kNm

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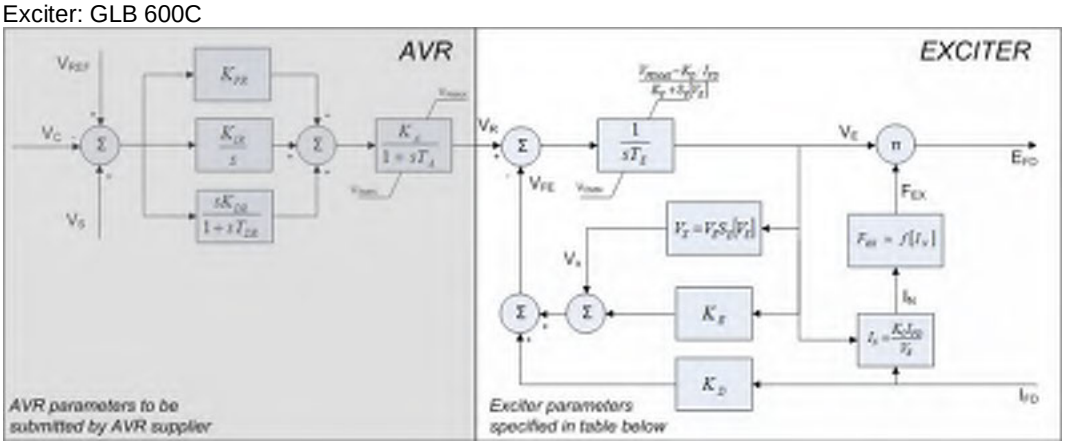
TRANSFER FUNCTION FOR BRUSHLESS AC EXCITER MACHINE WITH RECTIFICATION (IEEE STD. 421.5)
Excitation system for synchronous machine type: AMS 1120LA 4P BS
Exciter: GLB 600C



IEEE Std. 421.5 Type AC excitation system model. The illustrated model is Type AC8B.

The table below provides a computer representation of the brushless AC exciter with rectification in accordance with IEEE Std. 421.5.
Note that the AC exciter with rectification only constitutes one part of a complete AC excitation system model, as shown in the figure above.

IEEE 421.5 Type AC Model Parameter	Unit	Value
K_C		1.41
K_D		0.67
K_E		1.00
T_E	s	0.248
SE (VE1 = 7.1 p.u.)		0.0220
SE (VE2 = 4.4 p.u.)		0.0219
VEMIN	p.u.	0
VFEMAX	p.u.	19.86
Exciter Machine Base Values		
VRBASE	V	13.69
EFDBASE	V	31.93
IFDBASE	A	349.84

Note
The function $F_{EX} = f(I_N)$ describes the rectifier voltage drop due to commutation and phase retard. For the definition of $f(I_N)$, refer to IEEE Std. 421.5-2005, annex D.

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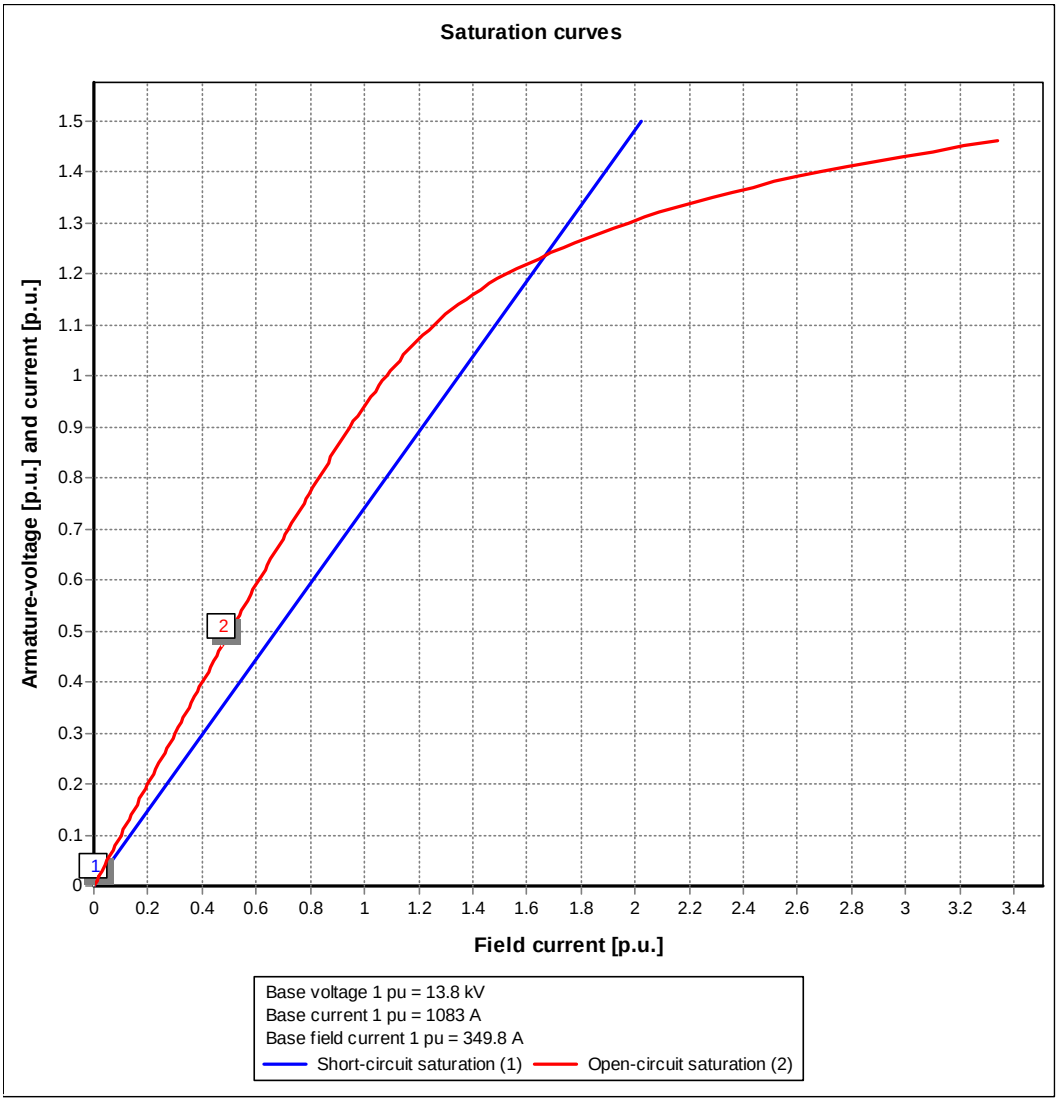
Generator type code: AMS 1120LA 4P BS



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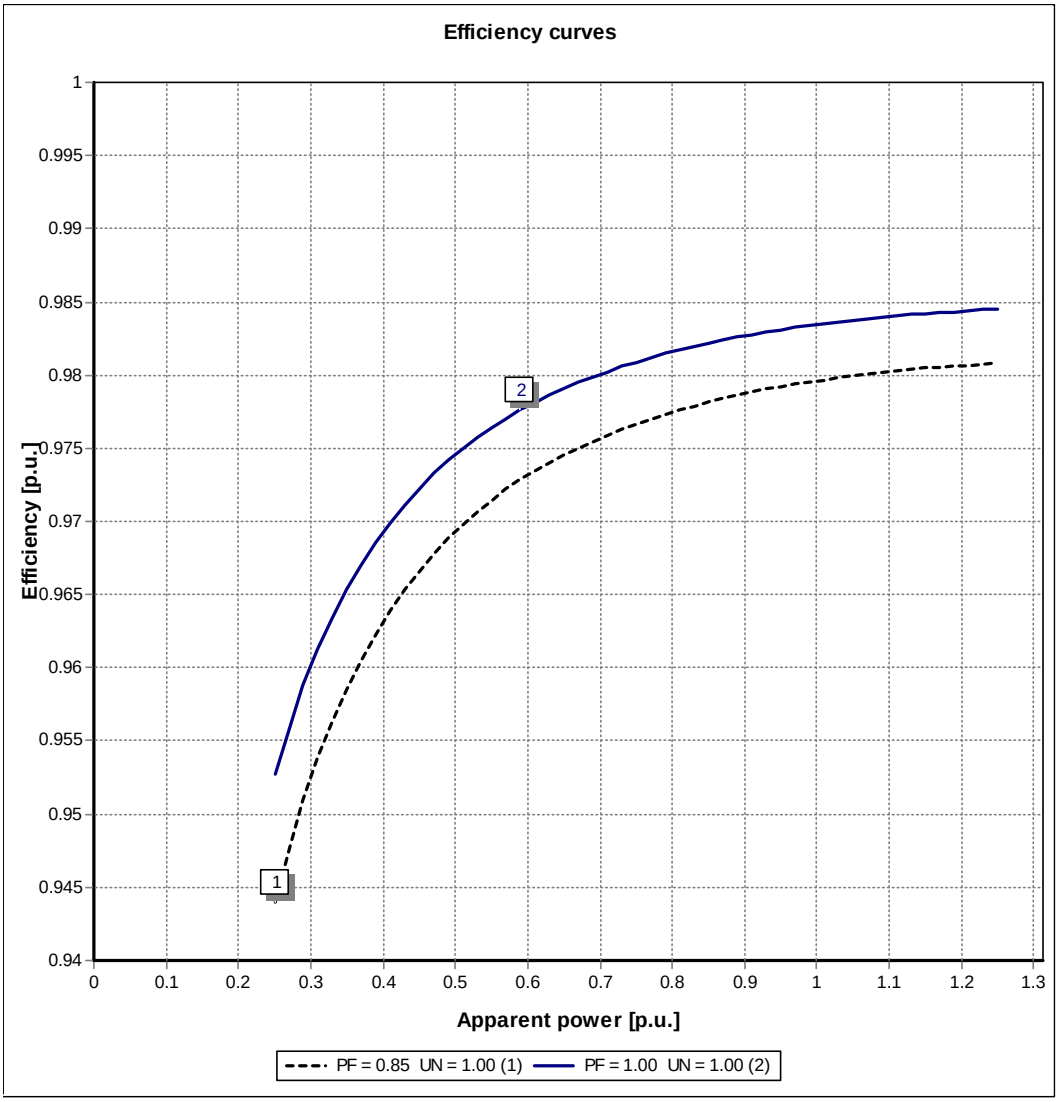
Generator type code: AMS 1120LA 4P BS



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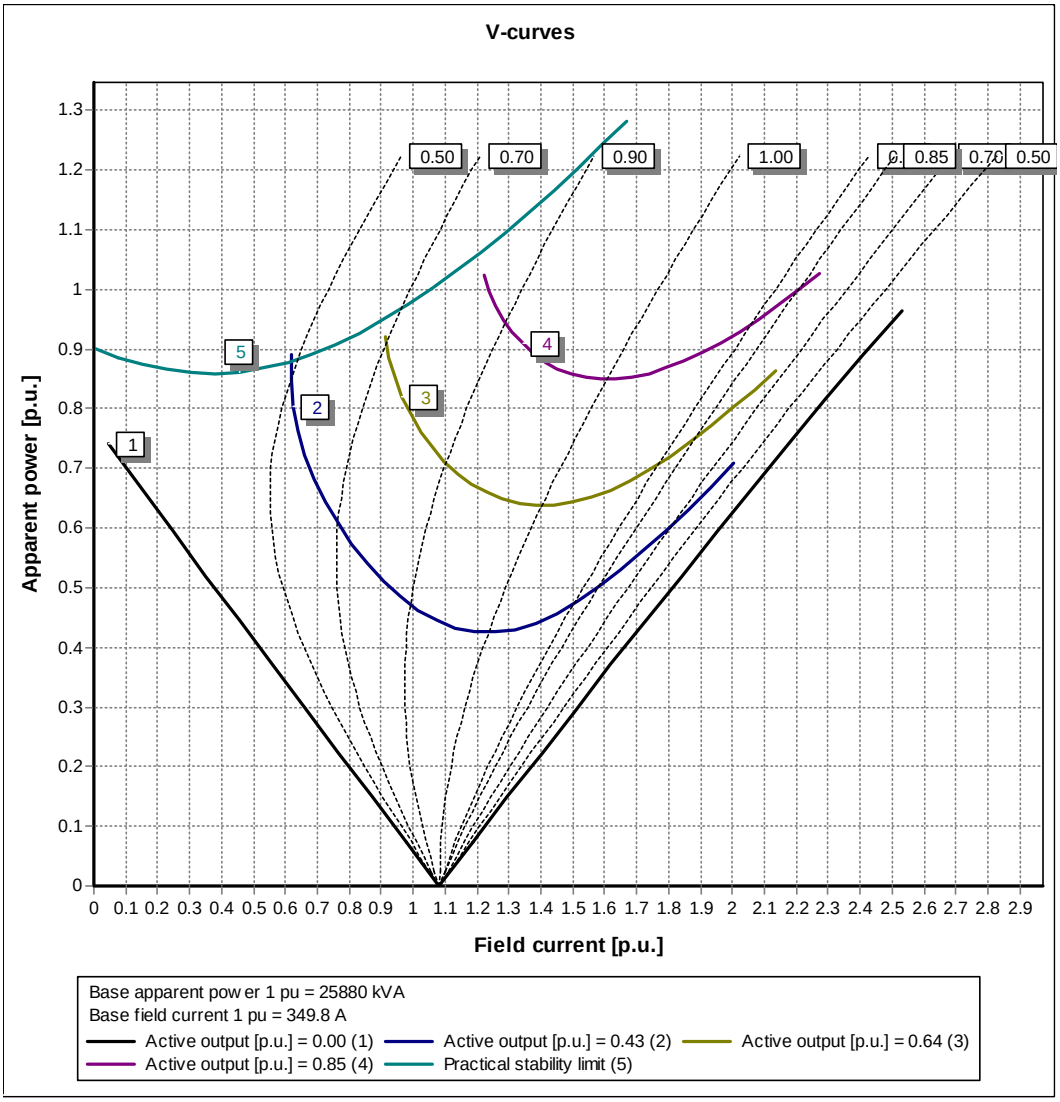
Generator type code: AMS 1120LA 4P BS



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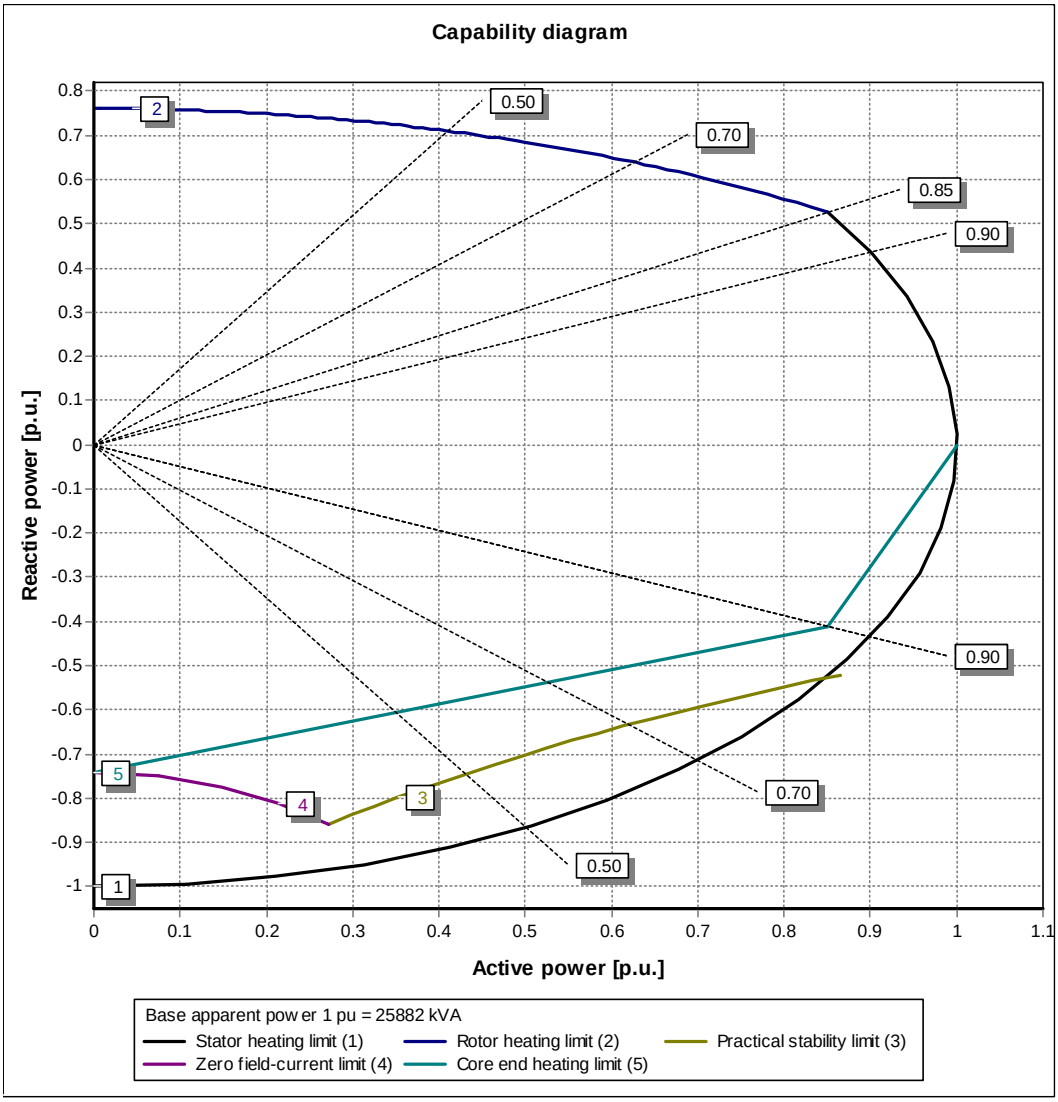
Generator type code: AMS 1120LA 4P BS



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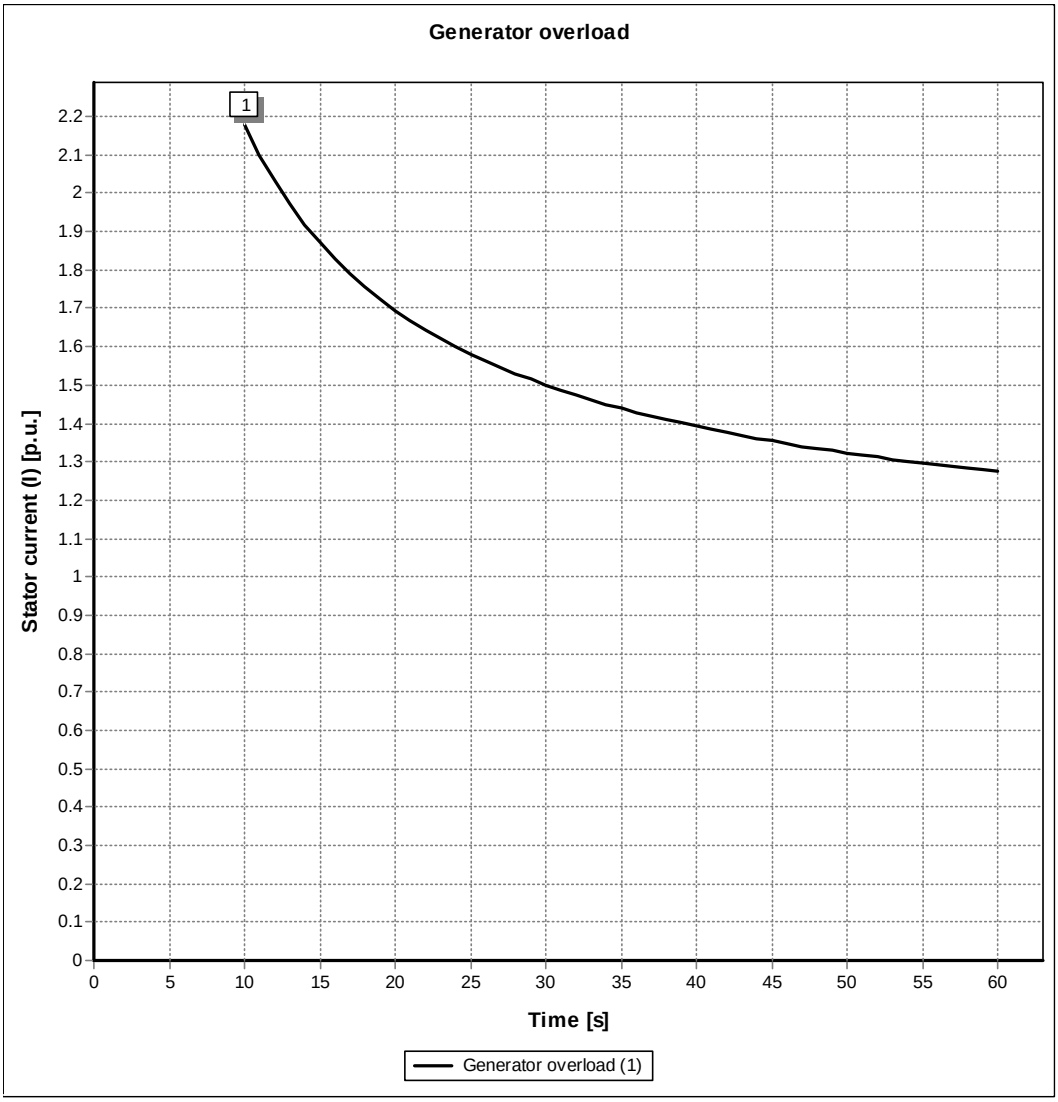
Generator type code: AMS 1120LA 4P BS



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Generator type code: AMS 1120LA 4P BS

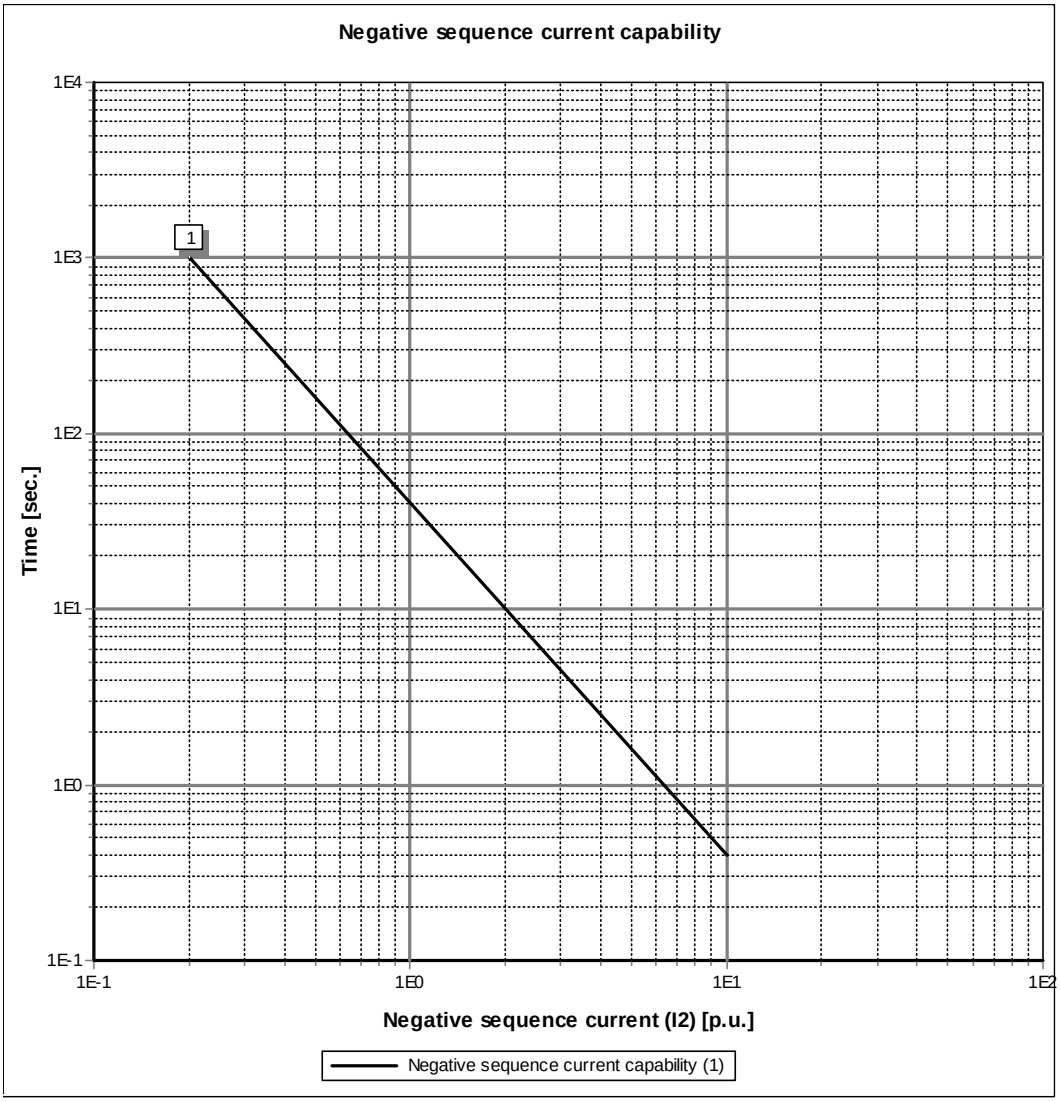

ABB AB	Doc. no. XYK210045-XXX	Lang. en	Rev. ind. A	Page 19 / No. of p. 20

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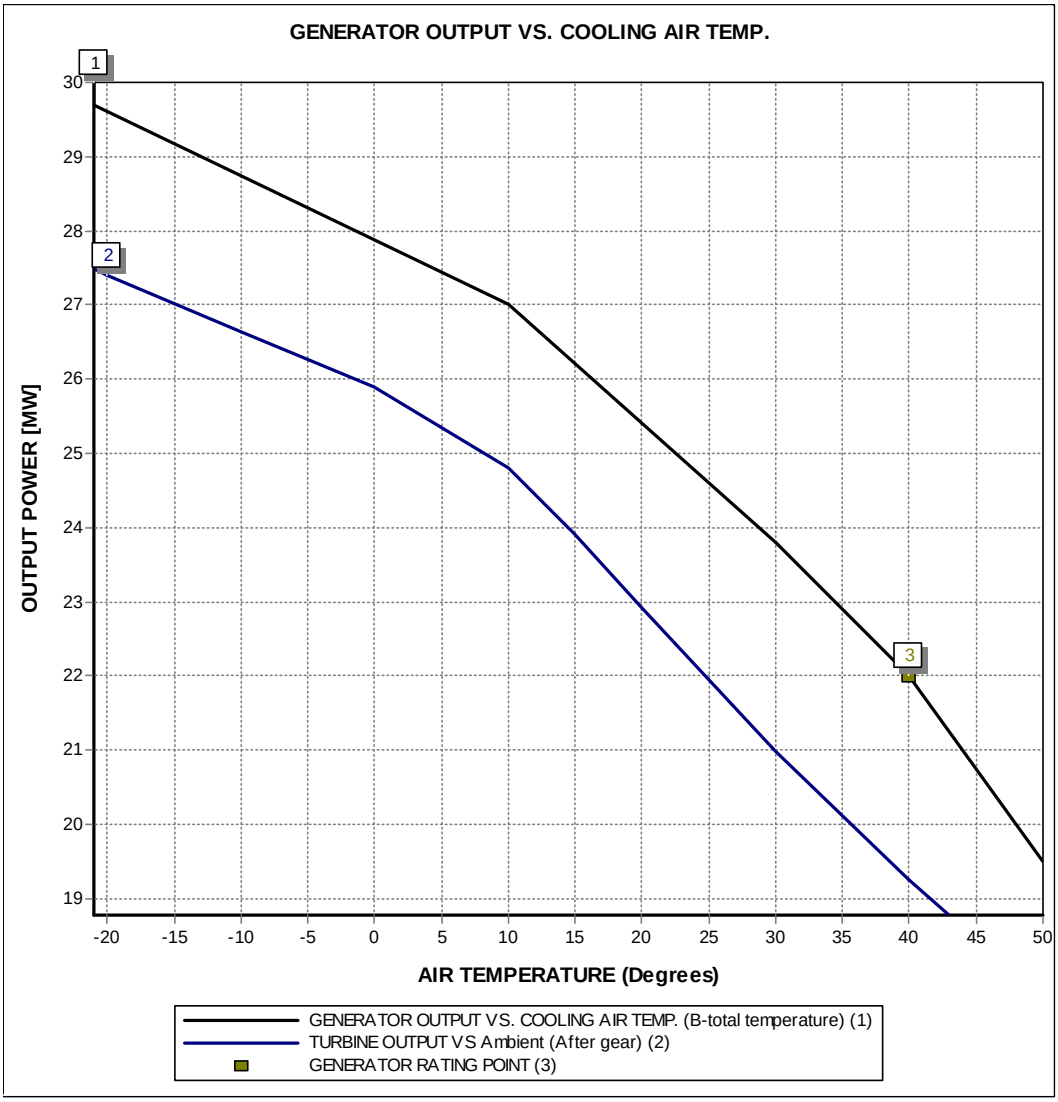
Generator type code: AMS 1120LA 4P BS



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Single Line Diagram, Medium Voltage
GT Generator protection diagram
SIEMENS
PVSC 3-SGT-600
P.Hebbar
P.Annenlingam
2018-08-31
2018-08-31
F4101
J3501518E
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en
Page 55

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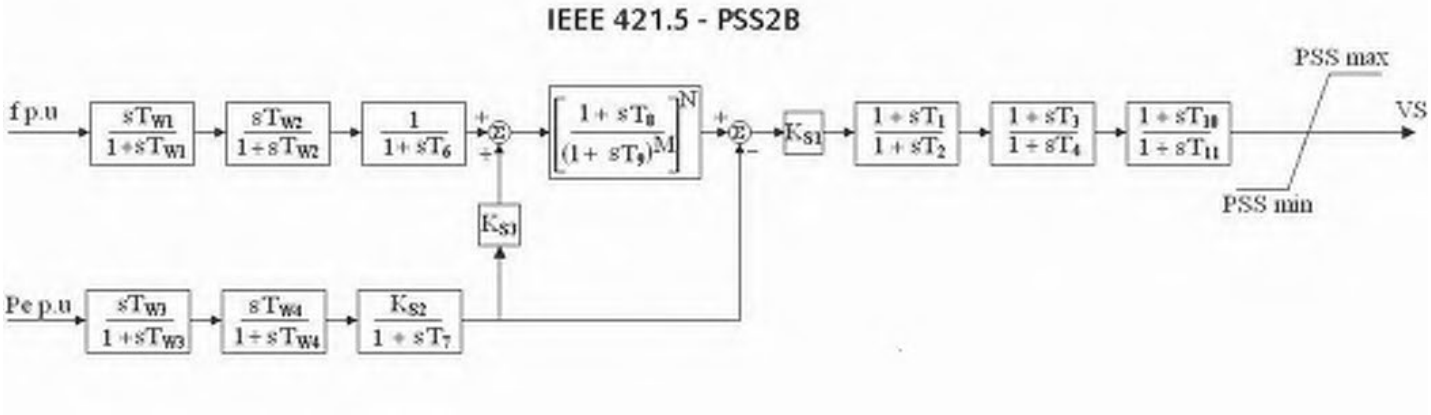
The Power System Stabilizer is an IEEE 421.5 – PSS2B type controller and operates with the active power [p.u] & frequency [p.u] as inputs.



Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision	GS/AS with the same Doc.no yes
	IEEE 421.5 – PSS2B with default settings			Vanesa Hadziselimovic			Model of Power System Stabilizer	-	☐
				Approved	Resp dept: TEC	HG/UPS		Language	
				SIEMENS		Date: 20/10/2015	Document No.	Sh./No. of sh.: 1 (2)	

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Parameter/Signal	Description	Value	Unit
T1	Lead time constant 1	0.08	s
T2	Lag time constant 1	0.04	s
T3	Lead time constant 2	0.18	s
T4	Lag time constant 2	0.02	s
T10	Lead time constant 3	0.27	s
T11	Lag time constant 3	0.02	s
T6	Transducer time constant	0.06	s
T7	Time constant for calculation of integral of electrical power	5	s
T8	Ramp tracking filter time constant	0.50	s
T9	Ramp tracking filter time constant	0.10	s
TW1	Wash out time constant 1 on frequency input	5	s
TW2	Wash out time constant 2 on frequency input	5	s
TW3	Wash out time constant 1 on power input	5	s
TW4	Wash out time constant 2 on power input	0 (bypassed)	s
KS1	PSS gain	9.4	p.u.
KS2	Compensation factor	0.21	p.u.
KS3	Matching factor for calculation of integral of mechanical torque	1	p.u.
M	Ramp tracking filter degree	5	--
N	Ramp tracking filter degree	1	--
PSS min	Negative signal of stabilizing signal	-0.10	p.u.
PSS max	Positive signal of stabilizing signal	0.10	p.u.

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision	GS/AS with the same Doc.no yes ☐
	IEEE 421.5 – PSS2B with default settings			Vanesa Hadziselimovic			Model of Power System Stabilizer	-	
				Approved	Resp dept	HG/UPS		Language	
				SIEMENS	TEC				
					Date		Document No.	Sh./No. of sh.	
					20/10/2015			2 (2)	

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SIEMENS	Driven Equipment SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W580004E	
		Document number		1CS26767	
		Revision	R	Page	1

Brushless excitation equipment and automatic voltage regulator (AVR)

Basic principle

The excitation of the generator is provided from a rotating Alternating current (AC) exciter and diode rectifier. The AC exciter is a generator with a stationary field winding and a rotating armature winding driven by the main generator shaft. The excitation power required for the AC exciter is provided by a pilot exciter, Permanent magnetized generator (PMG) also driven by the generator shaft.

The control of the excitation power to the main field winding is achieved by varying the excitation of the rotating AC exciter, this regulation is performed by the AVR system.

Equipment on the main generator

Data of the excitation system can be found in the generator specification.

Rotating Rectifier

The rotating rectifier is built up as a three-phase full wave rectifier with one diode in each branch. The diodes are mounted on heat sinks on the exciter rotor and are amply dimensioned to successfully cope with the large current transients arising as a result of an eventual short circuit on the generator terminals. The main field winding is protected from induced over voltages by an overvoltage protection device shorting the field winding at excessive voltage levels.

Pilot exciter

The pilot exciter is a three-phase synchronous generator of the permanent magnet type (PMG) with a linear speed voltage characteristic. Data can be found in the generator specification. The pilot exciter is protected from overload by a protection module in the feeder breaker to the AVR.

FO / SGT-600/SGT-700(PG B, PG EX B), SGT-750(PG), SGT-800(PG B, PG B2, PG Ex B2, PG B2 US, PG Ex B2 US, PG B LS) /& DF101	

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SIEMENS	Driven Equipment SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W580004E	
		Document number		1CS26767	
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AVR System

The system consists of an AVR and a field breaker unit mounted in the main terminal box of the generator. The unit is supplied with excitation power from the PMG and provides regulated Direct current (DC) back to the exciter field winding of the rotating AC exciter. The unit is also provided with a current signal from the current transformer on the neutral side of the generator for positive or negative compensation to the AVR as a function of reactive line current (Reactive droop). Voltage signal from the potential transformer on the line side of the generator is provided via the Generator control panel (GCP).

The system is connected to the turbine control system via a serial interface. The serial interface provide set points and control to the AVR and provide the operator with all necessary information of the system on the Human machine interface (HMI) of the turbine control system.

The system is supplied with auxiliary power from the PMG when the generator is running and from a back-up DC supply during generators standstill.

The AVR system contains following functions:

- Voltage control, controls the generator voltage to a pre set level from the turbine control system. The voltage control is provided with a reactive current compensation (voltage droop). The reactive compensation is immediately disconnected when the Generator Circuit Breaker (GCB) is opened.
- Field current control, controls the excitation field current in a closed loop. When operating in field current control all AVR limiters are disabled.
- Power factor control, controls the generator power factor.
- Reactive power control, controls the generator reactive power.
- Change over between all above mentioned control modes is performed without any disturbance to the operation (automatic follow up).

The system also includes the following limiting functions:

- Temperature dependent (internal cooling air) maximum Stator current limiter active in both the over- and underexcited area of the capability diagram.
- Temperature dependent (internal cooling air) maximum Field current limiter allows field forcing during a pre-set time before limiter action.
- V/Hz limiter prevents over excitation of the generator or its connected unit transformer.
- Under excitation limiter, preventing operation beyond generator limits.
- Maximum Stator voltage limiter is to prevent over voltage on the stator. The limiter is released only when Reactive power control or Power factor control is in operation.
- Minimum Stator voltage limiter, preventing under voltage on the stator, the limiter is released only when MVAr or PF control is in operation.

Apart from the excitation control and limiting functions above, the following functions are also included in the AVR module:

Rotating diode supervision/protection, should a short or open circuit of the rotating diodes occur an AC current component will be seen in the excitation current to the exciter. The protection monitors the AC component and provides an alarm in case of open circuit diode and a trip at short circuit condition.

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SIEMENS	Driven Equipment **SGT-600, SGT-700, SGT-750, SGT-800**	GTI number		W580004E	
		Document number		1CS26767	
		Revision	R	Page	3

Type and technical data

Type	SIEMENS Unitrol 1020
Rectifier type:	PWM controlled DC-chopper
PMG supply; voltage and frequency	1-phase 16-250VAC,40-600Hz 3-phase 9-250VAC, 40-600Hz
Maximum continuous current	20 ADC @ 55°C (131°F). 10 ADC @ 70°C (158°F)
Current at field forcing	38 ADC, 10 sec
Regulation accuracy	0,2% @ 25°C (77°F)
Reactive current droop:	0 - ± 10%
Cooling method	Convection cooling
Ambient temperature at:	
Operation	-40 to +70°C (-40 to 158°F)
Storage	0°C to +55°C (32 to 131°F)
Measuring Circuits	
Potential transformer circuit	3 x 100-120 V, <0,1VA/phase
Current transformer circuit	1 x 1/5 A, <0,1 VA/phase
Frequency	50/60 Hz

Standards

EMC Immunity	EN 61000-6-2:1999
EMC Emission	IEC 61000-6-4
Vibration	IEC 60068-2-6 Class 2
Shock and bump	IEC 60255-21-2 Class 2
Seismic	IEC 60255-21-3 Class 2
Isolation Coordination	IEC 60255-5
PSS	IEEE Std. 421.5-2005 2A/2B
Certificates	CE certification
	GOST and NIIPT
	UL-508 File E 251846
	DNV according class B

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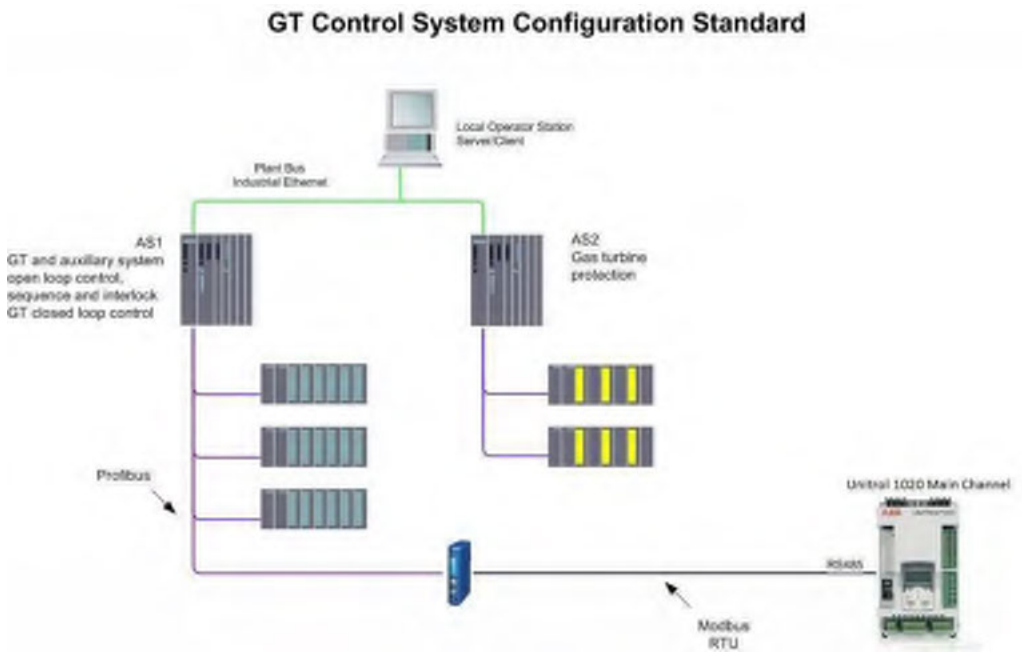
SIEMENS	Driven Equipment SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W580004E	
		Document number		1CS26767	
		Revision	R	Page	4



AVR HMI display

Picture: Siemens Industrial Turbomachinery AB

AC

Picture: Siemens Industrial Turbomachinery AB

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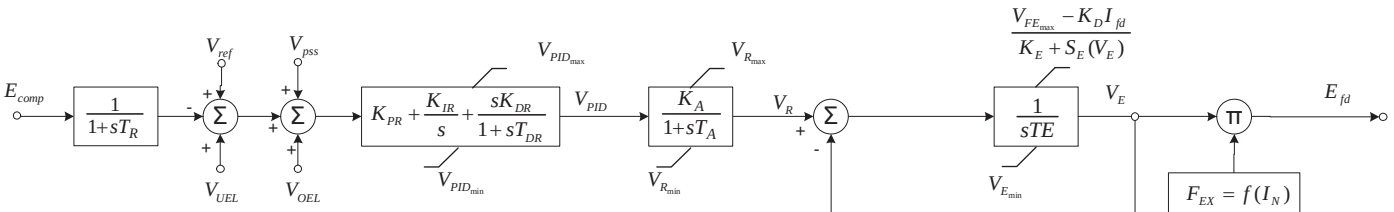
The indirect excitation system utilizing a rotating exciter machine is well represented by an IEEE 421.5 – AC8B type model.



$$E_{comp}=V_T+X_C\cdot I_q$$

$$F_{EX}(I_N)=\begin{cases}1 & I_N\le 0\\ 1-0.577I_N & 0<I_N\le 0.433\\ \sqrt{0.75-I_N^2} & 0.433<I_N<0.75\\ 1.732(1-I_N) & 0.75\le I_N\le 1\\ 0 & I_N>1\end{cases}$$

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision	GS/AS with the same Doc.no yes
	IEEE 421.5 – AC8B SGT-600 Example			Vanesa Hadziselimovic			Excitation system model		☐
				Approved	Resp dept	HG/UPS		Language	
				SIEMENS		Date	Document No.	Sh./No. of sh. 1 (2)	

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Parameter/Signal	Comment	Value
T_R	Voltage measurement filter time constant	0.02
K_{PR}	PID controller proportional gain	26.90
K_{IR}	PID controller integral gain	11.85
K_{DR}	PID controller derivative gain	4.93
T_{DR}	PID controller derivative filter time constant	0.23
V_{PIDmax}	Max output from PID controller	7.763
V_{PIDmin}	Min output from PID controller	0.1553
K_A	Voltage regulator proportional gain	1
T_A	Voltage regulator time constant	0
V_{Rmax}	Regulator output max limit	12.243
V_{Rmin}	Regulator output min limit	0
K_C	Rectifier loading factor proportional to commutating reactance	1.04
K_D	Demagnetizing factor, function of AC exciter reactances	0.49
K_E	Exciter constant related to self-excited field	1.0
T_E	Exciter Time Constant	0.308
V_{FEmax}	Exciter field max limit	16.84
V_{Emin}	Exciter field min limit	0
E1		8.4
S(E1)	Exciter saturation value at E1	0.02
E2		4.2
S(E2)	Exciter saturation value at E2	0.02
X_C	Reactive droop	0.04

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision	GS/AS with the same Doc.no yes ☐
	IEEE 421.5 – AC8B SGT-600 Example			Vanesa Hadziselimovic			Excitation system model		
				Approved	Resp dept	HG/UPS		Language	
				SIEMENS		Date	Document No.	Sh./No. of sh. 2 (2)	

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Load Shedding Study

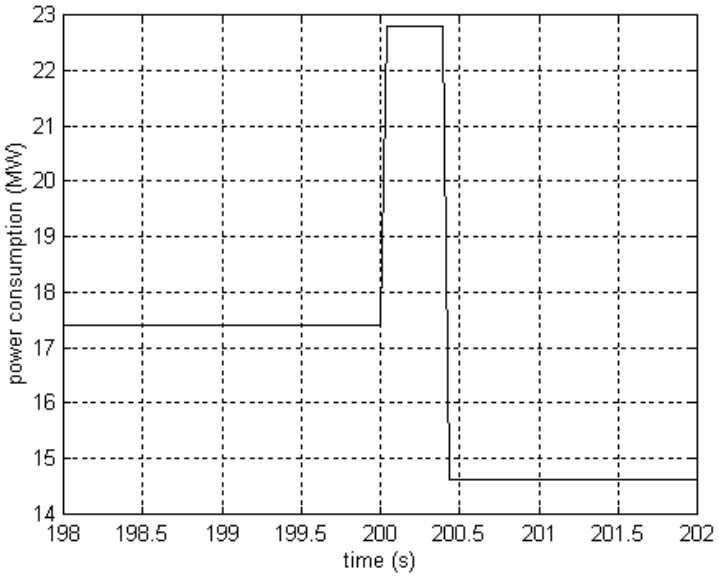
SGT600

Load Shedding study

From documents received from the customer we can see three cases which are studied in this report. In all simulations the set point is 59.4Hz for the first step. The results are shown below.

First case:

- Co-generation power 17.4 MW
- Utility power 5.4 MW
- Total power to plant 22.8 MW
- Shed power (1-step) 8.19 MW
- Remaining power on the generator 14.6 MW



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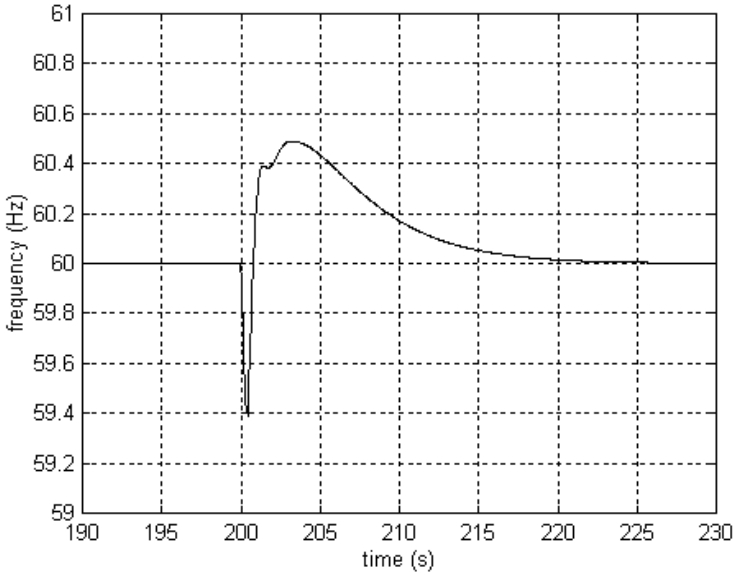

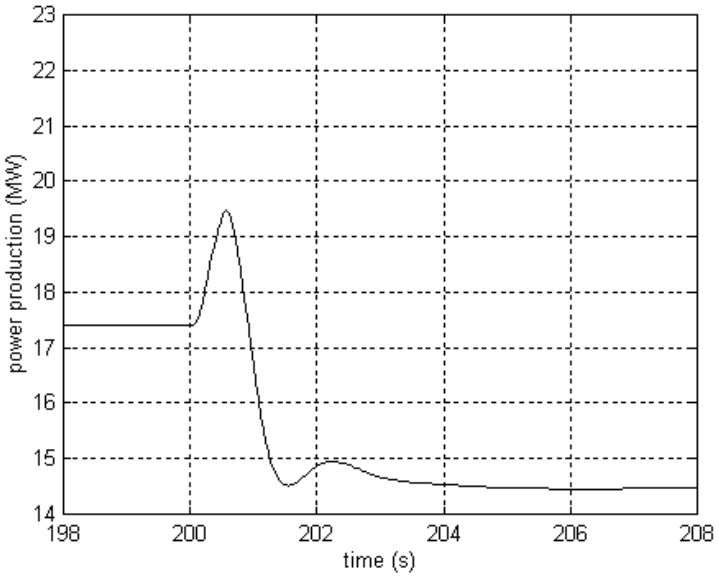

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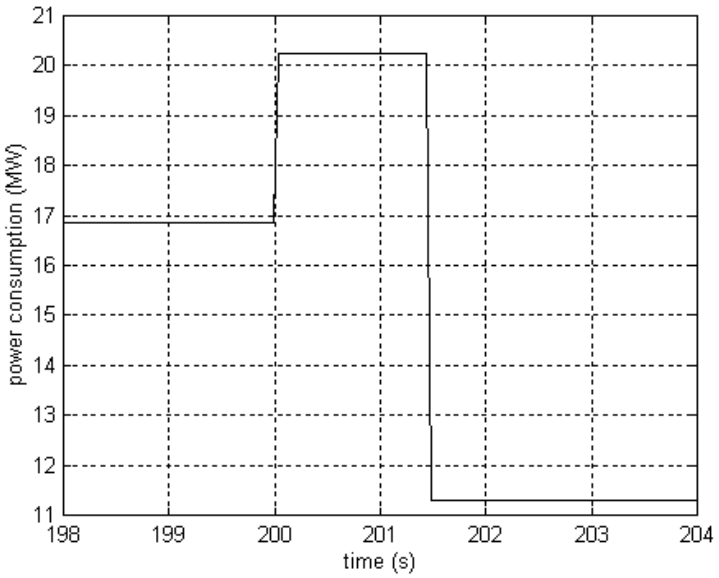
Second case:

- Co-generation power 16.85 MW
- Utility power 3.4 MW
- Total power to plant 20.25 MW
- Shed power (1-step) 8.96 MW
- Remaining power on the generator 11.29 MW



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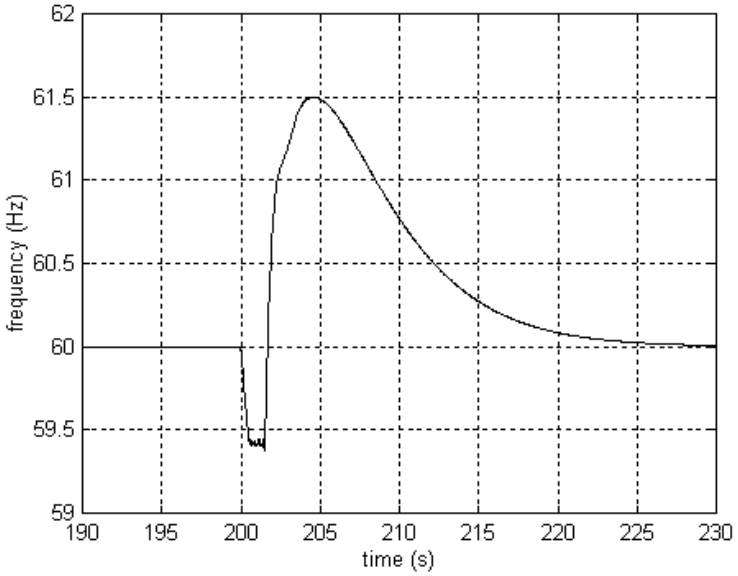

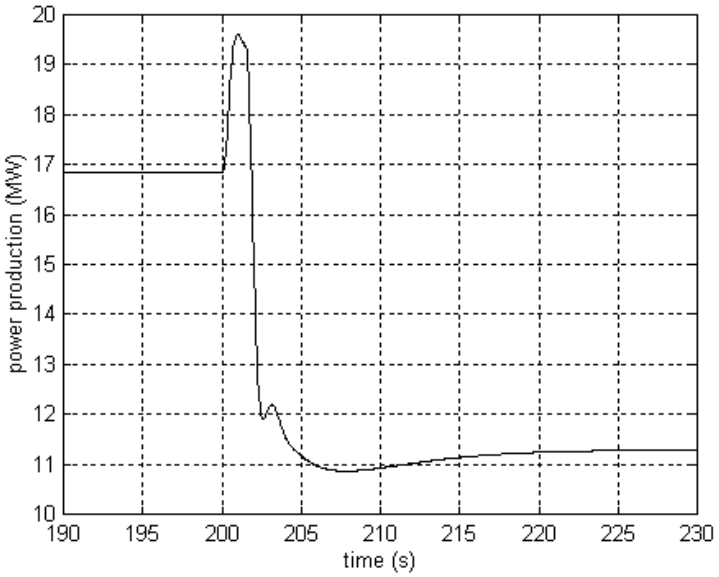

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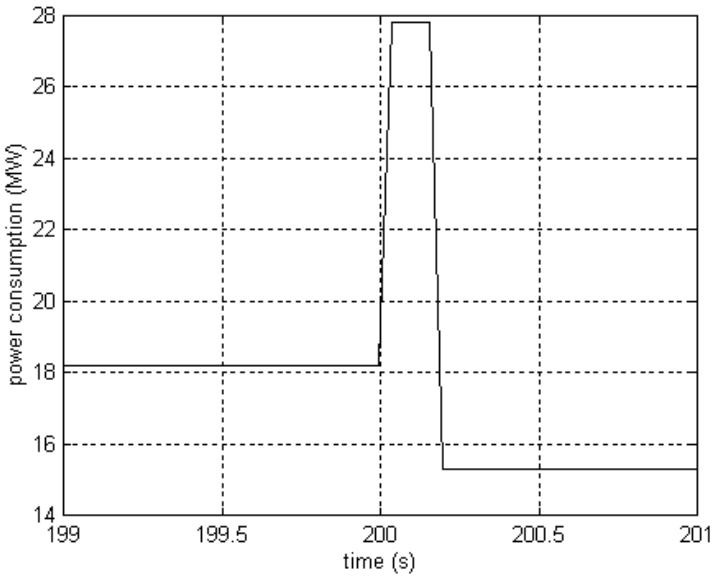
Third case:

- Co-generation power 18.2 MW
- Utility power 9.6 MW
- Total power to plant 27.8 MW
- Shed power (1-step) 12.5 MW
- Remaining power on the generator 15.3 MW



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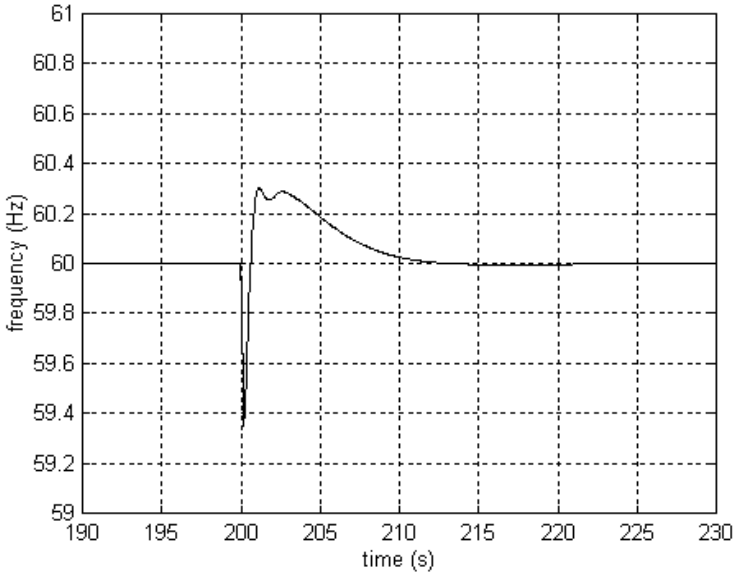

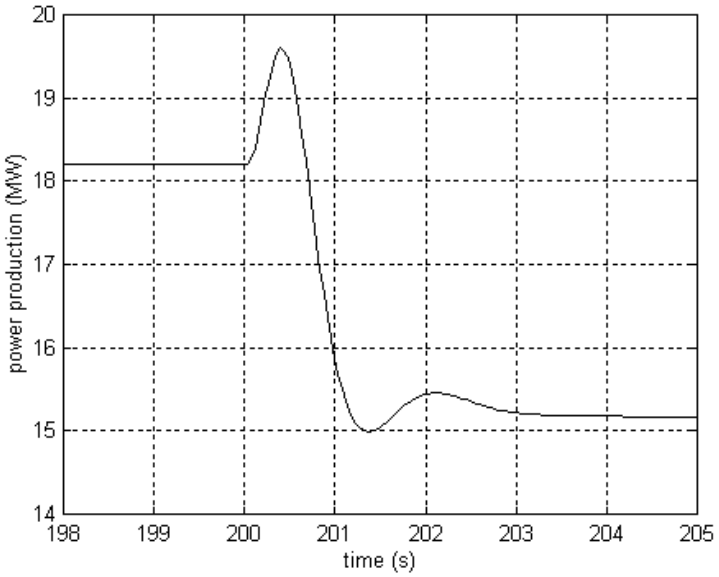

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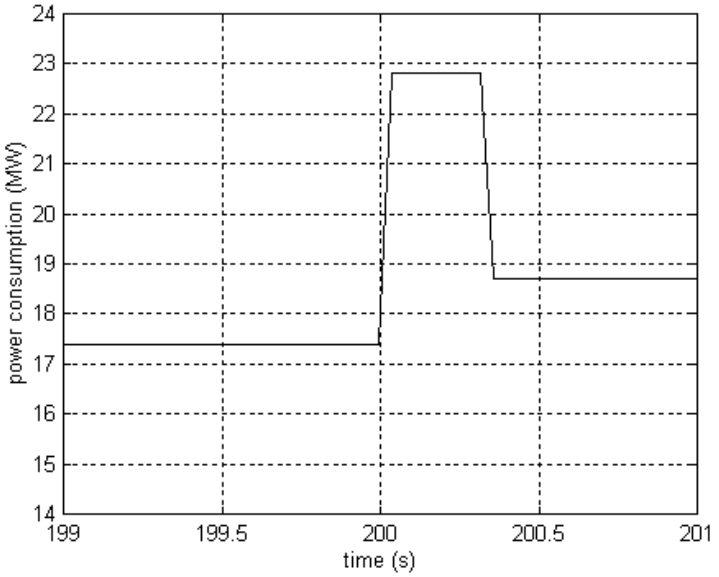
First case, with 2-step shedding:

· Co-generation power	17.4	MW	
· Utility power	5.4	MW	
· Total power to plant	22.8	MW	
· Shed power (first step)	4.1	MW	
· Shed power (second step)	0	MW	(not activated)
· Remaining power on the generator	18.7	MW	



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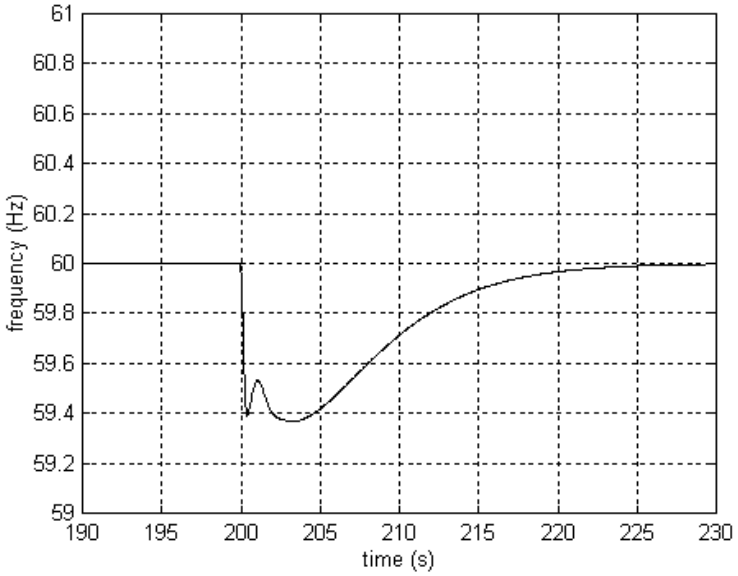

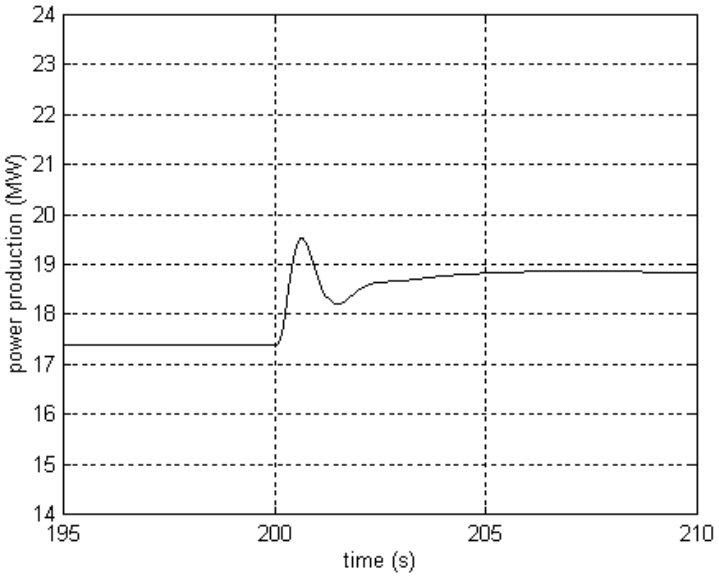

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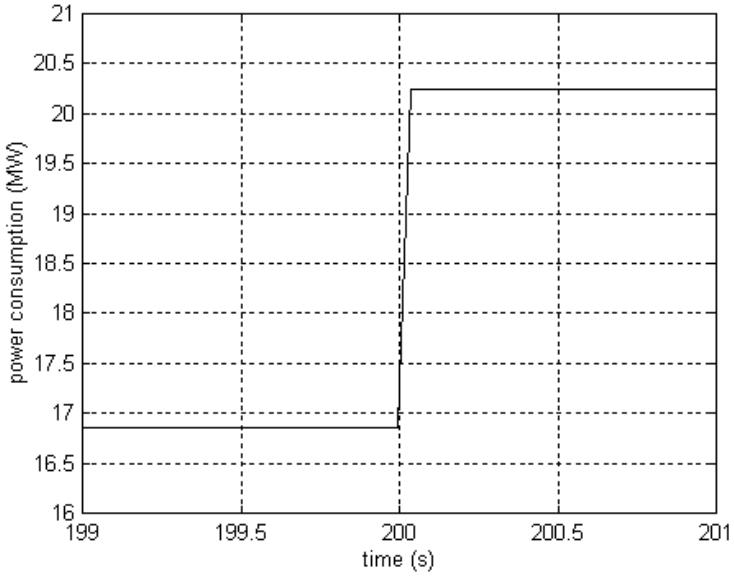
Second case, with 2-step shedding:

· Co-generation power	16.85	MW	
· Utility power	3.4	MW	
· Total power to plant	20.25	MW	
· Shed power (first step)	0	MW	(not activated)
· Shed power (second step)	0	MW	(not activated)
· Remaining power on the generator	20.25	MW	



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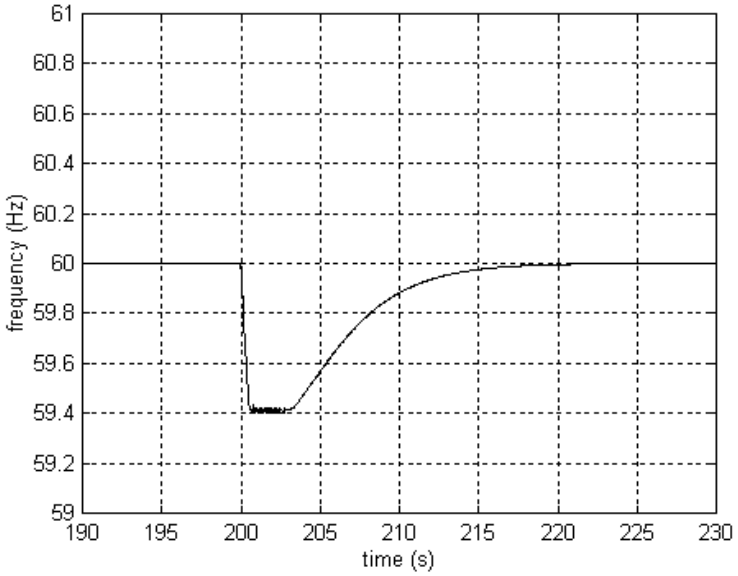

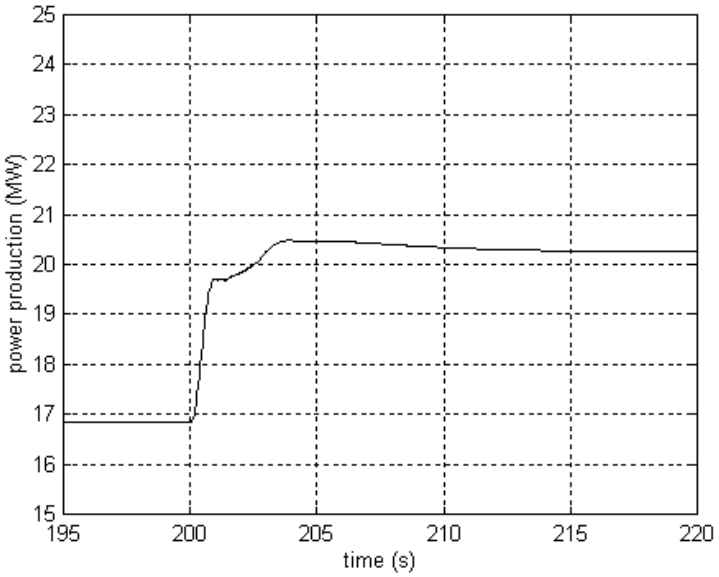

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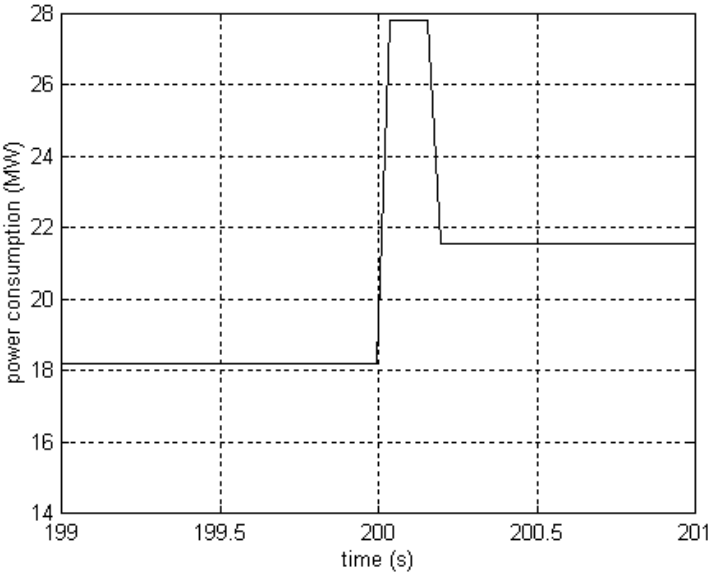
Third case, with 2-stage shedding:

- Co-generation power 18.2 MW
- Utility power 9.6 MW
- Total power to plant 27.8 MW
- Shed power (first step) 6.25 MW
- Shed power (second step) 0 MW (not connected)
- Remaining power on the generator 21.55 MW



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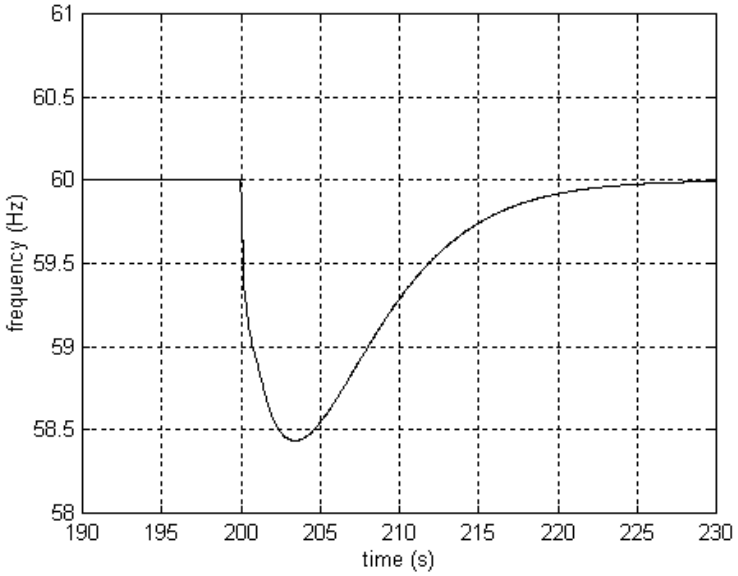

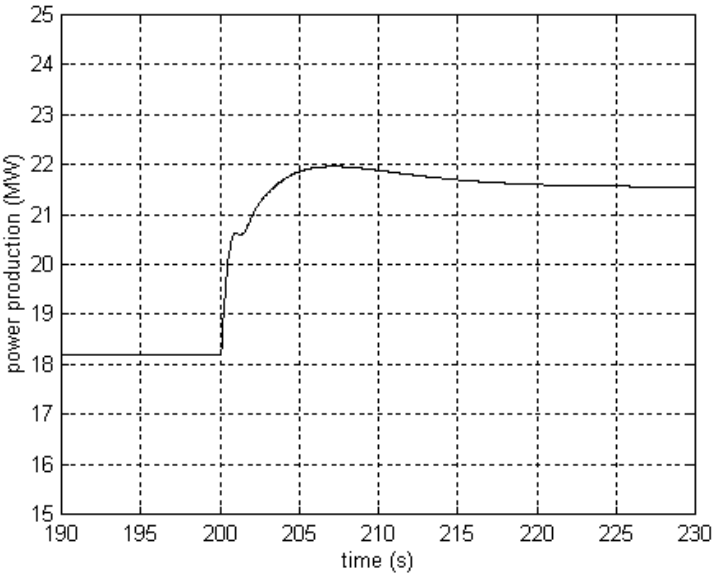

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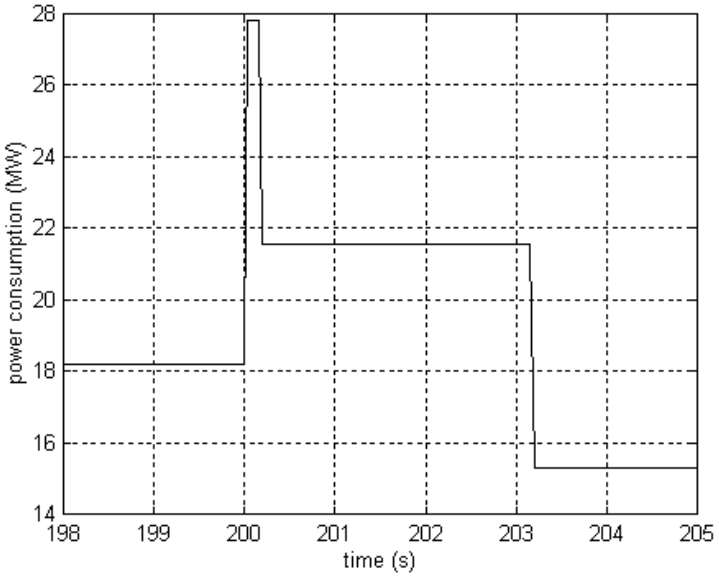
Third case, with a 3 sec delay of the 2'nd stage:

·	Co-generation power	18.2	MW
·	Utility power	9.6	MW
·	Total power to plant	27.8	MW
·	Shed power (first step)	6.25	MW
·	Shed power (second step)	6.25	MW
·	Remaining power on the generator	15.3	MW



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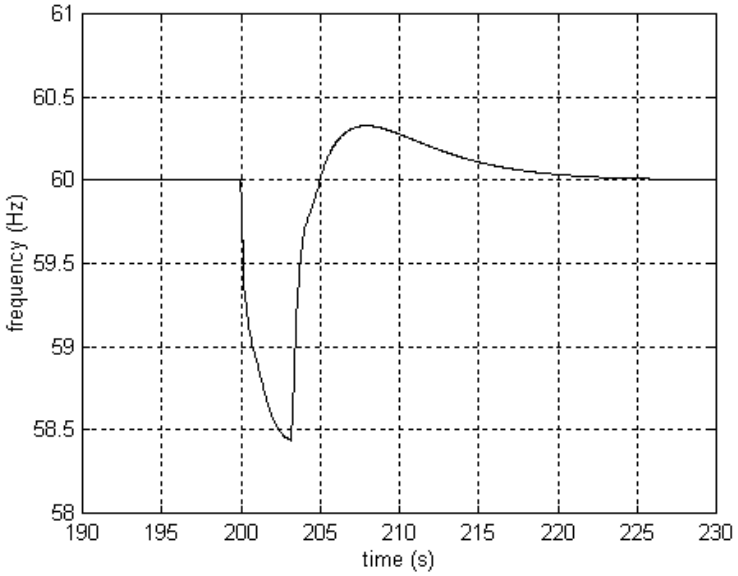

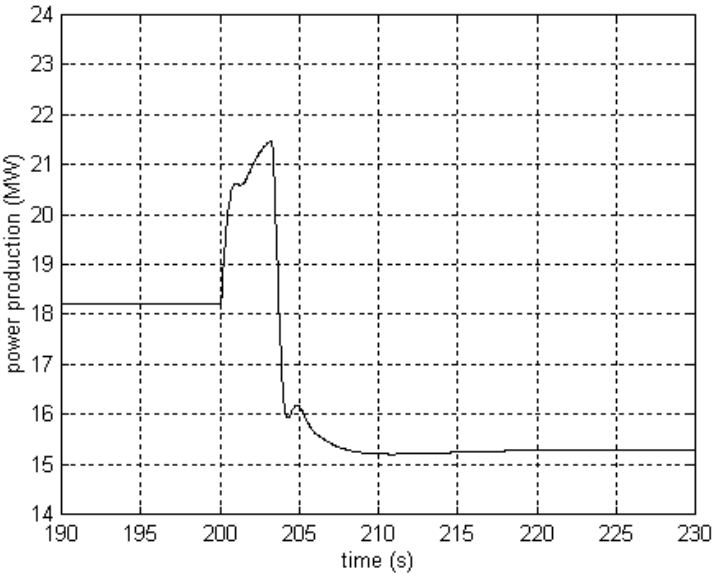

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1.1.1 Conclusions

- All three cases show that a reduced setting of the shed power will improve the present situation by
    1. minimizing the risk of flame-out due to rapid unloading.

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2. keeping a larger part of the plant alive.

- The shedding should be done in two steps with half the shed power in each step.
- A lower set point, preferably 58Hz, without time delay, is preferred for the second step because of the fairly long recovering time of the turbine.

1.1.2 This is as far as we can get with the present available information. To go further on with an investigation on how to control the load shedding system in a more precise way requires a thorough investigation of all possible load situations regarding both produced and consumed power and the priority order for the load to shed.

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LV Single Line Diagram

Electrical Equipment
SGT-600
PVSC

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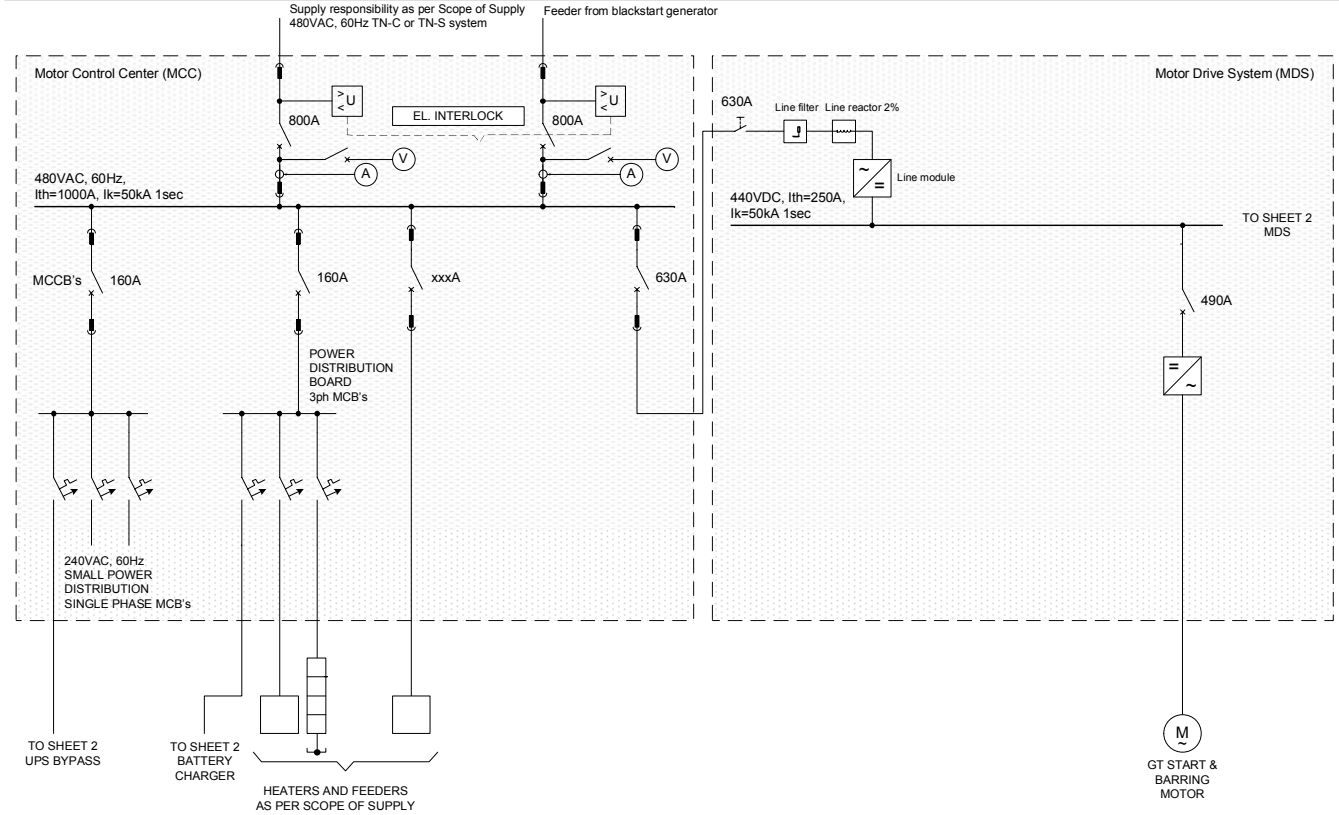

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Based on: .
Ref. des.: -
Doc. Des.: FO / SGT-600(6-PG41) / &FA101

Author: Joakim Adamsson
Approved: Håkan Pettersson
Doc. Kind: Overview Diagram
Language: en

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LV Single Line Diagram

Electrical Equipment
SGT-600
PVSC

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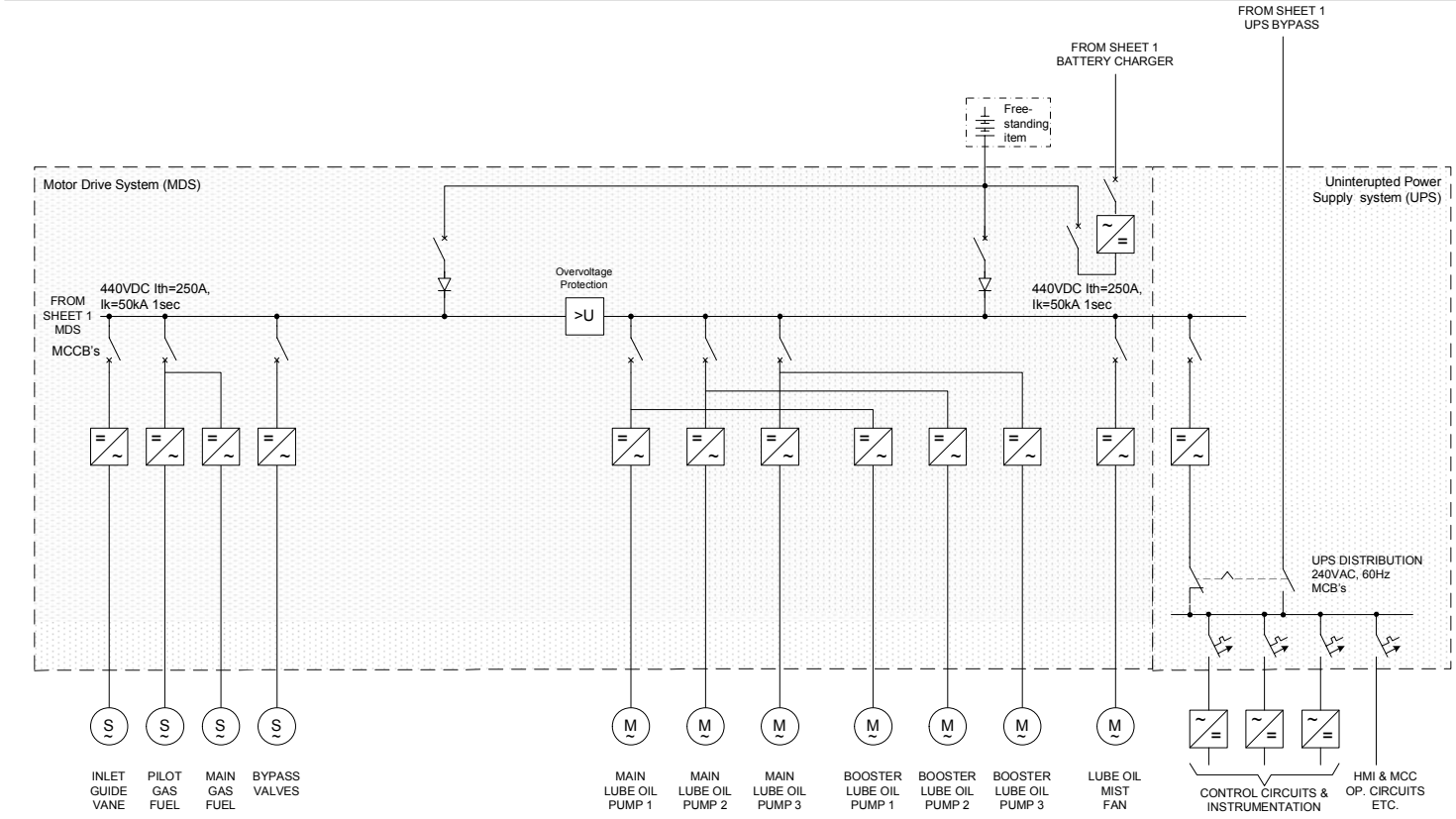

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Based on: .
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Author: Joakim Adamsson
Approved: Håkan Pettersson
Doc. Kind: Overview Diagram
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Electrical Equipment

SGT-600, SGT-700

Doc. No.
1CS91029

Rev. ind.
A

GTI No. J623012E

Page 1 (4)

Battery system - Pb

Lead acid GEL Batteries

Design

The lead acid GEL battery is of the international superior dry fit technology and is maintenance-free throughout the lifetime.

The system consists of a battery pack which supplies the important systems such as lubrication and UPS at AC mains failure. Depending on configuration the battery pack can also be dimensioned to supply DC barring and autonomous operation (3 minutes power loss ride through).

The basic dimensioning is done to ensure the required 10 hours post-lubrication capacity after 10 years of normal use and maintenance at a temperature of 25 °C. Recharge time is 12h after a 10h discharge cycle.

When SIT (Siemens Industrial Turbomachinery) delivers a complete battery module (including enclosure) the ventilation in the battery area is calculated in accordance with European standard EN 50272-2.

The battery is valve-regulated for stationary applications.

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Based on: J623009E

Ref.des.:

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Appr.

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Specifications

General

The lead acid GEL batteries have high current discharge capability, with excellent energy storage capacity.

The construction is of thick grid plate consisting of a lead calcium alloy.

Very low gassing due to internal gas recombination.

Short recharging time.

Proof against deep discharge according to DIN 43539 T5.

Completely recyclable.

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Battery pack	
- Supplier:	Exide
- Voltage:	440V
- Number of battery cells:	204
- Short-circuit value (in ampere)	2383 A
- Recycling:	Recycling plant for batteries
- Approval:	Germanisher Lloyd (GL), DIN/Gost/TUV
-Standards:	DIN 40741 T1, EN/IEC 60896-22
- Degree of Protection:	IP 20

Battery blocks	
- Voltage:	2, 4 or 6 volt blocks depending on application
- Cell connection:	F-M8 (20Nm)
- Container:	Polypropylene (PP) acc. to UL 94-HB
- Duty class (acc to Eurobat guide)	10 years at 25 °C

Maintenance

The lead acid GEL batteries are maintanance free and shelf life (storage) up to 2 years at 20 °C without recharge due to very low self discharge rate.

Transportation

Trouble-free transportation of operational blocks, no restriction for rail, road, sea and air transportation (IATA, DGR clause A 67).

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Configuration

There are several different configurations available and choice of configuration is specified in scope of supply. The choice of configuration depends on different needs of Ah capacity. The different needs are fulfilled by using different types and sizes of battery cells and accordingly different sizes of battery racks.

The type of cell used for required Ah capacity at basic[1] oil flow is the following:

- Configuration	Basic
- Type:	Sonnenschein A706/175
- Capacity:	175 Ah
- Number of blocks:	68
- Number of cells/block	3
Dimensions of one battery block	
- Voltage:	6 V
- Type according to DIN 40741 T1	6V 5 OGiV 160
- Length:	285 mm
- Width:	232 mm
- Height:	327 mm
- Weight with electrolyte:	42.5 kg
Dimensions of the battery rack	
- Length (L):	5100 mm
- Width:	720 mm
- Height:	1600 mm
- Weight (battery cells + rack)	1830.1 kg
- Total weight (2 x 1830.1)	3660.2 kg

[1] "Basic" means an oil flow of 1250 l/min, without DC barring and without autonomous operation (3 minutes power loss ride through).

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SIEMENS

Electrical Equipment

SGT-600, SGT-700

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A

GTI No. J623012E

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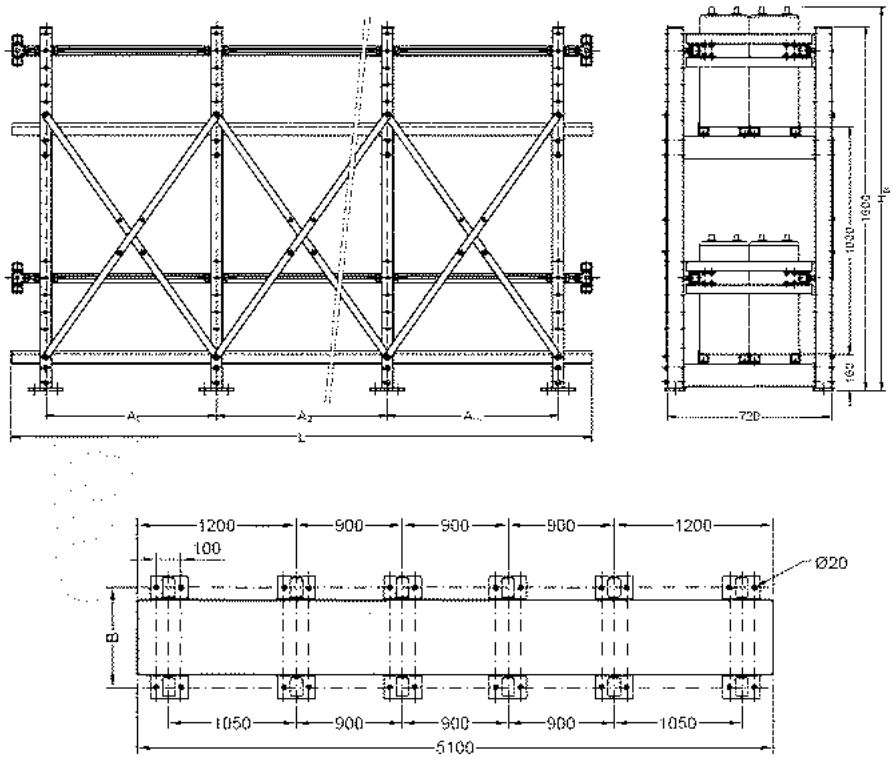
Battery stand - typical configuration

Rack type	EQ-E-PGS 2-51 B5
Article No.	EQPSB20515
Number of structures	2
Acceleration	0.9g - UBC Zone 4
Weight –batteries on one rack structure	68/2 x 42.5 = 1445 kg
Weight –one battery rack	385.1 kg
Projected surface load	891.9 kg/m^2
Load per insulator	366 kg
Other Rack dimensions	
B	650 mm
H_B	1484.5 mm



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Battery charger 440V DC

Switch-mode charger with built-in monitor

Charging rectifier is a primary switched, modular charging rectifier with integrated monitoring unit focused on safety of operation. Single fault does not affect other chargers or the monitoring unit. A faulty monitoring unit does not prevent the battery from being charged. The charger is constant voltage controlled with current limitation and can manually be switched over to equalizing charging. Charge time sufficiently for a second full 10 hours discharge of battery is 12 hours. Charger is located in UCP.

- Base configuration for SGT-600 and SGT-700 is single charger, except for configurations with the 5 hours battery back-up barring selected where redundant chargers are included.
- For SGT-750 redundant chargers are always included except for configurations without battery back-up barring combined with standard flow lube oil system.

Always refer to scope of supply for included selections.

Features:

- Modular, hot-swap design
- Rugged soft-switch IGBT control
- AC high/low voltage protection
- Long-life, speed controlled and monitored cooling fans
- All adjustments made from graphic display menu system
- Float charge for normal service
- Equalizing charge with increased current to equalize cell voltages
- Temperature regulated float charging voltage
- Automatic battery circuit test
- Active load sharing
- Over voltage protection (OVP)
- Long life design
- Low audible noise
- Low weight

SGT-600(PG B, PG Ex B, MD B), SGT-700(PG B, PG Ex B, MD B), SGT-750(PG A, PG Ex A, MD A)	

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Monitoring:

Monitoring on local display:

- Digital current/voltage read-outs
- Earth fault resistance
- Mid point voltage
- Battery temperature

Alarms:

The alarms are hardwired to package PLC:

- General alarm (over voltage U>>, symmetry fault, battery circuit fault, mains fault, charging fault, rectifier fault, measurement circuit fault, overload, high/low temp battery, internal fault & communication fault)
- Earth fault (earth fault to negative & earth fault to positive)
- System L/H volt (over voltage U> & under voltage U<)
- Charger failure (under voltage U<<)

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Technical data

Input voltage range:	340-440VAC, 45-65Hz
Class of enclosure:	IP20 according to EN/IEC 60529
Ambient temperature (inside cubicle):	0-45°C
Immunity:	EN/IEC 61000-6-2
Emission:	EN/IEC 61000-6-3
Safety:	EN 50178/IEC 62103
Voltage regulation:	+/-0.5%
Current regulation:	+/-1%
Voltage measuring, inaccuracy:	<0.2%
Ripple voltage (RMS):	<0.2%
Efficiency, typical:	>92%
Power factor:	>0.97(fundamental)
Cooling:	Fan ventilator
Output DC (per module):	440V, 18A
Max main power (per module):	10.6kVA
Max main current (per module):	18A
'External AC fuse:	40A
External DC fuse:	40A
AC terminals:	35mm^2
DC terminals:	35mm^2
I/O terminals:	2.5mm^2
Weight (module):	20kg
Weight (complete unit with two modules):	60kg
Size (redundant configuration) width x height	490mm x 780mm

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Motor drive system

Figure 1: Typical motor drive system

Reference: SIT AB

The Motor Drive System (MDS) containing Uninterruptible Motor Drive (UMD) and Uninterruptible Power Supply (UPS) systems are vital systems for the operation of the gas turbine. The systems provide power supply to non critical loads, UPS to emergency service motors and Instrument and Control (I&C) systems. The system consists of a freestanding panel arrangement and utilizes a common battery bank for back-up emergency operation on DC power when external AC power is lost[1]. The drives are of type Siemens Sinamics S120 and can be replaced during operation (hot swap). The prioritized loads, i.e. lubrication oil system and UPS, are protected from transients and overvoltages by an overvoltage protection. The protection disconnects the loads from the net supply and the loads are supplied only from the battery. The panels are mounted and factory tested with the order bound gas turbine equipment before delivery. The system is compact and requires a minimum of space. The system is normally installed in the LER and the battery bank in the battery container module for the gas turbine, or delivered as loose items when installed elsewhere by others. For SGT-750 the batteries are placed in a compartment integrated with LER.

The system consists of the following panels:

[1] Optionally the system can provide a 3 minutes autonomous operation (gas fuel only) to allow an emergency generator to start up.

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- Line supply module
  - EMC-filter
  - Line reactor
  - Main circuit breaker
  - Line rectifier
  - Measuring Instrument
- UMD & UPS module:
  - Static Frequency Converter's (SFC) for lubrication oil pumps
  - SFC's for lubrication oil system ventilation fan
  - SFC servo's for gas fuel system
  - SFC servo for bypass valve (SGT-600 only)
  - SFC servo for IGV (Inlet Guide Vane)
  - SFC's for ventilation system and (if applicable) also lube oil and seal/purge air coolers (with the option: autonomous operation, the SFC's can be battery backup supplied)
  - UPS Inverters for I&C equipment
  - UPS distribution board with Miniature Circuit Breaker's (MCB)
  - Battery charger with on-line battery diagnostics[2]
  - Control Units (CU) with safety logic for the lube oil system
- Starter motor module
  - SFC for starter motor
- Liquid fuel module (if applicable)
  - SFC for liquid fuel pumps

The motor drive system is connected to the following auxiliary systems/equipment:

- Low voltage distribution panel (unless supplied by others or optional switchgear supplied by Siemens) with 1-ph and 3ph MCB's, see separate document.
- Valve regulated lead-acid (optional Ni-Cd) back-up battery designed for two hour operation with I&C (UPS) load and a complete post lubrication run[3], see separate document.

[2] Turbine operation is not dependent of the battery charger and is therefore always in single configuration.
The charger can easily be exchanged during normal operation. See separate document for details.

[3] Battery is maintenance free and requires no testing during operation; capacity test is normally performed (if required) during a scheduled turbine inspection or overhaul.

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UMD

The UMD system provides uninterruptible AC and battery back-up power via SFC's to the AC driven lubrication oil pumps, oil system ventilation fan(s), servo motors, ventilation fans, lubrication oil coolers and seal/purge air coolers. The system eliminates the need for separate DC-driven back-up motors, pumps and batteries and significantly increases availability (AF) and reliability (RF) of lubrication oil supply to the turbine.

The lubrication oil system works with the principle of 3x50% capacity pumps and frequency inverters[4] ensuring the high AF/RF of the system. The oil system ventilation fan is a single motor/inverter configuration and is used in start up until the ejector is working and in battery mode. In battery mode the motor speeds are reduced for battery saving.

The liquid fuel SFC, starter motor SFC, ventilation SFC, lubrication oil cooler SFC and seal air cooler SFC is disabled in case of an AC loss, hence no battery backup in the normal configuration. If the option autonomous operation is chosen, the ventilation, lubrication oil cooler and seal/purge air cooler system can be operated during AC loss < 3min. Also as an option, the starter motor can be battery supplied for barring purposes during a limited time (2h).

UPS

The rugged and high integrity UPS provides uninterruptible AC and battery back-up power to I&C system via one or two inverter units with true sine wave output. The UPS unit is normally delivered in a single configuration with a manual bypass switch (1x100%), but is optionally delivered in a full redundant scheme with two synchronized inverters (2x100%). The use of synchronized parallel inverters allows an uninterruptible changeover. The redundant UPS unit(s) can be replaced during operation (hot-swap).

The common battery for the UMD and UPS system eliminates the need of a separate UPS battery with normally considerably lower lifetime and integrity class than for the design of the back-up motor battery. The design of the UPS supply ensures high degree of availability and reliability (AF/RF) along with a minimum of maintenance. Optionally the UPS inverters can be excluded when UPS supply is provided by others.

UPS inverters: Power Innovation, 4kVA per module, 19" plug-in case. >50% power margin.

The UPS loads are supplied from a MCB distribution located below the UPS inverters. The MCB's have B-characteristic to ensure full selectivity.

4 Turbine operation can be performed with only one main and booster pump in operation, safety logic require minimum two operational main and booster pumps.

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SFC

The drive system mainly consists of two parts, a rectifier bridge converting the AC to a DC voltage and a second part, the inverter bridge that transforms the DC voltage back to an AC voltage of which the amplitude and frequency can be controlled.

The frequency inverters are designed for heavy-duty applications with constant torque applications. They provide steeples control and use the latest Insulated Gate Bipolar Transistor (IGBT) technology. Extensive built-in diagnostics and protections minimize maintenance and interruptions. Supervisory information from the SFC's (status, speed, power and torque etc.) is displayed in the gas turbine operator's station. The inverters are possible to replace during operation (hot-swap).

SFC for starter motor:
Siemens Sinamics S120, 250kW

SFC for other loads:
Siemens Sinamics S120, 9,7-46kW (9,7-132kW for liquid fuel option)

General for SFC, overload capacity 150% for 1 minute.

Control units

The drives are controlled by Control Units (CU). The communication to the Simatic control system is performed via Profibus. Internal communication between the CU's is performed by digital hardware signals.

Control Units:	Siemens S120 CU320-2 DP
- Power Supply:	24VDC
- Digital input:	12, -3...+30VDC
- Digital output:	8, 24VDC

Features:
- Compact flash card
- Integrated safety functions

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Distributed I/O system

The communication for e.g. charger signals, UPS signals and safety signals between the drive system and the control system is performed by digital hardware signals via distributed I/O, type Simatic PCS7 I/O ET200M which is placed in the panel.

Reference: SIT AB

Figure 2: Simatic PCS7 I/O ET200M

Remote I/O		
Base unit:	IM153-2	
-Power Supply:	24VDC	
-Digital inputs:	SM321	16, 24VDC
-Digital outputs:	SM322	8, 24-120V, 24-230VAC, max. 5A, relay

Drive system technical data

Nominal AC voltage:	380-480, +/-10% (-15% <1min)
Nominal DC voltage:	440, +/-15%
Nominal frequency:	47-63Hz
Rated insulation voltage:	600VAC/DC
Overvoltage category:	Class III acc. to EN 60664-1
Short circuit current rating:	50kA
Protection class:	IP21 as standard
Standards:	IEC/EN: 60529, 60947, 61800-3, 50178, 61000-2, 61000-4
Color code:	RAL 7035
Installation temperature range:	5-40°C
Design temperature:	25°C[5]
Relative humidity:	0-90% non-condensing
Altitude:	max. 1000 m (2000 m optional) a.s.l.
Frequency inverters:	Siemens Sinamics S120
Line Rectifier:	Siemens Sinamics S120
CU type:	Siemens Sinamics CU320-2 DP

[5] Normal prevailing temperature in electric room.

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UPS modules:	Power Innovation INVB (1x100%) or INVP (2x100%). Output: 230VAC, 50/60Hz, 4kVA per module
Battery charger:	Kraft Powercon PRM3, Output: 440VDC, 18A per module
Main circuit breaker (MCCB):	Siemens Sentron 3VL5763, 3-pole, 630A
MCB's DC distribution:	ABB S802, 2-pole, 10-63A
MCB's UPS distribution:	Siemens BETA 5SY6, 1-pole+N, 6A
Cables/wiring:	
-Type:	RQ/RZ (halogen free Polyofin-isolation)
-Internal wiring:	1,0 mm^2 connected without end sleeves
-Internal wiring to I/O:	0,5 mm^2 connected without end sleeves
-Connection:	Max. two cables to one connection
Total dimensions (LxHxW)	
-Standard configuration:	3100 x 2200 x 654 mm
-Maximal configuration:	6640 x 2200 x 654 mm

Options (Please refer to main scope of supply for included options)

- Ingress protection class IP42 or IP54
- 2x100% line module
- 2x100% battery charger
- Redundant battery
- 2x100% UPS with uninterruptible changeover
- 2h DC barring
- 3 min autonomous operation
- Ni-Cd battery
- Hazardous area installation, zone 2, Ex(p) class. Includes N2 back-up for purging during emergency conditions.[6]

[6] Materials for zone1, purge air 3-8 bar(g), 75 l/min. during normal operation provided by others, (300 l/min. during pressurising).

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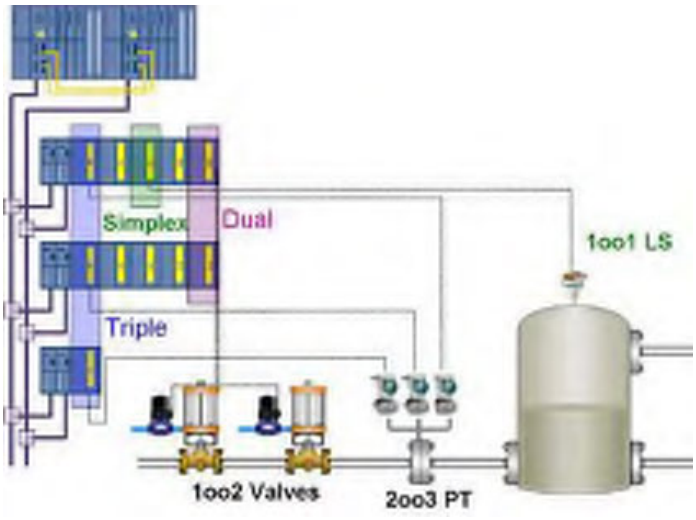
Reliability and availability – simatic PCS7 control system

Flexible modular redundancy

The SIMATIC S7-400FH system features a unique design that is flexible, modular and redundant and which enables the assembly of extremely fault-tolerant architectures. Unlike traditional leg-based architectures, where the failure of a single component causes shutdown of an entire leg of the system, the SIMATIC S7-400FH system integrates certified safety-fieldbus technology, allowing each module to function independently of the other modules in the system.

The level of fault-tolerance can be tailored to match the needs of the application by mixing and matching single, dual and triple redundancy in the same system.



Benefits with flexible modular redundancy™:

- Highest flexibility to choose the redundancy levels to fit the Safety Instrumented Function (SIF)
- Field device redundancy can be designed to achieve safety and availability goals
- I/O and field device redundancy can be matched to:
  - Minimize cost
  - Maximize availability
- Multiple fault-tolerance
  - Fieldbus architecture allows system to tolerate multiple faults without interruption
- Components rated up to SIL3
  - Safety not dependent on redundancy

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Benefits of safety solutions from Siemens:

- Different safety requirements, one solution for applications up to SIL 3
- More flexibility and reduction of stock-keeping due to the possibility to separate or combine safety and standard applications in one CPU
- Easier and less wiring due to the parallel use of PROFIsafe on PROFIBUS for safety communication
- Easier handling thanks to the use of one engineering tool with the standard Siemens programming environment, CFC, used for both failsafe and non-failsafe applications
- Can be fully integrated into SIMATIC PCS 7, giving you one platform for control and safety, including the complete functionality of PCS 7
- Easy operation and maintenance with the integrated, improved diagnostic functions

Benefits of the high-availability systems from Siemens:

- High flexibility with Flexible Modular Redundancy, Mix and Match to meet the goals of the application
- High availability due to the automatic switchover to the redundant hardware without loss of data, should a hardware failure occur

The result is an increase of your productivity during all phases of your plant life cycle.

Reliability and availability calculations

A system comprises a set of components which are interconnected and thus represent a specific structure (hardware, information flow etc.).

System reliability (availability) can be determined from the reliability structure which is a representation of the system structure.

The goal of a reliability prediction is to obtain values which are as close as possible to reality. A calculation should be verifiable, should be highly realistic and should be within the same order of magnitude in a later comparison with values from operation (test, field).

There are various models which are based on a wide variety of procedures and which achieve more or less high accuracy.

The following factors are considered:

- System structure and size
- Component dependencies
- Signal flow
- Maintainability, reparability, time
- Down times
- Failure modes
- Influences such as temperature, stress
- Process engineering

Basic concepts

The quantitative assessment of redundant automation systems is usually based on their

reliability and availability parameters. These are described in detail below.

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Reliability

Reliability refers to the capability of technical equipment to fulfill its function during its operating period. This is usually no longer the case if any of its components fails.

So a commonly used measure for reliability is the MTBF (Mean Time Between Failure), or the MTBFO (Mean Time Between Forced Outage) if you want to separate the failures that causes unavailability from those that do not. This document defines MTBF as failures that causes unavailability (MTBF = MTBFO).

It can be analyzed statistically based on the parameters of running systems, or by calculating the failure rates of the components used.

Reliability of modules

The reliability of Simatic components is extremely high as a consequence of extensive quality assurance measures in design and production.

Reliability of automation systems

The use of redundant modules considerably prolongs the MTBF of a system. The combination of integrated high-quality self-tests and error detection mechanisms of the S7-400H CPUs allows the detection and localization of virtually all errors.

The MTBF of an S7-400H is determined by the MDT (Mean Down Time) of a system unit. This time is derived in essence from the error detection time plus the time required to repair or replace defective modules.

In addition to other measures, a CPU provides a self-test function with an adjustable test cycle time. The default test cycle time is 90 minutes. This time has an influence on the error detection time. The repair time usually required for a modular system such as the S7-400H is 4 hours.

The diagnostic coverage expresses the level of automatic self-testing, which is the percentage of all failure modes together with their failure rates that are covered by self-testing. (For example: a diagnostic coverage of 90% means that if a failure occurs, the probability that this failure will be immediately detected is at least 90%).

Definition of failure
Non- availability of components of the specified system due to component failure (combination of components or single component) in the associated I&C which leads to a non-availability of the I&C system functionality.

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Mean down time (MDT)

The MDT of a system is determined by the times outlined below:

- Time required to detect an error
- Time required to find the cause of an error
- Time required for troubleshooting and to restart the system
- The system MDT is calculated based on the MDT of the individual system components. The

structure in which the components make up the system also forms part of the calculation.

Correlation between MDT and MTBF: MDT << MTBF

The MDT value is of the highest significance for the quality of system maintenance. The

most important factors are:

- Qualified personnel
- Efficient logistics
- High-performance tools for diagnostics and error recognition
- A sound repair strategy

The figure below shows the dependency of the MDT on the times and factors mentioned

above.

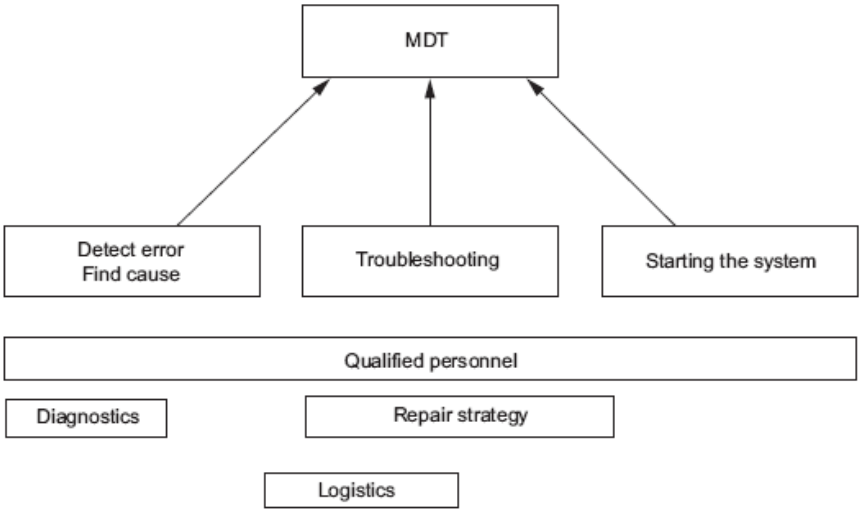

Figure 1 MDT

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The figure below shows the parameters included in the calculation of the MTBF of a system.

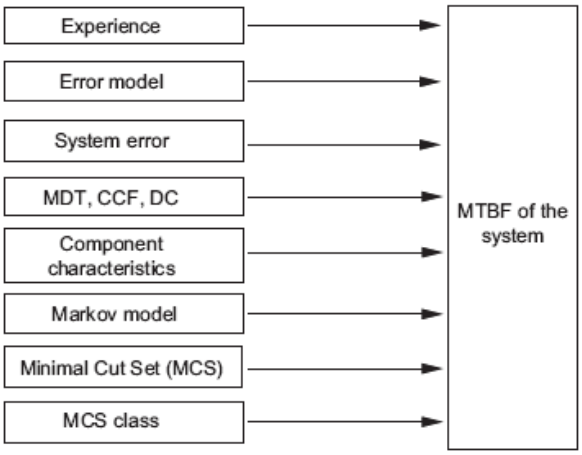

Figure 2 MTBF

Requirements

This analysis assumes the following conditions:

- The failure rate of all components and all calculations is based on an average temperature of 40 °C.
- The system installation and configuration is free of errors.
- All replacement parts are available locally, in order to prevent extended repair times due to missing spare parts. This keeps the component MDT down to a minimum.
- The MDT of individual components is 4 h. The system's MDT is calculated based on the MDT of the individual components plus the system structure.
- The MTBF of the components meets the following standards:
  - SN 29500

This standard is compliant with MIL–HDBK 217–F.

  - IEC 60050
  - IEC 61709
- The calculations are made using the diagnostic coverage of each component.
- A CCF factor between 0.2% and 2% is assumed, depending on the system configuration.
- We suppose that all process information as well as eventual DCS system failures are displayed continuously to an operator. The operator is trained enough to recognize all DCS system faults. This fact plays a key role in the process of keeping the MDT of the components as low as possible.
- The current Siemens component MTBF list provides the basis of the analysis. For the AS level MTBF field values are used for calculation. The field values are approx. 5 times better than the theoretical MTBF values
- Sensors and field equipment are not considered in the calculation.
- The Engineering Station (ES) is not considered in the calculation.
- The Operator Station (OS) is not considered in the calculation.
- UPS devices are not considered in the calculations.
- No printer is considered in the calculations.

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Reliability of an S7-400H

The use of redundant modules prolongs the system MTBF by a large factor. The integrated high-grade self-test and the test/message functions of the S7-400H CPUs enable the detection and localization of virtually all errors. The calculated diagnostic coverage is around 90%.

The reliability in stand-alone mode is described by the corresponding failure rate. The failure rate for all S7 components is calculated according to the SN29500 standard.

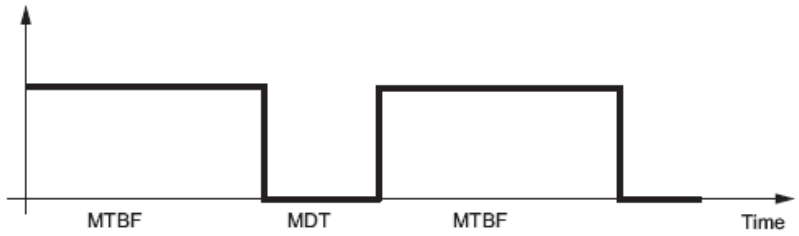
The reliability in redundant mode is described by the failure rate of the components involved. This is termed "MTBF" below. Those combinations of failed components which cause a system failure are described and calculated using Markov models. Calculations of the system MTBF take account of the diagnostic coverage and the common cause factor.

Availability

Availability is the probability that a system is operable at a given point of time. This can be enhanced by means of redundancy, for example by using redundant CPU's or multiple encoders at the same sampling point. Redundant components are arranged such that system operability is not affected by the failure of a single component. Here, again, an important element of availability is a detailed diagnostics display.

The availability of a system is expressed as a percentage. It is defined by the mean time between failure (MTBF) and the mean time to repair MTTR (MDT). The availability of a system can be calculated using the following formula:

$$Availability = \frac{MTBF}{MTBF + MDT} * 100\%$$



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System reliability and availability data

Standard system

MTBF (h)	MTBF (a)	MDT(h)	Availability(%)	Unavailability(h/a)
35012	3,99682	4,0	99,9886	1,00067

Redundant CPUs

MTBF (h)	MTBF (a)	MDT(h)	Availability(%)	Unavailability(h/a)
50360	5,74889	4,0	99,9921	0,69573

Redundant CPUs & enhanced instrumentation

MTBF (h)	MTBF (a)	MDT(h)	Availability(%)	Unavailability(h/a)
61989	7,07636	4,0	99,9936	0,56523

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		Document number		1CS176818	
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Unit control panel and package system FAT

General

All auxiliary systems are tested at sub-suppliers workshop after assembly. After installation in the gas turbine package, the auxiliary systems are also subject to package system FAT at Siemens workshop. The main objectives of the FAT are to verify settings, check adjustments and to carry out wiring checks as well as clean-flushing, tuning and functional checks of systems together with the control system.

Control system FAT is a description of the standardized software and network factory acceptance test performed on all projects. All standard and project specific software is downloaded, installed and tested in the project PLC prior to package system FAT. The software FAT is performed with a software simulator emulating a complete gas turbine package with auxiliaries. The main objective is to verify all project specific logic.

Package system FAT includes project control system panel, with approved software from control system FAT, and remote I/O units on skid. External system which is not available at FAT will not have its remote I/O unit connected to the unit control panel during the FAT.

Temporary cabling will be used between GT package and control equipment, either in a local equipment room (LER) or placed on the workshop floor. Temporary feeders are insulation-tested without test record.

Extent of commissioning during this FAT is dependent on scope of supply contents and availability of auxiliary systems. Some equipment is commissioned earliest on site, for contractual or logistical reasons.

BU / SGT-600(PG B, PG Ex B), SGT-700(PG B, PG Ex B), SGT-750 (PG A)/&EC107	

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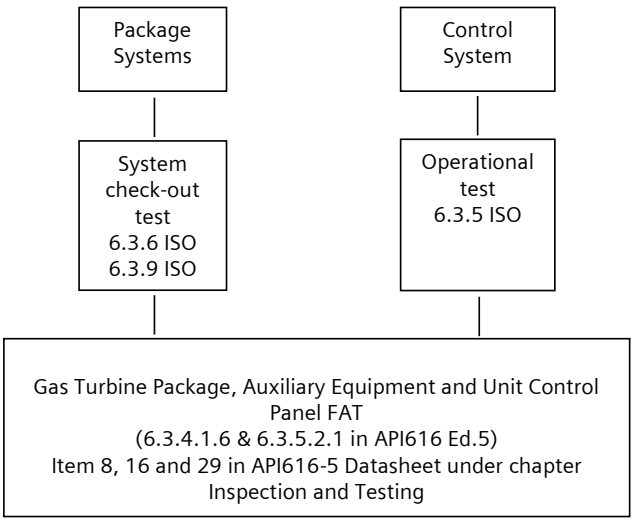
API616 & ISO3977

The gas turbine equipment is functional and operating tested in accordance with ISO 3977-8:2002 and API616 Ed.5:2011 as described below:



a) System check-out test of package systems, such as lube oil unit, fuel units and coolers are conducted by each manufacturer in accordance with Siemens procedure and specified standards prior to package system FAT.

b) Operational test of the unit control panel is conducted during a package system FAT with the control system hardwired to the contract gas turbine package equipment. The communication, alarms, shutdown and package system operation is tested.

c) Lubrication oil system is flushed according to API614 during package system FAT.

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Control system FAT

Software FAT

Automatic start and stop of sequence

Startup with check of all included sequences for driver and driven equipment such as; unit, turbine, fuel, etcetera sequences.

Standard logic

Simulation of package standard logic from complete standstill to reach of maximum load including the following functions for turbine governor: All included controllers and limiters such as; flame sustain control, maximum power controller, gas generator speed limiter, maximum primary pressure ratio control, etcetera. And for AVR (generator governor) if applicable; voltage control, MVAr control, power factor control and field current regulator control.

Gas turbine auxiliary systems

All process systems are tested according to system descriptions.

- Gas turbine auxiliary systems as applicable
- Compressor auxiliary systems, coolers, scrubbers, valves, etcetera as applicable
- Compressor control modes; flow, discharge pressure, suction pressure, load sharing, et cetera as applicable
- Communication as applicable; Modbus, OPC, etcetera.

Project specific logics

All project specific logic that is not within package base standard is tested for correct function and implementation according to system description and setting list.

Project specific safety functions

All safety functions are tested for correct function and implementation according to system description.

Human machine interface

HMI displays are checked for correct implementation and function according to P&ID's.

Alarms and shutdowns

All project specific alarms and shutdowns are tested individually for correct function and indication in HMI.

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Communication FAT

Communication FAT is performed with project equipment setup according to project control system architecture. All network settings are inserted and names and addresses are setup. While compiling all system parts the online loading capability is checked.

All network connections and redundancies, project specific time synchronization, normal operation system load and memory utilization is controlled.

For security the HMI user administration is set.

Preconfigured trends are tested.

System auto start and lock of workstation for all operator station servers and operator station clients are configured. Also each backup battery is tested.

If applicable, external communication via OPC, Modbus or other protocol, is configured and tested.

If applicable, dual language and dual tagging systems are setup and checked.

Finalizing

After FAT completion all documentation and protocols are checked and signed prior to archiving.

Package system FAT

Component FAT loop checks

Instruments

All instrument circuits connected to control system and available at FAT are tested.
Operating values and ranges are checked against the setting list and calibration protocol.
Electrical function including wiring is checked against electrical documentation.
I/O in control system for all connected signals will be verified during the loop check.

Pressure switches and pressure transmitters

Function is checked by means of an adjustable pressure source applied to the pressure line to the switch.

Temperature transmitters, vibration, axial displacement and transducers

Function check is made by signal simulation.

Position transducers, limit switches and level switches

The position is tested by moving the actuator cam or float.

The operating values of the switch are checked against the setting list.

Adjustments are made if necessary.

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Control objects

All control objects connected to control system and available at FAT are tested.
Electrical function including wiring is checked against electrical documentation.
Checklist may be signed even if temporary cabling is used at package system FAT. Test record will then be completed on site with permanent cabling.

Electrical motors

Electrical motors are tested regarding insulation, rotating direction and current draw.

All data is recorded in test form.

Electrical heaters

Electrical heaters are tested regarding insulation and current rating.

All data is recorded in test form.

Pneumatic valves

The function of all valves is checked against system drawings.

Opening and closing times to be recorded.

System FAT

A general visual inspection of mountings, pipe connections and electrical cabling and connections is carried out. The piping and all components are checked against the system drawings, (P&ID´s) and component lists. System FAT requires energised unit control panel, frequency converters, UPS, charger and low voltage switchgear.

All systems available at FAT are checked against system drawings and circuit diagrams.
All available signals are tested against the unit control panel.

Unit control panel

Project software will be downloaded in unit control panel for normal operation during package system FAT.

100% of I/O hardware in unit control panel and available at package system FAT is tested.

Gas turbine, starter and main gear system

- Flame detectors are tested.
- Combustor by-pass valves are verified (if included in delivery)
- Operation of variable inlet guide vanes is verified.
- Operation of bleed valves is verified.
- T7 individual check for correct connection
- GT is rotating up to ignition speed with start motor system

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Instrument air system

Valves and transmitters are operated under normal working conditions.

- The system is checked for leaks and is clean blown.

Lubricating oil system

The tank is filled and the system is flushed clean. Pumps, fans, heaters and transmitters are operated under normal working conditions.

- Lubricating oil heaters are switched on.
- Lubricating oil pumps and oil ventilation fans are started up; converters commissioned and pump change over tested.
- The system is flushed with bearings by-passed. Flushing ends when the degree of purity has reached an acceptable level and bearings are reconnected.
- The pressures after the pumps and oil tank vacuum are adjusted and the complete system is checked for leaks.
- Filters change over tested and inspected for cleanliness.
- Emergency oil verified by AC/DC switch over.

Compressor cleaning system

- Tanks and filters are inspected and cleaned if required.

Liquid fuel system, dosage / steam- / water injection

The liquid fuel and related systems has been subject to a standard FAT before delivery from the supplier and normally not available or installed in package unit.

Gas fuel and ignition gas systems

- Control valves, shut-off valves and transmitters are operated.
- The operation of valves is verified.
- Internal piping is clean blown and leak tested.

AC Generator and main terminal box (PG units)

The AC generator has been subject to a standard FAT before delivery from the AC generator supplier's workshop and only few tests are made if available and installed in the package unit:

- ID Check of transformers in main terminal box.

Gas compressor and seal gas system (MD units)

The compressor unit has been subject to a standard FAT before delivery from the compressor manufacturer workshop and only few tests are made if available and installed in the package unit:

- The installation is checked against P&ID´s and circuit diagrams.
- Available instrument loops are tested against the control system, and verification of systems against system description.

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400 or 460V AC-System

The low voltage switchgear will be used under normal working conditions, energising pumps heaters and fans during all tests.

- The system is checked regarding busbar insulation resistance and protective earthing.
- The system is energised and the phase sequence is checked. If included, the switchover and interlocking circuits for switching between alternative incoming supplies are tested.
- Outgoing feeders for motors and heaters are tested regarding insulation, protective earthing, control circuits, setting and function of overload protection, labelling of components, direction of rotation for motors, service current for motors, function and current of heaters.

DC-System and UPS

The DC system will be used under normal working conditions as backup for converter systems or direct emergency oil system during the FAT. The UPS system will be used under normal working conditions, energising the control equipment during the FAT.

- Insulation and protective earthing of the system are checked.
- The system is energised.
- The battery charger is tested and settings verified.
- The outgoing feeders are tested regarding insulation, protective earthing, control circuits, protections and interconnections.
- Battery and inverter mode is tested on UPS.

Relay protections (PG units)

The relay protection is energised, tested and settings are recorded in the setting list.

- The circuits for the relay protections are checked against the circuit diagram.
- Secondary injection tests including check of indications and trip pulses to the unit circuit breaker are conducted.
- The relay protection is set according to the setting list.

Voltage regulator (PG units)

If available and installed in the package unit, the following tests will be completed:

Functions and settings used for the specific project are tested and values are recorded in the setting list. Field current regulator is operated from the controller and tested.

- Communication with control system.

Compressor, suction, discharge and anti surge system (MD units if included)

The programmable controller for the anti surge controller is subject to a standardised test procedure. Selected functions and settings are tested and values are recorded in the setting list.

- Instruments are tested according to component tests.
- Wiring check. The installation is checked against the circuit diagram.

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Protection system

Protection relays are energised and function-tested.

Systems not included in package system FAT

- Fire extinguishing system
- Gas detection system
- Ventilation system
- Air intake system
- Exhaust system
- Liquid fuel system
- Dosage/steam-/water injection system

In addition to the above list, the following systems are in some applications not installed on skid and therefore not included in the package system FAT.

- AC generator and voltage regulator
- Compressor cleaning system

FAT completion and report

After the FAT is completed, all oil and fuel are drained. Pipe connections for fuel inlet and to the oil cooler as well as air inlets and exhaust outlet are carefully blanked off to prevent contamination during transport. Protective covers, which are necessary for transport, are fitted.

An internal report will be written where all outstanding items are specified for each system. Installation and commissioning manual checklist signatures for package system FAT cover the level of equipment installed for standard packages. All documentation, including report, will be handed over to the site organisation and backup of control system application software to design office.

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SIEMENS	Auxiliary Systems SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W631025E	
		Document number		1CS26775	
		Revision	P	Page	1

Generator relay protection

General

The purpose of the generator protection is to protect the gas turbine generator and turbine from abnormal running condition that could cause damages to the unit.

The Gas turbine generator unit from Siemens Industry Turbomachinery (SIT) is equipped with a multifunction generator protection unit from Siemens SIPROTEC 4 family and is of type 7UM62x. The protection is of fully numerical type and is rack mounted in a swing frame in the control cubicle.

The exposition of the relay protection system is shown on the single line diagram.

Purpose of the system

Generators are designed to run at a high load factor for a large number of years and permit certain incidences of abnormal working conditions. The machine and its auxiliaries are supervised by monitoring devices to keep the incidences of abnormal working conditions down to a minimum. Despite the monitoring, electrical and mechanical faults may occur, and the generators must be provided with protective relays which, in case of a fault, quickly initiate a disconnection of the machine from the system and, if necessary, initiate a complete shut down of the machine.

The relay protection system shall, together with the Generator Circuit Breakers (GCB), Field Circuit Breakers (FCB), Gas Turbine (GT) and eventually Utility Circuit Breaker (UCB), disconnect faulty parts of the power system to:

- Protect the primary equipment against damages.
- Save people in the vicinity of the electrical plant from injuries.
- Enable continued service in the undamaged parts of the network.

Protection Functions

The design of SIT relay protection system is determined by consideration of a variety of factors such as machine/gas turbine performance data (capability diagram, overload curve, output curve etc.), availability requirements, experience and design philosophy. Protection functions in order to handle different mode of operations and different plant configuration is in all normal cases handed outside SIT machine protection terminals, however normal adjustments of e.g. short circuit and earth fault functions in order to fit in to the plant owners selectivity plan, is normally carried out.

In order to satisfy above mentioned requirements, a combination of protection functions is included in the basic SIT generator protection.

For included protection functions see scope of supply.

The following basic generator protection functions are always included in the gas turbine scope of supply.

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Protection functions	ANSI code	Description	Comments
Inverse time O/C - short-circuit and backup protection	**51V** I>+U<, t=f(I)	3-phase, normal inverse current dependent time delay, with voltage restraint influence.	**Voltage restraint:** The pickup threshold of the overcurrent stage depends on the voltage level.
Unbalance load (negative sequence) Protection - detects an asymmetrical load in three-phase generators & evaluates the negative sequence from the phase currents.	**46** I2>, t=f(I2)	The negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element. Warning stage I2>, thermal inverse characteristic, cool down time, definite time tripping stage I2>>.	The generator manufacturer indicates max. continuous negative sequence current I2 and fault condition capability $(I2/In)^2xt$.
Differential - high speed selective short-circuit protection based on the current differential protection principle.	**87G** Idiff>	Current stabilization, attenuation of disturbances such as aperiodic component and harmonics, a very high sensitivity, adjustable restraint characteristic, harmonic analysis of the differential current, inrush (2nd harmonic) current, high speed tripping stage IDiff>>.	Connected to CT's placed in terminal box on the line and neutral side of the generator.
Underexcitation (loss of field) protection protects a synchronous generator from asynchronous operation in the event of faulty excitation or regulation and from local overheating of the rotor.	**40** Φ<	The calculated admittance corresponds to the generator diagram scaled in per unit. Three characteristics for monitoring static and dynamic stability provided which allow the protection to be optimally adapted to the generator capability diagram. Correctly operation even with asymmetrical network conditions.	The generator manufacturer provide generator capability diagram which shows e.g. stability limits of the generator. The setting values to be directly read out.
Reverse power protection is used to protect a turbine unit on failure of energy to the prime mover when the synchronous generator runs as a motor and drives the turbine taking motoring energy from the network.	**32R** P<	The level of the active power input is determined by the friction losses to be overcome and pick-up value is set to P>reverse/Sn= -1%. Tripping delay times with or w/o emergency tripping is available (with stop valve (SV) open/closed).	
Undervoltage protection detects voltage dips in electrical machines and avoids inadmissible operating states and possible loss of stability.	**27** U<	2-stages U<=84%xUn and U<<=65%xUn with time delays. Drop-out ratio = 1,05.	Time delays do not include the operating times (measuring time, dropout time) of the protective function.

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Protection functions	ANSI code	Description	Comments
Overvoltage protection serves to protect the electrical machine and connected electrical plant components from the effects of inadmissible voltage increases.	**59** U>	2-stages U>=115%xUn and U>>=130%xUn with time delays. Drop-out ratio = 0,95.	Time delays do not include the operating times (measuring time, dropout time) of the protective function.
95% - stator earth fault (neutral voltage) protection detects earth faults in the stator windings of the generator.	**59N** UN>	The criterion for the occurrence of an earth fault is mainly the emergence of a neutral displacement voltage. This principle makes possible a protected zone of 90 % to 95 % of the stator winding. Exceeding the set value Uo>=(5%/√3)*Urg causes pickup for stator earth protection.	The device calculates the displacement voltage from the phase- to-earth voltages.
Watchdog for continuous monitoring of the program sequences		Hardware and software watchdog is provided. This initiates a restart of the processor system. After three unsuccessful restarts within a 30 second window of time, the device automatically removes itself from service and the red "Error" LED lights up. The operational readiness relay ("Life contact") opens and issues an alarm (alternatively as NO or NC contact).	
Voltage transformer (VT) circuit supervision – operate in the event of a measured voltage failure due to a short circuit fault or a broken conductor in the voltage transformer secondary circuit.	**60FL**	When a VT circuit failure is detected, this status is stored. This ensures that the VT circuit failure indication is maintained even in the event of a short circuit. As soon as the VT circuit failure has been eliminated, and the voltage has risen above 85 % of the nominal voltage, the stored value is cancelled, and the VT circuit failure indication is reset with a delay of 10 s.	The miniature circuit breaker (MCB's) supervision is implemented in GT control system.
Stator overload protection - Protect the stator windings of the generator from high, continuous overload current.	**49** Ith>	All load variations are evaluated by a mathematical model. The thermal effect of the r.m.s. current value forms the basis of the calculation. This conforms to IEC 60255-8. Independence of the current, the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant is injected, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed. Temperature detectors are also implemented in the stator winding.	**NOTE:** The overload protection is implemented and set in the GT control system.
Rotating diode failure protection (excitation system)	**58** I~>	Diode monitoring is used for detecting the failure like break of a diode and short circuit of a diode. It is needed in brushless excitation system and can only be done indirectly, because the diodes are parts of the rotor. The device evaluates the alternating current induced in the field circuit of the exciter in the event of a fault in the rotating rectifier.	**NOTE:** This function is included and set in the Automatic Voltage Regulator (AVR) unit for synchronous machines.

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Additional protection functions (not included in basic scope of supply)

For included *additional* protection functions see scope of supply.

Protection functions	ANSI code	Description	Comments
Block generator transformer differential - high speed selective short-circuit protection based on the current differential protection principle. **Note:** Block generator – transformer differential protection will be implemented only in channel 2.	**87GT** Idiff>	Current stabilization, attenuation of disturbances such as aperiodic component and harmonics, a very high sensitivity, adjustable restraint characteristic, harmonic analysis of the differential current, inrush (2nd harmonic) current, high speed tripping stage IDiff>>.	This function is included in one of the two SUB systems by extending the generator diff zone. Connected to CT's placed on HV side of two-winding step-up transformer as well as on neutral side of generator.
Directional stator earth fault – detect earth faults for machines in busbar connection.	**67GN** Uo> 3Io>	The protection detects a machine earth fault if the following three criteria are fulfilled: • Displacement voltage larger than set value U0>, • Earth fault current across the measurement location larger than set value 3I0>, • Earth fault current is flowing in the direction of the protected machine.	The device calculates the displacement voltage from the phase-to-earth voltage. The earth fault current is measured using a toroidal current transformer placed on line side of the generator. **Note**: The CT is not included in SIT Scope of Supply, if not otherwise agreed in scope of supply.
Impedance protection is used as a selective time graded protection to provide shortest possible tripping times for short-circuits in the synchronous machine, on the terminal leads as well as in the unit transformer.	**21** Z<	Polygonal tripping characteristic. 1st stage Zone (Z1, T-Z1) cover faults in the generator and the LV side of the unit transformer. 2nd stage Zone (Z2, T-Z2) covers the network. Faults outside this range are switched off by the T-END final time stage. Overreach zone (Z1B, T-Z1B) can be enabled via binary input controlled by circuit breaker auxiliary contact. (CB open).	Provide also backup protection functions to the main protection of a equipment connected in series like generator, transformer differential and system protection devices.

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Protection functions	ANSI code	Description	Comments
Out of step protection. Dynamic occurrences such as load jumps, short-circuits not disconnected quickly enough, autoreclosure or switching actions, may cause system swings. Such power swings endanger power network stability and can lead to **pole-slipping** and generator overloading.	**78** dZ/dt	Based on impedance measurement and evaluation of the complex impedance vector trajectory. Power swing Phi polygon determined by the settings parameter of impedances Za,Zb,Zc and (Zd-Zc). Positive sequence component of the currents pick-up I1>=120%xIng, negative sequence component of the current pick-up I2<=20%xIng.	
Sensitive earth fault (rotor ground fault) protection detects earth faults in the rotor of the generator.	**64R** IEE>	2 stages, 1st threshold value IEE> with the alarm command transmitted subsequent to the T-IEE> delay time and 2nd threshold value IEE>> with no any alarm command (T-IEE>> set to oo value). Current through the earth capacitance is set to IEE<=0mA.	**Note:** Rotor Earth Fault Protection will be implemented only in channel 1.
Breaker failure protection monitors proper switch off of the generator circuit breaker (GCB).	**50BF** Imin>	Three phase, two pick-up criteria, current criterion and CB auxiliary contact (GCB open). Start with internal TRIP command via BO12. Supervision current pick-up I>=20%xIn with time delay TRIP-timer.	
Frequency protection function detects abnormally high and low frequencies of the generator.	**81** f<, f>	Four frequency elements f1 to f4, 2 of stages used for frequency decrease and 2 of stages for frequency increase. Siemens standard settings are calculated according to GT rotor speed limitation as well as generator permissible voltage and frequency variations during operation.	**Note:** The frequency protection is not intended for use as power network protection. The actual network conditions are **NOT** considered as well as eventually network decoupling and load shedding.

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Protection functions	ANSI code	Description	Comments
100% Stator earth fault with 20 Hz Voltage injection If an earth fault occurs in the generator starpoint, the 20 Hz voltage drives a current through the fault resistance. From the driving voltage and the fault current, the protective relay determines the fault resistance. The protection principle described here also detects earth faults at the generator terminals, including connected components such as voltage transformers.	**64G** **R<SEF** **R<<SEF**	The 20 Hz voltage is injected into the generator starpoint via a powerful voltage transformer and drops off at the primary load resistor. In the presence of an earth fault, an earth current flows through CT in the starpoint. The protection function detects and processes this current in addition to the 20 Hz voltage. **Note 1:** 100% Stator Earth Fault Protection with 20Hz Voltage Injection will be implemented only in channel 1.	The 100 % stator earth fault protection detects earth faults in the stator windings of generators which are connected with the network via a unit transformer. This protection function, which works with a 20 Hz injected voltage, is independent of the network frequency displacement voltage appearing in earth faults, and detects earth faults in all windings including the machine starpoint.
100% stator earth fault with 3rd harmonic If an earth fault occurs in the generator stator winding, the 3rd harmonic measured in the starpoint decreases, whereas the 3rd harmonic measured at the generator terminals increases. The 3rd harmonic forms a zero phase-sequence system and can thus also be determined.	**27/59TN** **Uo 3.H<** **Uo 3.H>**	The content of the 3rd harmonic in the measurement value is the pickup criterion. The 3rd harmonic is determined from the displacement voltage measured over two cycles by means of digital filtering.	The extent of the 3rd harmonic depends on the operating point of the generator, i.e. a function of active power P and reactive power Q. For this reason, the working range of the stator earth fault protection is restricted in order to increase security.
Sensitive earth fault– detects earth faults in system with isolated or high-impedance earthed star point.	**50N/51N** IEE>	The protection consists of two stages. A pickup is detected as soon as the first parametrized threshold value IEE> is exceeded. The trip command is transmitted subsequent to the T IEE> delay time. A pickup is detected as soon as the second parametrized threshold value IEE>> is exceeded. The trip command is transmitted subsequent to the T IEE>> delay time.	**Note:** Sensitive Earth Fault Protection will be implemented only in channel 2.

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Protection functions	ANSI code	Description	Comments
Overexcitation protection detect inadmissibly high induction in generator.	**24** U/f>	The voltage/frequency ratio U/f is measured, which is proportional to the induction and puts it in relation to the nominal induction. In this context, both voltage and frequency are related to nominal values of the protected generator. Two staged characteristics and one thermal characteristic are included for approximate modeling of the heating of the protection object due to overexcitation.	
Trip lockout function is used to prevent accidental closing of the circuit breaker after a trip.	**86G**	As long as no trip occurs, lockout relay will be opened. Every trip signal which has been routed to lockout relay will activate the trip lockout function and open the contacts of lockout relay. When the contacts have opened, they will be locked into the open state. The trip lockout function can be reset remotely/locally with a separate reset command before the circuit breaker can be closed again.	

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Tripping Logic

Tripping matrix is shown on the single line diagram. The tripping signals for all protective functions are allocated to respective LED's for alarm indication and associated relay outputs for tripping of GCB, FCB and GT.

To fulfil the single failure criteria (as far as possible) a protection system is divided into two SUB systems, SUB1 and SUB2, each of them having its own protection unit with the same protection functions included.

Communication interfaces

The following interfaces are available as a SIT standard for the communication with operating, control and memory systems.

Communication interface	Connection	Description
Operator interface	Front side	Used for local communication with a personal computer.
Service interface	Rear side	Used for remote communication via personal computer.
System interface	Rear side	Used for central communication between SIPROTEC device and a GT control system SIMATIC S7. As a standard it operates through data cables. Siemens SIT standard protocol available for data transmission: • Profibus DP slave, electrical RS485 This protocol of automation technology allows transmission of indications and measured values. To maintain the unit clocks and keeping the time data accurate and synchronized, Profibus DP is available as Siemens standard for time synchronization.

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SIEMENS	Electrical Equipment SGT-600, SGT-700, SGT-800	GTI number		W631031E	
		Document number		1CS93673	
		Revision	E	Page	1

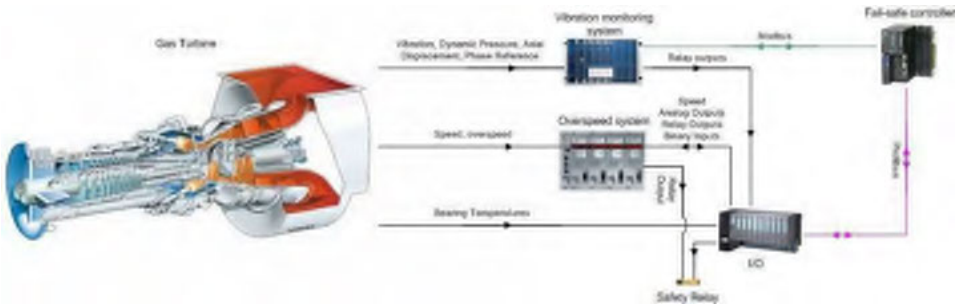
Machinery Protection

This publication describes machinery protection system for vibration, axial displacement, bearing temperature, speed, overspeed and combustion dynamic pressure. Applications covered are Mechanical Drive and Power Generation for onshore and offshore installations of the gas turbine package.

All parts covered in this publication are delivered assembled and tested. All components are carefully selected to ensure satisfactory function with respect to operating and environmental conditions.

The system is designed for continues operation, with maximum availability and reliability.

Machinery protection for driven equipment; refer to scope of supply for included equipment.



Vibration, Dynamic Pressure, Axial Displacement and Phase reference

The machinery protection system main task is to protect the machine train from dangerous levels of vibration, axial displacement and combustion dynamic pressure (dynamic pressure is included for SGT-700 and SGT-800, added on request for SGT-600). The system is a 19” rack based system consisting of modular slots.

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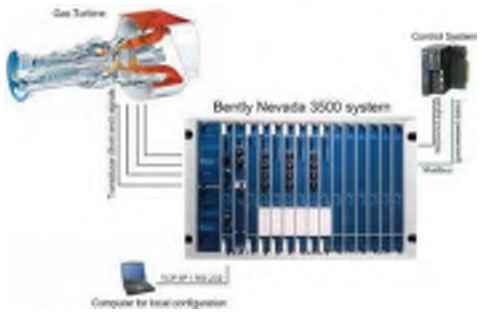
Features

- Real-time measurement and monitoring
- Fully programmable and easy-to-use configuration software
- Integrated event & alarm list
- Wide range of processing possibilities for one input channel
- High flexibility
- Continues online monitoring



Design

The machinery protection system is delivered as a 1-out-of-Q[1], 2-out-of-W[1] can be delivered on request (optional). The system is supplied preassembled, configured and tested according to application to be served. Transducers are connected to the rear input cards and are power supplied by the rack. Processed transducer data is send to the overall control system via Modbus communication. The interface between the machinery protection system and control system for danger (shutdown) signals are via relay outputs.

The machinery protection system comprises

- 19” 6 HU rack with backplane and terminal strips on rear side
- Rack interface module (CPU) with rack supervision
- Single or redundant power supply(ies)
- 4 Channel vibration modules
- 4 Channel dynamic pressure module(s) (for SGT-700 and SGT-800, added on request for SGT-600)
- 2 Channel phase reference module(s)
- 16 Channel relay module
- Communication module

Function

The BN3500 machinery protection system provides continues online monitoring. The BN3500 provides transducer diagnostics such as wire break, limit check and short circuit. All transducers connected to the system will have their diagnostic included in the danger voting. The transducers input values are signal processed (filtered, integrated and so forth) and the processed values are compared with pre-defined danger and/or alarm set points. If the value exceeds the set point or if the system has recognized a faulty transducer and the transducer is included in the danger and/or alarm logic the corresponding danger and/or alarm relay will switch state. The relays are hardwired to the control system and if the control system detects a danger signal from the BN3500 the control system will initiate a shutdown (start abort, unloading shutdown or emergency shutdown depending on level and

[1] Q and W are depending on product, available space inside the machine and safety level of the measuring point. In general the delivery is 1oo1 or 2oo3 on request, but with the exceptions mentioned before.

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operation sequence).
The safety signals are hardwired, all other non critical signals, such as overall values, monitor status and so forth, are send to the control system via Modbus communication.

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SIEMENS	Electrical Equipment SGT-600, SGT-700, SGT-800	GTI number		W631031E	
		Document number		1CS93673	
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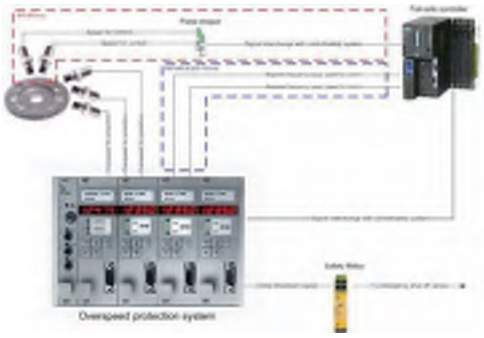
Overspeed protection and speed measurement

The overspeed detection system is protecting the rotating shafts in the machine train from overspeeding. The overspeed detection system is a 2-out-of-3 voting bulkhead/wall mounted system consisting of modular slots.

Features

- SIL-certified acc to IEC61508
- Standard 2-out-of-3
- Fast total response time, <15 ms
- High level protection
- API 670 compliant, with comments
- Redundant power supplies
- Test procedure



Design

The overspeed system is delivered preassembled, configured/programmed and tested according to application to be served. For the SGT-800 package are speed signals for controls handled separate from speed signals aimed for monitoring of overspeed conditions i.e speed for controls and speed for overspeed protection is two separate systems. For the SGT-600 & SGT-700 packages are speed sensors for controls and overspeed protection shared due to space restrictions. All signals to and from the overspeed system are of conventionally hardwired type, no bus communication.

The overspeed protection system can be used in protection loops up to and including SIL level 3.

The overspeed system includes test functions.

All three speed signals for overspeed detection are permanently monitored and evaluated by each overspeed monitor.

The safety relays are with force guided contact sets.

The overspeed system and speed system comprises

SGT-800

- 1 off 2-out-of-3 bulkhead mounted overspeed system per gas turbine shaft
- 3 off speed measurement chains for overspeed protection per gas turbine shaft, including Hall-effect sensor and galvanic isolator if necessary.
- 2 off speed signal shapers per gas turbine shaft
- 2 off speed measurement chains for speed per shaft, including eddy current sensor, driver/conditioner and galvanic isolator.

SGT-600 & SGT-700

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- 1 off 2-out-of-3 bulkhead mounted overspeed system per gas turbine shaft
- 3 off speed measurement chains for overspeed protection (2 sensors are repeated for controls) per gas turbine shaft, including Hall-effect sensor and galvanic isolator if necessary.

Function

The speed probes deliver a pulse train proportional to the rotor speed to the overspeed system. The input speed is compared with a pre-defined speed set point (overspeed) and all speed channels measuring on the same shaft is voted.

Total response time to overspeed condition is 15 ms, from a sensed overspeed condition to the relays have changed state. Each channel have an internal voting with detection of true overspeed, speed probe failure (measurement chain failure), power supply failure, speed probe limit control and monitoring module failure as included elements.

The overall voting includes each voted channel, speed deviation and overall system failure. The voting is 2-out-of-3.

A 1-out-of-3 condition will generate an alarm, a 2-out-of-3 condition will generate immediate emergency shutdown.

Speed levels are displayed at the HMI.

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Bearing temperatures

The bearing temperature together with the axial displacement and lubrication oil temperatures provides the gas turbine bearing monitoring and will alert in the event of an unfavourable change to the bearing.

Features

- High quality RTD sensors
- Ø3mm bendable coat, stainless steel
- Bendable protection spring at cable reducing point

Design

The bearing temperature sensors are delivered tested and assembled in the bearings and comprises;

- Wirewounded IEC 60751 Class B PT100 elements
- Dual PT100 in one sensor

Bearing temperature sensors are installed in all active bearings.

Function

The bearing temperature sensor performs continues monitoring of the bearing temperatures. The sensors are connected to and processed in the control system.
The temperatures are displayed at the HMI.
In the control logic are the temperatures compared with a pre-defined set point. If the temperature exceeds the set point, the control system will initiate an alarm.
Shutdown functions for bearing temperatures are not implemented. Shutdown functions related to the bearings are only initiated by lubrication oil temperature and axial displacement.

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SIEMENS	Electrical Equipment SGT-600, SGT-700, SGT-750 SGT-800	GTI number		W631026E	
		Document number		1CS26843	
		Revision	N	Page	1

Unit protection and emergency shutdown

General

The unit protection system is built up around one fail safe controller proven according to IEC61508. The controller is capable of SIL levels up to 3. To the PLC various instruments are connected and via evaluation logic necessary objects are tripped in case of danger. In series with the controller a lock out relay is connected. Over speed protection is hardwired. The system communicates with the operator station where all system information can be observed.

Operating principle

The system works with the "fail safe" principle, i.e. the input device is energised during service. This is in general valid for the devices connected to the alarm system as well.

The fuel shut-off valves are for safety reasons of the open/energised type.

Both the CPU and input and output cards are equipped with a number of checks in order to detect dangerous malfunctions. These checks are carried out periodically and automatic by the CPU and I/O cards them self. Program execution uses a technique of diverse execution, i.e. the program is executed twice using different algorithms. End results are compared and in case of differences a fail safe state is forced. Data within CPU memory as well as on the buses uses CRC (check sums) in order to ensure high integrity of the data.

Description

The fail safe controller forms the unit protection system. Process signals connected to the system are treated and compared with internal setting values and are if exceeding the set values distributed to the system outputs which activates the shut off valves and the GCB (Generator Circuit Breaker only with Power Generation)as well as the back-up "lock out trip relay". The unit protection system works with the tripping scheme 1oo1 and 1oo2. Please see system configuration on page 3.

The following trip signals are duplicated and thereby working on the 1oo2 principle:

- Over-speed turbine
- Flame-out detection
- Purge monitoring
- Ignition failed
- Exhaust temperature high
- Lubricating oil pressure low
- Lubricating oil temp high
- Gas detection

FO / SGT-600(PG B, PG EX B, MD B), SGT-700(PG B, PG EX B, MD B), SGT-750(MD A, PG A, PG EX A), SGT-800(PG B, PG B2, PG Ex B2, PG B LS) /&DF101	

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		Document number		1CS26843	
		Revision	N	Page	2

Annunciation

All shutdown and alarm signals of the gas turbine set are being displayed on the operator station. The alarm/shutdown signals will be displayed in a list form where all signals are time marked for easy troubleshooting and fault/event analysis.

Fire extinguishing control unit

The fire extinguishing equipment covers the gas turbine room. It is powered from a separate battery/charger set.

On the front panel there is a key switch used for blocking the extinguishing media initiators.

The central unit triggers the initiator upon a signal in the detector line either from the fire-detectors or upon a manual release order. Immediately the sirens and flashlights are turned on and the fire dampers are released, the turbine is tripped and the auxiliary equipment is stopped accordingly. The extinguishing media will be released after a time delay. Fire protection equipment failure and fire alarms are indicated on the Operator Station.

Gas warning system

The system consists of gas detectors, connected to a central unit. Alarm and trip levels are detected from each detector signal. When a trip level is exceeded the gas turbine unit is shut down.

The detectors are supervised by the central unit and a detector failure alarm is provided in the operator station.

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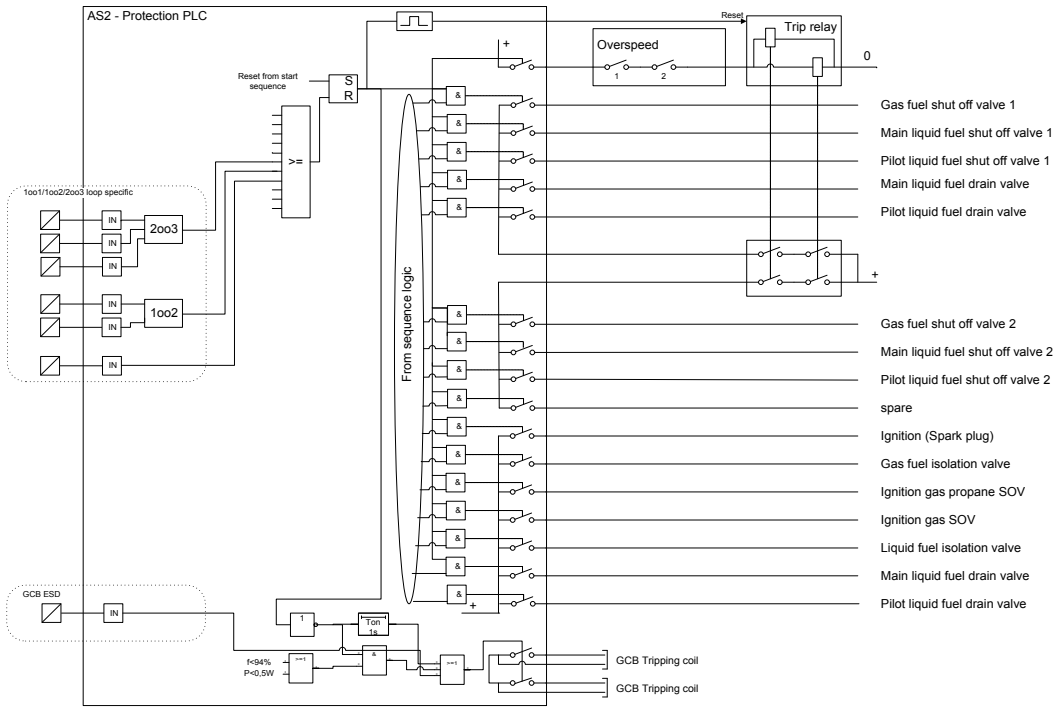
Blockdiagram



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SIEMENS	Electrical Equipment SGT-600, SGT-700	GTI number		J633015E	
		Document number		1CS73677	
		Revision	C	Page	1

Enhanced instrumentation reliability

1. General

In order to avoid that single faults of instruments causes the turbine to trip, the installation can be equipped with additional instruments for 2oo3 voting.

The table below shows the instruments that are included in the enhanced instrumentation reliability option.

The table also shows which instruments those are possible to change during operation.

2. Control equipment

The ET 200 iSP distributed I/O station supports removal and insertion of one electronic module during operation (RUN mode), if at least two electronic modules are present in an ET200iSP station.
If one electronic module is removed the ET 200iSP remains in the RUN mode. If removing more than one electronic module, this leads to an ET200iSP station failure.

All current parameters and identification data of the ET200iSP are stored in an internal flash memory in the interface module IM 152. After change of a module, IM 152 automatically transfers these data to the new module. This function is always active on the ET200iSP and cannot be influenced by the user.

No disconnecting of wires when swapping, all wires are connected to the terminal modules.

3. Instruments

Note 1: Possible to change during operation.

Note 2: Not possible to change during operation.

BO / SGT-600(PG B, PG Ex B, MD B) SGT-700(PG B, PG Ex B, MD B) / &DF101	

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SIEMENS	Electrical Equipment SGT-600, SGT-700	GTI number		J633015E	
		Document number		1CS73677	
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Measuring point	SGT-600 KKS	SGT-700 KKS	Note
Axial displacement bearing 4	**MBB10CG005**	**MBB10CG005**	**2**
Axial displacement bearing 4	MBB10 CG015	MBB10 CG015	2
Axial displacement bearing 4	MBB10CG020	MBB10CG020	2
Exhaust duct diff pressure	**MBB10CP010**	**MBB10CP010**	**1**
Exhaust duct diff pressure	MBB10CP015	MBB10CP015	1
Exhaust duct diff pressure	MBB10CP020	MBB10CP020	1
Power turbine speed 1	**MBB10CS005**	**MBB10CS005**	**2**
Power turbine speed 1	MBB10CS010	MBB10CS010	2
Power turbine speed 1	MBB10CS020	MBB10CS020	2
Exhaust gas temperature outer	**MBB10CT005-P01**		**2**
Exhaust gas temperature inner	**MBB10CT005-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT005-P03		2
Exhaust gas temperature outer	**MBB10CT010-P01**		**2**
Exhaust gas temperature inner	**MBB10CT010-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT010-P03		2
Exhaust gas temperature outer	**MBB10CT015-P01**		**2**
Exhaust gas temperature inner	**MBB10CT015-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT015-P03		2
Exhaust gas temperature outer	**MBB10CT020-P01**		**2**
Exhaust gas temperature inner	**MBB10CT020-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT020-P03		2
Exhaust gas temperature outer	**MBB10CT025-P01**		**2**
Exhaust gas temperature inner	**MBB10CT025-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT025-P03		2
Exhaust gas temperature outer	**MBB10CT030-P01**		**2**
Exhaust gas temperature inner	**MBB10CT030-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT030-P03		2
Exhaust gas temperature outer	**MBB10CT035-P01**		**2**
Exhaust gas temperature inner	**MBB10CT035-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT035-P03		2
Exhaust gas temperature outer	**MBB10CT040-P01**		**2**
Exhaust gas temperature inner	**MBB10CT040-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT040-P03		2
Exhaust gas temperature outer	**MBB10CT045-P01**		**2**
Exhaust gas temperature inner	**MBB10CT045-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT045-P03		2
Exhaust gas temperature outer	**MBB10CT050-P01**		**2**
Exhaust gas temperature inner	**MBB10CT050-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT050-P03		2
Measuring point	**SGT-600 KKS**	**SGT-700 KKS**	**Note**

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Exhaust gas temperature outer	**MBB10CT055-P01**		**2**
Exhaust gas temperature inner	**MBB10CT055-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT055-P03		2
Exhaust gas temperature outer	**MBB10CT060-P01**		**2**
Exhaust gas temperature inner	**MBB10CT060-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT060-P03		2
Exhaust gas temperature outer	**MBB10CT065-P01**		**2**
Exhaust gas temperature inner	**MBB10CT065-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT065-P03		2
Exhaust gas temperature outer	**MBB10CT070-P01**		**2**
Exhaust gas temperature inner	**MBB10CT070-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT070-P03		2
Exhaust gas temperature outer	**MBB10CT075-P01**		**2**
Exhaust gas temperature inner	**MBB10CT075-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT075-P03		2
Exhaust gas temperature outer	**MBB10CT080-P01**		**2**
Exhaust gas temperature inner	**MBB10CT080-P02**		**2**
Exhaust Gas Temperature Inner (2oo3)	MBB10CT080-P03		2
Vibration bearing 3	**MBB10CY005**	**MBB10CY005**	2
Vibration bearing 3	MBB10CY035	MBB10CY035	2
Vibration bearing 3	MBB10CY040	MBB10CY040	2
Vibration bearing 4	**MBB10CY010**	**MBB10CY010**	2
Vibration bearing 4	MBB10CY045	MBB10CY045	2
Vibration bearing 4	MBB10CY050	MBB10CY050	2
Seal air supply temperature	**MBH10CT005**	**MBH10CT005**	1
Seal air supply temperature	MBH10CT010	MBH10CT010	1
Seal air supply temperature	MBH10CT015	MBH10CT015	1
Purge air temp after cooler	**MBH20CT005**		1
Purge air temp after cooler	MBH20CT010		1
Purge air temp after cooler	MBH20CT015		1
Casing vibration pinion gear system	**MBK10CY005**	**MBK10CY005**	1
Casing vibration pinion gear system	MBK10CY006	MBK10CY006	1
Casing vibration pinion gear system	MBK10CY007	MBK10CY007	1
Air intake diff pressure	**MBL30CP015**	**MBL30CP015**	**1**
Air intake diff pressure	MBL30CP020	MBL30CP020	1
Air intake diff pressure	MBL30CP025	MBL30CP025	1
Air intake filter diff pressure	**MBL30CP030**	**MBL30CP030**	**1**
Air intake filter diff pressure	MBL30CP035	MBL30CP035	1
Air intake filter diff pressure	MBL30CP040	MBL30CP040	1
Liquid fuel tank level	**MBN10CL005**	**MBN10CL005**	1
Liquid fuel tank level	MBN10CL010	MBN10CL010	1
Liquid fuel tank level	MBN10CL015	MBN10CL015	1
Axial displacement bearing 1	**MBT10CG005**	**MBT10CG005**	2
Axial displacement bearing 1	MBT10CG015	MBT10CG015	2
Measuring point	**SGT-600 KKS**	**SGT-700 KKS**	**Note**

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Axial displacement bearing 1	MBT10CG020	MBT10CG020	2
Compressor inlet pressure	**MBT10CP005**	**MBT10CP005**	1
Compressor inlet pressure	MBT10CP030	MBT10CP030	1
Compressor inlet pressure	MBT10CP035	MBT10CP035	1
Main flame	**MBT10CQ005**	**MBT10CQ005**	1
Main flame	MBT10CQ010	MBT10CQ010	1
Main flame	MBT10CQ015	MBT10CQ015	1
Main flame	MBT10CQ020	MBT10CQ020	1
Speed gas generator	**MBT10CS005**	**MBT10CS005**	2
Speed gas generator	MBT10CS010	MBT10CS010	2
Speed gas generator	MBT10CS015	MBT10CS015	2
Vibration bearing 1	**MBT10CY005**	**MBT10CY005**	2
Vibration bearing 1	MBT10CY035	MBT10CY035	2
Vibration bearing 1	MBT10CY040	MBT10CY040	2
Vibration bearing 2	**MBT10CY010**	**MBT10CY010**	2
Vibration bearing 2	MBT10CY045	MBT10CY045	2
Vibration bearing 2	MBT10CY050	MBT10CY050	2
Gas fuel diff temperature	**MBP05CT905**	**MBP05CT905**	1
Gas fuel diff temperature	MBP05CT910	MBP05CT910	1
Gas fuel diff temperature	MBP05CT915	MBP05CT915	1
Gas fuel pressure	**MBP10CP015**	**MBP10CP015**	**1**
Gas fuel pressure	MBP10CP050	MBP10CP050	1
Gas fuel pressure	MBP10CP055	MBP10CP055	1
Gas fuel temperature	**MBP10CT005**	**MBP10CT005**	**1**
Gas fuel temperature	MBP10CT010	MBP10CT010	1
Gas fuel temperature	MBP10CT015	MBP10CT015	1
Water injection temperature	**MBU30CT005**		**1**
Water injection temperature	MBU30CT015		1
Water injection temperature	MBU30CT020		1
Lube oil tank diff pressure	**MBV10CP015**	**MBV10CP015**	**1**
Lube oil tank diff pressure	MBV10CP020	MBV10CP020	1
Lube oil tank diff pressure	MBV10CP040	MBV10CP025	1
Lube oil supply pressure	**MBV40CP015**	**MBV40CP015**	**1**
Lube oil supply pressure	MBV40CP025	MBV40CP025	1
Lube oil supply pressure	MBV40CP050	MBV40CP050	1
Lube oil supply temperature	**MBV40CT005**	**MBV40CT005**	**1**
Lube oil supply temperature	MBV40CT015	MBV40CT015	1
Lube oil supply temperature	MBV40CT020	MBV40CT020	1
Bearing 2 diff pressure	**MBV54CP015**	**MBV54CP015**	**1**
Bearing 2 diff pressure	MBV54CP020	MBV54CP020	1
Bearing 2 diff pressure	MBV54CP025	MBV54CP025	1
HH level bearing 2 tank	**MBV60CL005**	**MBV60CL005**	**1**
HH level bearing 2 tank	MBV60CL010	MBV60CL005	1
HH level bearing 2 tank	MBV60CL015	MBV60CL005	1
Generator stator temp ph 1	**MKA10CT030**	**MKA 10CT030**	**2**
Generator stator temp ph 1	MKA10CT031	MKA 10CT031	2
Generator stator temp ph 1	MKA10CT032	MKA 10CT032	2
Generator Stator Temp Ph 2	**MKA10CT035**	**MKA 10CT035**	**2**
Generator stator temp ph 2	MKA10CT036	MKA 10CT036	2
Generator stator temp ph 2	MKA10CT037	MKA 10CT037	2
Vibration generator bearing de	**MKA10CY005**	**MKA10CY005**	**1**
Measuring point	**SGT-600 KKS**	**SGT-700 KKS**	**Note**

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Vibration generator bearing de	MKA10CY035	MKA10CY035	1
Vibration generator bearing de	MKA10CY040	MKA10CY040	1
Vibration generator bearing nde	**MKA10CY010**	**MKA10CY010**	**2**
Vibration generator bearing nde	MKA10CY045	MKA10CY045	2
Vibration generator bearing nde	MKA10CY050	MKA10CY050	2
GT room vent fan diff pressure	**SAG10CP010**	**SAG10CP010**	**1**
GT room vent fan diff pressure	SAG10CP015	SAG10CP015	1
GT room vent fan diff pressure	SAG10CP020	SAG10CP020	1
Gas Detector 1 GT ventilation outlet	**SFY10CQ005**	**SFY10CQ005**	**1**
Gas Detector 2 GT ventilation outlet	SFY10CQ010	SFY10CQ010	1
Gas detector 3 GT ventilation outlet	SFY10CQ015	SFY10CQ015	1
Gas detector 1 GT enclosure	**SFY10CQ020**	**SFY10CQ020**	**1**
Gas detector 2 GT enclosure	SFY10CQ025	SFY10CQ025	1
Gas detector 3 GT enclosure	SFY10CQ030	SFY10CQ030	1
Gas detector 1 GT inlet	**SFY10CQ050**	**SFY10CQ050**	**1**
Gas detector 2 GT inlet	SFY10CQ055	SFY10CQ055	1
Gas detector 3 GT inlet	SFY10CQ060	SFY10CQ060	1

4. Trip functions which are not working according to 2oo3 principle

Fire detection system is equipped with 4 heat detectors and 4 flame detectors in the gas turbine room and works with the principle that 2 oo8 principle.

The following trips do not work according to 2oo3 principle

-Emergency stop

-Control equipment failure

-CO2 jalousies not open

-Trips depending on wrong position of valves and dampers

-Bearing no 2 tank level high

-Exhaust gas temperature high (SGT-700)

The AC generator protection equipment doesn't work according to 2oo3 principle.

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GT controllers and operators interface

Control and automation summery overview

The control system is built up around standard micro-computer based products from the Simatic PCS7 family of integrated and distributed control systems (DCS) for industrial automation. The system is rugged and fulfils applicable standards for resistance to interference.

The type of process stations used is the S7-400 series. As programming language they utilize the SFC (sequential function chart) and CFC (continuous function chart), function block languages with graphic presentation also integrating in the WinCC operator station. The SFC and CFC are specially oriented to process control.

Together with various dedicated front end systems, the PCS7 hardware and standard gas turbine application software constitutes the control system. The controllers transfer mainly all instrumentation signals of the gas turbine to the operator station.

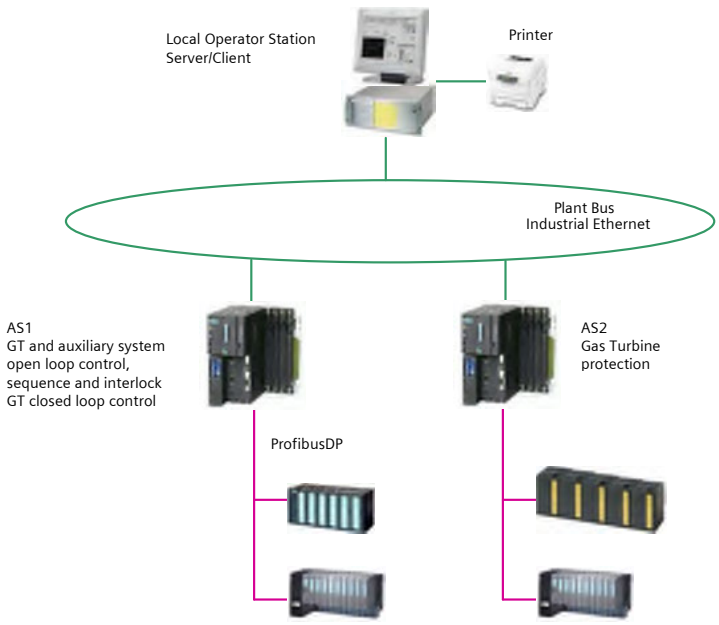

Figure 1 GT Control and automation overview

BO/FO SGT-800 (PG B, PG EX, PG B2, PG Ex B2, PG B2 US, PG Ex B2 US, PG B LS), SGT-700 (MD B, PG B, PG EX B)/&DB101, SGT-600 (MD B, PG B, PG EX B)	

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Automation system (AS)

The Automation System is based on the Simatic S7-400 series and is a large programmable controller for binary, regulatory and supervisory control. The programmability covers a wide range of functions, such as logic and sequence control, arithmetic's, positioning and regulatory control.

The S7-400 series is fully modular with circuit boards mounted on the back plane of the cabinet. The Automation System station for the gas turbine plant consists of two main CPU (central processing unit) racks where the ET200 I/O modules are distributed. The S7-400 series is designed to operate in an industrial environment, and are TÛV-certified and comply with the requirements up to SIL3 (Safety integrity level) according IEC61508.

The Automation System 1 (AS1) has the functions for controlling the operation of the gas turbine such as sequencing, open and closed loop control, interlock, signal collection, supervision and filtering for signal transfer to the operator station (OS). It handles also the bus interface to third party system when included.

The Automation System 2 (AS2) has the functions and control over the gas turbine safety and protection system according a failsafe design.

Overview

The following characteristics make the SIMATIC S7-400 predestined for use as a SIMATIC PCS 7 automation system:

- Modular and fan-free design
- High degree of expansion capability and robust design
- Simple or redundant design
- Comprehensive communications capabilities
- Integral system functions
- Simple connection of distributed I/Os

Various automation systems are available with a price/performance ratio which can be tailored to your system requirements. Please see scope of supply, code 630 in which extent the automation system is included.

All automation systems are equipped with an onboard PROFIBUS DP field-bus connection. Additional PROFIBUS communication modules can be fitted if required.

Design

The automation systems are delivered as preassembled and tested complete systems, and are comprised of:

- Sub racks with 9 slots, which are physically, separate in the case of redundant systems
- Standard CPU 416-5F and 416-5 or the redundant CPU 416-5FH and 416-5H
- 120/230 VAC power supply including backup battery
- Main memory 30 Mbyte for AS416-5F and 30 Mbyte for AS416-5
- Memory card with 4 Mbyte RAM (random access memory)
- Connection to Industrial Ethernet

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Simatic PCS7 process station AS 416

Reference: SIT AB/2016-05-17

AS 416-5 Automation system

Comprising:

- CPU 416-5 with integrated PROFIBUS DP interfaces, 30 Mbyte main memory (15 Mbyte available user memory), memory card 4 Mbyte RAM.
- CP 443-1 communications module for connection to Industrial Ethernet plant bus.
- PS 407 power supply; 4 A for 120/230 VAC, 1 backup battery.
- UR2 (9 slots) backplane.

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Simatic PCS7 process station AS 416-FH

Reference: SIT AB/2016-05-17

AS 416-F Failsafe automation system

Comprising:

- CPU 416-5H with integrated PROFIBUS DP interfaces, 15 Mbyte main memory (15 Mbyte available user memory), and memory card 4 Mbyte RAM.
- Failsafe license and function block library.
- CP 443-1 communications module for connection to Industrial Ethernet plant bus.
- PS 407 power supply; 4 A for 120/230 VAC, 1 backup battery.
- UR2 (9 slots) backplane.

Failsafe automation systems (F/FH systems) are used for critical applications in which an incident can result in danger to persons, plant damage or environmental pollution. They detect not only errors in the process but also their own internal errors, and will automatically set the plant to a safe state if an error is detected.

The failsafe automation systems (F/FH systems) based on AS 416 H and AS 416 H combine standard factory automation and safety engineering in a single system. They are certified by TÜV (German Technical Inspectorate) and comply with safety requirements class SIL 1 to SIL 3 according to IEC 61508, requirements class AK 1 to AK 6 according to DIN V 19250/DIN V VDE 0801, and category 2 to 4 according to EN 954-1.

The safety function configured by the user in CFC is executed twice in various parts of the processor by means of redundant, diversified command processing. Potential errors are then detected in the subsequent comparison of results.

Failsafe automation systems can be designed as single-channel systems (F systems with a CPU) and redundant systems (FH systems).

The redundancy of FH systems is not relevant for failsafe. It is not used for error detection, but serves only to increase the availability of failsafe automation systems.

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Benefits

- Use of SIMATIC S7 standard components for failsafe applications
- Safety levels SIL 3, AK 6 can be achieved with just one CPU
- Safe monitoring of communication through PROFIBUS with PROFIsafe
- Safe communication through Industrial Ethernet plant bus
- S and F functions can be mixed in the same automation system
- S and F I/Os can be operated on the same PROFIBUS DP line
- Configuration of S and F functions using a common engineering tool - CFC
- F-Tool (S7 F Systems) provides support for the TÜV acceptance:
  - separation of S and F functions
  - checksum by means of application program
  - comparison function
  - access to F functions is password protected
- Minimum training requirements since same tools are used for standard and failsafe systems
- Simple fault analysis since same operation and monitoring for standard and failsafe systems (message sequence)
- Minimization of life cycle costs

Function

The safety functions of the F/FH systems are present in the F program of the CPU and in the failsafe ET 200 I/O modules. The PROFIsafe profile is used for the safety-oriented PROFIBUS DP communication between CPU and process I/Os. Using this additional safety message, F/FH systems and F I/O modules can recognize corrupt data and can initiate appropriate error responses. Standard modules as well as failsafe I/Os can be used in F/FH systems. A plant consisting of safety-oriented and standard areas can thus be automated with one and the same system and be configured with uniform standard tools. Integrated in the SIMATIC Manager is the F-Tool (S7 F systems). This engineering tool enables the parameterization of the CPU and the F signal modules as well as the generation of failsafe applications in the CFC based on predefined, TÜV-approved blocks. The failsafe blocks are extremely robust and intercept programming errors such as division by zero or out-of-range values. They save the user having to perform diverse programming tasks for detecting and reacting to errors. Functions such as the comparison of F programs, the detection of changes in F programming using a checksum, or access privileges using passwords provide further support and guarantee simple, safe operation.

The application program may contain failsafe (F) and non-failsafe standard programs (S), where strict separation of F and S program components together with data exchange by means special conversion blocks prevent conflicts. An error detected in the F program does not result in stopping of the CPU, but leads to triggering of configurable shutdown logic which sets either the affected F sequence group or the entire F program to a safe state. The standard program continues to run as normal and can trigger reactions as required. After the fault is eliminated, the F program can be started again with the CPU still running.

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Simatic PCS7 I/O ET200M

Reference: SIT AB/2016-05-17

Overview

The ET 200M distributed I/O stations are the line of choice from the ET 200 family for process control applications with SIMATIC PCS 7. The ET 200M line contains a diversified selection of I/O modules in S7-300 design, some with special control functions:

- Standard-S7-300 signal modules
- I & C modules with enhanced diagnostics capability
- Ex I/O modules
- Controller and counter modules
- F modules for failsafe applications

When active bus modules are used (option), defective I/O modules can be replaced during operation of the plant without neighbouring modules being affected (hot swapping function). Following actions are possible in RUN mode of the automation system:

- Adding new modules within a station
- Re-parameterisation of modules
- Adding ET 200M stations

The ET 200M distributed I/O station consists of

- 1 or 2 (redundant) IM 153 interface modules for connecting through PROFIBUS DP with data transfer rates up to 12 Mbit/s
- Up to 8 I/O modules for connecting the sensor/actuator technology

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All I/O modules are optically isolated from the backplane bus. Up to 8 I/O modules can be connected to one interface module. The interface modules can be also be configured for a redundant architecture if required. In addition to the SIMATIC S7 standard input/output modules there are special I/O modules offering e.g. the following functions:

- Channel-specific diagnostics, e.g. wire break, short-circuit, overflow/underflow values
- Internal module monitoring, e.g. parameterisation error, RAM error, fuse drop
- Chatter monitoring for transducers
- Pulse extension
- Outputting a parameterisable substitute value when the CPU fails

The modules with diagnostics capability automatically send the corresponding signal to the operator system when a fault occurs, enabling the trouble to be solved quickly and easily. The ET 200M can be run in standard environments or in Ex zone 2. The actuators/sensors can be positioned in Ex zone 1 area when suitable Ex I/O modules are used. The hot swapping of I/O modules within Ex zone 2 area is allowed with the right permit (e.g. fire certificate).

Digital input 6ES7 321-7BH01-0AB0

- 16 inputs, 24 V DC
- Floating in groups of 16
- Redundant design possible
- Time stamp on the module, 5 ms accuracy, rising or falling edge, channel-selective parameterization possible
- Two short-circuit resistant sensor power supplies, each for 8 channels
- Sensor power supply through the module; external redundant sensor power supply also possible
- Diagnostics of missing sensor power supply for channel group (8 channels)
- Diagnostics inside module

Digital output 6ES7 322-1HF10-0AA0

- 8 outputs, electrically isolated in groups of 1
- Relay AC 230 V/5 A
- Rated load voltage 24 VDC to 120 VDC, 48 VAC to 230 VAC
- Suitable for AC/DC solenoid valves, contactors, motor starters, FHP motors and signal lamps
- suitable for switching current < 3 A
- suitable for switching current < 3 A

Analog input 6ES7 331-7NF10-0AB0

- 8 inputs in 4 channel groups
- Resolution 15 bit + sign
- Fast module cycle (min. 10 ms for 4 channels)
- Current measurement 0/4...20 mA (8 channels; 2 wires with external supply or 4 wires)
- Voltage measurement (8 channels)
- Wire break monitoring
- Short-circuit-proof
- Isolation between channel groups
- Diagnostics inside module

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Analog input RTD 6ES7 331-7PF01-0AB0

- 8 inputs in 4 channel groups
- Resolution: 15 bit
- Resistance thermometer Pt100...1000, Ni100...1000, Cu10 (8 channels; 2, 3 or 4 wires)
- Short-circuit-proof
- Wire breaks monitoring
- Diagnostics inside module

Analog output 6ES7 332-7ND02-0AB0

- 4 outputs in 4 channel groups
- Resolution 15 bit + sign
- Voltage 0/1...5/10 V; ±10 V (4 channels; 4 wires)
- Current 0/4...20 mA; ±20 mA (4 channels; 2 wires)
- Parameterisable substitute value output in case of CPU stop
- Isolated channel by channel
- Diagnostics inside module

Simatic PCS7 I/O ET200M failsafe

Overview

The special safety functions of the failsafe systems are coordinated with the failsafe I/O modules of the distributed ET 200M devices, whose job it is to also ensure plant safety should the CPU fail. The failsafe signal modules of these peripheral devices (digital inputs/outputs, analogue input) are able to diagnose internal and external errors, have a redundant setup on account of safety demands, and meet requirements up to SIL 3 (IEC 61508) or AK 6 (VDE 0801).

The input modules work in SIL 3/AK 6 with internal 2-of-2 channel evaluation. A safety response is triggered immediately there are any differences. The digital output modules enable safe disconnection through a second disconnect path in the event of a faulty output.

Interface module, 6ES7 153-2BA02-0XB0

- Connects the ET 200M with the PROFIBUS DP
- Prepares the data for the assembled electronic modules
- PROFIBUS address setting by means of switch
- The maximum address space is 244 bytes for inputs and 244 bytes for outputs
- Up to 12 S7-300 modules with redundancy

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Digital input 6ES7 326-1BK02-0AB0

- 24 inputs, 24 V DC, floating in groups of 12
- 4 short-circuit resistant sensor power supplies, each for 6 channels, floating in groups of 3
- External sensor power supply possible
- SIL 2: single-channel evaluation, 24 channels
- SIL 3: 2-of-2 evaluation on the module, 12 channels (adjustable discrepancy time)
- Redundant design possible
- Short-circuit monitoring after L+
- Discrepancy monitoring
- Diagnostics inside module
- ProfiSafe frame

Digital output 6ES7 326-2BF10-0AB0

- 10 outputs, 24 V DC, 2 A, floating in groups of 5
- SIL 2, SIL 3 parameterisable (10 channels)
- Redundant design possible (outputs with internal diode)
- Wire break and short-circuit monitoring0
- Diagnostics inside module
- ProfiSafe frame

Analog input 6ES7 336-4GE00-0AB0

- 6 inputs, 4...20 mA
- Isolated from the backplane bus
- 2- or 4-wire connection
- SIL 2: two-channel evaluation, 6 sensors
- SIL 3: two-channel evaluation, 12 sensors (adjustable tolerance window)
- Wire break monitoring
- Tolerance monitoring between 2 sensors (SIL 3)
- Diagnostics inside module
- ProfiSafe frame

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Simatic PCS7 I/O ET200iSP

Reference: SIT AB/2016-05-17

Overview

ET 200iSP is an intrinsically-safe distributed I/O system with IP30 degree of protection and can be used in areas where explosion protection is required according to ATEX: **II 2 G (1) GD EEx de [ia/ib] IIC T4**. The ET 200iSP consists of a power supply module, an interface module and up to 32 electronics modules for the digital and analog inputs and outputs. The modules are snapped onto terminal modules, and hot swapping is possible. ET 200iSP can also be used for redundant operation in fault-tolerant systems.

To achieve intrinsically-safe operation of an ET 200iSP, the bus segment must also have an intrinsically-safe design. This is achieved by using Profibus RS 485-IS coupler, and with a certified fast connectors for an easy and fast connecting/disconnecting of the bus. The maximum data transfer rate is 1.5 Mbit/s.

An ET 200iSP distributed I/O station can consist of:

- 1 or 2 Power Supply modules
- 1 or 2 interface modules for data transfer through Profibus RS 485-IS with the transfer rate up to 1.5 Mbit/s
- And up to 32 I/O modules for connecting the sensor/actuator technology

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Interface module, 6ES7 152-1AA00-0AB0

- Connects the ET 200iSP with the PROFIBUS RS 485-IS
- Prepares the data for the assembled electronic modules
- PROFIBUS address setting by means of switch
- Switching off the 24 VDC supply voltage at terminal module TM-PS-A also switches off the IM 152 interface module
- The maximum address space is 244 bytes for inputs and 244 bytes for outputs
- Backup of electronic module parameters: the parameters / data are stored in IM 152 flash memory, after power on the ET200iSP, the IM152 distributes the stored parameter / data to the electronic modules (substitution values at output modules, for example), then PROFIBUS DP is enable and the automation system is put into operation by the DP master, once the ET 200iSP begins exchanging data with the DP master, the substitute values (in the flash memory) in the output are replaced with the current data of the DP master.
- FM Approved for Hazardous Locations, UL listed Class I Zone 1, AEx ib IIC T4

Digital input, 6ES7 131-7RF00-0AB0

- 8 inputs
- Electrical isolated between channels and backplane bus
- Short-circuit monitoring
- Wire break monitoring
- FM Approved for Hazardous Locations, UL listed Class I Zone 1, AEx ib [ia] IIC T4

Digital output, 6ES7 132-7HB00-0AB0

- Digital output module for EEx e with 2 relay outputs
- Suitable for solenoid valves, DC contactors, indicator lights
- Relay output current up to 2 A with 60 V UC per output
- Isolated from the supply voltage
- NO contact
- FM Approved for Hazardous Locations, UL listed Class I Zone 1, AEx e ibmb IIC T4

Digital output, 6ES7 132-7RD11-0AB0

- Digital output module for EEx i with 4 outputs or 2 outputs connected in parallel
- Nominal load 17.4 VDC/27mA 4 outputs or 54mA 2 outputs connected in parallel
- Outputs suitable for EEx i solenoid valves, DC current relay and actuators
- Module SHUT DOWN via High deactivation
- Short-circuit monitoring
- Wire break monitoring
- FM Approved for Hazardous Locations, UL listed Class I Zone 1, AEx ib [ia] IIC T4; AEx ib [ia] I

Digital output, 6ES7 132-7GD00-0AB0

- Digital output module for EEx i with 4 outputs
- Nominal load 23.1 VDC/20mA
- Outputs suitable for EEx i solenoid valves, DC current relay and actuators
- Module SHUT DOWN via Low deactivation
- Short-circuit monitoring
- Wire break monitoring
- FM Approved for Hazardous Locations, UL listed Class I Zone 1, AEx ib [ia] IIC T4; AEx ib [ia] I

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Analog input, 6ES7 134-7TD50-0AB0

- 4 inputs for connecting HART field devices, 4-wire transducers
- Configurable input range: HART, 0 to 20 mA, 4 to 20 mA
- Resolution 12 bits + sign
- Electrical isolation between channels and the backplane bus
- Electrical isolation between channels and power bus
- Wire break monitoring, I < 3.6 mA
- Resolution 12 bits + sign
- Safety information, KEMA 04ATEX1245

Analog input, 6ES7 134-7TD00-0AB0

- 4 inputs for connecting HART field devices, 2 wires transducer (standard applications)
- Configurable input range: HART / 4 to 20 mA
- Electrical isolated between channels and backplane bus
- Electrical isolated between channels and Powerbus
- Short-circuit monitoring
- Wire break monitoring
- Resolution 12 bits + sign
- FM Approved for Hazardous Locations, UL listed Class I, Zone 1, AEx ib [ia] IIC T4

Analog input, 6ES7 134-7SD51-0AB0

- 4 inputs for resistance thermometer or resistance measurement
- Input ranges: resistance thermometer Pt 100, Ni 100, resistance measurement 600 ohms absolute
- Electrical isolated between channels and backplane bus
- Electrical isolated between channels and Powerbus
- Wire break monitoring
- Resolution 15 bits + sign
- FM Approved for Hazardous Locations, UL listed Class I, Zone 1, AEx ib [ia] IIC T4

Analog input, 6ES7 134-7SD00-0AB0

- 4 inputs for thermocouples or voltage measurement
- Input ranges: thermocouples: type B, E, J, K, L, N, R, S, T, U, functional galvanic isolation, permissible common mode voltage 6,5 VDC, 30 V_{pp}AC
- Linearization of sensor characteristic curves
- Resolution 15 bits + sign
- Internal compensation of the reference junction temperature by means of TC sensor module (temperature sensor).
- Electrical isolated between channels and backplane bus
- Electrical isolated between channels and Powerbus
- Wire break monitoring
- FM Approved for Hazardous Locations, UL listed Class I, Zone 1, AEx ib [ia] IIC T4

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Simatic PCS7 I/O ET200iSP failsafe

Digital input 6ES7138-7FN00-0AB0

- 8 inputs Namur EX 1 upto category 4

Analog input 6ES7138-7FA00-0AB0

- 4 inputs for connectiong HART field devices
- Configurable input range: HART / 4 to 20 mA and 0 to 20 mA

Digital output, 6ES7138-7FD00-0AB0

- Digital output module for EEx i with 4 outputs or 2 outputs connected in parallel
- Nominal load 17.4 VDC/40mA 4 outputs or 80mA 2 outputs connected in parallel
- Outputs suitable for EEx i solenoid valves, DC current relay and actuators
- Short-circuit monitoring
- Wire break monitoring
- Up to SIL3
- FM Approved for Hazardous Locations, UL listed Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] I

Analog output, 6ES7 135-7TD00-0AB0

- 4 current outputs
- Output range (configurable): HART, 4 to 20 mA, 0 to 20 mA
- Resolution 14 bits
- Electrical isolated between channels and backplane bus
- Electrical isolated between channels and Powerbus
- Short-circuit monitoring
- Wire break monitoring
- FM Approved for Hazardous Locations, UL listed Class I, Zone 1, AEx ib [ia] IIC T4

Reserve module, 6ES7 138-7AA00-0AA0

- Is suitable for all terminal modules on which you can insert an electronic module.
- Reserves a slot for any electronic module. Insert the reserve module on the reserved slot of the ET 200iSP configuration.
- FM Approved for Hazardous Locations, UL listed Class I Zone 1, AEx ib IIC T4; Ex ib I

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Simatic WinCC, a PC based operator station

The SIMATIC WinCC Operator Station is a SIMATIC rack PC 547C, it is a rugged industrial PC in 19" rack format (4HU). It is based on Intel Core Duo technology, and is system-tested with SIMATIC components, and has a global marketing certification (cULus). The Operator Station program SIMATIC WinCC is running on Microsoft Windows operating system and the user interface is Windows standard. The system and application software is stored on the hard disc drive.

SIMATIC rack PC 547C consists of:

- Intel Core Duo 2.6GHz
- 2GB DDR2 SDRAM
- 2x500GB SATA HDD, RAID 1
- 2xGBit LAN (RJ45)
- DVD±/-R/RW optical drive
- Keyboard standard MF2, 105 keys (international, German, Cyrillic)
- Windows MUI (English, German, French, Russian, Spanish, Italian)
- Office Word and Excel multi-language pack
- Simatic PCS7 software

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Turbine Governor Dual Fuel

The turbine governor is digital and realised with control system components, AC servo driver boards and variable frequency drives.
Positioning is electrical, i.e. electrical signals from the turbine governor controls the AC servo motors. These motors actuate the gas fuel control valves and the inlet guide vanes.
Two static frequency converters control the speed of the liquid fuel pumps.
The controlled bleed valve 2 is provided with a pneumatic actuator and the combustor bypass valves are provided with a modulating motor actuator.

Principles of the Function

The principal components (see figure below) are:
Transducer (1) for sensing governed variables (actual values such as speed, temperature, position. In the figure the rotor speed is shown).

Set values (2) of the controlled parameters.

Control channels (3) All incoming sensed quantities are compared with their set point and the deviation are adapted to derive the signals that control the servo motor drivers and /or the static frequency converter.

Position loop controllers (4): Controls the position of the valves and vanes by the use of a position feedback signal.
AC Servo motors and drivers (5): The drivers transform the output signals from the governor into servo motor phase currents giving torque that move the valves and vanes.

Static Frequency Converter (6) controls the speed of the liquid fuel pumps and thus the amount of fuel fed to the combustor.

Pneumatic actuator (7) positions the controlled bleed valve 2.

Modulating motor actuator (8) positions the controlled combustor bypass valves.

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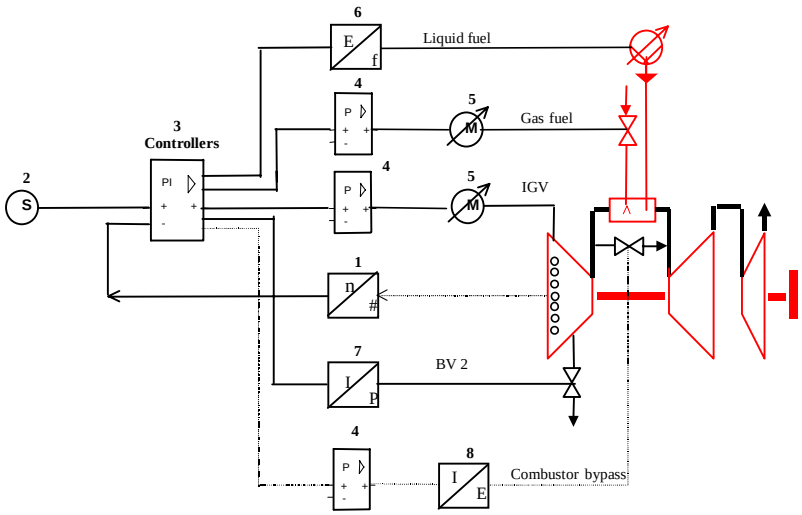

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The actual values of the speeds are brought to the governor as pulse trains. Other feedback signals are transmitted in the form of standard current signals. In the various control channels the actual values are compared with their respective set values. The difference between actual and set value gives an error signal that, properly manipulated, forms the output signal. The governor output signals are proportional to gas control valve positions, inlet guide vanes (IGV) position and a liquid fuel pump speed respectively.
The control signals from the various control channels are connected to the servo motor drivers and / or the static frequency converter via minimum selectors, thus the fuel flow is controlled by the channel requiring the smallest fuel flow. An exception to this is the gas generator deceleration control, which is connected through a maximum selector in order to prevent flameout of the burners. The channel in control is indicated on the operator station (OS).

Start up

With starting up, the fuel control valve is opened (or the fuel pump is started) by the sequencer at the same time as the ignition is switched on.
The *starting control (STC)* controls the fuel flow to a scheduled value for ignition.
At a gas generator speed of 6000 rpm the *gas generator speed control* takes over and ramps the gas generator speed up to the point where synchronous speed of the power turbine is reached. Now the *frequency load control (FLC)* takes over.

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Synchronizing

When the AC generator has reached nominal voltage, the grid frequency discriminator is connected to bias the *frequency load control*. In this way the correct synchronising speed is achieved.

Normal operation

The *frequency load control* governs the output according to the load set point and the droop setting. For operation on small networks and 0% droop, the frequency is controlled independently of the load (isochronous operation).
For operation on larger grid networks the droop setting must be greater than 0%. The output is controlled by means of the load control error signal. By the droop setting, a frequency increase provides a load reduction, and a frequency reduction provides load increase.

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Load limitation

The gas turbine output is limited by the *gas generator exhaust temperature control* (limiter).
The gas turbine output can also be restricted by the *gas generator rotor speed control*.

Gas generator acceleration

Surging and transient over temperatures in the gas generator at load pick up are prevented by the *gas generator acceleration control.* The maximum fuel flow possible is restricted as a function of the gas generator speed.

Gas generator deceleration

To prevent the combustor flame from extinguishing during a rapid reduction of the turbine load, the turbine governor has a flame sustain control. *The gas generator deceleration control* ensures that the lowest possible fuel quantity, sufficient for keeping a stable flame, is supplied to the combustor when the load is decreased. The deceleration control also prevents the gas generator speed from dropping to a too low value.

Loss of load detector

A *loss of load detector (LLD)* senses a loss of electrical load during or upon switching to isochronous operation. The *loss of load detector* then gives a full closing signal to the fuel controls, which will engage the *gas generator deceleration control* to prevent flame out.

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Split range fuel control

The combustor for fuel firing is equipped with dual gas fuel control valves, one primary valve for start and low load operation and a main valve for high load operation.
The governor controls the desired split between the valves.
Liquid fuel works with the same principal, dual SFC controlled pumps. The governor controls the desired split between the pumps.

Combustor bypass

In order to minimise the CO-emissions at part-load, a certain amount of air is bypassed the combustor. This is done by controlling the calculated flame temperature.

Fuel change

To accomplish a smooth transition when changing fuel the *fuel change circuit* puts a decrease ramp upon the valve / pump of the fuel to be exchanged. This starts simultaneously with the opening / speed increase of the new fuel valve / pump. The controller in operation then controls the new fuel to keep the total heat flow fed to the machine at the desired level.

Normal Stop

At a normal stop the governor ramps down the output load to zero. Then the gas fuel control valves are brought to minimum position and the liquid fuel pump is brought to minimum speed**.**

Emergency stop

At a trip order the governor quickly closes the gas fuel control valves and / or stops the liquid fuel pump.

Bleed valve 2 and Inlet guide vane control

Both parameters are controlled as a function of the gas generator speed. The bleed valve has a feed forward to open it quickly at load rejections.

Design criteria and standards

The turbine governor meets requirements according to
– NEMA SM24 NEMA "D"
– IEC 45

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SIEMENS

Electrical Equipment

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Technical data

Fuel servo response	0.35 sec/full stroke
Fuel pump response	0.35 sec/full speed
Bleed valve response	1.2 sec/full stroke
Inlet guide vane response	1.5 sec/full stroke
Frequency dead band	0% adjustable is optional
Frequency adjustment	10%
Droop setting	0 - 10%

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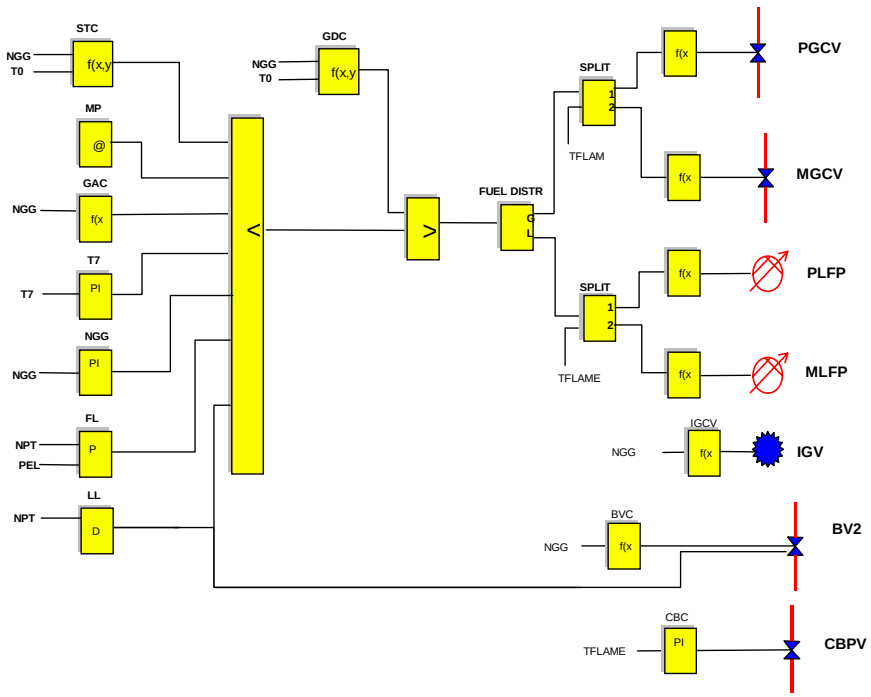
Block Diagram



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Legend for Block Diagram

BVC	Bleed valve 2 control
BV2	Bleed valve 2
CBC	Combustor bypasses control
CBPV	Combustor bypasses valves
FLC	Frequency/Load control
GAC	Gas generator acceleration control
GDC	Gas generator deceleration control
IGV	Inlet guide vanes
IGVC	Inlet guide vanes Control
LLD	Loss of load detection control
MAX(>)	Selector for passing of max desired fuel flow
MIN(<)	Selector for passing of min desired fuel flow
MGCV	Main gas control valve
MLFP	Main liquid fuel pump
MPC	Maximum servo position control
NGG	Gas generator speed
NGGL	Gas generator speed limiter
NPT	Power turbine speed
PEL	Electrical output
PGCV	Primary gas control valve
PLFP	Primary liquid fuel pump
STC	Starting control
T0	Ambient temperature
T7	Power turbine exhaust temperature
T7L	Power turbine exhaust temperature limiter
TFLAME	Calculated temperature flame

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Synchronizing System

The synchronising system consists of a combination of functions implemented in the GT control system, the Multifunction Paralleling Device 7VE61 and necessary relays for up to three circuit breakers (Generator Circuit Breaker (GCB) and two optional external circuit breakers in the network). The 7VE61 paralleling device (synchronizer) of the SIPROTEC 4 family is multifunctional compact unit used for paralleling power system and generator. The 7VE61 is a 1½-channel unit (paralleling function + synchro-check function) for use with small to medium-size generators and power systems. The system can be operated in the following modes.

- Automatic mode
- Manual mode (with synchro-check function)
- Dead bus energizing mode
- Off-mode

The system is completely operated from the turbine control system and all operator actions are performed from the HMI (Human Machine Interface) of the gas turbine.

The system require that the synchronizing voltages shall be taken “across” (directly on both sides of the breaker), and the closing voltage, normally 100-120VDC is to be supplied from the power supply system in the circuit breaker panel.

Functional description

Automatic synchronization mode

In automatic synchronization mode, the synchronizer releases the closing command to the selected breaker, GCB, CB1 (Circuit breaker 1) or CB2 (Circuit breaker 2). In auto mode, speed and voltage matching is fully automatic. Upon turbine start the synchronization is performed as a part of the start up sequence. The synchronizing function can be blocked during start up and synchronizing can be initiated by the operator at a time considered suitable. The speed control of the turbine generator in automatic synchronisation mode is performed in such a way that the generator always receive a constant frequency offset (slightly higher) than the network frequency. The dwell time of the frequency slip is therefore always constant regardless of net frequency variations during synchronization and highest possible accuracy for breaker closing is achieved.

Manual synchronization mode

In manual synchronization mode matching of frequency and voltage has to be done manually by the operator. Check of phase coincidence, matching of frequency and voltage is done with help of the HMI display. When voltage and frequency are matched to equality the breaker can be closed at correct phase coincidence. This is done through a manual command from the operator which orders the synchronizer to release the closing command to the breaker. The synchronizer will still perform a check to ensure that voltage and frequency is matched before releasing the command. The closing voltage is to be supplied from each breaker used.

The synchronizing display include a synchro-scope, voltage and frequency meters and a check window clearly showing that the machine is within correct borders for closing of the breaker.

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Dead bus energizing mode

In dead bus energizing mode, only the GCB can be closed and the synchronizing system shall be selected for manual mode.

The closing command will be sent to the synchronizer after the operator has performed a dead bus confirmation process. In addition, the synchronizer does a check of its own to ensure that the bus is dead and the generator is energized before releasing the closing command to the selected breaker to ensure that harmful situations does not occur. The switching to the dead net is allowed only after the signal confirming the net is dead is available from customer. The dead bus indication (provided by customer) has to be given from contacts in the external electrical system. The contacts have to be configured in such a way that closing of the breaker against an energized bus is not possible. Criteria like voltage on bus, in-feeds to bus etc. shall be used to create this. The voltage transformer protection switch is also scanned by the synchronizer; if this is active no enabling is allocated.

OFF-mode

In OFF-mode the synchronization is blocked.

Synchronizing parameters

The operating range of the synchronizing function is defined by the following limits:

Frequency	f_{nom} ± 3 Hz
Voltage	U_{nom} ± 11 V

Technical Data

The synchronization conditions are defined by the following values:

Nominal input voltage, U_{nom}	100 - 120 V
Nominal input frequency, f_{nom}	50 - 60 Hz
Max voltage difference	11 V
Max frequency difference $f_{gen} > f_{net}$	0.10 Hz
Max frequency difference $f_{net} > f_{gen}$	0.00 Hz
Max angle difference	10°
Closing time of the circuit breaker	10 ms to 1000 ms

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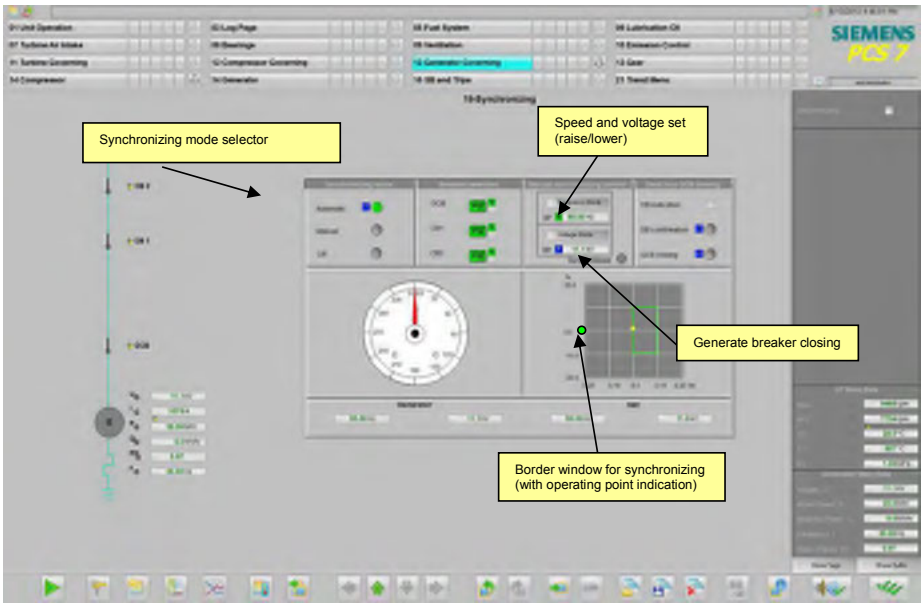
Operator screen – Synchronizing



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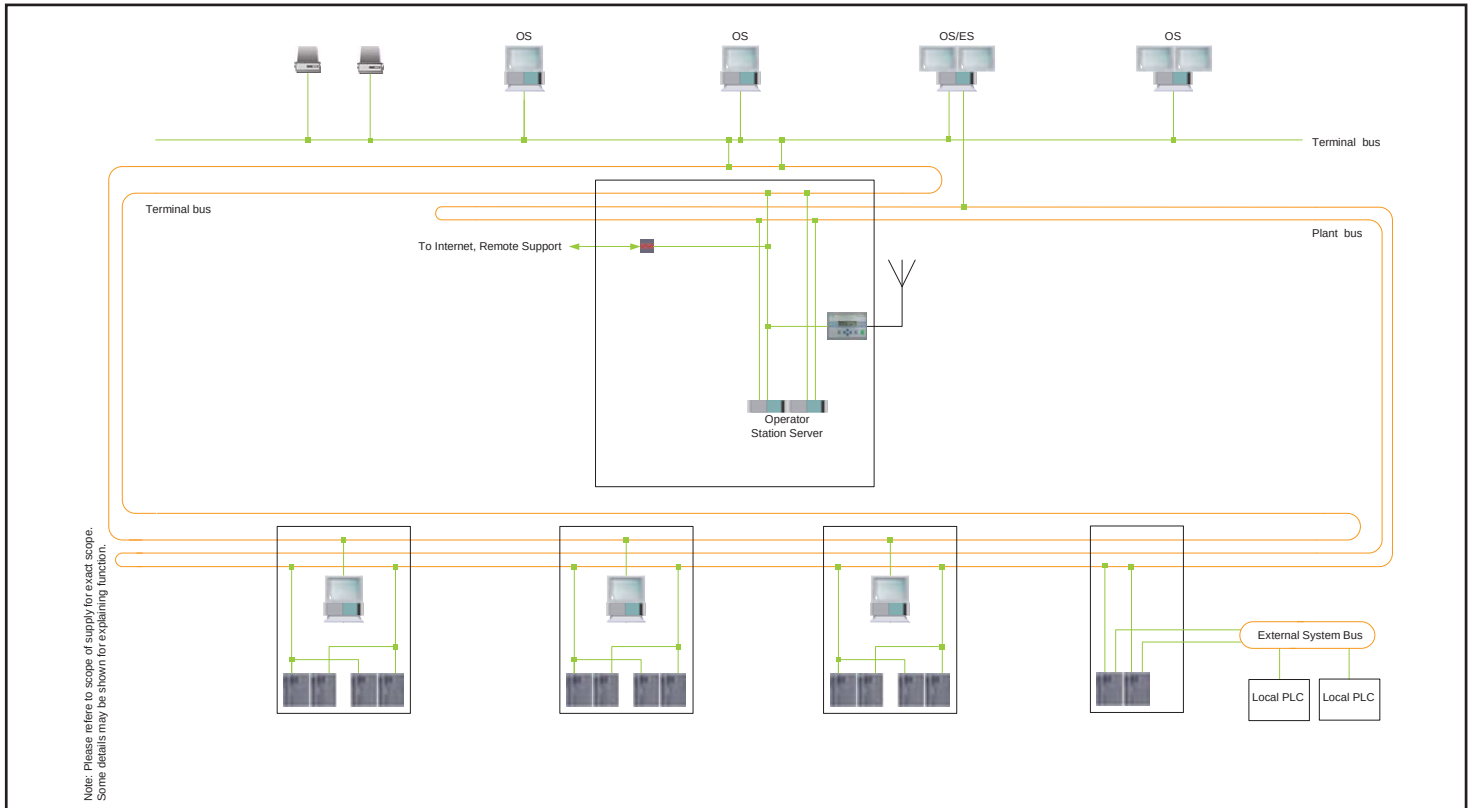

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision
A	First issue, for proposal	180828	AD	Anton Dahl			Control system overview	A
-				Approved	Resp dept	HG	PVSC	Language
				SIEMENS	OEEC1	6353		en
					Date		Document No.	Sh./No. of sh.
					2018-08-28		J640219E	1 (4)

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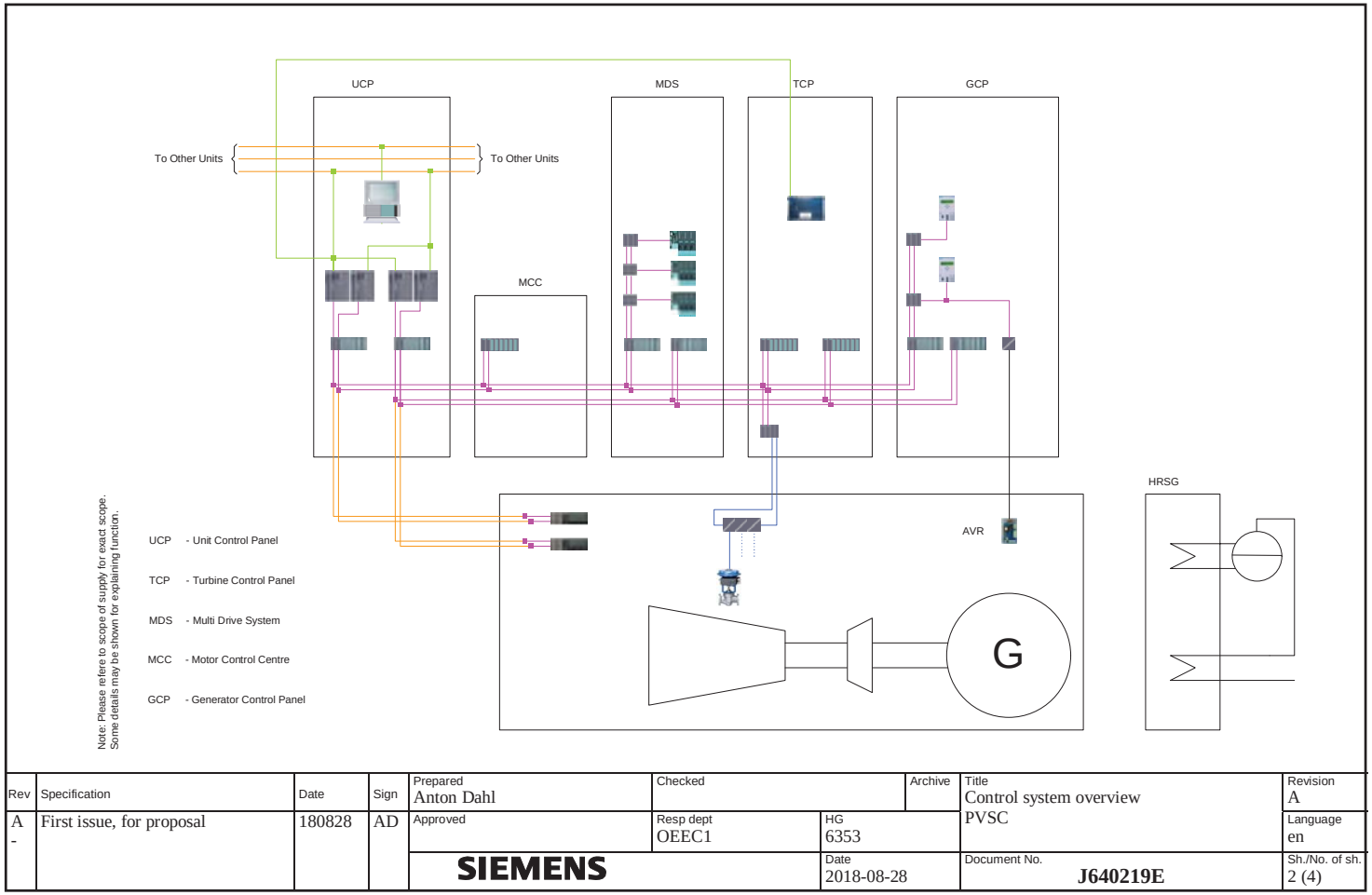

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision
A	First issue, for proposal	180828	AD	Anton Dahl			Control system overview	A
-				Approved	Resp dept	HG	PVSC	Language
				SIEMENS	OEEC1	6353		en
					Date		Document No.	Sh./No. of sh.
					2018-08-28		J640219E	2 (4)

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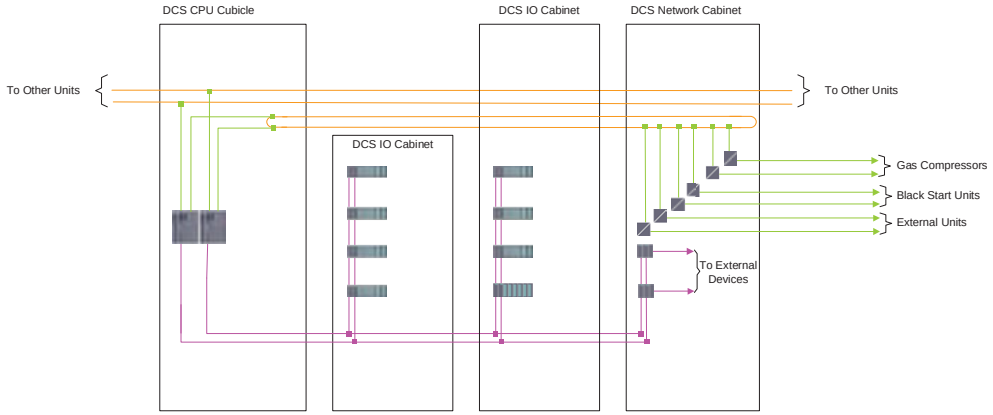

Note: Please refere to scope of supply for exact scope.
Some details may be shown for explaining function.

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision
A	First issue, for proposal	180828	AD	Anton Dahl			Control system overview	A
-				Approved	Resp dept / HG		PVSC	Language
				SIEMENS	OEEC1 / 6353			en
					Date	Document No.		Sh./No. of sh.
					2018-08-28	J640219E		3 (4)

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PC/terminal

PC/terminal with dual screen

Server

Printer

System clock

Fire wall

Antenna

AVR – Automatic Voltage Regulator

Relay protection

SFC – Static Frequency Converter

Vibration/pulsation meassurement rack

Valve/positioner

Temperature probe

Automation Station

Automation station redundnat

IO module

IO module

Protokoll/media converter

Protokoll/media converter

Electric Ethernet

Instrument bus Profibus PA

Electrical bus general

Profibus Electrical

Optical bus

Hard wired signal(s)

Rev	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision
A	First issue, for proposal	180828	AD	Anton Dahl			Control system overview	A
-				Approved	Resp dept	HG	PVSC	Language
				SIEMENS	OEEC1	6353		en
					Date		Document No.	Sh./No. of sh.
					2018-08-28		J640219E	4 (4)

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SIEMENS	Electrical Equipment SGT-600, SGT-700, SGT-800	GTI number		W663003E	
		Document number		1CS73653	
		Revision	F	Page	1

S7 Communication

S7 communication for SGT-600, SGT-700 and SGT-800 Gas Turbines, designed and configured by Siemens.

General information

Siemens Industrial Turbomachinery AB (SIT AB) delivers industrial turbines with Siemens PCS7 as package control system. In this control system WinCC is used as HMI. To meet varying demands Siemens also offers the possibility to connect other HMI's via OPC, Modbus or the S7 protocol. This document describes the S7 alternative.

Delivery limit

Hardware

A switch connected to the internal plant bus of the SIT AB PCS7 control system.

Software

The S7 connection(s) configured in Net Pro.

The CFC logic together with the Function Blocks for S7 communication and its corresponding data blocks.

BU / SGT-600(MD B, PG B, PG Ex B), SGT-700(MD B, PG B, PG Ex B), SGT-800(PG B, PG B2, PG B2 US, PG Ex B2, PG Ex B2 US, PG B LS)/&DF101	

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Scope of supply

Hardware:

- A switch connected to internal plant bus, optical or electrical.
- If Profibus is used, a connection point to this bus.

Software:

- Software in PCS7 includes System Function Blocks (SFB) 12 (BSEND) and SFB 13 (BRCV).
- Two data blocks. One for send and one for receive.
- Logic to connect values to and from the communication interface.
- Logic to handle orders and set-points from the DCS system.
- Logic for summary alarms

Functionality:

The DCS control system connects to the SIT AB S7 controller via the plant bus.

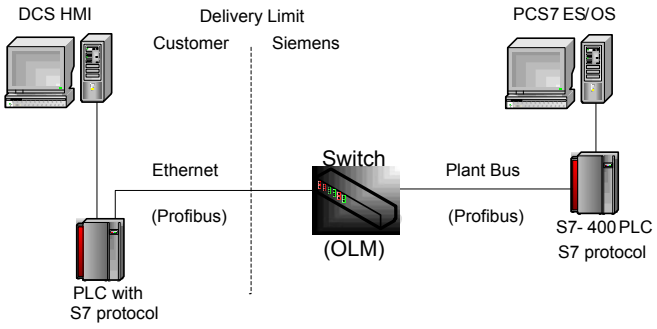

Fig 1: Overview of the S7 communication

Tests:

As additional service a one week of communication test between gas turbine PCS7 system and customer's communication interface in Finspong can be offered (refer to scope of supply document in if included).

S7 communication test in other location can be performed on daily rate basis.

Performance:

The performance of the S7 communication is verified in each project. Ethernet (plant bus) S7 communication has a better performance compared to the Profibus physical layer.

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Documentation:

- Signal Transfer List.
- Printouts of the Operator displays.
- A guideline document for the DCS engineer.

Signal transfer

Signals

All I/O and calculated signals that are used on the WinCC operator displays are included in the signal transfer.

Process alarms

Summary alarms are connected on the S7 interface. These alarms are divided into groups according to package process systems, e.g. lube oil system, fuel system etc.

System alarms

System alarms will be configured as a summary alarm. These alarms will only come if the WinCC server is up and running.

Control from external HMI

From the external control system it is possible to:

- View data
- Start and Stop the Gas turbine
- Change the set-points to the turbine governor
- Change the set-point to the generator governor on generator sets
- Change the set-point to the compressor governor on mechanical drive sets
- Change control modes

Functionality to maneuver objects, like fans, function-groups valves etc. is not included.

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Signal transfer list

A project specific signal transfer list (STL) is delivered for each project and it includes all signals sent to the external system/DCS. All signals available in the PCS7 database are possible to send. Below is an example of a typical STL shown.

STL for Modbus or S7 DCS Communication

Modbus/S7 Communication information

	Modbus Type	RTU	TCP		S7 DB Receive to Siemens PCS7	DB36		
	Media	RS485	TCP/IP		S7 DB Send from Siemens PCS7	DB35		
	Node number GTG (Slave)	1			S7 protocol media	Ethernet	Plantbus	
	Node number DCS (Master)	2			S7 alternative media	Profibus	DP	
	Baud Rate	19200						
	Stop Bit	1						
	Parity	None						
	Duplex	Half						
	Characters	8						

Analogue signals SIEMENS Simatic System -> Customer DCS

Rev No	SIEMENS Tagname	Modbus Address	S7 Address		Description	Unit	Range	X
	CFA10CE005XE01	40101	REAL101	0.0	NET VOLTAGE	kV	0-15	10
	CFA10FS005XE01	40102	REAL102	4.0	NET FREQUENCY	Hz	45-55	10
	CHA10EE001ZE01	40103	REAL103	8.0	POSITIVE MVAr HOUR COUNTER	no	0-999999999	1
	CHA10EE002ZE01	40104	REAL104	12.0	MW HOUR COUNTER	no	0-999999999	1
	CHA10EE003ZE01	40105	REAL105	16.0	NEGAITIVE MVAr HOUR COUNTER	no	0-999999999	1
	CJP10DE902ZE01	40106	REAL106	20.0	DROOP SETPOINT	%	0-10	10
	CJP10DE903ZE01	40107	REAL107	24.0	LOAD CONTROL SETPOINT	MW	0-50	10
	CJP10DE904ZE01	40108	REAL108	28.0	FREQUENCY CONTROL SETPOINT	Hz	45-55	10
	CJP10DG901ZE02	40109	REAL109	32.0	MPC SP	MJ/s	0-100	10
	CJP10DG901ZE06	40110	REAL110	36.0	MPC OPERATOR SP	MJ/s	0-100	10
	CJP10DG902ZE02	40111	REAL111	40.0	STCG SP	MJ/s	0-100	10

Re	Specification	Date	Sign	Prepared	Checked	Archive	Title	Revision
-	First edition STL SGT500	071019	PE	Peter Ettling			Modbus/S7 Signal Transfer List SGT-500	
				Approved	Resp. dept	HG		Language
					GRAE	6353		en
						Date	Document No.	Sh. / No. of sh.
						2007-10-19		1 (19)

Fig 3: Example of the Signal Transfer List (STL)

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Operator displays

Printouts of all Process displays are delivered. On these displays it is possible to see the tag connection to all dynamical objects. An example is displayed below.

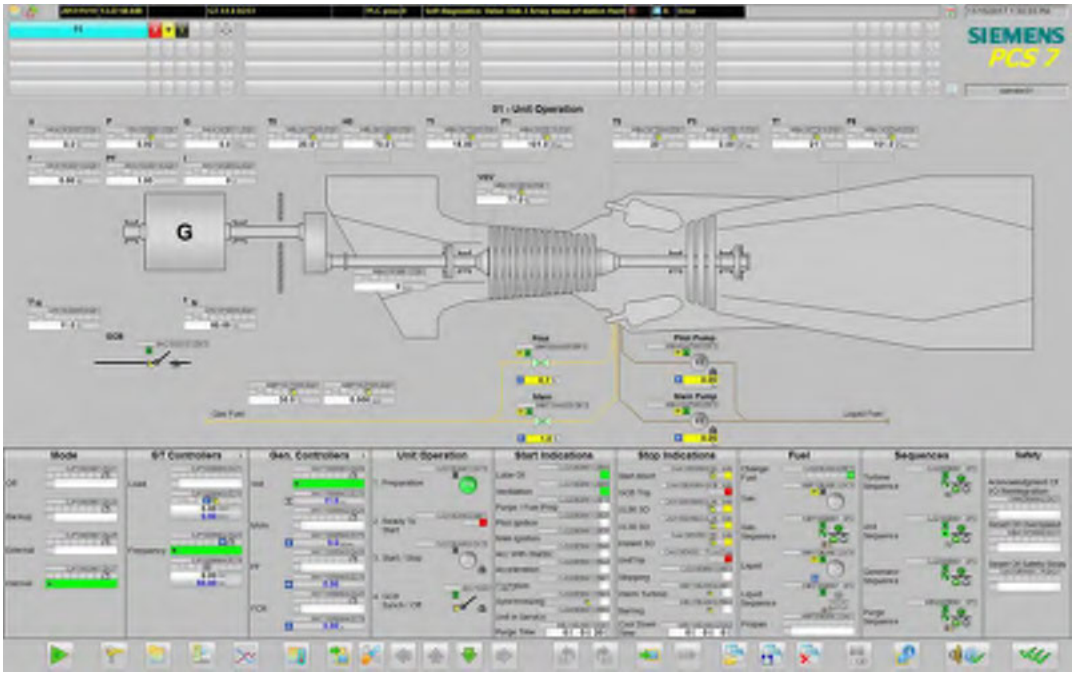

Fig 4: Operator Display, "Unit operation"

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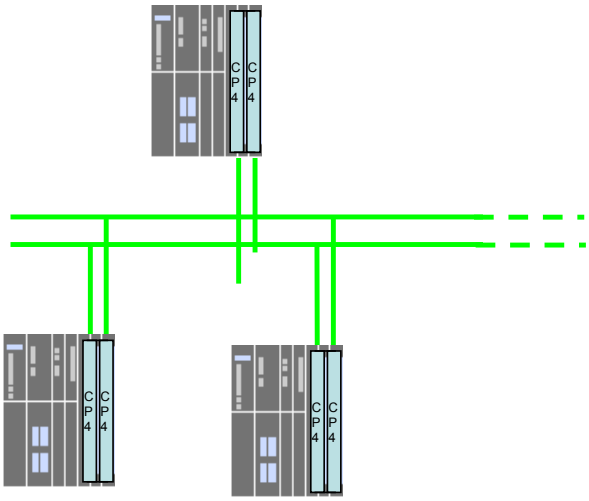
System layout example

Below are two typical system layouts for S7 communication between a SIT AB PCS7 gas turbine package control system and an external Siemens S7 DCS is shown. These configurations are also possible to modify according to different levels of redundancy etc. Recommended solution is to use the Ethernet (plant bus) for S7 communication due to its better performance compared to the Profibus physical layer.

1. Physical layer is the Ethernet plant bus



S7 DCS Controller

TCP/IP

Ethernet-Plant Bus 1 and 2

PCS7 AS417 Package control system

Fig 5: Physical set-up of a redundant S7-Connection over Ethernet

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2. Physical layer is a profibus DP field bus.

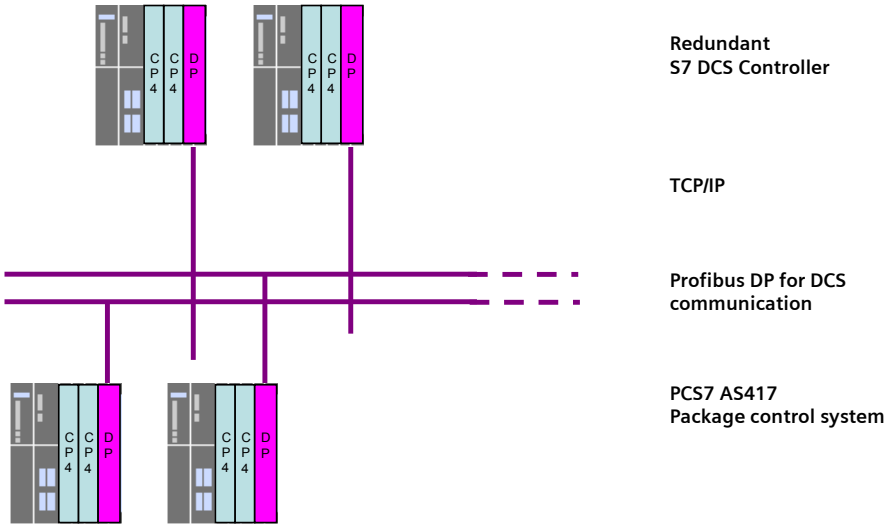

Fig 6: Physical set-up of a redundant S7-application over Profibus

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ISO

OSHA

Occupational Safety & Health Administration (OSHA) Safety Regulations are enforced by U.S. law and contain requirements for "approval" (i.e., testing and certification) of certain products by a Nationally Recognized Testing Laboratory (NRTL). Code of Federal Regulations 29 CFR 1910.303a

ANSI

American National Standards Institute

The OSHA standards do not specify the safety requirements the products must meet; these requirements are specified by U.S. standards-developing organizations (SDOs). Most SDOs operate as independent, private-sector organizations under the ANSI umbrella. ANSI develops and administers the procedures by which other organizations can create the actual standards.

Many OSHA regulations address similar topics as ANSI standards, but where ANSI standards are voluntary, OSHA regulations are law. ANSI standards, however, can be adopted by OSHA and become law.

Typical NRTLs

NRTLs certify the product by evaluate and verify it meet the standard.

Sub-supplier 1

Product Listed

Sub-supplier 2

Product Recognized

Sub-supplier 3

Product Classified

Siemens assembly workshop

PRE EVALUATION

Site Installation

FIELD LABELING

Authorities Having Jurisdiction (AHJ 's)

- Added as part of the local authority of the State or town.
- Usually local electrical inspectors (including machine, fire , health ..)
- Approve all installations in the area.
- AHJ 's agree and accept NRTL marks as evidence that products meet applicable requirements.

123456

General Description Electrical Installation

This specification covers the electrical installation for the American version of SGT-600/700 package. It is a standardised package design, i.e. types, installation, manufacturers, and design praxis et cetera are of a well-proven design and provided with a fully functional guarantee. The entire electrical system is fully assembled for the whole package when delivered; excluding interconnecting cabling to external skids e.g. external gas fuel unit and air-cooled lube-oil coolers that don't have their interconnecting cables connected to the package. The complete package is tested with its project electrical equipment at the manufacturer workshop.

The package is built for installation in unclassified (safe) area. Areas inside the gas turbine package enclosure are classified is defined as Zone 2NE according to ISO21789 (gas turbine safety).

CODES AND STANDARDS

NFPA 70 - 2017	National Electric Code
NFPA 79 - 2015	Electrical Standard for Industrial Machinery
NEMA MG1	Motors and Generators
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
IEEE C57.12.01	Standard for General Requirements for Dry-Type Distribution and Power Transformers
UL 13	Standard for Power-Limited Circuit Cables
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	Standard for Industrial Control Equipment
UL 508A	Standard for Industrial Control Panels
UL 508C	Standard for Power Conversion Equipment
UL 698A	Standard for Industrial Control Panels Relating to Hazardous Locations
UL 845	Motor Control Centers
UL 1004	Standard for Rotating Electrical Machines - General Requirements
UL 1077	Standard for Supplementary Protectors for Use in Electrical Equipment
UL 1277	Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
UL 1561	Dry-Type General Purpose and Power Transformers
UL 1778	Uninterruptible Power Systems
IEC/EN/AEx 60079-0	Explosive Atmospheres - Part 0: Equipment - General Requirements
IEC 61800-5-1	Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy
IEC/TR 61641	Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault

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GENERAL DESIGN

Design and installation of electrical equipment and components are in accordance with applicable parts of NFPA 70-2017, National Electric Code and NFPA 79-2015, Electrical Standard for Industrial Machinery.

ENVIRONMENT

Skid-mounted electrical equipment is designed to suit the complete package environment temperature limits ranging from 5°F to +104°F (-15°C - +40°C) (lower and higher temperatures are optional).

HAZARDOUS AREA & SAFETY EXECUTION

All skid-mounted electrical equipment for use in hazardous area is suitable for Class I, Division 2. The installation complies with NFPA70 Article 501 and 504. Electrical equipment and components listed and marked in accordance to either or both Division and Zone may be used, if equipment are listed and marked in accordance with 505.9(C)(2) for use in Class I, Zone 0, 1, or 2 and the temperature class is suitable for Class I, Division 2 according to Article 501.5 of the NFPA70, National Electrical Code.

Motors connected to a variable frequency drive (VFD) have temperature code suitable for VFD operation.

Intrinsically safe circuits is either connected to intrinsically safe barriers integrated in the Siemens Simatic ET200ISP I/O mounted in junction boxes at the gas turbine skid edge or to listed intrinsically safe isolators in the control panels.

When placed in hazardous areas the following safety executions are used for skid mounted equipment.

Type of equipment	Marking
Low-Voltage Motors	Class I, Division 2, Groups A, B, C, D; T3 and T4
AC Servo motors	Class I Zone 1 AEx db IIC T6-T4
Solenoids	Class I, Division 1, Groups A, B, C, D
Limit Switches	Simple Apparatus (Intrinsically safe circuit)
Cable Fittings	Class I, Division 2, Groups A, B, C, D
Lighting fittings	Class I, Division 2, Groups A, B, C, D; T4A
Junction boxes	Class I, Zone 1, AEx e IIC Gb T6-T4
Pressure transmitters	Class I, Division 2, Groups A, B, C, D; T5
Level transmitters	Class I, Division 1, Groups A, B, C, D; T5
Thermocouples / RTD	Simple Apparatus (Intrinsically safe circuit)

For details on instrumentation refer to separate document "Instrumentation on Packaged Equipment".

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Enclosures for Electrical Equipment

Enclosures for electrical equipment meet the requirements of NEMA 250 and enclosures of low voltage motors meet the requirements in ANSI/IEC 60529 according to NEMA MG 1.

The list below describes minimum level of protection.

Equipment	Standard Rating
Gas turbine package -indoor	Type 3X / IP 44
Gas turbine package -weather protected	Type 3X / IP 54
Gas turbine package -outdoor	Type 4X / IP 65
Power Control Module –Control equipment	Type 1 / IP2x

VOLTAGE LEVELS

Equipment	Voltage Level
Heat tracing, Anti condensation heaters, Sockets, Lights	120V AC 60Hz
Motor Control Center, Uninterruptible Motor Drive	480V AC 60Hz
Battery System	440V DC
UPS Powered Equipment such as control equipment and luminaries.	240V AC 60Hz
Control Circuits - Panels	24V DC

ON-SKID CABLE INSTALLATIONS

Tray cables according to UL 1277 (TC), UL 13 (PLTC) and UL 2250 (ITC) are used. Conduits are used between components such as valves and junction boxes in some cases.

Cables are located on ladder cable trays, wire basket cable trays, perforated- and solid- cable supports. Cable routing materials are made of heavy-duty hot dipped galvanized steel as standard and an option in stainless steel are available. Cable routing on the outside of the package enclosure always have cover plates. Cable routing inside the package have cover plates in places where there is a risk of mechanical damage.

Conductors and cables are secured by straps and cable ties.

Signal cables are routed separately from power cables with a minimum distance of 250 mm (10”) in between. Intersection of power and signal cable tray routes is 90°.

Tray cables can hang freely up to 300 mm (12”), and in exceptional cases with additional protection up to 500 mm (20”).

Conductors and cables be secured by straps, cable ties

EARTHING SYSTEM, EARTHING CONNECTIONS

There are two main earth bosses welded to the skid. All metallic parts on the package are bonded to the skid except for parts that are welded or bolted together in a way that ensures sufficient metallic contact.

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Minimum conductor size as follows:

Equipment	Earth Bond Size mm2	Earth bond size AWG
Motors <30kW	16	5 AWG
Motors >30kW	50	1/0 AWG
Junction boxes	16	5 AWG
Cable trays/ladders	16	5AWG
Enclosure walls	16	5 AWG
Generator/Terminal box	95	4/0AWG
Auxiliary units	70	2/0 AWG

VARIABLE FREQUENCY DRIVES (VFD)

VFDs are used for pump and fan motors in the lube oil system, starter motor, ventilation fans, cooling fans and optional liquid fuel pumps. VFDs are of type Pulse Width Modulation (PWM) with open-loop vector control. All drives are listed to UL 508C.

LOW VOLTAGE AC MOTORS

Low-voltage AC motors are used for pumps and fans. All skid mounted low-voltage motors are Totally Enclosed Fan Cooled (TEFC) fulfilling NEMA electrical requirements. Motors on fin fan coolers have also NEMA frame type.

SERVO MOTORS

The inlet guide van, combustion chamber bypass and gas fuel valves are actuated by AC servomotors.

ANTI-CONDENSATION HEATERS

When ambient conditions so require, anti-condensate space heaters are available for motors as an option. Connection voltage of 115V AC single phase. Suitable for Class I, Division 2 when motor is located in hazardous area.

DISCONNECTING MEANS

During gas turbine operation the functionality of systems like the lube oil system is vital for the environmental and personal safety. If system is stopped by mistake it can create hazards resulting in fire. Electrical motors are therefore installed without disconnecting switch adjacent to the motor. The installation meets the requirements in NEC, Article 430. During maintenance / service electric motor circuits can be lockout and tag out at the MCC or UMD in align with requirements in NFPA 70E. Disconnect switches installed adjacent to the motors are available as an option and must be locked in closed position during operation.

POWER OUTLETS

Power outlets in the Power Control Module (if applicable) and in the Gas Turbine enclosure are 1-phase 120 Volts AC.

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TERMINALS

Spring terminals mounted on DIN rails. Suitable for standard conductors and crimping lugs or sleeves are not needed but are available as option. All wires for external connection are brought to individual accessible terminals.

LIGHTING FIXTURES

Package is equipped with listed internal lighting of LED type in a classic fluorescent fixture with standard T8 LED bulbs. Suitable for ambient temperature ranges from -30°C to +85°C. The lamp reflector is corrosion resistant heavy gauge aluminum and coated with a high gloss reflective finish.

INSTRUMENTATION

For details on instrumentation refers to separate documents regarding "Instrumentation on Packaged Equipment" respectively "Hook-up drawings for packaged equipment".

JUNCTION BOXES

Junction boxes are, due to environmental conditions made of stainless steel. All junction boxes have a tag plate on the front and are named in accordance with KKS designation system. Stainless steel is uncoated. Generally all cable entries are from bottom or one side of the junction box. For hazardous area installations stainless steel vents and drains are included for junction boxes located outdoors. Junction boxes are prepared with gland plates and glands for internal cabling and with undrilled gland plates for the external cabling to allow customization during site installation of cables between GT-package and auxiliary control equipment. Other options are available upon request.

POWER CONTROL MODULE (if applicable)

The Power Control Module (PCM) can be supplied in two different designs, either with integrated battery room or free standing battery container.

As an alternative the package can be supplied without PCM. The electrical and control panels are then supplied as loose items to be placed elsewhere by client (safe, non-hazardous area under controlled environmental conditions

The PCM can be placed adjacent or away to the package.

The PCM then comes to site fully wired and factory tested up to ignition at manufacturer test facility. It is significantly man hour saving compared to having the loose items alternative and keeps site erection work to a minimum.

As a general figure the cable length between turbo-generator/compressor and electrical/control equipment shall be kept at a maximum length of 150 meters.

Up to 150 m the installation is usually only adapted to current circumstances by dimensioning of the cables. For longer distances and for many loads, in addition to substantially increased cable cross sectional area, many other modifications and methods like filters after lube oil system SFC has to be introduced.

The electrical and control system is placed in the ventilated and climate controlled PCM. If electrical and control panels are supplied as loose items, i.e. for installations without manufacturer PCM, ambient design temperature for the electrical and control panel location has to be within 5-25°C and 20-50 % rH.

All electrical and control panels placed in our PCM (see item 0 for details regarding the PCM) (See scope of supply document). (Batteries: IP20, low voltages switch gear: IP30).

Other, higher, IP-class for placement of the panels in a harsher environmental condition can when needed be offered as an option on all electrical and control panels.

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CONTROL PANELS

The control panels consist of functions as unit control, turbine control, generator control and fire alarm. All built and certified according to applicable parts of UL 508A (and UL 698A when panel contains intrinsically safe isolators).

MOTOR CONTROL CENTER

The MCC consist of 480 volt motor starters, feeders and 120 volt switchboard. Meet the requirements in UL845. Arc fault tested according to IEC/TR 61641 (Up to 100kA for 1000ms). Standard design have SCCR of 65kA at 480 Volts.

MOTOR DRIVE SYSTEM (MDS) / UNINTERRUPTIBLE POWER SUPPLY (UPS)

The MDS/UPS contains of variable frequency drives and autonomous controllers designed to supply uninterruptible power to pumps and fans in the lube oil system. The UPS contains as standard of redundant battery chargers and the UPS is supplying control equipment and some valves. The MDS/UPS panel is via one transformer fed from the MCC and also direct connected to a backup battery. Switching between the two sources is seamless. Power supply to the panels is factory pre-wired if not delivered as loose items. Panels are built and certified according to applicable parts of UL 508A.

SUB SUPPLIERS

Refer to separate document "Vendors list" for a list of approved sub suppliers of electrical equipment

INSPECTION AND TEST

Products are developed, designed, manufactured, installed and delivered in accordance with the Quality System, as described in the manufacturer overall (QAM),

WORKSHOP TESTS

Auxiliary systems are tested at the workshop. For a more detailed description of the workshop tests performed refer to separate documents, "Workshop test".

MOTORS

Tests are performed according to manufacturer routine tests. No type tests are included.

TEST CERTIFICATES

All certificates from above mentioned test are included; see scope of supply for quantity.

Manufacturer type test certificates are only included upon special request.

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DRAWING AND DATA, DOCUMENTATION

GENERAL

Technical data needed by the customer for design of electrical equipment, e.g. electrical power consumers and equipment-grounding requirements

CIRCUIT DIAGRAMS

Cover all supplied equipment and components identified by their item designation. The drawings also show location-oriented item designations for equipment not dedicated to one component solely, e.g. equipment mounted in control cubicles.

SINGLE LINE DIAGRAM

Gives an overview of the supplied auxiliary power.

CABLE TABLE

Describes all cables in the plant with cable specification and a definition of start and end.

CABLE INTERCONNECTION TABLES

Describes field wiring terminal connections for the cable cores. Terminal points for signals are listed and identified by their item designations

WIRING TABLES

Defines the connection points for wires internally in electrical equipment such as cubicles, junction boxes.

LIST OF APPARATUS

Defines all electrical apparatus in the delivery with technical information as well as ordering information.

ELECTRICAL LAYOUT DRAWINGS

Show the general arrangement of electrical equipment and main cable routing.

Show the interface for terminals during electrical installation.

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General Description Electrical Installation

This specification covers the electrical installation for the American version of SGT-600/700 package. It is a standardised package design, i.e. types, installation, manufacturers, and design praxis et cetera are of a well-proven design and provided with a fully functional guarantee. The entire electrical system is fully assembled for the whole package when delivered; excluding interconnecting cabling to external skids e.g. external gas fuel unit and air-cooled lube-oil coolers that don't have their interconnecting cables connected to the package. The complete package is tested with its project electrical equipment at the manufacturer workshop.

The package is built for installation in unclassified (safe) area. Areas inside the gas turbine package enclosure are classified is defined as Zone 2NE according to ISO21789 (gas turbine safety).

CODES AND STANDARDS

NFPA 70 - 2017	National Electric Code
NFPA 79 - 2015	Electrical Standard for Industrial Machinery
NEMA MG1	Motors and Generators
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
IEEE C57.12.01	Standard for General Requirements for Dry-Type Distribution and Power Transformers
UL 13	Standard for Power-Limited Circuit Cables
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	Standard for Industrial Control Equipment
UL 508A	Standard for Industrial Control Panels
UL 508C	Standard for Power Conversion Equipment
UL 698A	Standard for Industrial Control Panels Relating to Hazardous Locations
UL 845	Motor Control Centers
UL 1004	Standard for Rotating Electrical Machines - General Requirements
UL 1077	Standard for Supplementary Protectors for Use in Electrical Equipment
UL 1277	Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
UL 1561	Dry-Type General Purpose and Power Transformers
UL 1778	Uninterruptible Power Systems
IEC/EN/AEx 60079-0	Explosive Atmospheres - Part 0: Equipment - General Requirements
IEC 61800-5-1	Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy
IEC/TR 61641	Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault

Unrestricted 600/700 US

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GENERAL DESIGN

Design and installation of electrical equipment and components are in accordance with applicable parts of NFPA 70-2017, National Electric Code and NFPA 79-2015, Electrical Standard for Industrial Machinery.

ENVIRONMENT

Skid-mounted electrical equipment is designed to suit the complete package environment temperature limits ranging from 5ºF to +104ºF (-15°C - +40°C) (lower and higher temperatures are optional).

HAZARDOUS AREA & SAFETY EXECUTION

All skid-mounted electrical equipment for use in hazardous area is suitable for Class I, Division 2. The installation complies with NFPA70 Article 501 and 504. Electrical equipment and components listed and marked in accordance to either or both Division and Zone may be used, if equipment are listed and marked in accordance with 505.9(C)(2) for use in Class I, Zone 0, 1, or 2 and the temperature class is suitable for Class I, Division 2 according to Article 501.5 of the NFPA70, National Electrical Code.

Motors connected to a variable frequency drive (VFD) have temperature code suitable for VFD operation.

Intrinsically safe circuits is either connected to intrinsically safe barriers integrated in the Siemens Simatic ET200ISP I/O mounted in junction boxes at the gas turbine skid edge or to listed intrinsically safe isolators in the control panels.

When placed in hazardous areas the following safety executions are used for skid mounted equipment.

Type of equipment	Marking
Low-Voltage Motors	Class I, Division 2, Groups A, B, C, D; T3 and T4
AC Servo motors	Class I Zone 1 AEx db IIC T6-T4
Solenoids	Class I, Division 1, Groups A, B, C, D
Limit Switches	Simple Apparatus (Intrinsically safe circuit)
Cable Fittings	Class I, Division 2, Groups A, B, C, D
Lighting fittings	Class I, Division 2, Groups A, B, C, D; T4A
Junction boxes	Class I, Zone 1, AEx e IIC Gb T6-T4
Pressure transmitters	Class I, Division 2, Groups A, B, C, D; T5
Level transmitters	Class I, Division 1, Groups A, B, C, D; T5
Thermocouples / RTD	Simple Apparatus (Intrinsically safe circuit)

For details on instrumentation refer to separate document "Instrumentation on Packaged Equipment".

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Enclosures for Electrical Equipment

Enclosures for electrical equipment meet the requirements of NEMA 250 and enclosures of low voltage motors meet the requirements in ANSI/IEC 60529 according to NEMA MG 1.

The list below describes minimum level of protection.

Equipment	Standard Rating
Gas turbine package -indoor	Type 3X / IP 44
Gas turbine package -weather protected	Type 3X / IP 54
Gas turbine package -outdoor	Type 4X / IP 65
Power Control Module –Control equipment	Type 1 / IP2x

VOLTAGE LEVELS

Equipment	Voltage Level
Heat tracing, Anti condensation heaters, Sockets, Lights	120V AC 60Hz
Motor Control Center, Uninterruptible Motor Drive	480V AC 60Hz
Battery System	440V DC
UPS Powered Equipment such as control equipment and luminaries.	240V AC 60Hz
Control Circuits - Panels	24V DC

ON-SKID CABLE INSTALLATIONS

Tray cables according to UL 1277 (TC), UL 13 (PLTC) and UL 2250 (ITC) are used. Conduits are used between components such as valves and junction boxes in some cases.

Cables are located on ladder cable trays, wire basket cable trays, perforated- and solid- cable supports. Cable routing materials are made of heavy-duty hot dipped galvanized steel as standard and an option in stainless steel are available. Cable routing on the outside of the package enclosure always have cover plates. Cable routing inside the package have cover plates in places where there is a risk of mechanical damage.

Conductors and cables are secured by straps and cable ties.

Signal cables are routed separately from power cables with a minimum distance of 250 mm (10”) in between. Intersection of power and signal cable tray routes is 90°.

Tray cables can hang freely up to 300 mm (12”), and in exceptional cases with additional protection up to 500 mm (20”).

Conductors and cables be secured by straps, cable ties

EARTHING SYSTEM, EARTHING CONNECTIONS

There are two main earth bosses welded to the skid. All metallic parts on the package are bonded to the skid except for parts that are welded or bolted together in a way that ensures sufficient metallic contact.

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Minimum conductor size as follows:

Equipment	Earth Bond Size mm2	Earth bond size AWG
Motors <30kW	16	5 AWG
Motors >30kW	50	1/0 AWG
Junction boxes	16	5 AWG
Cable trays/ladders	16	5AWG
Enclosure walls	16	5 AWG
Generator/Terminal box	95	4/0AWG
Auxiliary units	70	2/0 AWG

VARIABLE FREQUENCY DRIVES (VFD)

VFDs are used for pump and fan motors in the lube oil system, starter motor, ventilation fans, cooling fans and optional liquid fuel pumps. VFDs are of type Pulse Width Modulation (PWM) with open-loop vector control. All drives are listed to UL 508C.

LOW VOLTAGE AC MOTORS

Low-voltage AC motors are used for pumps and fans. All skid mounted low-voltage motors are Totally Enclosed Fan Cooled (TEFC) fulfilling NEMA electrical requirements. Motors on fin fan coolers have also NEMA frame type.

SERVO MOTORS

The inlet guide van, combustion chamber bypass and gas fuel valves are actuated by AC servomotors.

ANTI-CONDENSATION HEATERS

When ambient conditions so require, anti-condensate space heaters are available for motors as an option. Connection voltage of 115V AC single phase. Suitable for Class I, Division 2 when motor is located in hazardous area.

DISCONNECTING MEANS

During gas turbine operation the functionality of systems like the lube oil system is vital for the environmental and personal safety. If system is stopped by mistake it can create hazards resulting in fire. Electrical motors are therefore installed without disconnecting switch adjacent to the motor. The installation meets the requirements in NEC, Article 430. During maintenance / service electric motor circuits can be lockout and tag out at the MCC or UMD in align with requirements in NFPA 70E. Disconnect switches installed adjacent to the motors are available as an option and must be locked in closed position during operation.

POWER OUTLETS

Power outlets in the Power Control Module (if applicable) and in the Gas Turbine enclosure are 1-phase 120 Volts AC.

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TERMINALS

Spring terminals mounted on DIN rails. Suitable for standard conductors and crimping lugs or sleeves are not needed but are available as option. All wires for external connection are brought to individual accessible terminals.

LIGHTING FIXTURES

Package is equipped with listed internal lighting of LED type in a classic fluorescent fixture with standard T8 LED bulbs. Suitable for ambient temperature ranges from -30ºC to +85ºC. The lamp reflector is corrosion resistant heavy gauge aluminum and coated with a high gloss reflective finish.

INSTRUMENTATION

For details on instrumentation refers to separate documents regarding "Instrumentation on Packaged Equipment" respectively "Hook-up drawings for packaged equipment".

JUNCTION BOXES

Junction boxes are, due to environmental conditions made of stainless steel. All junction boxes have a tag plate on the front and are named in accordance with KKS designation system. Stainless steel is uncoated. Generally all cable entries are from bottom or one side of the junction box. For hazardous area installations stainless steel vents and drains are included for junction boxes located outdoors. Junction boxes are prepared with gland plates and glands for internal cabling and with undrilled gland plates for the external cabling to allow customization during site installation of cables between GT-package and auxiliary control equipment. Other options are available upon request.

POWER CONTROL MODULE (if applicable)

The Power Control Module (PCM) can be supplied in two different designs, either with integrated battery room or free standing battery container.

As an alternative the package can be supplied without PCM. The electrical and control panels are then supplied as loose items to be placed elsewhere by client (safe, non-hazardous area under controlled environmental conditions

The PCM can be placed adjacent or away to the package.

The PCM then comes to site fully wired and factory tested up to ignition at manufacturer test facility. It is significantly man hour saving compared to having the loose items alternative and keeps site erection work to a minimum.

As a general figure the cable length between turbo-generator/compressor and electrical/control equipment shall be kept at a maximum length of 150 meters.

Up to 150 m the installation is usually only adapted to current circumstances by dimensioning of the cables. For longer distances and for many loads, in addition to substantially increased cable cross sectional area, many other modifications and methods like filters after lube oil system SFC has to be introduced.

The electrical and control system is placed in the ventilated and climate controlled PCM. If electrical and control panels are supplied as loose items, i.e. for installations without manufacturer PCM, ambient design temperature for the electrical and control panel location has to be within 5-25°C and 20-50 % rH.

All electrical and control panels placed in our PCM (see item 0 for details regarding the PCM) (See scope of supply document). (Batteries: IP20, low voltages switch gear: IP30).

Other, higher, IP-class for placement of the panels in a harsher environmental condition can when needed be offered as an option on all electrical and control panels.

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CONTROL PANELS

The control panels consist of functions as unit control, turbine control, generator control and fire alarm. All built and certified according to applicable parts of UL 508A (and UL 698A when panel contains intrinsically safe isolators).

MOTOR CONTROL CENTER

The MCC consist of 480 volt motor starters, feeders and 120 volt switchboard. Meet the requirements in UL845. Arc fault tested according to IEC/TR 61641 (Up to 100kA for 1000ms). Standard design have SCCR of 65kA at 480 Volts.

MOTOR DRIVE SYSTEM (MDS) / UNINTERRUPTIBLE POWER SUPPLY (UPS)

The MDS/UPS contains of variable frequency drives and autonomous controllers designed to supply uninterruptible power to pumps and fans in the lube oil system. The UPS contains as standard of redundant battery chargers and the UPS is supplying control equipment and some valves. The MDS/UPS panel is via one transformer fed from the MCC and also direct connected to a backup battery. Switching between the two sources is seamless. Power supply to the panels is factory pre-wired if not delivered as loose items. Panels are built and certified according to applicable parts of UL 508A.

SUB SUPPLIERS

Refer to separate document "Vendors list" for a list of approved sub suppliers of electrical equipment

INSPECTION AND TEST

Products are developed, designed, manufactured, installed and delivered in accordance with the Quality System, as described in the manufacturer overall (QAM),

WORKSHOP TESTS

Auxiliary systems are tested at the workshop. For a more detailed description of the workshop tests performed refer to separate documents, "Workshop test".

MOTORS

Tests are performed according to manufacturer routine tests. No type tests are included.

TEST CERTIFICATES

All certificates from above mentioned test are included; see scope of supply for quantity.

Manufacturer type test certificates are only included upon special request.

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DRAWING AND DATA, DOCUMENTATION

GENERAL

Technical data needed by the customer for design of electrical equipment, e.g. electrical power consumers and equipment-grounding requirements

CIRCUIT DIAGRAMS

Cover all supplied equipment and components identified by their item designation. The drawings also show location-oriented item designations for equipment not dedicated to one component solely, e.g. equipment mounted in control cubicles.

SINGLE LINE DIAGRAM

Gives an overview of the supplied auxiliary power.

CABLE TABLE

Describes all cables in the plant with cable specification and a definition of start and end.

CABLE INTERCONNECTION TABLES

Describes field wiring terminal connections for the cable cores. Terminal points for signals are listed and identified by their item designations

WIRING TABLES

Defines the connection points for wires internally in electrical equipment such as cubicles, junction boxes.

LIST OF APPARATUS

Defines all electrical apparatus in the delivery with technical information as well as ordering information.

ELECTRICAL LAYOUT DRAWINGS

Show the general arrangement of electrical equipment and main cable routing.

Show the interface for terminals during electrical installation.

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Specification of industrial cables

This specification cover the power and instrument cable types used for packaged gas turbines and turbo compressors, in safe- and general hazardous areas. In the delivered package the cabling is guaranteed to be of halogen free, low smoke density and fire classified type.

It is a standardised package design, i.e. types, installation, manufacturers, and design praxis et cetera are of a well-proven design.

All cabling is fully assembled for the whole package when delivered; excluding interconnecting cabling to external skids. The complete package is tested with its project bound instrument and power cabling up to start sequence ignition point at the manufacturer workshop.

The only cables that are not covered are the prefabricated “flying lead” cables. The prefabricated “flying lead” cables are mainly those connected to the vibration, speed and temperature sensors at gas generator and power turbine.

Cable installation

BU/ SGT-600(MD B, PG B, PG Ex B), SGT-700(MD B, PG B, PG Ex B), SGT-750(PG A, PG Ex A), SGT-800(PG B, PG B2, PG Ex B2, PG Ex B2 US, PG B2 US, PG B LS) / &DF101

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Cables for instrument installation

For safe area and general hazardous area installations the cable type FQAR (*Depending on package ambient conditions*) is used for general instrumentation and control. The cable type LiHCH is used for vibration measurements and for fire, gas and safety related circuits SICHF is used. Within the fire and gas system a cable supplied by the deliverer of the system, as part of delivery, is also used.

When cables are used in Intrinsically Safe circuits the outer sheathing is blue, or blue marked at each entry.

Instrument cables have twisted pairs, minimum diameter 1.0 mm^2, and stranded conductors (thermocouple compensating-cables and the cable to the flame detector may have a smaller diameter).

Instrument cables are routed via junction boxes and multicore cables to the control system.

The wiring is continuously shielded from the instrument to the control system. Shields are grounded at the control system end of the cable only.

Wires are marked at ends, numbering and tagging according to scope of supply.

Spare cores are terminated in hazardous area applications.

Cables for electrical power installation

For general hazardous area installations the cable types used are FXQJ-EMC and FQLQ.

Spare cores are terminated in hazardous area applications.

Minimum wiring cross section is as follows:

Current transformers 2.5 mm^2

Power circuits 2.5 mm^2

Motors 2.5 mm^2

Cable glands

Type of cable gland depends on type of installation. Appropriate cable glands are used according to area classification, protection concept and cable type.

For general hazardous area installations EExd brass cable glands with an ingress protection of IP66/67/68 are used. Metric threads, 1.5 mm pitch medium fit.

For safe area installations cable glands with an ingress protection of IP54 are used.

MCT (Multi Core Transits) seals are used for cable entries to local electrical & control module panels at entry point.

For cable gland and multi-penetration seal brands see separate document "*Sub suppliers list*"

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Recommended colour and alphanumeric coding

Function	Colour	Alphanumeric
AC Power Cables:		
Single phase system	Brown (BN)	L
Phase 1 in 3 phase system	Brown (BN)	L1
Phase 2 in 3 phase system	Black (BK)	L2
Phase 3 in 3 phase system	Grey (GY)	L3
Neutral	Light Blue (LBU[1])	N
Protective Earth	Green and Yellow (GNYE)	PE

DC Power Cables:

(Negative earthed system)

24V (+)	Blue (BU)	L+
0V (–)	White (WH)	M

[1] LBU is a SIT specific code in order to separate the different applications/nuances of blue in circuit diagram

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Cable ties

On base frame cabling is tied with UV resistant plastic ties. In hot area are ties of nylon coated stainless steel used.

Cable marking

For cable and core marking system manufacturer see separate document, “sub suppliers list”.

Cable markers are of permanent marked type for use with holders.

Markers for cable cores and smaller diameter cables are of permanent marked sleeve type.

Markings are printed by thermal transfer process or written with system manufacturer recommended pen to produce durable UV stabilised markers.

Cables are marked at both ends with both "*cable number*" and "*individual core number*" according to KKS marking system.

Standards

Cables are designated according to the international standards as shown for each cable type below.

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Power cable FXQJ -EMC

Application: Motors and Power

EMC-LINE FXQJ 0,6/1 kV

Application fields
Halogen free and fire classified cable. No emittance of corrosive gases, low smoke density in case of fire. Open, fixed installation, indoors and outdoors, in pipes and in ground/water. In switchgear rooms and rooms where explosions may occur. Can be carefully ploughed down. The copper screen have 100 % covering and complyes with the EMC-directive with a right practicable installation.

Alternative designation
FXQJ-EMC
NIZCZI-R
NIZCZI-S

Standard
CENELEC HD 604 Part 5 Section D and IEC 60502-1
CENELEC HD 604 (Halogen free materials)
IEC 60754-1, -2 (corrosive gases)
IEC 61034 (smoke density)

Fire propagation class
F4C acc. to SS 424 14 75 and IEC 60332-3 cat. C and SS-EN 50266-2-4

Temperature range
In continuous operation max. conductor temp 90 °C.
Lowest cable temperature under installation: -20 °C and below 0 °C special precaution shall be taken.

Approval
CE

Material declaration
EMC-LINE

Bending radius
At fixed mounting: 8 x D
At pulling-in: 12 x D
At ploughing-down: 8 x D

Design

Conductor:	Stranded and annealed copper acc. to IEC 60228 class 2 2,5-35 mm²: round (FR) 50-240 mm²: sector-shaped (FV)
Insulation:	XLPE
Core identification:	3-core: brown, black, grey 4-core: Brown, black, grey, blue
Filler:	Halogen free, taped
Concentric conductor:	Copper-folie with overlap and annealed copper wires
Sheath:	Halogen free compound, black, metre-marked
Marking e.g.:	EMC-LINE FXQJ 0,6/1 kV 3x50 FV/25 CE DRAKA "Year"

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Power cable RQ

Application: DC Power, Batteries

H07Z1-K 450/750 V

Application fields
Halogen free connection cable, no emittance of corrosive gases, low smoke density in case of fire. Intended for laying in pipes and ducts and as connection cable in apparatus cubicles.

Alternative designation
RQ

Standard
CENELEC HD 21.15
IEC 60754 (corrosive gases)
IEC 61034 (smoke density)

Fire propagation class
IEC 60332-1
and EN 50265-2-1

Temperature range
In continuous operation
max. conductor temp 70 °C.
Lowest cable temperature under installation: -20 °C and below 0 °C special precaution shall be taken.

Approval
<HAR>, CE

Material declaration
EQ, FQ, RQ, Twisted FQ

PVC alternative
H07V-K

Design

Conductor:	Flexible and annealed copper acc. to IEC 60228 class 5
Insulation:	Halogen free compound

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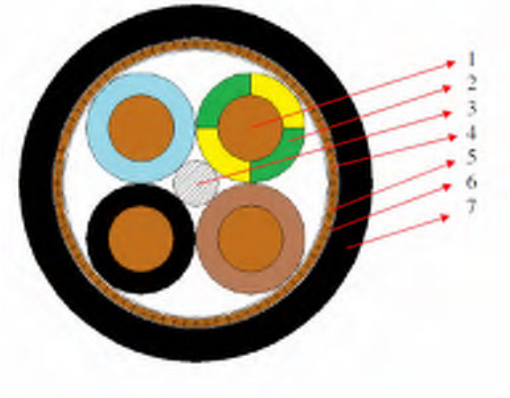
Power cable RXFX –EMC

Application: power to servo motor gas fuel system

RXFX EMC shielded flexible power cable 0,6/1 kV



Construction

		Material	Standard	Properties	value
1	Conductor	Tinned Cu wires	IEC60228	Resistance	< 5,1 Ω/km
2	Insulation	XLPE	EN50363	Temp range used material	-45 to + 120 °C
				Colour	BK, LBU, BN, GNYE
3	Filler				
4	Lapping tape	Textile			
5	Braiding	Tinned Cu wire		Covering	85 %
6	Lapping tape	Textile			
7	Outer sheath	XHFFR	EN50363	Temp range	-45 to +120 °C
				Colour	BK

Properties

Voltage range	0,6/1 kV
Max ambient temp	120 °C
Min bending radius, (DIN 0298-3)	76 mm

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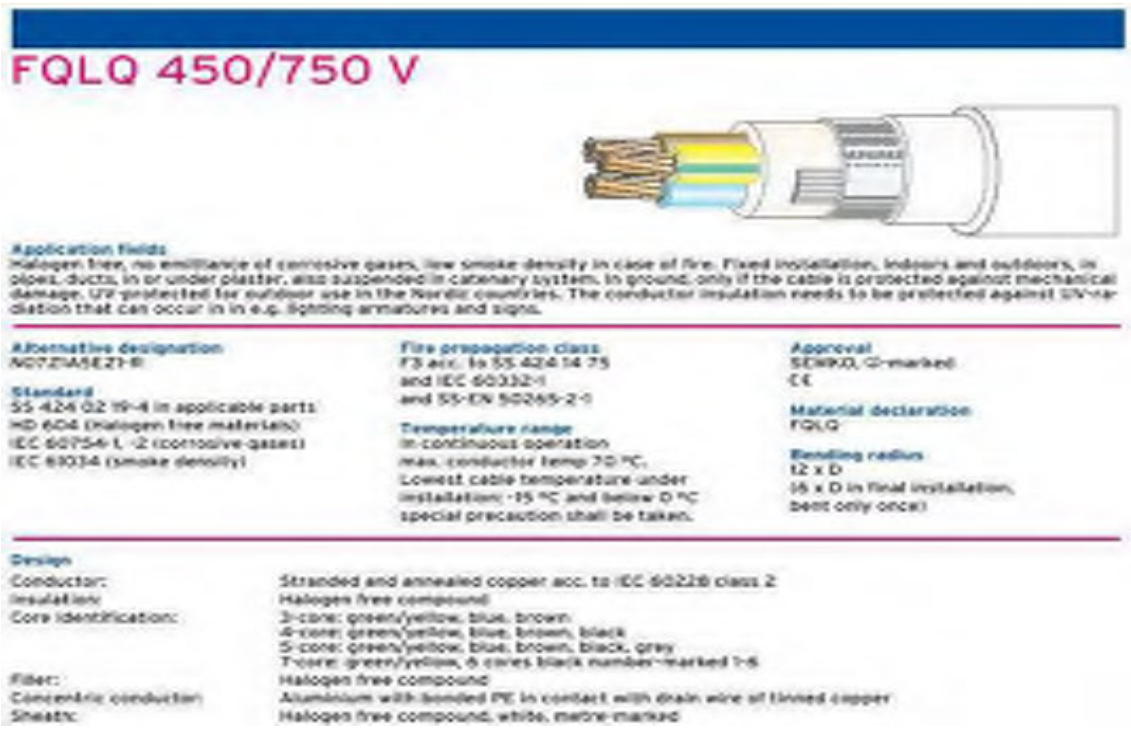
Installation cable FQLQ

Application: Power, Lighting and Control



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Instrumentation cable FQAR-TG

Application: Instrumentation and control

FQAR-TG 150/250 V

Application fields
Halogen free, no emittance of corrosive gases, low smoke density in case of fire. Open, fixed installation, in pipes and ducts, also outdoors. Intended for signal transmission where stringent demands are imposed on interference immunity, crosstalk protection and mechanical strength.

Alternative designation
SE-N01Z1A7Z1-R

Standard
SS 424 03 21
CENELEC HD 627 Part 4
Section C-2
CENELEC HD 604 (Halogen free materials)
IEC 60754-1, -2 (corrosive gases)
IEC 61034 (smoke density)

Fire propagation class
F3 acc. to SS 424 14 75
and IEC 60332-1
and SS-EN 50265-2-1

Temperature range
In continuous operation max 70 °C
Lowest cable temperature under installation: -20 °C and below 0 °C special precaution shall be taken.

Approval
SEMKO, Ⓢ-marked
CE

Material declaration
FQAR-G, -PG, -TG

Bending radius
12 x D
(8 x D in final installation)

Design

Conductor:	Stranded, annealed and tinned copper
Insulation:	Halogen free compound
Core identification:	Numbers
Triple:	The cores are twisted in triple
Concentric screen:	Aluminium/plastic laminate with drain wire of tinned copper, the metal is outwards
Sheath:	Halogen free compound, grey

Electrical data at +20 °C

Resistance, measured in loop (max)	40,4 Ω/km
Resistance in continuity conductor (max)	18,8 Ω/km
Insulation resistance (min)	2000 MΩkm
Pair capacitance at 1 kHz	140 nF/km
Capacitance, core-screen at 1 kHz	270 nF/km
Pair inductance at 1 kHz	620 µH/km
Attenuation at 1 kHz; 100 kHz	1,3; 10 dB/km
Crosstalk attenuation at 1 kHz; 100 kHz	130; 90 dB/km
Characteristic impedance at 1 kHz; 100 kHz	200; 65 Ω

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Instrumentation cable FQAR-PG

Application: Instrumentation and control

FQAR-PG 150/250 V

Application fields
Halogen free, no emittance of corrosive gases, low smoke density in case of fire. Open, fixed installation, in pipes and ducts, also outdoors. Intended for signal transmission where stringent demands are imposed on interference immunity, crosstalk protection and mechanical strength. For intrinsically safe circuits, choose a blue sheath.

Alternative designation
SE-N01Z1A7Z1-R

Standard
SS 424 03 21
CENELEC HD 627 Part 4
Section C-2
CENELEC HD 604 (Halogen free materials)
IEC 60754-1, -2 (corrosive gases)
IEC 61034 (smoke density)

Fire propagation class
F3 acc. to SS 424 14 75
and IEC 60332-1
and SS-EN 50265-2-1

Temperature range
In continuous operation max 70 °C
Lowest cable temperature under installation: -20 °C and below 0 °C special precaution shall be taken.

Approval
SEMKO, -marked
CE

Material declaration
FQAR-G, -PG, -TG

PVC alternative
FKAR-PG

Bending radius
12 x D
(8 x D in final installation)

Design

Conductor:	Stranded, annealed and tinned copper
Insulation:	Halogen free compound
Core identification:	Numbers
Pairs:	The cores are twisted to pairs (2x2x0,5 mm2, quad twisted 1-3-2-4)
Concentric screen:	Aluminium/plastic laminate with drain wire of tinned copper, the metal is outwards
Sheath:	Halogen free compound, grey

Electrical data at +20 °C

	0,5 mm²	1,0 mm²
Resistance, measured in loop (max)	80,8 Ω/km	40,4 Ω/km
Resistance in continuity conductor (max)	18,8 Ω/km	18,8 Ω/km
Insulation resistance (min)	2000 MΩkm	2000 MΩkm
Pair capacitance at 1 kHz	90 nF/km	110 nF/km
Capacitance, core-screen at 1 kHz	130 nF/km	160 nF/km
Pair inductance at 1 kHz	680 µH/km	620 µH/km
Attenuation at 1 kHz; 100 kHz	1,4; 8 dB/km	1,3; 10 dB/km
Crosstalk attenuation at 1 kHz; 100 kHz	120; 85 dB/km	130; 90 dB/km
Characteristic impedance at 1 kHz; 100 kHz	350; 90 Ω	200; 65 Ω

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Instrumentation cable P/ALPTWK

Application: Thermocouple extension cable

Standard applied: IEC 60584 with locate temp of <90°C

Extension wire for thermocouple PVC-insulated

Model P/ALPTWK

Example of use
Signal connection of thermocouples.

Maximum temperature
90 °C

Minimum temperature
-15 °C

Specification (example type K)

Extension wire (KX)

Material	Thermocouple material reclassified due to limited temperature range, normally -25 - 200 °C. Cable insulation material can further limit temperature range.
Requirement	Class 1 (IEC 60584-3, K,N,S,R) Class 2 (IEC 60584-3 J,T)

Compensating cable (KCA or KCB)

Material	Thermocouple-like within a limited temperature range (KCA: 0 - 150 °C and KCB:0 - 100°C). Cable insulation material can further limit temperature range.
Requirement	Class 2 (IEC 60584-3) or worse

Conductors

Area	0,52 mm² (AWG 20)
Strands	1 x 0,81 mm
Insulation	PVC

Conductors are twisted in the outer sheathing and each pair is numbered.

Communication conductor
Multistrand PVC-insulated

Outer sheathing

Screen	Aluminum tape on polyester base plus ground conductor
Isolering	PVC

Bending radius must not be less than 6 times the outer diameter.

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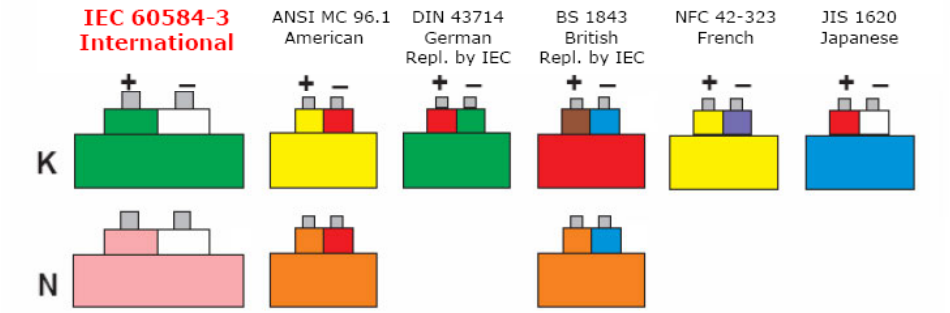
Colour codes for thermocouple material



Thermocouple wire
Thermocouples are defined by single letters - B, E, J, K, N, R, S, T - having tolerances according to the IEC 60584-2. The American ANSI standard dictates brown-coloured outer insulation sheath for thermocouples. Thermocouple wires intended for high temperatures normally have sheaths which can't be coloured. However, it occurs that a fiber - coloured according to the codes above - is integrated to the sheath for identification.

Extension wire and compensation cable
Extension wires are nominally made by the same alloys as the corresponding thermocouples. These are defined by the additional letter X - e g KX - with temperature range -25 to +200 °C. The limits of tolerance equal thermocouple class 1 or class 2 of the IEC 60584. Note that the sheath (e g PVC) can further limit the allowed temperature of the cable location.

Compensation cables are produced from alloys differing from the original materials. Hence the environmental temperature will be more limited and the tolerances will not be better than class 2 of the IEC 60584. Compensation cables are defined with the additional letter C combined with another letter identifying the alloys used - e g SCA or SCB. Compensated materials are used because they are cheaper and easier to produce.

For instance type K has the extension cable - KX - made by the very same material as the pure thermocouple. Moreover there is the compensation cable KCA with the temperature range 0 - 150°C and iron in the positive lead. Also there is the KCB cable with the more limited temperature range 0 - 100 °C and copper in the positive lead. Compensation cables are only qualified to the class 2. Generally cable sheathing can limit the temperature ranges still more. For example PVC-sheathing limits the location temperature below 100°C.

Connectors
Connectors should be colour marked as the corresponding cable.

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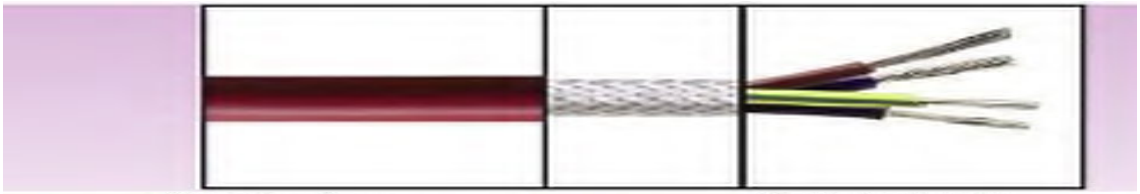
Cable type: SICHF

Application: Fire & gas, safety systems

SICHF



Construction:

Conductor:	tinned copper strands acc. to IEC 60228, EN 60228, VDE 0295, class 5
Insulation:	Besiflex® EI2 acc. to DIN VDE 0282 part 1 and HD 22.1
Colour code:	up to 5 cores coloured acc. to HD 308 (VDE 0293 part 308); from 6 cores black cores with consecutive numbers; from 3 cores a green-yellow earth wire
Stranding:	in layers
Wrapping:	PETP foil
Screen:	tinned copper braiding
Sheath material:	Besiflex® EM9 acc. to DIN VDE 0282 part 1 + HD 22.1
Sheath colour:	reddish brown (similar RAL 3016)

Outstanding features:

- good EMC characteristics
- halogen free
- flexible at low temperatures
- heat resistant

Technical data:

Nominal voltage:	Uo/U 300/500 V
Testing voltage U:	2000 V core/screen 1000 V
Min. bending radius fixed laying: flexible application:	 5 x d 12 x d
Radiation resistance:	2 x 10^7 cJ/kg
Temperature range fixed laying: flexible application: short-time use:	 -40/+180 °C -25/+180 °C +250 °C
Halogen-free:	acc. to DIN VDE 0472 part 815 and IEC 60754-1
Fire performance:	flame retardant and self-extinguishing acc. to IEC 60332-1-2 + EN 60332-1-2
Corrosiveness of conflagration gases:	IEC 60754-2 + EN 50267-2-2 + VDE 0482 part 267-2-2 – no development of corrosive conflagration gases
Chem. resistance:	see page N/9
Weather resistance:	very good
Absence of harmful substances:	acc. to RoHS-guideline 2002/95/EG as well as GefStoff/ appendix IV no. 24, see page N/14

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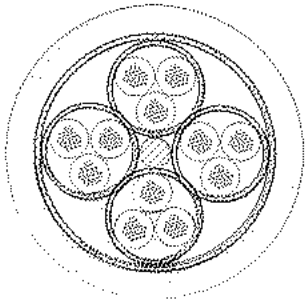
Instrumentation cable LiHCH

Application: Vibration & Speed

EUROFLEX LiHCH

Example: 2x(2x1,0)



Example:4x(3x1,0)

Conductor:	Bare copper
Conductor insulation:	Halogen free compound
Conductor marking:	Numbered conductors
Twisting:	Twisted and screened with a tinned copper braid
Screen:	Total screen of a tinned copper braid, coverage appr. 85%
Jacket:	Halogen free compound, gray
Voltage rating:	Max 500 V
Test voltage:	3000 V (conductor-conductor)
	2000 V (conductor-screen)
Conductor resistance:	Max 19,5 ohm/km
Insulation resistance:	Min 20 Mohm x km
Minimum bending radius:	10 x d
Temp.rating:	-40°C / +90°C (fixed installation)
	-20°C / +90°C (flexible installation)
Burning characteristics:	Flame retardant DIN VDE 0482 part 266-2-2 / IEC 60332.3
Halogen free:	Halogen free acc. to DIN VDE Part 815 / IEC 60754-1
Low smoke:	Low smoke development by fire
Corrosivity:	No corrosive gases DIN VDE 0472 part 813 / IEC-60754-2

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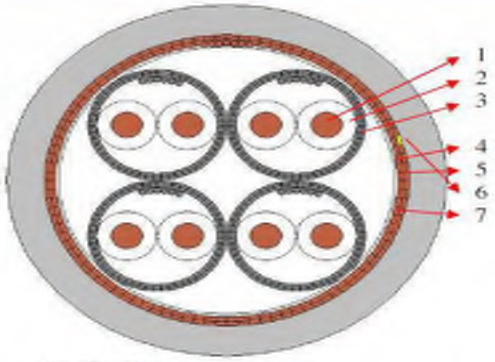
Instrumentation cable FXFQ

Application: Control and instrumentation, servo motor gas fuel

FXFQ-HF (c)(i) HF 250V individual braided screened pairs and overall braided screen



250V, Halogen free, EMC, Instrumentation cable with individual braided screened pairs and overall braided screen.

Max conductor temperature :	125°C
Voltage Rating. Uo:	250V
Standards	
Construction	IEC 60092-376 IEC 60092-350
Conductor	IEC 60228,2-5
Insulating compound	IEC 60092-353
Sheathing compound	IEC 60092-359
Flamability test:	IEC 60332-3C
Approval:	DNV E-11391

Application
For fixed installation inside or outside if black jacket.
Suitable for instrumentation and communication applications.
Class 2 or class 5 conductors with XHFFR insulation.
Twisted pairs with individual braided screen.
Braided overall screen, drain wire on request
Halogen free outer jacket.
Which gives the cable excellent temperature and installation properties.

		Material	Properties	value
1	Conductor	Class 2 or 5		
2	Insulation	XHFFR	Colour/Marking	WH/numbers
3	Braided screen	Tinned Cu wire		
4	Inner sheath	Halogen free tape		
5	Braided screen, EMC	Tinned Cu wire		
6	Rip yarn	Textile		
7	Outer sheath	Halogen free, SHFI	Temp range	-40 to +100 °C
			Colour	GY (or as spec)

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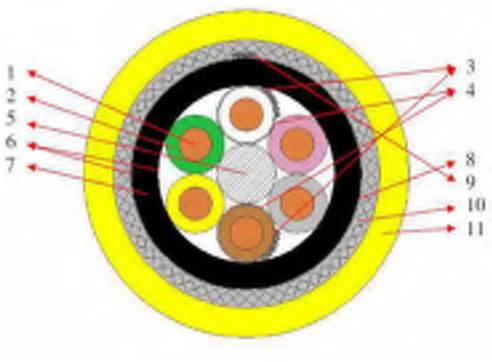
Instrumentation cable RXLFI

Application: Control and instrumentation, flame detection

RXLFI, halogen free, overall braided screen



Construction

		Material	Standard	Properties	value
1	Conductor	Tinned Cu wires	IEC60228	Resistance	< 39 Ω/km
2	Insulation	XLPE	EN50363	Temp range used material	-45 to +120 °C
				Colour	WH, BN, YE, GN, GY, PK
3	Screening of BN and WH conductor	Al-/polyester foil			
4	Drain wire	Tinned Cu wire			
5	Filler				
6	Lapping tape	Textile			
7	Inner sheath	Poly Ethylene			
8	Braided screen	Al-/polyester foil			
9	Drain wire	Tinned Cu wire			
10	Braiding	Tinned Cu wire		Covering	85 %
	Lapping tape	Textile			
11	Outer sheath	TPU		Temp range	-55 to +100 °C
				Colour	YE (or as spec)

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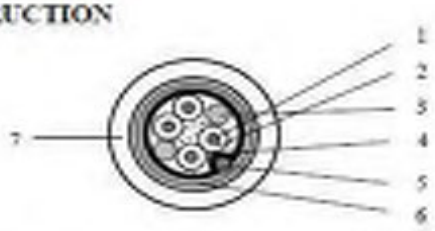
Instrumentation cable BELDEN

Application: Communication, EIA RS-485, Automatic Voltage Regulator

CONSTRUCTION



1. **Conductor**	AWG24 (7xAWG32) tinned Cu
2. **Insulation**	
Material	Polyethylene
Diameter over insulation	1.73 ± 0.05 mm
Colour of insulation	Pair #1: White/blue and blue/white Pair #2: White/orange and orange/white
3. **Filler (2x)**	
Material	Polypropylene
Diameter	2.87 mm
Colour	White
4. **Foil (Z-fold®)**	
Material	Aluminium / Polyester
Thickness	9 / 23 µm
5. **Drainwire**	AWG20 (7xAWG28) tinned Cu
6. **Braiding**	
Material	0.122 mm tinned Cu
Coverage	90%
7. **Sheath**	
Material	FRNC (UV stabilised)
Colour	Chrome (like RAL 7037)
Thickness of sheath	0.89 ± 0.05 mm
Diameter over sheath	8.65 ± 0.10 mm

REQUIREMENTS AND TEST METHODS

Electrical:	
Nominal resistance conductor	78.7 Ω/km
Nominal resistance shield	7.2 Ω/km
Nominal capacitance conductor to conductor	42.0 pF/m
Nominal capacitance conductor to shield + other cond	75.5 pF/m
Nominal impedance @ 1 MHz	120 Ω
Nominal velocity of propagation	66 %
Nominal delay	5.2 ns/m
Nominal attenuation @ 1 MHz	1.97 dB/100m

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Testvoltage conductor-conductor	2500 VDC, 3 seconds
Testvoltage conductor-screen	2500 VDC, 3 seconds
Voltage rating	300 V RMS (CM application) 30 V RMS (AWM application)
Maximum continues current per conductor @ 25 °C	2.1 A

Mechanical and physical:

Flame resistance	IEC 60332-3C
Oil resistance	ASTMD741
Radiation resistance	IEC544 (CERN)
Application specification	BS 7655 section 6.1 table 1, LTS 3
Halogen content according to IEC754-1	zero
Corrosivity of fire gasses according to IEC754-2	
Conductivity	≤ 100 µS/cm
pH value	≥ 3.5
Temperature range installing	-15 to +80 °C
Temperature range operating (moving installation)	-15 to +80 °C
Temperature range operating (fixed installation)	-45 to +80 °C
Temperature range storage	-45 to +80 °C
Minimum bending radius	10 x cable diameter
Maximum pulling tension	395 N

MARKING
Colour code 2114: chrome sheath with text "BELDEN V 9842NH 2PR 24AWG SHIELDED LSNH IEC 332-3C"

PACKAGING
On non-returnable reels with a nominal length of 305m (-0, +10%) or on non-returnable reels with a nominal length of 500m (-0, +10%) or on non-returnable reels with a nominal length of 1000m (-0, +10%).

Each reel is labelled with the following data:
Belden Logo. Belden code number. Item description. Length on the reel. Date of manufacture. CE-marking.

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Communication cable FC FRNC

Application: Communication

FC-FRNC Cable (LAN cable with halogen-free outer sheath)

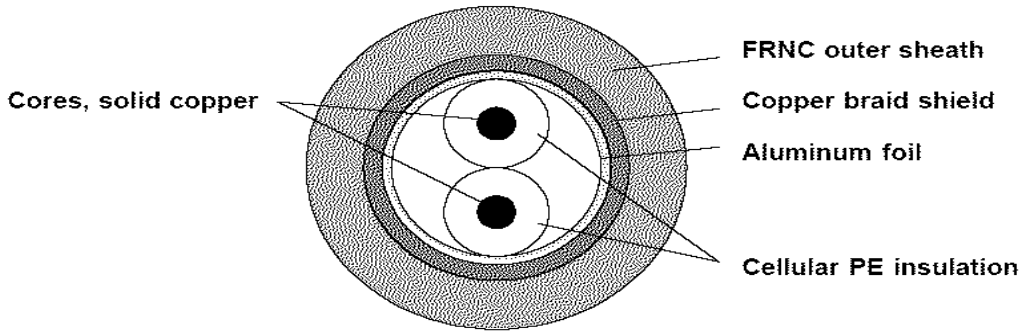

Figure 4-2 Structure of the FRNC LAN Cable (Halogen-Free Outer Sheath)

LAN Cable with Halogen-free Outer Sheath 6XV1 830-0LH10

The LAN cable with a halogen-free outer sheath 6XV1 830-0LH10 complies with the specification EN 50170, cable type A, with solid copper cores (22 gauge).

The structure of the cable allows the use of the FastConnect (FC) stripping tool for fast stripping of the PROFIBUS cable (see Section 4.2.3).

Properties

The characteristics of the sheath material differ from those of the standard LAN cable as follows:

- The material is free of halogens
- Not resistant to UV radiation
- The sheath material is flame resistant

Uses

The FRNC cable is particularly suitable for use inside buildings.

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Profibus PA

Technical Specifications [1] Cable Type	FC Process Cable for IEC 61158-2 [7]
Order Number	6XV1 830 -5EH10, -5FH10
Attenuation at 16 MHz at 4 MHz at 38.4 kHz at 9.6 kHz	 <= 3 dB/km
Characteristic impedance at 9.6 kHz at 31.25 kHz at 38.4 kHz at 3 to 20 MHz Rated value	 100 ± 20 Ω 100 Ω
d.c. loop resistance	≤ 44 Ω /km
Shield resistance	-
Effective capacitance at 1 kHz	-
Operating voltage (effective)	≤ 100 V
Cable type standard code	02Y SY (ST) CY 1x2x1.0/2.55-100 BL OE FR
Sheath Material Color Diameter	 PVC blue / black 8.0 ± 0.4 mm
Permitted ambient conditions – Operating temperature – Transport/storage temperature – Installation temperature	 -20°C + 60 °C -20°C + 60 °C -20°C + 60°C
Bending radii One-time bending Repeated bending	 ≥ 60 mm ≥ 160 mm
Max. tensile load	150 N
Weight approx.	103 kg/km
Halogen free	no
Behavior in fire	flame-retardant according to VDE 0472 T804 test type B
Oil resistance	good resistance to mineral oil and greases
UV resistance	yes

Profibus DP

Technical Specifications [1] Cable Type	FC FRNC Cable
Order Number	6XV1 830 -0LH10
Attenuation at 16 MHz at 4 MHz at 38.4 kHz at 9.6 kHz	 < 42 dB/km < 22 dB/km < 4 dB/km <2.5 dB/km
Characteristic impedance at 9.6 kHz at 31.25 kHz at 38.4 kHz at 3 to 20 MHz Rated value	 270 ± 27 Ω - 185 ± 18.5 Ω 150 ± 15 Ω 150 Ω
d.c. loop resistance	≤ 110 Ω /km
Shield resistance	≤ 9.5 Ω /km
Effective capacitance at 1 kHz	approx. 28.5 nF/km
Operating voltage (effective)	≤ 100 V
Cable type standard code	02YSH(ST)CH 1x2x0.64/2.55-150 VI KF25 FRNC
Sheath Material Color Diameter	 FRNC light violet 8.0 ± 0.4 mm
Permitted ambient conditions – Operating temperature – Transport/storage temperature – Installation temperature	 -25°C + 60°C -25°C + 60°C -25°C + 60°C
Bending radii One-time bending Repeated bending	 ≥ 75 mm ≥ 150 mm
Max. tensile load	100 N
Weight approx.	87 kg/km
Halogen free	yes
Behavior in fire	flame-retardant according to VDE 0472 T804 test type C
Oil resistance	Conditionally resistant to mineral oil and greases
UV resistance	no

[1] Electrical characteristics at 20 °C, tested in compliance with DIN 47250 Part 4 or DIN VDE 0472
[2] Cables capable of trailing for the following requirements:
- min. 4 million bending cycles at the specified bending radius and max. acceleration of 4 m/s²
[3] Outer diameter > 8 mm; bus connectors can only be attached after removing the outer sheath
[4] Not suitable for fitting in a bus connector (6ES7 972-0BA30-0XA0)
[5] At 38.8 Hz
[6] Unrestricted segment lengths
[7] Transmission rate 31.25 Kbps, cable corresponds to FISCO model
[8] Cable suitable for applications involving torsion: min. 5 million torsion movements on 1 m cable length (+/-180°)

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Cable type: Fiber-optic standard cable

Application: Communication

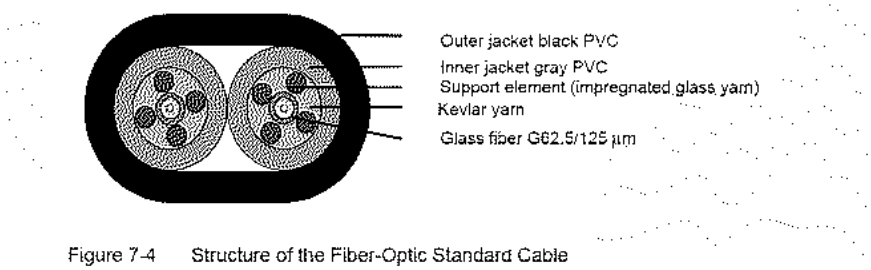

Figure 7-4 Structure of the Fiber-Optic Standard Cable

Fiber-Optic Standard Cable 6XV1820-5****

The fiber-optic standard cable contains two multimode graded fibers of type 62.5/125 µm.

Properties

The fiber-optic standard cable has the following properties:

- Can be walked on
- Flame-retardant complying with IEC 60332-3 cat. CF
- Not halogen free
- Available in meter lengths up to 4000 m
- Available preassembled with 4 BFOC connectors in lengths up to 1000 m

Uses

The fiber-optic standard cable is the universal cable for use indoors and outdoors. It is suitable for connecting optical ports operating at the wavelengths of 850 nm and 1300 nm.

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		Revision	H	Page	22

Cable Type	Fiber-Optic Standard Cable
Areas of application	Universal cable for use indoors and outdoors
Available as	Preassembled cable with 4 BFOC connectors in fixed lengths, also available in meters
Cable type (standard designation)	AT-VYY 2G62.5/125 3.1B200+0.8F600 F
Fiber type	Multimode graded fiber 62.5/125 µm
Power loss at 850 nm Power loss at 1300 nm	<= 3.1 dB/km <= 0.8 dB/km
Modal bandwidth at 850 nm at 1300 nm	 200 MHz *km 600 MHz *km
Number of fibers	2
Cable design	Splittable outdoor cable
Core type	Compact core
Basic element materials	PVC, gray
Strain relief	Aramid yarn and impregnated glass fiber yarn
Outer jacket/ color of cable	PVC/black
Dimensions of basic element	(3.5 ± 0.2) mm ∅
Outer dimensions	(6.3 x 9.8) ± 0.4 mm
Cable weight	approx. 74 kg/km
Permitted tensile load	<= 370 N (in operation) <= 500 N (brief)
Bending radii	100 mm Only the flat surface
Transverse compressive strength	5,000 N/10 cm
Impact strength	3 blows (initial energy: 5 Nm hammer radius: 300 mm)
Installation temperature	-5°C to +50°C
Operating temperature	-25°C to +60°C
Storage temperature	-25°C to +70°C
Behavior in fire	Flame retardant complying with IEC 60332-3 cat. CF
Free of halogens	no
UL approval	no
Ship building approval	no

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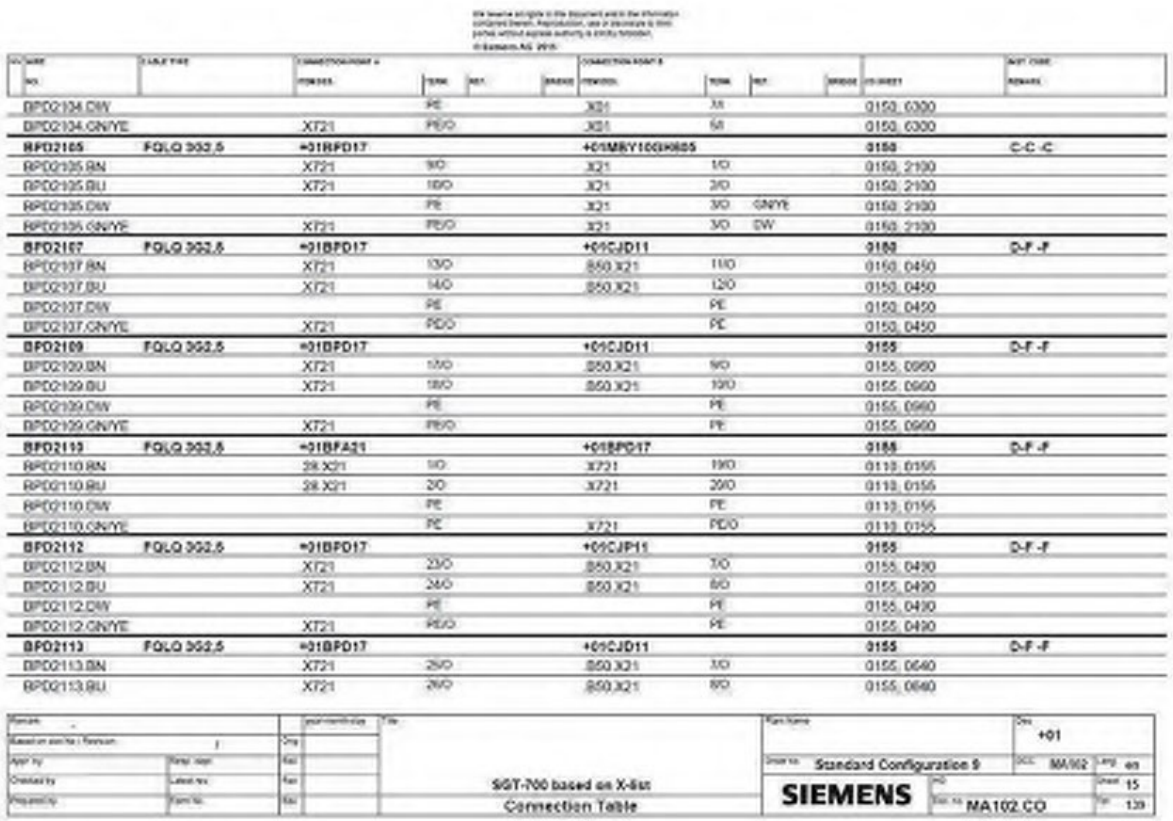
Typical interconnecting table



BPD2104.DW			PE		X21	38			0150, 0300	
BPD2104.GN/YE		X721	PE/O		X21	58			0150, 0300	
BPD2105	**FQLQ 3G2.5**	**=01BPD17**			**+01MBY100K005**				**0150**	**C-C -C**
BPD2105.BN		X721	1/O		X21	1/O			0150, 2100	
BPD2105.BU		X721	1PO		X21	2/O			0150, 2100	
BPD2105.DW			PE		X21	3/O	GN/YE		0150, 2100	
BPD2105.GN/YE		X721	PE/O		X21	3/O	DW		0150, 2100	
BPD2107	**FQLQ 3G2.5**	**=01BPD17**			**+01CJD11**				**0150**	**D-F -F**
BPD2107.BN		X721	13/O		B50.X21	11/O			0150, 0450	
BPD2107.BU		X721	14/O		B50.X21	12/O			0150, 0450	
BPD2107.DW			PE			PE			0150, 0450	
BPD2107.GN/YE		X721	PE/O			PE			0150, 0450	
BPD2109	**FQLQ 3G2.5**	**=01BPD17**			**+01CJD11**				**0155**	**D-F -F**
BPD2109.BN		X721	1/O		B50.X21	9/O			0155, 0960	
BPD2109.BU		X721	1PO		B50.X21	10/O			0155, 0960	
BPD2109.DW			PE			PE			0155, 0960	
BPD2109.GN/YE		X721	PE/O			PE			0155, 0960	
BPD2110	**FQLQ 3G2.5**	**=01BFA21**			**+01BPD17**				**0155**	**D-F -F**
BPD2110.BN		28.X21	1/O		X721	19/O			0110, 0155	
BPD2110.BU		28.X21	2/O		X721	20/O			0110, 0155	
BPD2110.DW			PE			PE			0110, 0155	
BPD2110.GN/YE			PE		X721	PE/O			0110, 0155	
BPD2112	**FQLQ 3G2.5**	**=01BPD17**			**+01CJP11**				**0155**	**D-F -F**
BPD2112.BN		X721	23/O		B50.X21	7/O			0155, 0430	
BPD2112.BU		X721	24/O		B50.X21	8/O			0155, 0430	
BPD2112.DW			PE			PE			0155, 0430	
BPD2112.GN/YE		X721	PE/O			PE			0155, 0430	
BPD2113	**FQLQ 3G2.5**	**=01BPD17**			**+01CJD11**				**0155**	**D-F -F**
BPD2113.BN		X721	25/O		B50.X21	3/O			0155, 0640	
BPD2113.BU		X721	26/O		B50.X21	4/O			0155, 0640	

SGT-700 based on X-6n
Connection Table
+01
Standard Configuration 9
SIEMENS
MA102.CO

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SIEMENS	Electrical Equipment SGT-600, SGT-700, SGT-750	GTI number		J693007E	
		Document number		1CS91974	
		Revision	D	Page	1

Installation Data –Electrical and control panels as loose items

The following auxiliary power and control equipment are, when delivered as loose items, to be installed in a suitable, non-classified location. Information given shall be seen as preliminary.
Please refer to scope of supply document for included equipment.

Control equipment

Panels (GT)	Width (in)	Depth (in)	Height (in)	Weight (lb)	Heat losses (kW)	Minimum Protection Class[1]
Generator Control Panel CHA11 (power generation)	31.5	23.6	82.7	660	0.5	IP55/Nema 12
Unit Control Panel CJD11	31.5	23.6	82.7	550	0.8	IP55/Nema 12
Fire protection control panel CYE11	23.6	23.6	82.7	660	0.4	IP55/Nema 12
Turbine Control Panel CJP11	47.2	23.6	82.7	400	0.6	IP55/Nema 12

Panels (BoP/DCS)	Width (in)	Depth (in)	Height (in)	Weight (lb)	Heat losses (kW)	Minimum Protection Class[2]
CKN11-13 (mounted together) - CKN11 (power distribution and CPU (Modell: SIEMENS S7-400H) - CKN12-13 (I/O and terminals)	94.5	31.5	82.7	600	1.5	IP55/Nema 12
CKN14 - Communication equipment (switches etc.)	31.5	31.5	82.7	250	0.5	IP55/Nema 12
CWA10 - Server/computer rack	31.5	31.5	82.7	300	1	IP21/Nema 1
CAB10 - ESD Panel (Pushbuttons and terminals)	15	9	12	30	0.6	IP55/Nema 12

[1] Actual protection class is specified in Scope of supply document for included equipment

[2] Actual protection class is specified in Scope of supply document for included equipment

SGT-600(PG B, PG Ex B, MD B), SGT-700(PG B, PG Ex B, MD B, MD FB), SGT-750(MD A, PG A, PG Ex A)

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Electrical equipment

Panel	Width (in)	Depth (in)	Height (in)	Weight (lbs)	Heat losses (kW)	Minimum Protection Class[1]
Start motor module BPD12	23.6	24.8	86.6	620	4.5/0.5/1[3]	Nema 1
Line supply module BPD14	27.6	24.8	86.6	710	3.2/1.2[4]	Nema 1
UMD and UPS modules BPD15,16,17	126	24.8	86.6	2425	2.7/3.2[5]	Nema 1
Low voltage switchgear BFA11-14, BFA21	160.6[5]	24.6	87.9	2500	1	UL type 2
BFT40GT005, 480-240/120V 25 kVA Transformer	28.75	25	23.9	325		Nema 3R

Batteries incl. battery stand

Panel	Width (inch)	Depth (inch)	Height (inch)	Weight (lbs)	Heat losses (kW)	Minimum Protection Class[1]
Lead Acid Batteries, 440VDC BTA10	200.8	28.3	63	7231	0/1[3]	IP20

Minimum distances

Please observe that all floor mounted panels requires a minimum distance to wall (100 mm) and roof, (~200 mm).

Environmental Conditions

As the equipment mentioned above will be delivered as loose items, the following temperature and humidity levels has to be maintained within the intended area of installation. The area shall preferably be air-conditioned.

Ambient Temperature for cabinets:	+40 to +77 optionally up to 104 (°F)
Humidity (R.H) :	10-90 %
Others:	Batteries should not be exposed to salt laden conditions. Battery is rated at temperature 20 °C. Excessive temperatures will shorten the lifetime.

Colour

All panels and cubicles are painted light grey. The colour is specified according to the RAL colour scale as 7035.

[3] Losses during: gas turbine start up (approximately 6 min) / idle / barring.

[4] Losses during: gas turbine start up (approximately 6 min) / normal operation.

[5] Losses during: normal operation / charging of batteries

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Installation Data –Electrical and control panels as loose items

The following auxiliary power and control equipment are, when delivered as loose items, to be installed in a suitable, non-classified location. Information given shall be seen as preliminary.
Please refer to scope of supply document for included equipment.

Control equipment

Panel	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)	Heat losses (kW)	Minimum Protection Class[6]
Generator Control Panel CHA11 (power generation)	800	600	2100	300	0.5	IP55
Unit Control Panel CJD11	800	600	2100	250	0.8	IP55
Fire protection control panel CYE10	600	600	2100	300	0.4	IP55
Turbine Control Panel CJP11	1200	600	2100	400	0.6	IP55

Electrical equipment

Panel	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)	Heat losses (kW)	Minimum Protection Class[1]
Start motor module BPD12	600	630	2200	280	4.5/0.5/1[7]	IP21
Line supply module BPD14	700	630	2200	340	3.2/1.2[8]	IP21
UMD and UPS modules BPD15,16,17	3200	630	2200	1100	2.7/3.2[9]	IP21
Low voltage switchgear BFA 11-13, BFA21	4080	624	2232	1140	1.5	IP30

[6] Actual IP protection class is specified in Scope of supply document for included equipment

[7] Losses during: gas turbine start up (approximately 6 min) / idle / barring.

[8] Losses during: gas turbine start up (approximately 6 min) / normal operation.

[9] Losses during: normal operation / charging of batteries

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Batteries incl. battery stand

Panel	Width (mm)	Depth (mm)	Height (mm)	Weigh t (kg)	Heat losses (kW)	Minimum Protection Class[1]
Lead Acid Batteries, 440VDC BTA10	5100	720	1600	3280	0/1[3]	IP20

Minimum distances

Please observe that all floor mounted panels requires a minimum distance to wall (100 mm) and roof, (~200 mm).

Environmental Conditions

As the equipment mentioned above will be delivered as loose items, the following temperature and humidity levels has to be maintained within the intended area of installation. The area shall preferably be air-conditioned.

Ambient Temperature for cabinets:	+5 to +25 optionally up to 40 (°C)
Humidity (R.H) :	10-90 %
Others:	Batteries should not be exposed to salt laden conditions. Battery is rated at temperature 20 °C. Excessive temperatures will shorten the lifetime.

Colour

All panels and cubicles are painted light grey. The colour is specified according to the RAL colour scale as 7035.

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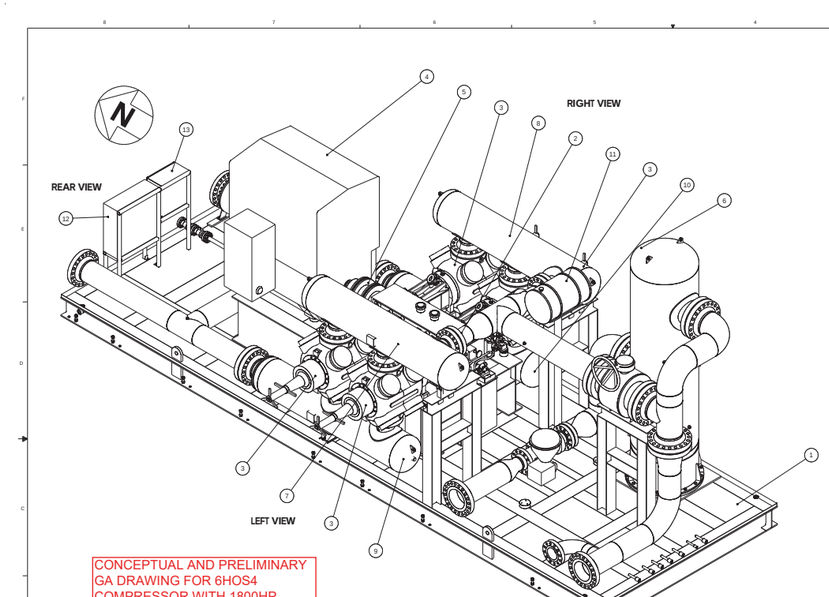

REV.	DESCRIPTION	REVISED BY	DATE APPROVED	APPROVED BY
C	LOCATED MOTOR CONDUIT BOXES, SHEET 3,4,5.	Admin	10/30/15	JK
D	RELOCATE SCRUBBER, CHANGE 21,22 AND ADD H1, H2, H3	Admin	12/18/15	Admin
E	AS BUILT. ADDED JUNCTION BOX, FIXED CONECTIONS 21, 22, SHEET 3.	Admin	04/07/16	RTS

GENERAL NOTES:

1. ESTIMATED UNIT WEIGHT 191,000#.
2. ALL CUSTOMERS PIPING THAT IS ATTACHED TO SKID CONNECTIONS SHALL BE SELF SUPPORTING.
3. EXACT LOCATION OF NOTED ITEMS ARE TO BE DETERMINED AT FINAL ASSEMBLY.
4. NOTED CONNECTIONS MUST BE VENTED TO A SAFE LOCATION.
5. PIPING CONNECTIONS TO THIS PACKAGE SHALL NOT BE COMPLETED WITH PRE- FABRICATED PIPING SPOOLS, THE MANUFACTURING TOLERANCES OF THE COMPONENTS INVOLVED ARE NOT SUFFICIENT TO ALLOW PRE-FABRICATED PIPE SPOOLS WITHOUT UNACCEPTABLE PIPING STRAINS. UE COMPRESSION WILL NOT BE HELD LIABLE FOR RE-WORK TO PRE-FABRICATED COMPONENTS ATTACHING TO THIS PACKAGE.
6. CENTERLINE HEIGHT OF CUSTOMER AUXILIARY CONNECTIONS IS BASED OFF OF BOTTOM OF PIPE LOCATION, UNLESS OTHERWISE NOTED.
7. SEE UE COMPRESSION DRAWING # 31386 FOR ANCHOR BOLT LOCATIONS, LIFTING PROVISIONS, LIFTING LUG SIZE AND LOCATION, AND FOUNDATION REQUIRMENTS.
8. USE LIFTING LUGS ON MAIN SKID ONLY. DO NOT USE LUGS ON VESSELS OR OTHER COMPONENTS FOR LIFTING UNITS.
9. GUARDS ARE NOT SHOWN FOR CLARITY. GUARDS WILL BE PROVIDED BY UE COMPRESSION INC. ON ALL ROTATING SHAFTS, COUPLINGS, SHEAVES AND BELTS.
10. THE COMPLETE PACKAGE SHALL BE PAINTED PER UEC STANDARD SDR008. TYPE 4 PAINT SYSTEM. THE FINAL COLOR SHALL BE ANSI 70 GREY.
11. NOTED ITEMS ARE TO SHIP LOOSE AND BE INSTALLED IN THE FIELD BY CUSTOMER.
    - RECYCLE COOLER
    - DISCHARGE COALESCING FILTER
    - PRESSURE REGULATION SYSTEM
    - FULL FLOW PRESSURE RELIEF VALVE
    - SUCTION SCRUBBER DRAIN TANK
    - BYPASS CHECK VALVE
    - INLET STOP VALVE
    - SUCTION SCRUBBER
    - DISCHARGE CHECK VALVE
    - DISCHARGE BLOCK VALVE

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION	WEIGHT	TOTAL WEIGHT
			TOTAL WEIGHT OF MAJOR COMPONENTS		100020
14	-	-	CONCRETE (~7.5 CU. YDS.)	31118	31118
13	1	JUNCTION BOX		50	50
12	1	POWER PANEL		100	100
11	1	55 GALLON DRUM	OIL DAY TANK	50	50
10	1	901985	DISCHARGE BOTTLE - THROW 1&3	2442	2442
9	1	901984	DISCHARGE BOTTLE - THROW 2&4	2442	2442
8	1	901983	SUCTION BOTTLE - THROW 1&3	1781	1781
7	1	901982	SUCTION BOTTLE - THROW 2&4	1781	1781
6	1	901981	STG 1 SUCTION SCRUBBER	8022	8022
5	1	AMR 700	REXNORD COUPLING	574	574
4	1	NIDEC 1650HP	ELECTRIC MOTOR	13000	13000
3	4	ARIEL 12.375 KL	COMPRESSOR CYLINDERS	7590	30360
2	1	ARIEL JGK/4	ARIEL COMPRESSOR	8300	8300
1	1	31385	BASE SKID	34000	34000

BILL OF MATERIALS

DRAWING CONTENTS		
SHEET #	SHEET DESCRIPTION	SHEET CONTENTS
1	GENERAL ARRANGEMENT COVER PAGE	ISOMETRIC VIEW, BOM, GENERAL NOTES, ITEM CALLOUTS.
2	RIGHT ISOMETRIC VIEW	
3	PLAN VIEW	CUSTOMER CONNECTIONS, DETAIL DIMENSIONS
4	LEFT ELEVATION VIEW	DETAIL DIMENSIONS
5	RIGHT ELEVATION VIEW	DETAIL DIMENSIONS
6	FRONT AND REAR ELEVATION VIEWS	DETAIL DIMENSIONS

CUSTOMER CONNECTIONS TOLERANCE UNLESS OTHERWISE SPECIFIED

FRACTIONAL: FRACTION ± 1"
DECIMAL: 1 PLACE ± .1, 2 PLACE ± .06, 3 PLACE ± .031
BREAK SHARP EDGES

STANDARD TOLERANCE UNLESS OTHERWISE SPECIFIED

FRACTIONAL: FRACTION ± 3/8"
DECIMAL: 1 PLACE ± .1, 2 PLACE ± .06, 3 PLACE ± .031
BREAK SHARP EDGES

DO NOT SCALE DRAWING
P37370-1-1
1 UNIT(S)

–	74472
–	71050
–	71049
–	31386
–	31385
74473	10676

RELATED DWGS

UE Compression
Gas Compression and Power Generation Parts and Service
DENVER, COLORADO

S. GIOACCHINI	08/31/15	1:24	GENERAL ARRANGEMENT
J. KIM	09/11/15	DRAWING NO. 10676	SIZE D / REV E

ALL DIMENSIONS IN INCHES — SHEET 1 OF 6

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Enclosure

General

Acoustic enclosure is an integrated part of gas turbine unit and covers the gas turbine, auxiliaries and gearbox. Noise reduction walls around electrical generator can also be included depending on the noise requirement. Refer to scope of supply for included equipment.

Enclosure serves the following main purposes:

- Noise suppression
- Heat insulation
- Weather protection
- Containment of fire extinguishing media.
- Support for equipment installed inside and outside of enclosure.

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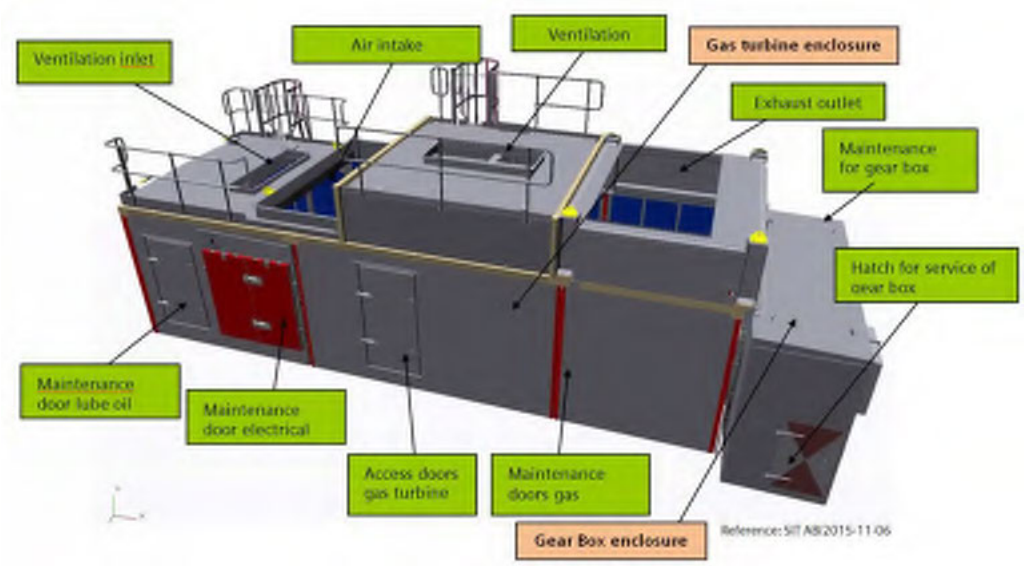

Figure 1. Typical gas turbine enclosure, left side

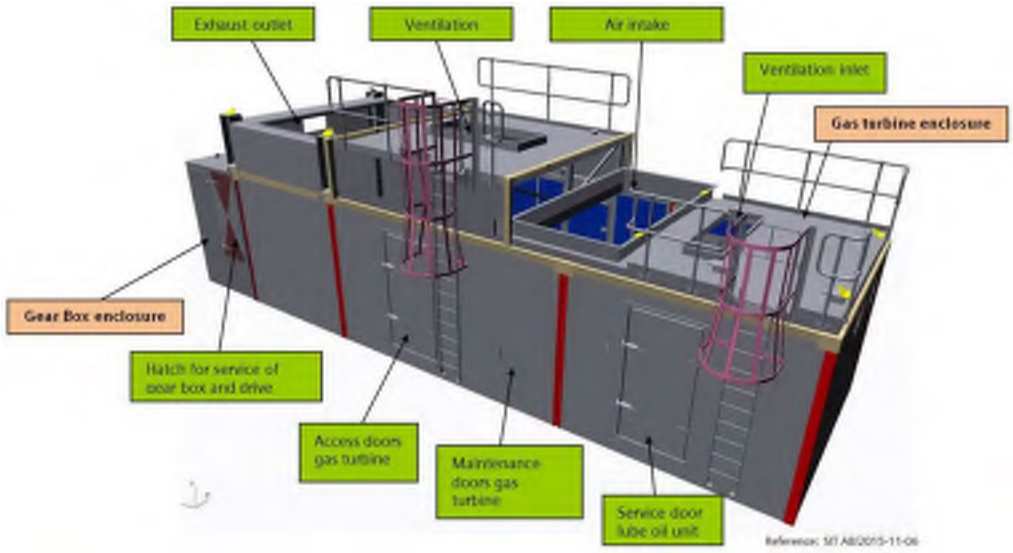

Figure 2. Typical gas turbine enclosure, right side

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Gas turbine enclosure design

Ambient temperature range for outdoor installation is from -30 °C to +55 °C/-22°F-131°F. A typical enclosure will withstand a snow and ice load on the roof of 100 kg/m^2 (20.5 lb/ft^2) and point load of 150 kg (330 lb) for maintenance. It is also designed to withstand wind loads of up to 60 m/s (135 mph).

Inside enclosure non-hazardous area is maintained by dilution ventilation, see separate ventilation system description.

Ventilation provides temperature not more than 60^{0}C (140°F) in walk-around inspection area near gas turbine. The enclosure is designed for a maximum inside temperature of 150°C (302°F).

Heat emission of equipment inside enclosure is approximately 190 kW. Outside surface temperature of enclosure walls is no more than 20^{0}C (68°F) above ambient temperature.

Typically the enclosure is designed for a maximum overpressure inside the unit of 15 mbar (0.22 psi). During gas turbine operation overpressure is maintained between 0.5 mbar (0.007 psi) and 3.5 mbar (0.051 psi).

Enclosure walls have 3 mm (0.12") painted carbon steel sheet outer skin. Roof is 5 mm (0.20") painted carbon steel sheet. The walls have infill of mineral wool 50 mm (1.97") cladded with perforated galvanized sheets 1 mm (0.039") on the inside. Enclosure has a sloping roof. The enclosure walls and roofs are attached towards the structure of base frame, made of painted carbon steel, assembled with galvanized ISO bolts. Inside enclosure there are removable floor grating panels. Enclosure roof is furnished with handrails in areas used by maintenance personnel and protected ladder.

The enclosure is fitted with access doors and maintenance panel as specified in figure 1 and 2. Maintenance access for gas turbine removal is from left or right side.

Access doors are equipped with emergency opening handles to ensure that it is always possible to exit the enclosure. Access doors have opening retarders due to overpressure inside the enclosure, the doors also have hold-open devices. All access doors have windows.

Access to machinery located inside enclosure and on top of it is arranged per ISO 14122.

Exhaust to either left or right side or vertical possible.

Flexible sealing is installed between the enclosure and exhaust duct.

The inside of the enclosure is equipped with permanent lighting. The lighting is made up of six lights, fed from UPS for emergency reasons.

Gearbox enclosure design

Sound pressure levels, surface temperature, wind loads, snow loads are same as for gas turbine enclosure.

Personal access only for maintenance when gas turbine is stopped.

No forced ventilation, pressure inside gearbox enclosure is atmospheric.

Enclosure is made by self-supporting parts and bolted to skid. The walls and roof have 3 mm (0.12") painted carbon steel sheet outer skin. The walls have, depending of noise demands, infill of mineral wool 50 mm (1.97") cladded with perforated galvanized sheets 0.9 mm (0.035") on the inside. Roof is made with slope to prevent water collection. The enclosure is assembled with galvanized ISO bolts.

Gearbox enclosure roof panel is removable for gear maintenance.

Gearbox enclosure has one hinged entrance hatch on right side, one inspection hatch on left and removable maintenance access panels towards the gas turbine.

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Built-in maintenance equipment

The enclosure is equipped with three lifting beams and with roll-out rails:

- One on top of the enclosure for maintenance of power turbine (PT):

  2000 kg/ 4409 lb capacity.
- One for maintenance of the start motor:

  1100 kg/ 2425 lb capacity.
- One for maintenance of the lube oil system:

  400 kg/ 882 lb capacity.
- Roll-out rails inside gas turbine enclosure for gas generator and PT roll-out:

  12000 kg/ 26455 lb capacity.

Surface treatment

Enclosure exterior surface is painted to fulfil C3 according to ISO 12944-2:1998, painted in pebble grey RAL 7032 top coat color.

Enclosure interior surface is painted or galvanized to fulfil C2 according to ISO 12944-2:1998.

Handrails, ladder and grating is galvanized according to ISO 1461:2009.

Additional features on request

- Enclosure exterior surface treatment up to C5-M, according to ISO 12944-2:1998.
- Enclosure exterior, including interior perforated sheet, in stainless steel 316.

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1. General information about the foundation

The gas turbine (GT) foundation consists of a simple concrete block as one unit without any joints. Also, with purpose to avoid distribution of vibrations generated by the machines, the foundation must be disconnected from the surrounding structure.

When designing a GT foundation, following inputs are supplied by Siemens:

1) Project design basis
2) Soil parameters (*)
3) Foundation layouts and loadings

(*) not supplied by Siemens when the customer designs the GT foundation themselves

1.1 Project design basis

The following are the major inputs for design of a GT foundation:

a) Material requirements

- All concrete work shall comply with the applicable legal and official laws and corresponding acceptance codes.
- All concrete shall be controlled concrete, mixed and placed under the supervision of an approved control engineer.
- All concrete shall attain a minimum compressive strength of:
  25 MPa (3500 psi) on cylinders with dimensions ø150 x 300 mm (6" ø by 12") or
  30 MPa (4200 psi) on cubes with dimension 150 mm (6") at 28 days, and shall be normal weight aggregate concrete.
  No horizontal or vertical casting joints are allowed.

b) Cleanliness

- Sleeve must be cleaned inside and to be protected from penetration of concrete during the pouring.
- Surface of embedded details to be cleaned after removal of the mould.
- Foundation to be clean and treated with a suitable concrete sealant.

c) Criteria for static analysis (see chapter 2.1)

d) Criteria for dynamic analysis (see chapter 0)

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e) Additional recommendations

If the GT includes liquid fuel and the liquid fuel unit is located outside the turbine sound enclosure, Siemens recommends a walled in foundation with suitable drain equipment to handle any possible fuel oil spill or rain water.

1.2 Soil parameters

Soil has a specific importance in the analysis of GT foundations. For determining the static and dynamic characteristics of the soil, a geotechnical investigation on the site must be done. Soil dynamics deals with engineering properties and behaviour of soil under dynamic stress. For the dynamic analysis of machine foundations, soil properties, such as poisson's ratio, dynamic shear modulus, and damping of the soil, are generally required.

Special treatment shall be taken when founding a GT foundation directly into the soil. In such case the depth to the firmer ground under the foundation must be known. If the elevation of the firmer ground varies i.e. the thickness of the soil layers under the foundation varies, then the soil spring stiffness along the foundation is going to vary. This will cause unwanted settlements under the foundation. Therefore, if it is economically and technically reasonable, the backfill stiffness should be made more uniform by excavating to the firmer ground and levelling it off. As results, the settlement under the foundation will be more even.

1.3 Foundation layouts and loadings

For designing of a GT foundation Siemens, as machine supplier provides foundation layouts and several loading cases for each component of the package.

2. Design of GT foundation

For maintaining the functionality of the GT foundation i.e. trouble free operation, Siemens has indicated permissible boundary values for the deformations and the vibration amplitudes of the foundation.

When designing and analyzing a GT foundation, Siemens' demands can be structured in four main parts:

- Design of the GT foundation with regards to the static loads including earthquake, seen as a high g-force
- Design of the GT foundation with regards to the dynamic loads
- Minimum data in the reports for documentation of the results
- Responsibilities

2.1 Design of GT foundation with regards to the static loads

Static dimensioning of the GT foundation shall be performed, including check for strength of the foundation, stability of the foundation and check for soil (pile) bearing capacity. For this purpose Siemens, as machine supplier, provides foundation layouts and a document with foundation loads Intensity. In the calculation and dimensioning of the foundation the characteristics of the soil must be taken into account.

When designing the foundation for the whole plant, the customer shall consider the tolerances for potential settlements between different concrete blocks, e.g. GT on one and boiler on another.

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Since the GT foundation behaves like a rigid body on a soft media like soil, piles or vibration springs, the block foundation should always prove to be sufficient against the forces generated by the machines.

The Strength design shall be performed considering the forces and moments on the foundation due to:

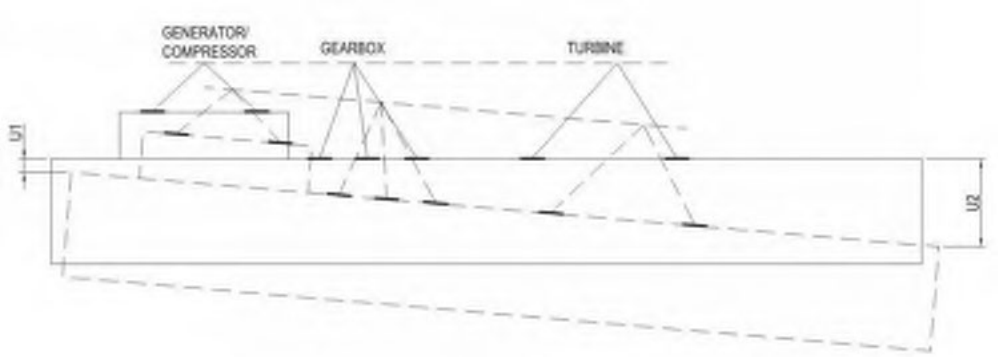
- Static loads (dead weight, torque, thermal forces, erection loads and maintenance)
- Emergency loads (short circuit and loss of blade)
- Wind and Snow loads
- Earthquake

2.1.1 Limits on deflection

All criteria stated below for the deformation of the GT foundation must be met. When designing the foundation the characteristics of the soil must be taken into account.

2.1.2 Dead load deflections and settlements

Following application and adjustment of all dead loads, the inclination of the foundation surface to the horizontal, as measured between machinery supports, shall at no point exceed 1 in 1000.



Reference: SIT AB/2016-02-22

Figure 1: Schematic view of foundation inclination

$$U = U2 - U1$$

$$U : A \leq 1 : 1000 \text{ i.e. } U \leq 0{,}001 \cdot A$$

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2.1.3 Live load deflections

Forces related to operation torque, external pipes, thermal forces etc. are not allowed to cause more vertical deflection than stated below (see also Figure 1):

- 0,5mm as total deflection for the whole foundation.

$$U1 \leq 0{,}5mm \qquad U2 \leq 0{,}5mm$$

- Between each component the embedded steel plates are not allowed to deflect more than 0,15mm/m.

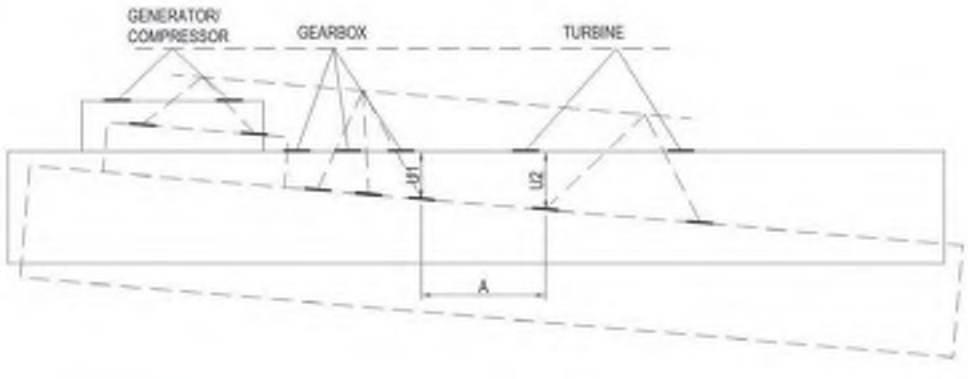

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Figure 2: Schematic view of deflection between two components

$$U = U2 - U1, \quad \frac{U}{A} \leq 0{,}15mm/m \text{ i.e. } U : A \leq 0{,}15 : 1000$$

- Two adjacent embedded steel plates (in axial or perpendicular direction of the driven equipment set) should not deflect more than 0,05mm/m relative to each other within each component.
  This requirement is not applicable for a three-point installed package, since it does not have adjacent steel plates.

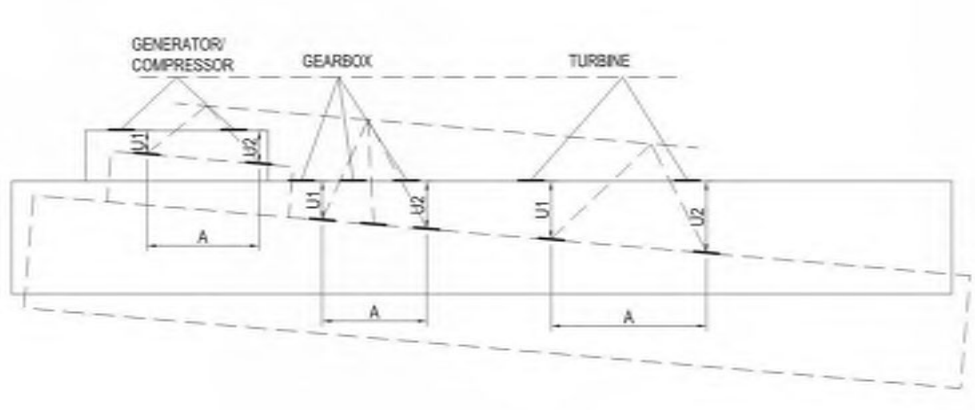

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Figure 3: Schematic view of deflection within each component

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$U = U2 - U1 \qquad \frac{U}{A} \le 0{,}05mm/m$ i.e. $U : A \le 0{,}05mm : 1000mm$

2.1.4 Emergency load deflections and settlements

The deflection and settlements caused by emergency loads (driving and/or driven equipment failure) shall not exceed three times the values that could have been acceptable as corresponding live-load deflections and settlements.

2.1.5 Reinforcement

The structural design of the GT reinforced concrete foundation should be in accordance with valid standards and codes in the country where the equipment is installed. The engineer may use allowable stress methods for non-prestressed reinforced concrete.

Cracking should be minimized to ensure protection of reinforcing steel. Therefore, minimum reinforcing steel shall be applied, if the reinforcement obtained with calculation is less than the minimum reinforcing steel suggested by the valid standards and codes. According to Eurocode 2, 1991-1-1, section 9.2.1.1 [5], the minimum cross section area of the primary reinforcement is:

$A_{s,\min} = 0{,}26 \cdot \frac{f_{ctm}}{f_{yk}} \cdot b \cdot d$ (but not less than $0{,}0013 \cdot b \cdot d$)

f_{ctm} - is the mean value of axial tensile strength of concrete

f_{yk} - characteristic yield strength of reinforcement

The higher of the two $A_{s,\min}$ values shall be chosen, which are calculated in accordance with both, Eurocode 2 and the valid standards and codes concerning the country in which the equipment shall be installed.

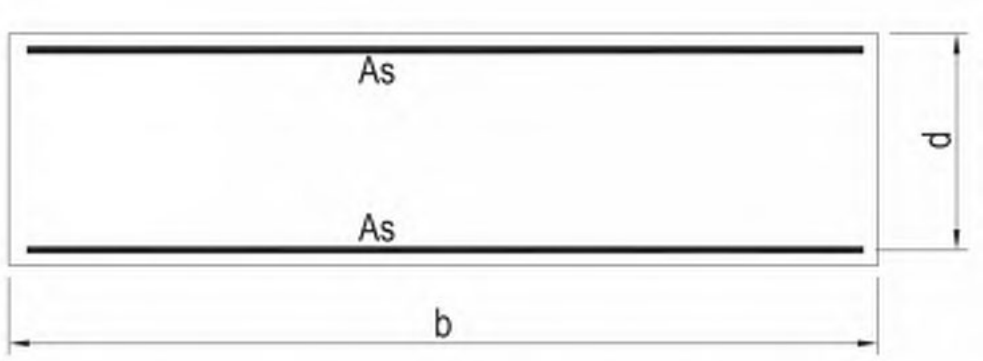

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Figure 4: Cross section of the concrete block

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The same primary reinforcement quantity shall be applied at the bottom and at the top of the concrete block.

2.2 Design of GT foundation with regards to the dynamic loads

The dynamic calculation of the GT foundation has the objective of assessing the vibration behavior of the machines and the surrounding.

For the vibration calculation the entire system (package, foundation and soil) is mapped by a computational model that takes into account the position of the application points of the excitation and of the system characteristics of mass, stiffness and damping. It should be so detailed that the vibration behavior of the entire system can be assessed with sufficient accuracy.

For this purpose Siemens, as machine supplier, provides foundation layouts and the applied masses (dead weights) on the foundation.

When designing the GT foundation, as a thumb rule, that the thickness of the concrete block can be assumed to L/15 to L/12, there L is the length of the concrete block. Another guideline is that the mass of the foundation is approximately 5 to 8 times of the machines which contain rotating masses.

In the following paragraphs: damping, the procedure for verification of sufficient vibration stability, the dynamic loads to be taken into account as well as the stipulated permissible limits to be maintained are described in further details.

2.2.1 Damping

Damping is a phenomenon of energy dissipation that opposes free vibrations of a system. Like the restoring forces, the damping forces oppose the motion, but the energy dissipated through damping cannot be recovered. A characteristic feature of damping forces is that they lag the displacement and are out of phase with the motion. The effect of damping in forced vibration reduces the amplitude but does not affect the frequency.

When no information about the damping characteristics of the machines and the concrete is available, the damping of the machines and the foundation together, suggested by DIN 4024 Part 1 (chapter 3.1) [4], can be assumed as 2% of the critical damping, under normal operating condition. The effect of damping may be neglected for free vibration analysis (calculation of the natural frequencies) but shall be considered for forced vibration analysis.

Additionally, the soil damping, estimated by the Geotechnical investigation, shall be also added to the entire system (package, foundation and soil).

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2.2.2 Procedure

For verification of the vibration stability, first it shall be calculated the natural frequencies of the entire system (package, foundation and soil).

The machine parts are generally modelled with mass elements at adequate position, which are coupled with rigid beam elements to the foundation. The stiffening effect of the technological equipment shall not be considered in the analysis. The foundation is generally modelled with volume elements.

If the influence of the foundation subsoil is to be taken into account (GT foundation onto soil or piles), then the foundation subsoil resilience can be replaced by springs with soil stiffness and damping. If possible use frequency dependent soil stiffness and damping.

In that way the springs shall perform the function of the boundary elements for the entire system.

The static and dynamic properties of the soil are represented by springs and can be attached in nodes obtained by equally dividing the bottom plan.

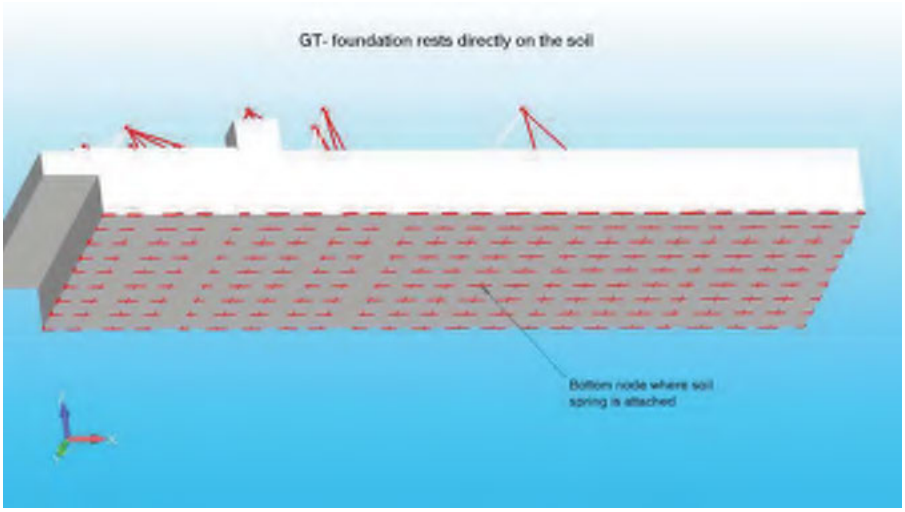

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Figure 5: Schematic view of a GT foundation which rests directly on the soil

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As an example, within Figure 5 is shown the bottom of a GT foundation block with proposed nodes where the soil springs are attached. The number of the attached soil springs at the bottom of the concrete block shall be sufficient and in the judgment of the engineer.

If the soil properties are such that piles must be used, then the spring elements shall be attached there the piles are intended to be placed (see Figure 6). The number of the springs is equal to the designed number of piles. The spring shall contain dynamic properties for both, the pile and the soil.

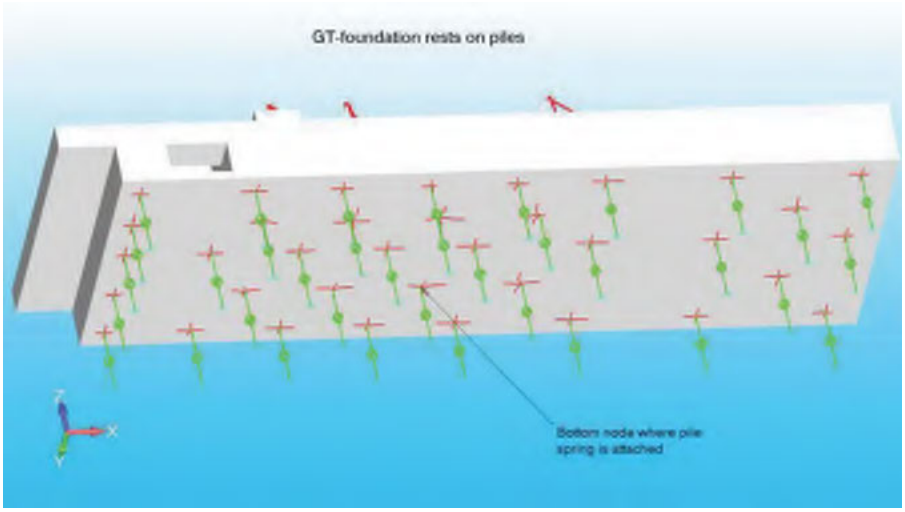

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Figure 6: Schematic view of a GT foundation which rests on piles

The number of the natural frequencies and mode shapes to be determined must, in principle, be selected so that the maximum calculated natural frequency is at least 10 % higher than the highest exciter frequency.

When the natural frequencies have been determined, then it shall be verified their sufficient margin from the given exciting frequencies of the generator/compressor and the turbine in order to avoid major resonance effects.

The judgement of the dynamic behaviour of a machine foundation can be done by comparing its natural frequencies, f_n, with the operation frequencies of the machine, f_0. According to DIN 4024 Part 1 (5.3.2) [4], the first order natural frequencies shall be at least 25% above or 20% below the operating frequency, and the higher order natural frequencies shall be at least ±10% above/below the operating frequency:

- First order natural frequency

$$f_1 \leq 0{,}8 \cdot f_0$$

$$f_1 \geq 1{,}25 \cdot f_0$$

- Higher order natural frequency

$$f_n \leq 0{,}9 \cdot f_0$$

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$$f_{n+1} \geq 1{,}1 \cdot f_0$$

This shall be checked for both operating speed of turbine and generator (or compressor).

However it is often impossible economically and technically to meet the above requirement. It is therefore recommended that a forced vibration analysis (Frequency/Harmonic response analysis) be performed on the entire system (package, foundation, soil) for determination of the vibration amplitudes.

2.2.3 Dynamic loads

Unbalanced forces in rotating machines are created during operation due to rotor unbalance, i.e. when the mass of the rotating part does not coincide with the center of rotation. These exciting (centrifugal) forces are assumed to be applied at the center of gravity of rotor (CoG), perpendicular to the rotor axis, as it shown with the figure below.

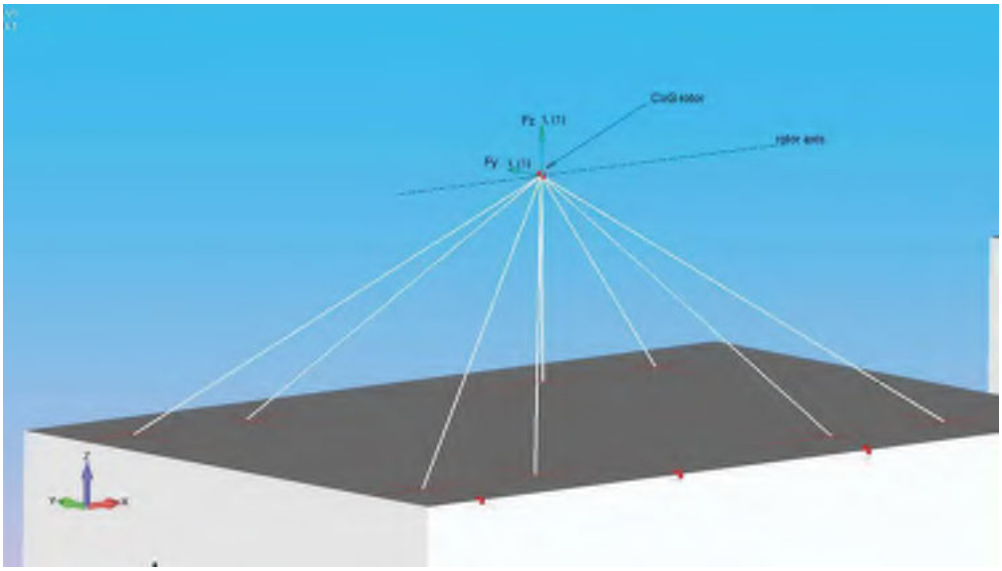

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Figure 7: Applied centrifugal forces at the CoG of the rotor, where the rigid body (white lines) has one independent node (CoG of the rotor mass) and eight dependent nodes (connection points to the foundation). This is also valid for a three-point supported package, but with only three dependent nodes.

The unbalanced forces from one rotating part at the CoG of the rotor are represented as a pair of forces with 90° phase shift, one horizontal force F_y and one vertical force F_z, acting at the corresponding operating frequency f_0.

According to ISO 1940-1 [3], the balance quality grade for turbines and generators shall be G=2,5mm/s. However, the increasing of the unbalance in the course of the operation has to be taken into account. Therefore, the balance quality grade is assumed to be one step worse i.e. G=6,3 instead of 2,5 (see DIN 4024 Part 1 [4], chapter 5.4.2).

Replacing angular speed with operation revolutions per minute gives centrifugal force:

$$F = \frac{m \cdot g \cdot n}{15000}$$

m → rotor mass [kg]

g → gravitational constant (g=9,81) [m/s2]

n → operation revolution per minute [RPM]

F → centrifugal force [N]

Let $F_{(f)}$ represents the unbalanced force for any rotor as a function of the frequency. The charting of this force shall be presented and applied in the analysis for the frequency range $0{,}85 f_0 \le f \le 1{,}2 f_0$, where f_0 is operating frequency.

Generally, there are four exciters on the GT foundation:

- Generator rotor or compressor rotor
- If any, gearbox – low speed shaft (same revolution per minute as the generator rotor/compressor rotor)
- Turbine
- If any, gearbox – high speed shaft (same revolution per minute as the turbine)

Modal frequency response analysis can be used to determine a structure's response to harmonic (oscillatory) excitation where all forces at each forcing frequency (loading case) are known and defined within a frequency domain.

Since the generator rotor/compressor rotor and gearbox with low speed shaft has the same revolution per minute then their unbalanced forces can be applied in the same loading case (see Figure 8).

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The low speed side is one rotor with generator and low speed gear wheel. Unbalance in the generator and gear wheel shall have the same phase (direction) and responses shall be added linearly. See Figure 8 for how the forces are applied to the foundation. The sum of the two excitation forces is the same as would result if the two rotor masses would have been added before calculation of *F* above.

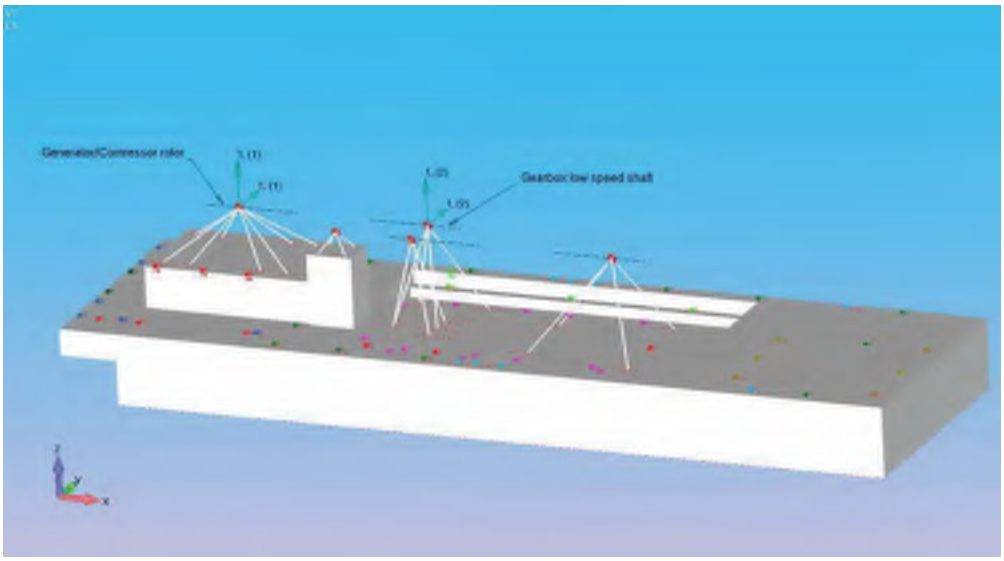

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Figure 8: Schematic view of applied unbalanced forces at generator/compressor and gearbox low speed shaft

Similarly, the unbalanced forces from the turbine and gearbox high speed shaft can be applied in another loading case since they have a same rotation speed (see Figure 9).

The high speed side with GT and high speed gear wheel shall be handled in the same way. It is one rotor with GT and high speed gear wheel. Unbalance in the GT and gear wheel shall have the same phase (direction) and responses shall be added linearly. See Figure 9 for how the forces are applied to the foundation.

If a compressor is driven with the same speed as the GT then the compressor shall be treated as the gear wheel above (added to the GT).

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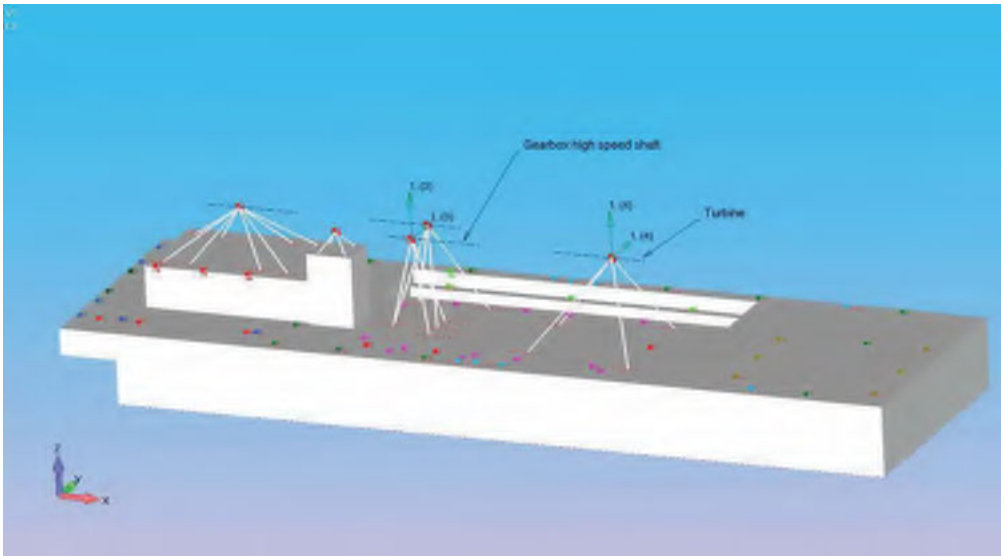

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Figure 9: Schematic view of applied unbalanced forces at turbine and gearbox high speed shaft

2.2.4 Vibration requirements

For the determination of the harmonic vibration amplitudes in the resonance case with modal frequency response analysis, the exciter forces recommended by Siemens shall be used with the exciter frequency at the associated load points in the dynamic model. The induced vibrations shall be determined at several points of the GT foundation for evaluation.

Loading cases on the foundation:

1) Generator/Compressor/ + if any, gearbox with low speed shaft
2) Turbine + if any, gearbox with high speed shaft (plus compressor if at same speed as turbine)

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For the selected evaluation points of the foundation the vibration amplitude curve shall be calculated and presented versus the exciter frequency for frequency range $0{,}85 f_0 \le f \le 1{,}2 f_0$ i.e. *Amplitude vs. Frequency*.

$\{ v_{i,x} ; v_{i,y} ; v_{i,z} \}$ → calculated all three space components (peak value) of the velocity vector for each loading case at several evaluation points of the GT foundation for the frequency range $0{,}85 f_0 \le f \le 1{,}2 f_0$

Use these data to calculate:

$$v_{x,RMS} = \frac{v_{x,peak}}{\sqrt{2}} \qquad v_{y,RMS} = \frac{v_{y,peak}}{\sqrt{2}} \qquad v_{z,RMS} = \frac{v_{z,peak}}{\sqrt{2}}$$

$$V_{RMS} = \sqrt{v_{x,RMS}^{\ 2} + v_{y,RMS}^{\ 2} + v_{z,RMS}^{\ 2}}$$

The vibration velocity components resulting from one separate rotor string (unbalanced forces acting with same operating frequency f_0) within the frequency range $0{,}85 f_0 \le f \le 1{,}2 f_0$ shall, at no point within a radius of 1,0m of one machine support, exceed values corresponding to a mean effective velocity $V_{RMS} \le 1{,}0 mm/s$.

Exceptions from this can be accepted for start motor (in package configurations with start motor installed direct on foundation) that not is in continuous operation. If so, 1,8 mm/s is applicable.

For the rest of the GT foundation the total effective vibration velocity shall not exceed 1,8 mm/s.

These values on V_{RMS} indicate a trouble free operation and is based on achieving low vibrations in the machine bearings. Foundation vibrations shall be lower than bearing vibrations. For bearing vibration limits see ISO10816-1 [1] and ISO10816-4 [2].

3. Responsibilities

The commissioned civil engineer is responsible for the calculation of the GT foundation for strength, suitability for use and vibration stability.

The commissioned civil engineer has to ensure that the calculated deformations and vibration amplitudes are maintained under the stipulated permissible values stated by Siemens.

The loads and load cases indicated by Siemens are to be taken into account additionally to the loads from the applicable standards and codes. The commissioned civil engineer is responsible for the application of the valid standards and codes in the country where the equipment is installed.

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4. References

[1] ISO 10816-1 Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts - Part 1: General guidelines

[2] ISO 10816-4 Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts - Part 4: Gas turbine sets with fluid-film bearings

[3] ISO 1940-1 Mechanical vibration – Balance quality requirements of rigid rotor

[4] DIN 4024 Machine foundations – Part 1: Flexible structures that support machines with rotating elements

[5] Eurocode 2. 1992-1-1 Design of concrete structure

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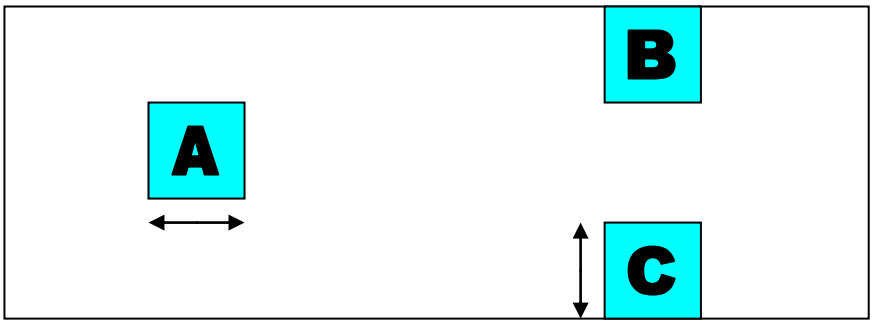
Gas turbine three-point supports and auxiliary systems supports

The base frame of the package is supported in three points . The diagram below shows the three point mounting system where the support points under the base frame are located as follows. Support point A is located under the GG and support point B and C are located under the Generator.



Support point A is locked in transverse direction and free in longitudinal direction. Support point B is fixed in transverse and longitudinal direction. Support point C is free in transverse direction and locked in longitudinal direction. Any thermal imbalance between the skid-unit and the foundation is accommodated by allowing the skid unit to slide on the supports.

The A, B and C supports are bolted to the turbine base frame and welded to embedded steel in the foundation. The height of the supports is 500 mm in order to make the installation convenient.

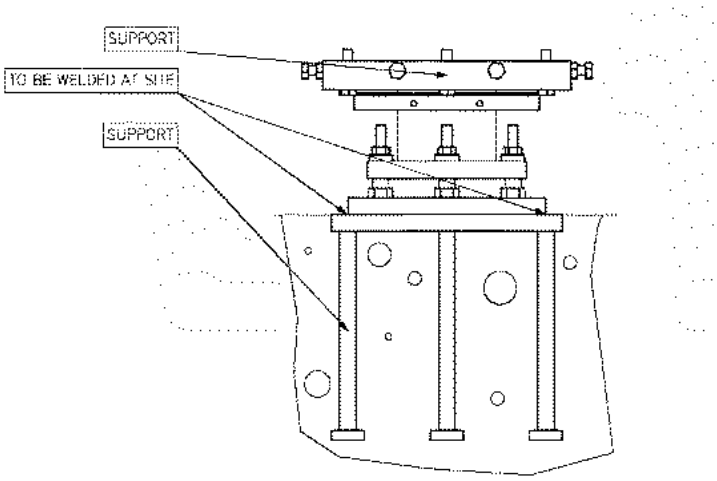


Fig2. Three point support

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Other equipment is typically supported according to Fig 3 and Fig 4 below.

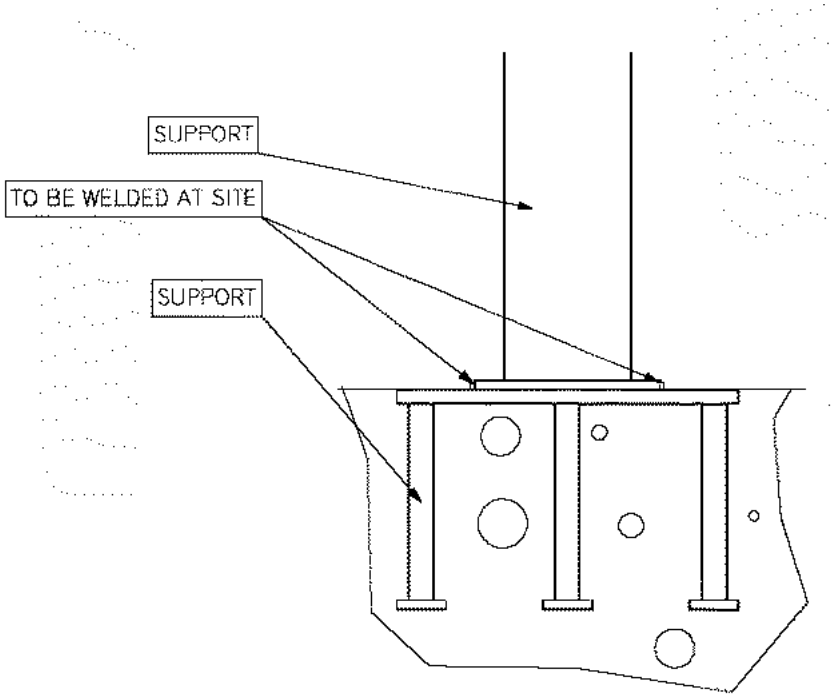

Fig 3. Typical installation of heavy details, embedded steel.

The following details are typically supported with embedded steel according to Fig.3 above: Air intake, Exhaust duct,

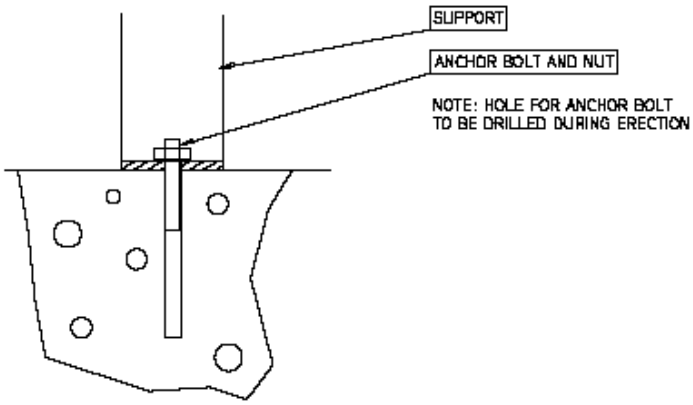

Fig 4. Typical installation of low and medium weight details, Minimum Concrete slab.

For example stairs, lube oil cooler, gas fuel unit.

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		Document number		1CS128535	
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Air intake system - static

General

This document includes description of equipment which is not necessarily included in the scope of supply. Refer to scope of supply for included equipment.

The air intake is always equipped with an air filter system in order to clean the air entering the compressor. There are two basic types of air inlet filter systems; static and pulse cleaned filter systems. Usually, static air filter systems comprise two or three stages of static filters, while current generation pulse cleaned filter systems comprise an initial pulse filter stage followed by a final static fine filter stage. Pulse filter systems are mainly selected for sites with ambient air containing significant amounts of large particles, e.g. desert areas. Pulse filter systems have earlier been supplied without the additional static fine filter stage. Investigations and practical experiences have, however, shown that the addition of a static filter stage offers considerably better and more reliable filtration.

All filters of standardized dimensions to utilize possibility for upgrading filtration in time.

Static filter systems

It usually includes weather hood (A), droplet separator (B), one or two stages of pre-filters (C) and a final fine filter stages (D). Depending on site conditions anti-icing system may also be included. Figure 1 shows some of the major components that may be included in a two stage static filter system, with component designation (A-B-C-D) as in text above.

Figure 1 – Major components in a typical two stage static air filter system

FO / SGT-600, SGT-700, SGT-750, SGT-800(All applications)	

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The purpose of the pre-filter is to remove coarse particles to extend the life time of the fine filter. Pre-filters are usually combined particle and coalescing filters, i.e. not only do they retain coarse particles, they also merge small water droplets to larger drops that are evacuated by the drain traps in the floor between the pre-filter and the fine filters. The filter media in the pleated fine filter elements is water-repelling and the filter elements are also designed to facilitate draining of water to the dirty side of the filter system.

The pre-filter initial efficiency is usually relatively low, but the efficiency as well as the pressure drop increases when the filtered dust is captured by the filters.

Last chapter, Classification of air filter gives some information regarding the basis for classification of static filter systems.

Filter house

The design of the filter house is robust to prevent liberation of any parts into the gas turbine. All fittings inside filter house and silencer are positively secured and material shall not fall away from any part of the filter house under the influence of air flow, vibration, corrosion, etc. The paint system and the materials are selected to withstand the environment.

The floor between the filter stages is sloped and equipped with drainage at the low point.

The air intake filter house is equipped with internal lighting and electrical socket.

In case of an indoor installation the face of the filter house or the entire filter house is placed outside the building and ducts are provided between the filter house and the gas turbine.

The pre-filter elements can be changed during operation. The exchange of the last filter stage has to be performed during gas turbine standstill.

Filter house is equipped with service platform and ladder.

Additional equipment available

The standard air filter system includes a droplet separator and a two stage static filter system; M6 + E10. Depending on site conditions it can include any of the following additional equipment:

Droplet separator

The purpose of a droplet separator is to protect the filters from excessive amounts of free water as most filters and filter systems are more efficient during dry than during wet conditions. Droplet separators are based on the inability of large droplets to follow the air stream at sudden changes of direction, i.e. on the inertia effect. Droplet separators can be of two different designs – vane type and honeycomb type, both based on the same inertia effect principle. The efficiency of droplet separators therefore decreases with decreasing droplet size, like during mist and fog. Problems caused by highly humid conditions (mist and fog) instead of water droplets cannot be eliminated by installation of droplet separators.

Figure 4 shows a vane type droplet separator. Figure 5 shows a honeycomb type droplet separator.

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Reference: Camfil 2015-11-19

Figure 4 - Droplet separator, vane type.

Reference: Zenittechnologies 2015-11-19

Figure 5 - Droplet separator, honeycomb type.

Salt particles are hygroscopic, i.e. they absorb water until they reach equilibrium with the ambient relative humidity. Salt particles may therefore exist as dry particles or as salt-saturated water droplets depending on the actual relative humidity. During humid conditions most of the salt will be in the form of fairly large droplets of salt-containing water. Droplet separators will consequently remove a lot of salt at offshore, marine and coastal applications during humid conditions.

Material of the droplet separator is either polypropylene or aluminum.

Droplet separators are excluded if anti-icing coils (water-air heat exchangers) are installed.

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Bug screen

The purpose of bug screen is to prevent bugs from entering the filter house. This configuration is for sites where bugs are so numerous that they can contaminate the pre-filter elements outer surface. The bug screen is located ahead of any equipment of the filter house (weather hood or droplet separator). The size of the mesh is 3x3 mm
(#7 mesh). The surface of the bug screen is big enough to decrease the air velocity to a level where the insects will not be sucked in to the mesh.

Bird screen

Bird screen is not needed where either anti-icing system or droplet separator is used; they have the function of preventing birds from entering the gas turbine.

Cold climate shut off dampers

The shut off dampers are located upstream the first filter stage. The dampers are always used in cold climate during standstill to prevent cold ambient air from cooling down the gas turbine. They can also be provided at other conditions on customer request. The shut off dampers are electrically actuated and furnished with feedback switches for open and closed position.

Hoist

Hand-operated hoist for filter elements replacement. The hoist is operated from filter house service platform.

Anti-icing systems and preheaters

Anti-icing systems are used to prevent ice formation on outer surface of filter elements on sites that experience icing conditions. Icing conditions are when the ambient air temperature is between -5 and +5°C (23 and 41°F) and the relative humidity are above 80%. Typically, the anti-icing systems increase the combustion air temperature not more than 10°C (18°F) above the ambient.

The anti-icing system is located upstream the first filter stage. Standard design of an anti-icing system is a water-air heat exchanger, also called anti-icing water coils. Hot water is supplied by customer.

Compressor bleed air nozzles can be used instead of anti-icing water coils when required by the customer. (Not valid for SGT-800)

For SGT-800 there is an air preheater available used for operation when the ambient air temperature is below -42°C (-44°F) to prevent turbine inlet case damage. Other Siemens SIT AB turbines do not require this pre-heater in the mentioned ambient air temperature range. The anti-icing system heat exchanger is used as the preheater.

Droplet separators are excluded if anti-icing coils (water-air heat exchangers) are installed.

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Blow-in door

The Blow-in door is available when required by the customer.

The Blow-in door is designed to open before delta pressure reaches the design pressure of the Air intake system ducts, thus protecting the ducts from structural damage in case of such extreme condition. It is a redundant protection – before the door opening delta pressure is reached, the turbine is already tripped for high inlet delta pressure.

The blow-in door has the flow capacity of at least 30% total turbine air flow. It has a turbine trip switch that is normally depressed by the closed door. The switch prevents turbine start or operation with open blow-in door. A safety net is included in the opening for protection.

Three stage static filter system –for critical applications

There are two different versions of three stage static filter systems, one with second and third stage close coupled and one with separate filter stages. The filter classifications in such system are normally M6 + F8 + E12.

Examples of critical applications where this kind of systems are preferred are units on sites with high fuel prices, units with tight margins between available and required output, and units where the number of stops for compressor wash should be kept minimal due to excessive costs for lost production during standstill. Units at sites with high concentration of corrosive contaminations in the ambient air are other examples.

The three stage setup offers a reduced turbine flow path fouling rate as well as increased intervals between off-line compressor washes at the expense of a higher initial pressure drop.

Evaporative cooler

See separate document.

Chiller coils

See separate document.

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Typical design data

Note this data is for general representation only, it can be different in a specific project.

Filter system

Pressure drop across a two stage static M6 + E10 filter system (only the filters):

	Pressure drop [mbar]	Pressure drop [inH_2O]
in clean condition	3-4	1.2-1.6
system alarm level*	17	6.8
turbine trip	19	7.6

*Separate alarm levels for each filter stage indicating time for replacement.

Pressure drop across a three stage static M6 + F8 + E12 filter system (only the filters):

	Pressure drop [mbar]	Pressure drop [inH_2O]
in clean condition	4-5	1.6-2.0
system alarm level*	17	6.8
turbine trip	19	7.6

*Separate alarm levels for each filter stage indicating time for replacement.

Number of filter elements (replaceable units of static filter) in each of the two stages:

Gas turbine	Type of filter house	Number of filter elements (in each of the stages)
SGT-600	single-side filter house	55
SGT-700	single-side filter house	60
SGT-750	single-side filter house	90
	three sided filter house	85 (typically 20+45+20)
SGT-800	single-side filter house	90
	two sided filter house	90 (45 per each side)

Life of a filter element (until replacement)	1-3 years depending on site conditions
Maximum air velocity at filter face	3.9 m/s (12.8 ft/s)

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Anti-icing water-to-air heat exchanger / coil:

Design pressure, water side 10 bar(g) (145 psi)

Water supply temperature 80 °C (176 °F)

Gas turbine	Nominal water flow [l/s]	Nominal water flow [gallon/s]	Required heat supply [kW]
SGT-600	11.8	3.1	600
SGT-700	11.8	3.1	660
SGT-750	11.8	3.1	900
SGT-800	11.8	3.1	930

Classification of air filters

Static filters for gas turbine applications are divided into three main groups according to their ability to retain solid particles - coarse filters or pre-filters, fine filters and EPA (Efficiency Particulate Air filters) / HEPA (High Efficiency Particulate Air filters) filters. These groups are further divided into different filter classes according to the result of the standardised specific test methods used for classification of air filters for general purposes.

Coarse filters – so called G-filters – are classified according to their average ability to capture and retain a coarse standardised synthetic dust.

Fine and medium filters – so called F-filters and M-filters are classified after their average efficiency for particles with a diameter of 0.4 µm ($1.575*10^{-5}$ inch) when loaded with test dust up to a defined final pressure drop. The F-filters also have requirement for minimum efficiency.

EPA/HEPA filters are classified according to their initial efficiency for the so called MPPS (Most Penetrating Particle Size).

The efficiencies of F-filters, M-filters and EPA/HEPA filters are not easily comparable as they are defined by different types of tests, but a class E10 filter is far more efficient than a class F9 filter for small particles.

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Table 1 - Classification of air filters according to EN 779:2012

Group	Class	Final test pressure drop [Pa/inH_2O]	Average arrestance of synthetic dust [%]	Average efficiency of 0.4 µm (1.575*10^5inch) particles [%]	Minimum efficiency[a] of 0,4 µm (1.575*10^5inch) particles [%]
Coarse	G1	250 / 1.0	50 - 65	-	
	G2	250 / 1.0	65 - 80	-	
	G3	250 / 1.0	80 - 90	-	
	G4	250 / 1.0	≥ 90	-	
Medium	M5	450 / 1.8	-	40 - 60	
	M6	450 / 1.8	-	60 - 80	
Fine	F7	450 / 1.8	-	80 - 90	35
	F8	450 / 1.8	-	90 - 95	55
	F9	450 / 1.8	-	≥ 95	70

[a] Minimum efficiency is the lowest efficiency among the initial efficiency, discharged efficiency and the lowest efficiency throughout the loading procedure of the test.

Table 2 - Classification of EPA/HEPA air filters according to EN 1822

EN 1822 for EPA/HEPA filters		
Class	Initial filter efficiency for MPPS, %	Initial penetration for MPPS, %
E10	≥ 85	≤ 15
E11	≥ 95	≤ 5
E12	≥ 99.5	≤ 0.5
H13	≥ 99.95	≤ 0.05
H14	≥ 99.995	≤ 0.005

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SIEMENS	SGT-600, SGT-700	GTI number		J740012E	
		Document number		1CS66444	
		Revision	C	Page	1

Exhaust system

This document includes descriptions of equipment which are not necessarily included in scope of supply. Refer to scope of supply for included equipment.

The exhaust consists of 3 main parts as follows: exhaust silencer, transition piece and flexible joint, (see figure 1.)

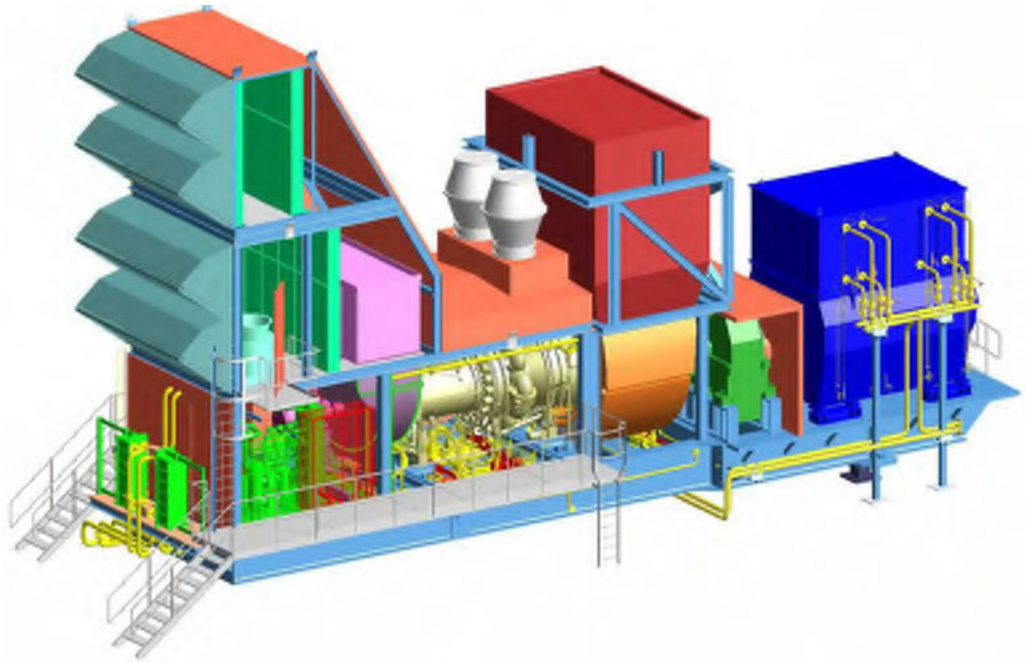

Figure 1. Typical exhaust with silencer transition piece and flexible joint

The flexible joint (see figure. 2) is designed to accommodate temperature movements and is welded to the gas turbine exhaust casing.

Figure. 2 Typical Flexible joint

BU / SGT-600(PG B, PG Ex B) SGT-700(PG B, PG Ex B) / &DF101	

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Downstream flange of the flexible joint is welded to the transition piece which is welded to the exhaust silencer.

The exhaust silencer and transition piece is lagged/cladded in order to meet the acoustical requirements around the package, and to act as personal protection from hot surfaces. The design of the lagging and cladding is such that the temperature outside of the cladding does not exceed 60 °C based on an ambient temperature of 20 °C and a wind speed of 5 m/s. The steel flanges on the flexible joint can reach a temperature of 450 °C and the fabric can reach a temperature of maximum 150 °C.

The transition piece and exhaust silencer casing is manufactured in the following materials.

Item	Material Standard	Material Optional Stainless steel
Flexible joint	The flexible joint is of high temperature woven glass fabric type with flanges in high temperature carbon steel material (EN10028-2 13CrMo4-5.	The flexible joint is of high temperature woven glass fabric type with flanges in AISI 316L material.
Transition piece	The casing is manufactured in high temperature carbon steel (EN10028-2 13CrMo4-5 or similar)	The casing is manufactured in AISI 316 L material.
Exhaust silencer	The casing is manufactured in high temperature carbon steel (EN10028-2 13CrMo4-5 or similar) The silencer splitters are filled with Basalt mineral wool covered by perforated steel plates of AISI 304 quality.	The casing is manufactured in AISI 316 L material. The silencer splitters are filled with Basalt mineral wool covered by perforated steel plates of AISI 316L quality.
Lagging/cladding	Lagging is mineral wool and the cladding is corrugated AluZink treated carbon steel .	The lagging is mineral wool and the cladding is corrugated AISI316L.
Optional Exhaust ducting	The ducting is manufactured in high temperature carbon steel (EN10028-2 13CrMo4-5 or similar)	AISI 316L

Table 1. Material quality in exhaust gas system

For information concerning sound levels for the complete package refer to separate document concerning sound levels.

The transition piece is equipped with connections for emission measurements and a maintenance hatch in order to enable inspection of the exhaust silencer and the exhaust casing of the gas turbine. Platforms and ladders to emission measurement connections is not included. Sealing between the enclosure and the exhaust ducting is described in a separate document concerning the enclosure.

The bottom of the exhaust is fitted with a suitable drain, in order to prevent water entering the gas turbine during periods of non operation. The standard height of the exhaust silencer is 11.6 m above the bottom of the base frame of the package, extra length can be supplied as an option. WHRU options can also be supplied.

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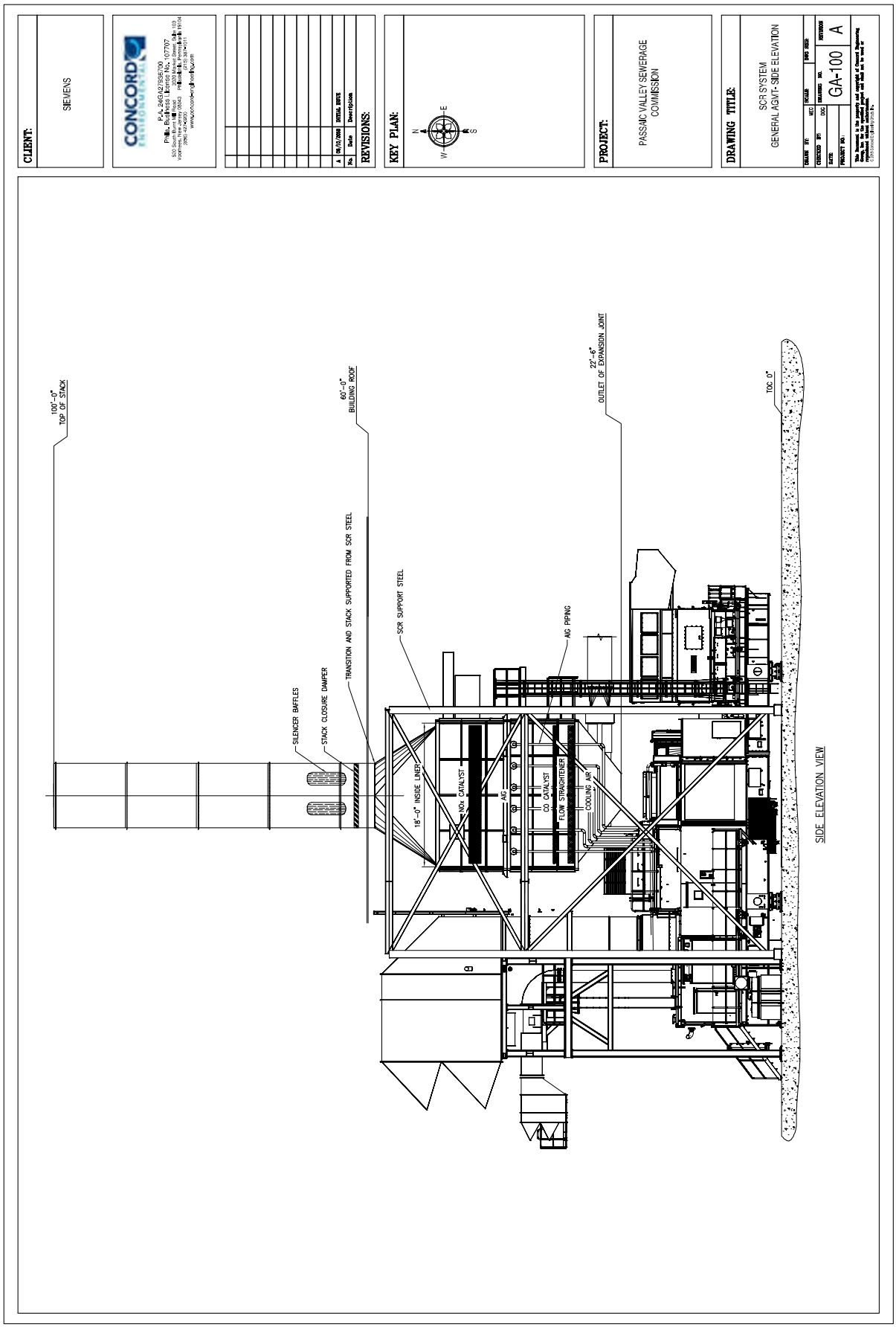

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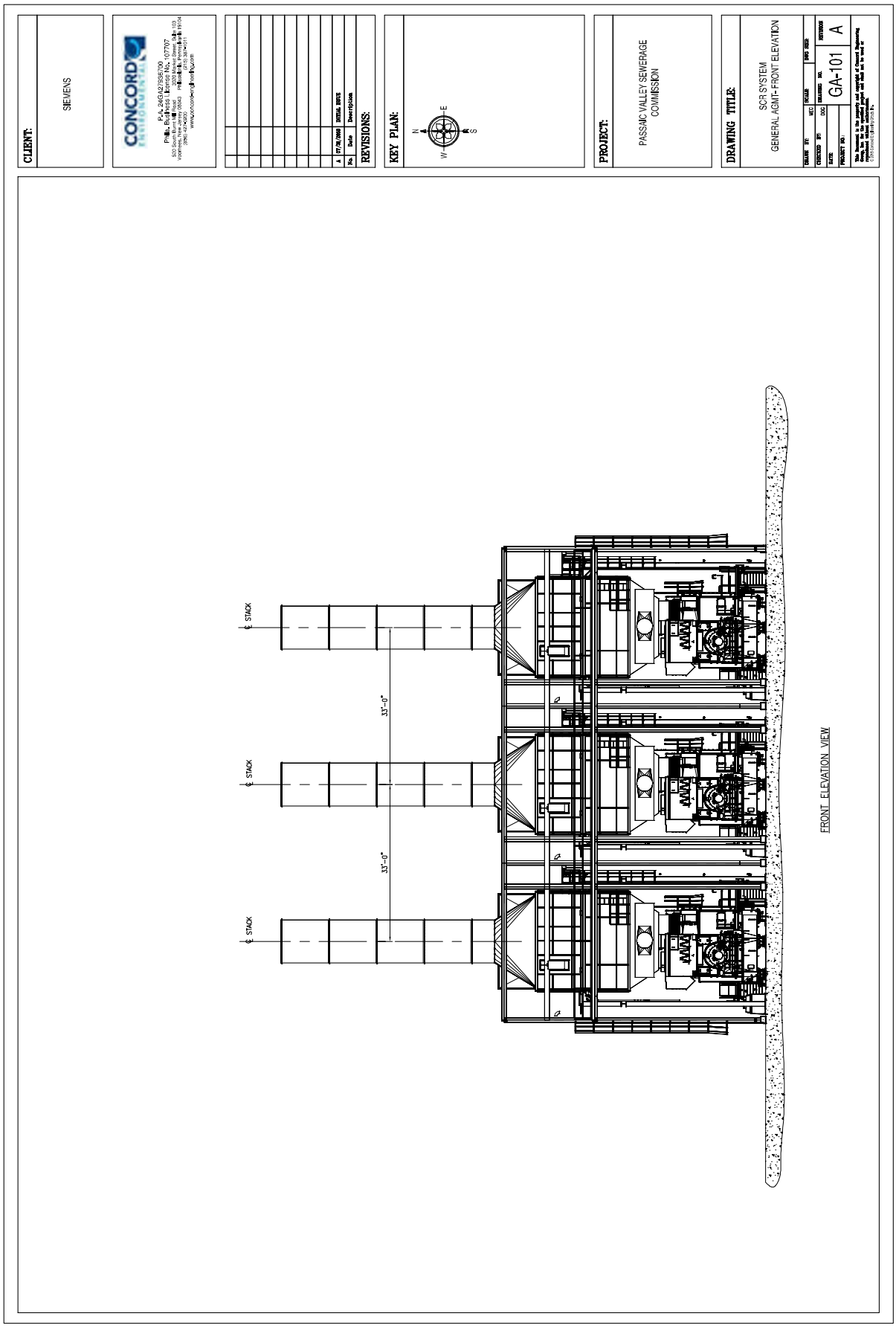

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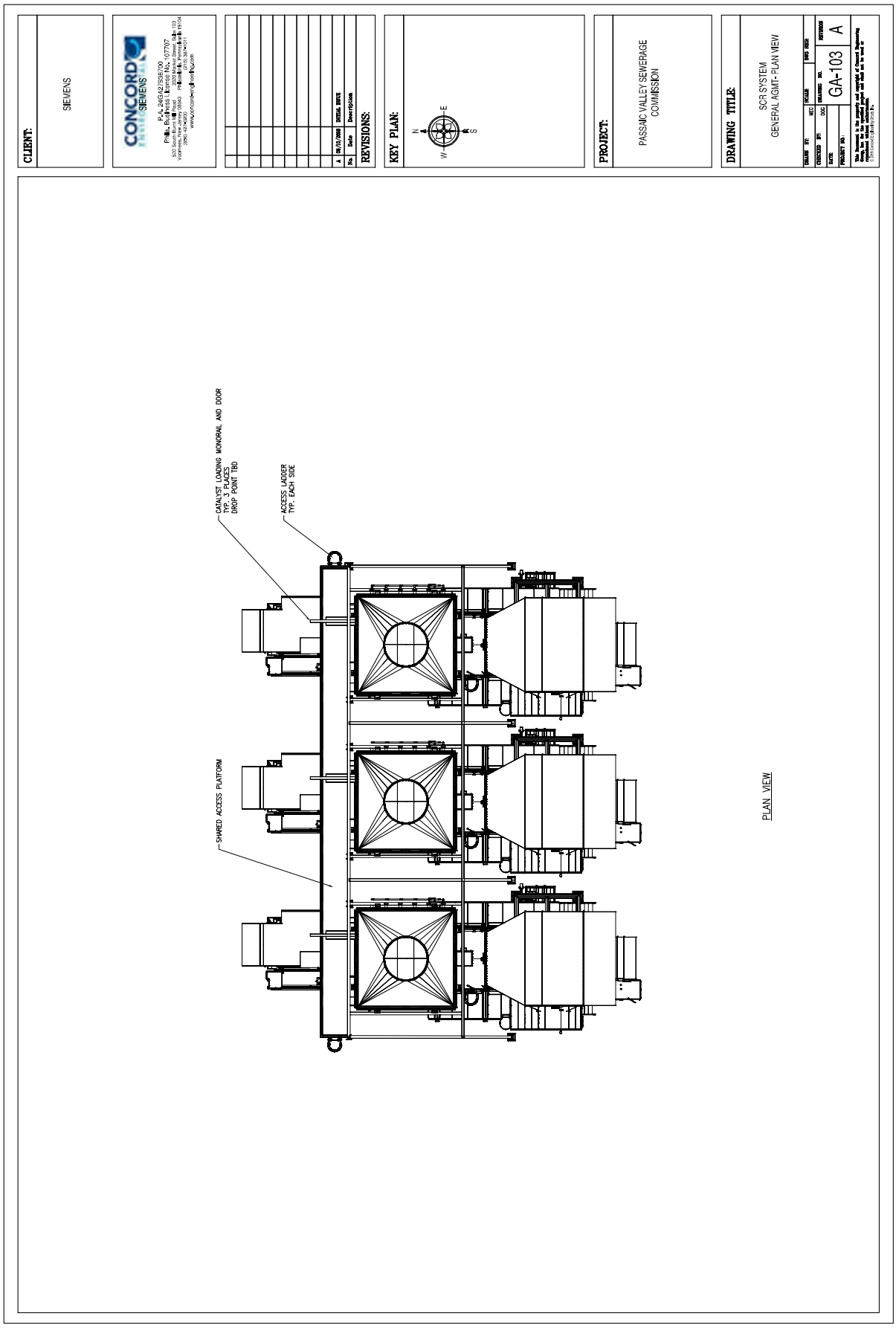

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REVISIONS:

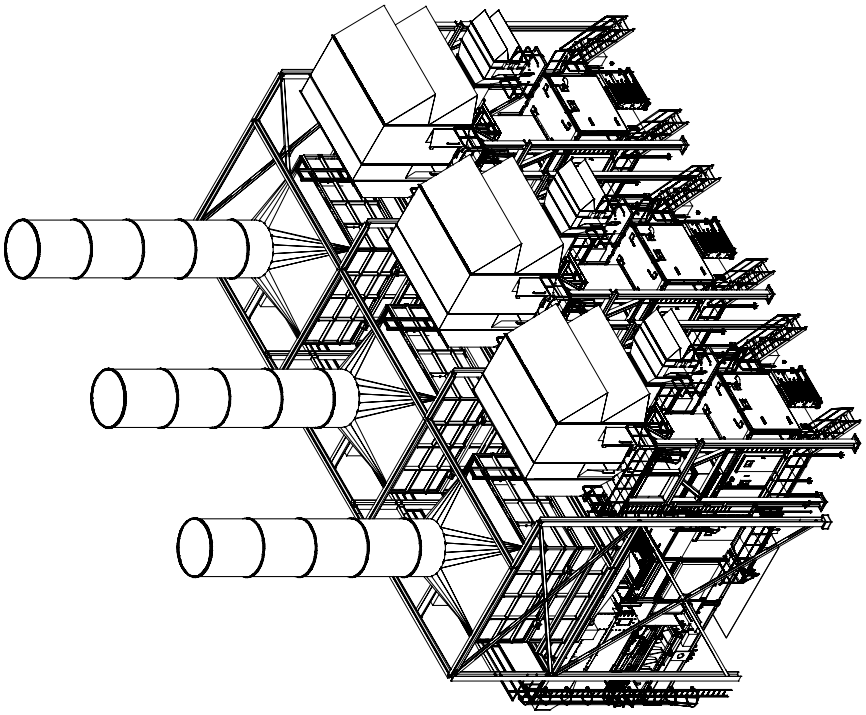
No.	Date	Description
A	09/10/2008	INITIAL ISSUE

KEY PLAN:

PROJECT: PASSAIC VALLEY SEWERAGE COMMISSION

DRAWING TITLE: SCR SYSTEM ISOMETRIC VIEW

DRAWING NO. GA-104 REVISION A



ISOMETRIC VIEW

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SIEMENS	Inspection, Erection, Testing SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W800005E	
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Quality assurance and product safety assessment

Quality management system

Siemens Energy Sector is the holder of a quality management system (QMS) that is certified in accordance with ISO 9001:2008 by Det Norske Veritas. The QMS and the quality policy is described and available for demonstration by use of Siemens process world in the Siemens Energy Sector intranet web site.

The cost effective achievement of quality in projects requires that quality assurance is planned and implemented prior to the activity being commenced. The quality objective for the works is to verify product safety, perform product certification, implement project specific tests and prevent non-conformities at the earliest possible opportunity as to avoid cost and delay due to corrective actions.

The quality assurance measures are defined in a project quality plan that cover all stages of the project and is applicable to all subcontracts under a contract.

The quality assurance measures shall give the purchaser a high degree of confidence that the requirement of the project is achieved. Within the respect of industrial property and upon the signature of a non disclosure agreement, the purchaser or their representative will have access to all locations and at all times where activities are performed within the scope of the project for auditing, surveillance, inspection and expediting purposes, after agreement between Siemens and the purchaser since such activities may have an impact on the product cost and time schedule.

The appointed sub-suppliers and contractors are required as well to comply with the minimum requirements for quality assurance and quality control to be applied to goods and services in accordance with ISO 9001 or other equivalent recognised quality standard.

Supply chain quality management

Siemens Energy Sector has a global system for supply quality assurance that is based on an initial approval and an annual evaluation:

The initial supplier evaluation is based on an assessment of QMS, commercial analysis, technical capability and when needed a product process qualification. The result is registered in a global approved supplier database (ASD). Any Manufacturer or their sub-contractors that are welding load bearing or pressure retaining equipment are assessed against the standard for comprehensive welding requirements, ISO 3834-2.

The annual follow up is performed by a cross functional team in four aspects, commercial, logistics, technical performance and quality performance. The result is documented in a global database, Siemens evaluation system (SES) that can be demonstrated to the purchaser on site.

FO / SGT-600(MD B, PG B, PG EX B), SGT-700(MD B, PG B, PG EX B), SGT-750 (MD A, PG A, PG EX A), SGT-800(PG B, PG B2, PG Ex B2, PG Ex B2 US, PG B LS) / &QA121	

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		Document number		1CS26782	
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Project quality organization

A quality manager in projects (QMiP) is nominated for each project where a turbine or a turbine plant is to be supplied.

The QMiP has the responsibility, delegated by the project manager, to plan and perform the required and needed verifications of the product to be delivered to a purchaser. The QMiP does also have the following project responsibilities:

a) Verify product safety prior to first use of the equipment.

b) Ensure correct product certification for the place of installation.

c) Ensure that the products are tested in accordance with any specific project requirement.

d) Monitor and report process non-conformances with the QMS.

If Siemens is responsible for the fabrication and installation on the construction site, a site quality manager (SQM) is nominated. The SQM has then the responsibility to implement the QMS on site, to plan and perform the required and needed verifications of the installed product to be handed over to the purchaser.

Project quality planning

Siemens gas turbines are designed to meet the essential safety requirements as stipulated by the international standard ISO 21789 gas turbine applications – safety and the corresponding requirements that are stipulated in the product safety directives in the european community.

Project quality planning is performed as to ensure that any technical, contractual or legal requirement that is considered critical, are monitored by technical assistance, audits, controlling and inspection in such way that the correct quality is achieved during engineering, procurement and manufacturing in the supply process.

A project quality plan (PQP) is submitted within 30 days of signing a contract. The PQP with its attached product related quality control plan (QCP) defines the programme of quality control and inspection activities that is implemented by Siemens and performed in the works, in the nominated major sub-suppliers and contractors works as to ensure that the procurement, fabrication and testing of the materials, equipment and plant installation comply with the specified requirements. The applicable procedures within Siemens and the nominated sub-suppliers, as referred to in the attached QCP are available for review at each manufacturer's premises on purchaser request.

The first submittal of the PQP and the attached QCP is based on the scope of supply only and will be revised when all major purchase orders have been completed. The first revision of the plans will then identify the names of the major manufacturers, the tests and the inspection of the equipment.

The project quality plan is based on ISO 10005:1996 due to the sufficient structure and the attached quality control plan it includes the following information:

- Definitions of abbreviations used in the plan
- Applicable regulations, codes and standards for certification of the equipment.
- Quality system requirements including references to applicable quality related procedures.
- The project organisation with personnel, responsibilities for management of quality and names of the resources assigned.
- Definitions of external interfaces such as other Siemens companies, third parties or certification bodies.
- Equipment related quality control plan (QCP) or inspection and test plans (ITP) for turbine package and other major process equipment if applicable.

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The level of quality surveillance is decided as a result of the certification requirements, contract requirements and supplier evaluation. The cost for Siemens activities is included in the total cost of quality control and inspection as specified in the contract with the purchaser.

The own cost for the purchaser or its representative's quality surveillance shall be on the purchaser. If the purchaser requires any extensive quality surveillance not specified in the contract, the total cost (for any activity) shall be on the purchaser, unless otherwise agreed.

The PQP with attached QCP is sent to the purchaser for review and approval.

Quality control plan

The product related quality control plan is a separate document attached to the QCP describes the scope of project quality surveillance through design review, inspections, tests, procedures, acceptance criteria and verification of the process system, equipment or component, as required to meet the technical requirements.

The operations and inspection/test activities included in the QCP follows a logical sequence of events with the following information:

- Steps/sequence of activities listed per process system
- Procedures to be used and acceptance criteria for each step/sequence
- Verifying records applicable to each step/sequence as applicable
- Columns for inspection and test points by manufacturer, contractor, purchaser, third party or certification bodies

Inspection and test plans

The inspection and test plan (ITP) that is submitted by each fabricator detail all test and inspections that are performed during fabrication of the equipment in the workshop. The ITP identifies the material and components with article numbers or project number as to ensure that the issued test reports are traceable with the production order and article or project number.

The ITP also identifies the acceptance criteria, used procedures or used standards for the test and inspections. Procedures written for local labour may be written in local language if they are referring to an international standard.

The ITP(s) submitted for fabrication and the reference procedures are only available for review by the purchaser at the fabricators premises.

Quality surveillance by the purchaser

The scope of quality surveillance, the required test and inspections to be witnessed by the purchaser or any engaged third party is marked up in the quality control plan (or in the applicable inspection and test plans) after agreement with the purchaser.

The legend for the quality surveillance codes are specified in each quality control plan since some projects require to use additional coding. Generally Siemens uses a coding based on European industrial standard which do not correspond to the American petroleum industry (API) standard.

The quality surveillance code witness point (WP) is defined as an observation or verification point in manufacturing and testing where, by prior agreement, Siemens will advise third party inspector, the purchaser or its representative. The WP dates will be preliminary planned during the purchasing process and the final date will be advised at least 5 working day's prior to test, unless otherwise agreed. The manufacturer will proceed

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with the work past the witness point if the customer or its representative can/will not be available at the appointed time.

The quality surveillance code hold point (HP) is defined as a critical step in manufacturing and testing where, by prior agreement, Siemens will advise third party inspector, the purchaser or its representative. The HP dates will be preliminary planned during the purchasing process and the final date will be advised at least 5 working day's prior to test, unless otherwise agreed. The manufacturer will not proceed with the work past the HP if the third part inspector, the purchaser or its representative is not available at the appointed time, except by documented agreement between Siemens and the purchaser.

Hold points are rarely used due to the impact in the agreed time schedule, except for products to be certified by a third party organisation. HP(s) will exceed the production lead time.

Any witness points required by the purchaser prior to assembly of the gas turbine can only be performed as in-process inspection without inspection of contract allocated equipment. Witnessing of rotors and other turbine parts are limited to in-process inspection since these parts are produced to stock orders and allocated to a specific contract during assembly of the gas turbine.

This applies also to the assembled turbine rotor that are high speed balanced up to operating speed and over-speed tested in a test bay with a vacuum chamber, following the balancing procedures as described in ISO 11342:1998.

The customer or its assigned inspector is only allowed access to Siemens premises and the sub supplier's premises as defined in the quality control plan (QCP), after invitation from Siemens.

If any tests, as specified in the QCP or in an inspection and test plan, fails or are being reported as not complete, a retest is to be performed by the manufacturer. The cost for witnessing any retest will then be charged back to each manufacturer.

Functional and operating test

The gas turbine equipment is functional and operating tested in accordance with ISO 3977-8:2002 as described below:

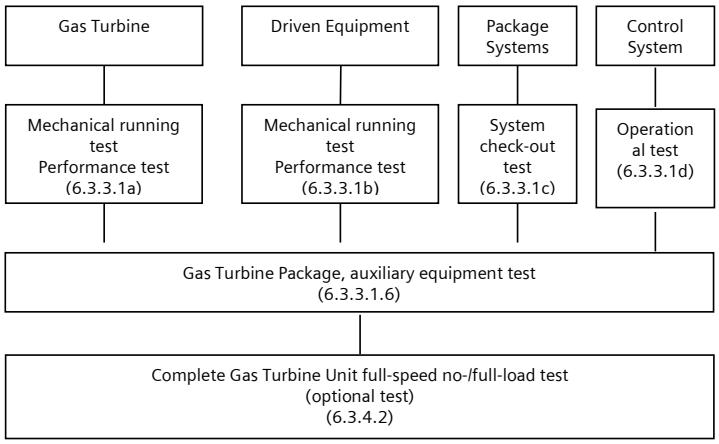

Figure 1 – Diagram of gas turbine functional/operating tests

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a) Mechanical running test (MRT) including the performance test of the assembled gas turbine is conducted in a slave test bay (Note: the SGT-800 is normally only tested at construction site, but an MRT may be offered on request). The driven equipment, all auxiliary systems, such as fuel system, lube oil system, control system and air filtration is part of the slave test bay.

b) Mechanical running test including the performance test (if applicable) of the driven equipment, such as electric generator, gas compressor and main gear is conducted by the equipment manufacturer in accordance with specified standards.

c) System check-out test of package systems, such as lube oil unit, fuel units and coolers are conducted by each manufacturer in accordance with Siemens procedure and specified standards.

d) Operational test of the control system (CS) is conducted during a stationary workshop test with the CS hardwired to the contract gas turbine package equipment. The communication, alarms, shutdown and start sequence up to ignition of the gas turbine is tested.

A complete gas turbine unit full-speed no-load test or a full load test may be performed in accordance with ISO 3977-8 item 6.3.11.1 as an optional test.

Product safety assessment and plant approval

The product safety has top priority and must be ensured regardless of the contractual boundaries. The products are tested and inspected in accordance with applicable regulations and standards with a level of inspection that is based on the hazardous use or the safety protection of the equipment. Some of the design standards also define the standards for inspection and the qualification level of inspectors.

Where specific qualifications of inspectors are required, Siemens have qualified specialists or let in third party specialist inspectors. When required, these specialists are replaced by authorized inspectors from the country of installation or from an Independent inspection agency.

The inspections are performed during fabrication of parts, installation in package systems and during final installation on construction site. The final assessment of the gas turbine unit including driven equipment is performed on construction site when all safety associated auxiliary systems, civil works and supply system are completed.

The final assessment on site shall be performed by qualified specialist or authorized inspectors on the complete installation as described above, regardless of if the fabrication and installation is done within Siemens scope of supply or within purchasers scope of supply.

As to ensure product safety, process safety and labour safety during commissioning, the complete final assessment shall be reviewed and approved by Siemens business unit QHS manager. The QHS manager reviews and accepts the procedures for the final assessment and the qualifications of the inspector. A safety assessment certificate will be signed after the approval of the final assessment. Submittal of this safety assessment certificate to the commissioning leader is the Siemens release for supply of fuel to the gas turbine and start of rotating commissioning.

The gas turbine unit can be finally approved and certified to any local regulations when the final assessment has been approved and all remaining non-hazardous inspection punch items are completed.

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Non-conformance reporting

Due to the application in the works, Siemens Industrial Turbomachinery AB uses two databases for administration of the workflow from initial recording, corrective actions and preventive actions to the final approval of all actions. The non-conformances can be traced trough marking on turbine components or through project reference numbers for assemblies. The purchaser has the right to review these reports at the Siemens's facility, if requested, but do not have the right to have copies of these documents since some information may be company protected information and also written in local language.

Quality documentation

Quality records are generated, reviewed, approved, collected and filed as to demonstrate conformance to applicable requirements. The document control system that meets the requirements in ISO 9001:2008 and the relevant european directives is based on both paper formats and electronic formats.

The document control system handles procedures, standards, drawings, specifications, qualifications, reports and certificates which identify and verify a produced product. The scope of review is based on a rating due to product safety and compliance with the contract. All such documents are filed and stored by Siemens for at least 20 years after the product has been handed over for operation.

Siemens will issue a declaration of conformity for the compliance with the product safety requirements and contract requirements if specified. The declaration of conformity (according to ISO/IEC 17050-1) will be supplied together with all needed declarations and type test certificates that are needed for the approval for use and for the periodical survey of the product. These declarations and type test certificates, including the performance test reports of the product, will be compiled in a manufacturing record book (MRB) and supplied in accordance with the contract.

If a customer requires a more comprehensive MRB, including inspection and verifying documentation according to customer detail specifications; this MRB will be quoted separately.

Quality management audit

To assure adequate implementation of the quality management system and to confirm that the program is effective, periodic planned internal audits of each functional area is performed by lead auditors, coordinated by the support organisation in Siemens Industrial Turbomachinery AB or through Siemens Energy Sector.

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Preliminary shipping specification

This shipping specification is for guidance only. Weight, dimensions and volumes may vary from project to project.

Refer to scope of supply document for included items in actual project.

Item	Name	Gross weight [tonnes]	Dimensions L x W x H ([m]/([ft])	Volume [m^3]/([ft^3])
1	Gas turbine block (dry) including gas turbine and it's base frame with integrated starting system, generator/gear and it's base frame.	151≤ W ≤157 (Weight depending on generator/gear)	19.1 x 4.3/5.0 x 3.8 (62'-7" x 15' x 12'-6")	~330 (~11650)
2	LER, including control equipment.	~10	7.8 x 3.3 x 3.9 (25'-7" x 10'-10" x 12'-10")	~100 (~3531)
3a	Battery container	~6.5	6.1 x 2.5 x 2.6 (20'-4" x 8'-4" x 8'-8")	~40 (~1412)
3b	Batteries (If container excluded in scope of supply)	~1.8	2.0 x 0.8 x 1.0 (6'-8" x 2'-8" x 3'-4")	~1.6 (~57)
4a	Static filter housing	9	7.5 x 5.5 x 4.6 (24'-7" x 18'-1" x 15'-1")	~215 (~7593)
4b	Filter house structure	8.5	8 x 4 x 4 (26'-3" x 13'-1" x 13'-1")	~128 (~4520)
5a	Ventilation inlet	6.0	5.0 x 2.5 x 2.0 (16'-5" x 8'-2" x 6'-7")	~25 (~883)
5b	Ventilation outlet	1.0	4.5 x 2.5 x 1.2 (14'-9" x 8'-2" x 3'-11")	~14 (~494)
6	Exhaust module	~14	3.1 x 5.0 x 5.6 (10'-4" x 16'-8" x 18'-8")	~87 (~494)
7	Exhaust bellow	~2	3.4 x 1.8 x 0.6 (11'-2" x 5'-11" x 2')	~3,7 (~131)
8	Base frame supports	~2.5	3.0 x 0.5 x 1.0 (9'-10" x 1'-8" x 3'-3")	~1.5 (~53)
9	Platforms and ladders	~5	6.1 x 2.0 x 2.7 (20' x 6'-7" x 8'-10")	~33 (~1165)
10	Air Condition unit, for LER	~0.5	1.2 x 1.8 x 1.1 (3'-11" x 5'-11" x 3'-7")	~2.5 (~88)

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Item	Name	Gross weight [tonnes]	Dimensions L x W x H ([m]/([ft])	Volume [m^3]/([ft^3])
11	Liquid fuel unit	~3.2	4.3 x 2.0 x 3.4 (14'-1" x 6'-7" x 11'-2")	~29,3 (~1035)
12	Lube oil cooler, water cooled (2 x 100%)	~1	1 x 0.7 x 2.1 (3'-3" x 2'-4" x 6'-11")	~1.5 (~53)
13	Fire extinguishing module	~1.7 – 4.5	2.2 x 2.8 x 2.6 (7'-3" x 9'-2' x 8'-6")	~16 (~565)
14	Washing unit	~0.2	0.9 x 0.7 x 1.2 (2'-11" x 2'-4" x 3'-11")	~0.8 (~28)
		∑ 224≤ W ≤233		∑~1029 (~36339)

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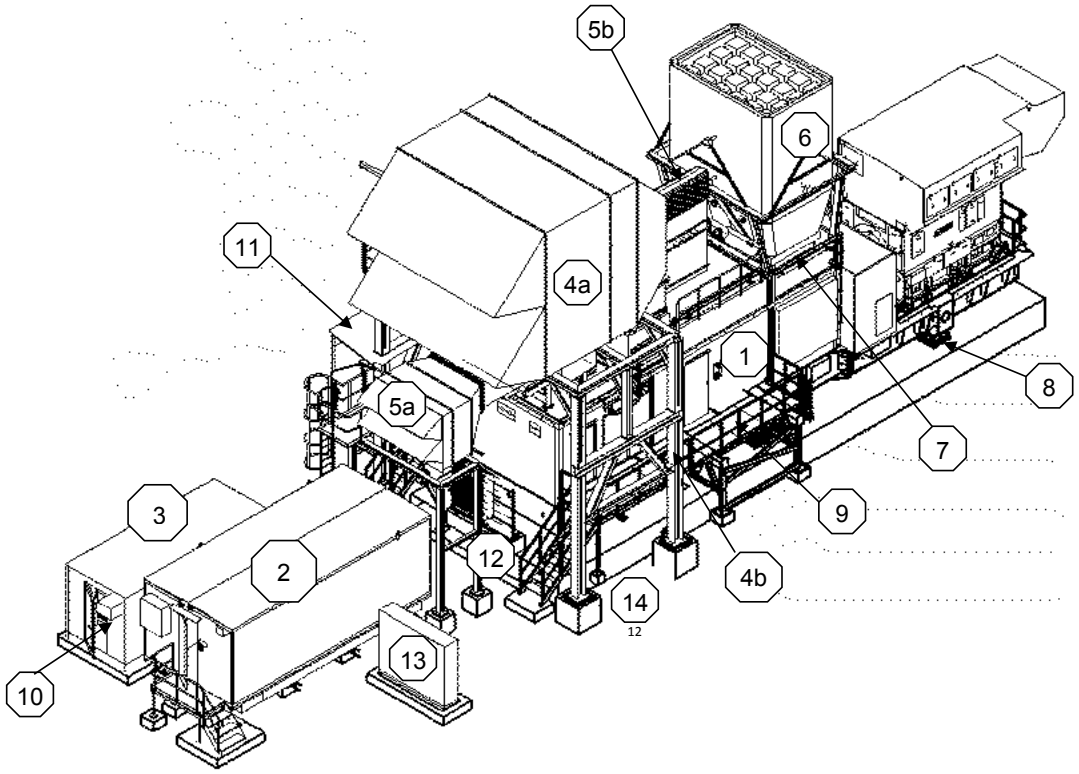
Item	Name	Gross weight [tonnes]	Dimensions L x W x H [m]/([ft])	Volume [m³]/([ft³])
	Equipment installed in LER			
	*) Control cubicles.	0.8	3.6 x 0.6 x 2.2 (12' x 2' x 7'-4")	~4.8 (~169)
	*) MCC.	0.8	1,6 x 0.6 x 2,2 (5'-3" x 2' x 7'-3")	~2.1 (~74)
	*) Frequency converter start motor.	0.3	1.2 x 0.6 x 2.2 (4' x 2' x 7'-4")	~1.6 (~56)
	*) Standard MDS.	1.4	3.74 x 0.625 x 2.2 (12'-4"' x 2' x 7'-4")	~5.1 (~180)
		∑ 3.3		∑ ~13.6 (~480)



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Packaging, Preservation and Marking

1. Purpose

This document describes packaging and storage of goods and materials related to turbines deliveries from Siemens and its sub-suppliers. This specification also includes description of preservation, marking, packing list and the responsibilities sub-suppliers undertake.

The purpose of applying packing and preservation is to avoid damage to equipment during transportation and/or storage. This document defines suitable packing methods for equipment to be transported and stored for a maximum of 12 months from date of EXW shipment.

Preservation and packing requirements are influenced by both the transportation method, route and storage locations. Transportation methods and routes are detailed in Section 3 and storage locations have been classified and defined in accordance with mainly environmental conditions and are detailed in Section 6.

All gas turbine equipment, when packed in line with the requirements of this packing standard, is required to be stored in accordance with Section 6. Each 'piece of equipment', as shown in Appendix 1, has been given a minimum storage classification code to meet the 12 month requirement. Storage locations that exceed these minimum requirements are acceptable.

1.1 Engine package types

This Packing Standard is applicable for the Siemens SGT, MGT and AGT gas turbine products packaged in Finspång, Sweden.

2. Reference standards, terms, abbreviations and definitions

2.1 Reference standards

This latest revision of standards shall always apply.

Standard No.	Standard Title	Comments
ISO 780	Packing. Pictorial Marking for Handling of Goods	
ISO 7010	Safety signs	
ISO 668	Series 1 freight containers - Classification, dimensions and ratings	
ISO 1496-1	Series 1 freight containers - Specification and testing	
ISO 6346	Freight containers - Coding, identification and marking	
IEC 60721-3-1	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 1: Storage	Referred to in this Packing Standard, but not necessarily complied with.
IEC 60721-3-2	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 2: Transportation	Not actually referred to in this Packing Standard, but included for completeness.
IEC 654-1	Industrial - process measurement and control	Referred to in this Packing Standard, but

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	equipment - Operating conditions - Part 1 - Climatic conditions	not necessarily complied with.
ISPM 15	International standards for phytosanitary measures no 15 Developed by the 'International Plant Protection Convention' (IPPC)	A wood material and marking requirement that affects all lumber wood packing material in the Siemens system. Applies to all hard and soft wood. Addresses the need to treat wood materials of a thickness greater than 6mm, used to ship products between countries.
IPPC	International Plant Protection Convention Guidelines	Referred to in ISPM 15 above.
AL	Export List, Annex I to EC Dual-use Regulation	
ECCN	Export Control Classification Number, Suppl. #1 to Part 774 of EAR	

2.2 Abbreviations, terms and associated definitions

Abbreviation or Term	Definition
SGT	Small Gas Turbine includes the SGT-100, SGT-300 and SGT-400 in both single and twin shaft configuration.
SGT	'Siemens Gas Turbine' used as the prefix for all Siemens gas turbines (e.g. SGT-800).
MGT	Medium Gas Turbine includes the SGT-600, SGT-700, SGT-750 and SGT-800.
AGT	Aeroderivative Gas Turbine includes the SGT-A30 RB, SGT-A35 RB, SGT-A45 and SGT-A65 TR.
Case	A rigid box having closed faces and is completely enclosed.
Contact Preservation	Surfaces coated with preservative. Requires greaseproof wrap or cover to confine the contact preservative to the item.
ISO Container	Metal freight container typically used to consolidate cargo freight coded / marked in accordance with ISO 668, ISO 1496-1 and ISO 6346.
Cover / Lid	The part that closes the top of a case, box or crate.
Crate	An open rigid box of framed construction. Typically of hit and miss lumber. An open crate is generally not adequate for export packaging, except as indicated.
Desiccant	A substance used to absorb water vapor to maintain a low relative humidity in a water vapor proof, hermetically sealed environment. Requires specific storage and use.
Dunnage	Temporary blocking, bracing or supports in a container to protect and make freight secure in or on a carrying device. Also used for filling space.
End Cap Hood Box	Three sided hood box used as protection for the ends of Turbine Skid units, typically used with Roof Sections.
FOD	Foreign Object Debris. A substance, debris or article alien to a vehicle or system which would potentially cause damage.
FOD	Foreign Object Damage
Hazardous Material, Dangerous Goods	Goods regulated by 49 CFR, IATA and IMDG.
LER	Local Equipment Room

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OSB	Oriental Strength Board. Sometimes referred to as 'Smartply'.
Pallet	A horizontal platform device used as a base for assembling, storing, handling and transporting materials and products in a unit load. Has a bottom deck. May also be the structural foundation for a unit load such as a box. Compare to Skid.
Plug Type Humidity Indicator	SAE AS26860 specification humidity indicating device for installation in rigid containers and flexible moisture-vapor-proof envelopes or bags
Preservation	In packaging, the application of protective measures such as cleaning, drying, and the use of preservatives, barrier materials, cushioning and containers.
Roof Section	An arched wood assembly used to force water runoff and close Turbine Unit intake, exhaust and other top openings as well as stabilize the End Cap Hood Box. Not a box cover or lid.
Skid	One of a pair or series of parallel runners, usually wood, affixed to the underside of boxes, crates, a deck, or an item to allow entry of pallet jacks, truck forks or facilitate sliding. Has no bottom deck. Compare to Pallet.
Rugged	Component that is sturdy, durable and not easily damaged.
Heavy duty PVC/Tarp/Tarpaulin	Heavy duty PVC (Poly Vinyl Chloride) sheet fitted over packed equipment.
Shrink Wrap	Polythene shrink wrap enclosing the complete packed unit.
SOC	Shippers Owned Container.
VCI	Volatile Corrosion Inhibitor.
VpCI	Vapor phase Corrosion Inhibitor.
VGM	Verified Gross Mass
EXW	Ex Works. International trade term by which a seller makes the product available at a designated location and the buyer incurs transport costs.

3. General packing requirements

3.1 All transportation types

Goods are packed in solid packages suitable for safe, appropriate & repeated handling and repeated indoor and outdoor loading and unloading. Packages prevent moisture, mold, rust and corrosion ensuring the equipment reaching destination without damage or corrosion. Forklifting is feasible with a minimum 100 mm bottom clearance for goods weighing more than 25 kg (55 lbs.).

Packed equipment having a height of less than 3 m has a structural strength to enable stacking. Any packages less than 3 m height and not stackable are marked with 'DO NOT STACK' signs. Refer to certain exceptions in Section 5.1. Goods with a height greater than 3 m or goods not suitable for stacking may be shrink wrapped using UV protected shrink wrap or using additional weather protection such as a heavy duty PVC cover.

- All cargo is suitable for sling handling which will be used at vessel loading and unloading.
- As far as possible all package dimensions allow standard transportation by truck.
- Ducts are blanked with covers; pipes are blanked with end caps.
- Packed equipment not safe to walk on is marked, refer to Appendix 2.

3.2 Road transportation

For road transportation the requirement of stackable packages, for some items, less than 3.0 m height may be relaxed.

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3.3 Deep sea transportation

All goods shall be transported under deck, not exposed on top deck, and all packages shall be adequately anchored or restrained for sea transportation. Heavy weight cargo can be anchored using one of the following alternatives:

- package lifting lugs or other features attached to the machinery base frames
- special sea transportation brackets
- welding between identified features on the machinery base frames and the ship deck

If under 3 m height, the packages are stacked as much as possible.

Where applicable, de-humidifiers are required active during transportation & storage within the gas turbine and the LER. Heaters for electric generators, if included, are supplied with a temporary connection cable with a 5-pin IEC type power socket. Heaters shall be connected during transportation and storage.

The transport ship shall be equipped with electrical power for heaters and de-humidifiers: 1phase 240V AC 50Hz or 60Hz (phase/ground/neutral) for de-humidifiers and 3phase 400VAC 16A 50Hz (3phase/ground) for generator heaters. After loading, it shall be possible to physically inspect the gas turbine unit, LER and AC generator in order to verify that de-humidifiers and heaters are in operation.

3.4 Air freight transportation

For air freight, lightweight and space-saving packing is used. Storage requirements are still applicable. All packing for air freight transportation is subject to reviews to meet the requirements of dynamic loadings associated with air freight transportation e.g. locking details for AC generator rotor restrain.

3.5 Train transportation

Goods are packed in cases or containers and are properly secured to withstand potential gravitational forces e.g. forces occurring when shunting.

3.6 Preservation

Products are preserved and packed to protect the equipment during transportation and storage for duration up to 12 months from EXW supplier facility/gas turbine packager facility. The degree of protection depends on the item being packaged. In all cases, appropriate quantities of suitable and compatible corrosion prevention materials are used. Detailed below are methods of temporary corrosion protection used:

- Protective coating wax, oil & spirit based corrosion inhibitors.
- Volatile Corrosion Inhibitors forms a protective molecular layer on ferrous materials by continuous vaporizing.
- Vapor phase Corrosion Inhibitors. Vapors insulate parts from humidity hence prohibiting corrosion. Typically a VCI coated plastic film is the preferred method used, see Figure 1.
- Airtight packaging with desiccant.
- Airtight packaging with vacuum created and desiccant.

Preservation material supplier instructions are followed. Equipment is preserved to be suitable for the storage location type, as defined by the classification code for the particular equipment in Appendix 1.

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Figure 1: Support in case and goods enclosed in moisture protective plastic.

3.7 Risk of condensation

Moisture formed on the surfaces after transportation shall be wiped off to avoid slight surface damage to materials such as unprotected carbon and low alloy steels until the component has reached the temperature of the storage facility. All surfaces shall be dry before application of any vapor phase corrosion inhibitors for corrosion protection.

3.8 Lifting considerations for base timbers

To ensure that the lifting loads are safely transferred directly from the base timbers through to feet of equipment, base frame timbers are positioned such that lifting slings can be located in the correct position. Care is taken to ensure that equipment with an off-set center of gravity in relation to the position of equipment mounting feet is adequately compensated for. To prevent lifting slings being used in more than one location, any potential slinging positions which are not suitably aligned to the correct points of lift are suitably "blocked out" with timbers. Base frame timbers and internal supports have sufficient strength to enable the equipment to be safely lifted. In certain cases, a separate metal sub-frame may be used. See also individual package lifting instructions.

4. Detailed packing requirements

4.1 Wood packing material requirements

Wood packing and dunnage timbers is free of bark, live pests or plants, and free of insect damage i.e. holes etc.. All wood packing material is heat treated with a minimum core temperature of 56 °C (133 °F) for at least 30 minutes as required by ISPM 15. All cases and crates are stamped with IPPC symbol on at least two opposite sides, see Figure 2.

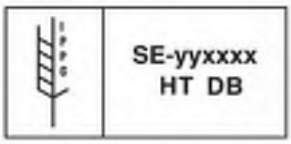

Figure 2: Example of ISPM marking.

Dunnage used to wedge or support cargo have at least one marking on each piece of wood. This is also applicable when securing the goods with wooden beams on a pre-approved pallet or when support is needed of any kind inside a container. The lid of the case is covered with a good quality, waterproof plastic film for protection; see Figure 3, Figure 4 and Figure 5.

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Figure 3: Example of a wooden box covered with plastic film.

Figure 4: Example of plywood case.

Figure 5: Example of OSB case.

The types of wood are homogeneous solid wood or plywood. In some cases OSB may be used when storage location and transportation details are well known, see also Section 6 for standard storage locations. There may be additional requirements regarding wood treatment depending on the local national requirements, e.g. Australia.

4.2 Shrink wrapping/unpacked cargo

Goods not suitable for stacking or goods with a height greater than 3 m may be shrink wrapped, see Figure 6. Sharp edges and protrusions are given additional protection to prevent damage to the plastic sheet. Lifting points are kept uncovered and sealed as necessary to protect the integrity of the wrapping.

Figure 6: Example of shrink wrapping.

Figure 7: Example of packed stackable metal beams

Robust goods, e.g. metal beams may be supplied open if the bundle is stackable, see Figure 7.

Goods assembled on a skid/enclosure are not packed in cases or crates, see Figure 8 and 9.

Figure 8: Example of tarpaulin cover.

Figure 9: Example of tarpaulin cover with supporting structure.

4.3 Usage of containers

Containers, when used, are in compliance with applicable national and international regulations meeting the requirements of the loaded goods as well as the requirements for securing the load. SOC type containers are used and are ISO 6346 classified. A VGM is created for each container according to SOLAS regulation and is

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signed by Siemens before dispatch.

4.4 Cover plates, blanking plates

Flanges, couplings and openings are protected during transportation with metal, plywood or plastic plates or covers depending on application. See Section 5 for equipment specific requirements.

4.5 Identification of equipment prior to packing

Equipment items placed in the package are clearly marked with individual drawing numbers.

4.6 Packing note

The packing note identifies the contents of each individual package. The material in each individual package is specified on an item level. Template for packing note - see Figure 10.

Minimum information in the packing note:

1) Project number or Customers order number
2) Storage Class
3) Material number or Equipment part number, for each item
4) AG (Head Group), for each item (if applicable)
5) Description, for each item
6) AL code, European export control classification number, for each item
7) ECCN code, American export control classification number, for each item
8) CO code, Country of origin, for each item
9) CN code or HS code, Custom code
10) Quantity, for each item
11) Unit, for each item
12) Drawing number, for each item

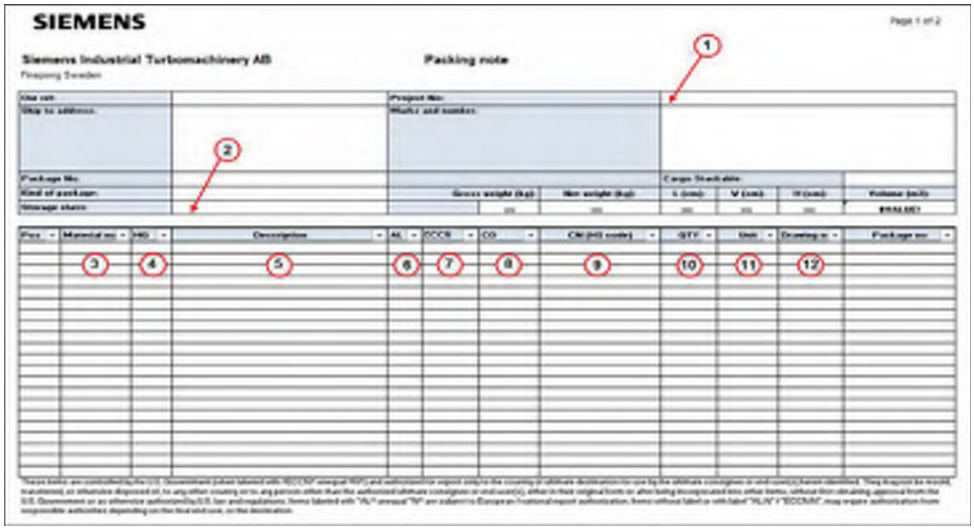

Figure 10: Example of packing note.

A copy of the completed packing note is be placed outside the package under a plastic or metal sheet marked 'packing note' or 'packing-list', see Figure 11.

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Figure 11: Example of packing note under metal sheet.

4.7 Marking of packed equipment

Project specific marking is printed on weatherproof material and nailed on at least two opposite sides. The marking is in suitable size and clearly visible, see Figure 12.

PROJECT:	**XXXXXX**	
GROSS WEIGHT:	**1050**	**KG**
NET WEIGHT:	**750**	**KG**
Dimensions (L x W x H):	**280 X 120 X 98**	**CM**
PKG NO:	**BD000428/GT1/SIT/001**	
DESTINATION:	**YYYYYY**	
STORAGE CLASS:	**D**	
HG:	**4150**	

Figure 12: Example of project specific marking.

Each individual package is marked with package number (PKG NO) at the top of each side. The package numbers are in black digits with a minimum height of 50mm (2”), suitable for the size of the package.

Symbol marking of packed equipment complies with ISO 780 and the additional requirements detailed in Appendix 2 of this standard.

4.8 Hazardous items

All equipment and/or materials defined as hazardous to handle is packed in accordance with ADR/RID/IMDG/IATA-DGR Dangerous or Hazardous Goods Regulations as applicable to the mode of transportation. All necessary documentation accompanies such shipments throughout the journey. Personnel responsible for shipping and packing of such goods shall be suitably qualified and competent and, where applicable, authorized to ensure compliance with statutory legislation.

5. Packing requirements for individual equipment items

5.1 Supplier equipment

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Section	Equipment	Packing Requirement including preservation for <u>storage up to 12 months</u>
5.1.1	**AC Generator** (when not included as part of GT generating set package)	AC generators are preserved and packed strictly in accordance with Supplier specific instructions. However, the following general notes and requirements are relevant: • AC generator covered with VpCI shrink wrap • covered with tarpaulin for transportation • desiccant fitted inside AC generator machine cooling circuit • bearings inhibited with inhibiting oil • open ducts blanked off by plywood with gasket • no wooden paneling • anti-condensation heaters in operation for storage period • lifting lugs protruding outside VpCI wrap, hence AC generator machine is lifted without removal of VpCI shrink wrap locally • transported directly on trailer without a separate base frame (a separate transportation base frame only required if lifting lugs not available) • no requirement to be stackable, even when height less than 3 m Example of AC generator packed:
5.1.2	**Fire Extinguishing System**	For deep sea transportation, the fire extinguishing skid is usually small enough to be delivered inside an ISO container. If supplied from Supplier in ISO container, no external packing is required. Bottles are always packed separately and in an unenclosed rack on a wooden base with heat shrink wrap. If not ISO container is used and height is less than 3 m; wooden case is used. Example of Fire Extinguishing System packed:

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5.1.3	**Electrical and Controls Cabinets**	Wooden case, not stackable due to height & stability (symbol added) with VpCI sponge/emitter inside cabinet. Preservative, foil bag & evacuate air or VpCI impregnated wrap. Desiccant between foil bag / wrap & cab. If relevant, touch screen display (HMI) is removed. Note significant amount of controls equipment is included in Gas Turbine package. Example of Electrical and Controls Cabinets packed:
5.1.4	**Lubricating Oil Cooler** (Air Blast - ABLOC)	Wooden case due to ease of lifting by fork truck & sling lift. Not stackable due to size of matrix and inability to use dunnage timbers within practical reasons, with 'do not stack label'. Ends of pipes capped. See cleaning & sealing standards. Inhibition for vulnerable surfaces. Example of Lubricating Oil Cooler packed in wooden case:
5.1.5	**Lubricating Oil Cooler** (Water Cooled)	Stackable wooden case with height less than 3 m and pipe ends capped. See cleaning & sealing standards. Inhibition for vulnerable surfaces. For sea transportation, would go inside container.
5.1.6	**Combustion Air Inlet Silencers** **Exhaust Silencers**	If less than 3 m height; stackable wooden case with duct ends blanked by plywood or PVC sheet. If above 3 m height; wooden base & heat shrink with duct ends blanked by plywood or PVC sheet. Example of acoustic component <3 m height packed in wooden case:

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	Ventilation Silencers **Ducting**	
5.1.7	**Air Intake Filter Houses**	Wooden base & heat shrink wrap. If greater than 3m, no requirement for stacking. Example of Air Intake Filter House items >3m height packed on wooden base with heat shrink wrap:
5.1.8	**Piping**	Stackable wooden case, in general with a max length of 6 m, with pipe ends capped. See cleaning & sealing standards. Examples of packed Stainless Steel Piping (stackable metal beams):
5.1.9	**Structural Steelwork** (Metal Beams)	Bundles Example of unpacked stackable Structural Steelwork (Metal Beams):

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5.1.10	**ISO Containers**	Example of equipment items shipped in an ISO container:
5.1.11	**GT Package** (with full enclosure) *Core engine can be installed for transportation for all engines except SGT-A65 TR*	SGT-100 to 400, SGT-600, SGT-700 & 750's, SGT-800FixedB2, SGT-A45 TR & SGT-A65 TR. Preservation. SGT-100 to 400 and SGT-A45 TR & SGT-A65 TR Desiccant in GT air intake and inside GT enclosure, VPCI only in end of skid controls JB and all I/O JB's (For SGT-A65 TR, VCPI emitter installed inside GT enclosure also) , un-painted machined surfaces protected by corrosion inhibitor. For SGT-A45 dehumidifier may be used instead of desiccant in GT intake. AC generator - desiccant inside suspended under blanking AC generator anti-condensation heaters for storage > 1 month. SGT-600, SGT-700, SGT-750 & SGT-800 FixedB2 Desiccant inside GT enclosure only, dehumidifiers in GT air intake required during sea transportation and for storage. Desiccant in GT air intake only used if situation occurs where dehumidifier not available or not in operation. If AC generator supplied as part of GT package, anti-condensation heaters for storage > 1 month. If AC generator included as part of GT package and is un-enclosed a tarpaulin is used over the AC generator. Heater required if storage environment <-20 °C to bring package temperature up to -20 °C minimum. Packing. • Duct apertures blanked with steel blanks and gaskets & Denso tape at joints. • SGT-100 to SGT-400 has additional plywood beneath steel blank to give insulation & minimize condensation. Not necessary for SGT-600 to 800 due to use of de-humidifier. • Vulnerable areas are blocked with wood or metal frame. • Possible to walk on package roof structure, including duct apertures, with additional personnel fall protection.

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	Example of SGT-700 GT gen set. No packing or tarpaulin over GT enclosure. Tarpaulin over AC generator:	
5.1.12	**GT Package** (without full enclosure) *For SGT-600 to SGT-800, GT core engine can be transported in package.*	<u>SGT-600 & SGT-700, SGT-A65 TR when there is a transportation height limit</u> Preservation <u>SGT-600 & SGT-700</u> Desiccant inside GT enclosure only, dehumidifiers in GT air intake required during sea transportation and for storage. Desiccant in GT air intake only used in situations where dehumidifier is not available or not in operation. Example of MGT GT package shipped without an enclosure (metal) roof:
	For iTrent, GT core not shipped with package.	<u>SGT-A65 TR</u> Desiccant in GT air intake and inside GT enclosure, VCPI emitter installed inside GT enclosure and all I/O JB's, un-painted machined surfaces protected by corrosion inhibitor. Heater required if storage environment <-20 °C to bring package temperature up to -20 °C minimum. Packing - Duct apertures steel blanks with gaskets plus Denso tape at joints. Plywood roof and tarpaulin over complete package. No requirement to walk on roof, but safety sign must be in place. <u>Example of AGT (SGT-A-65 TR):</u>

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5.1.13	**GT Package Including Core Engine** (without enclosure)	<u>SGT-800, and SGT-750 & SGT-800FixedB2 when there is transportation limits</u> Preservation - Desiccant in GT package area under tarpaulin, dehumidifiers in GT air intake required during sea transportation and for storage. Heater required if storage environment <-20 °C to bring package temperature up to -20 °C minimum. Packing - Duct apertures steel blanks with plywood & gaskets plus Denso tape at joints. Steel frame & plywood roof + tarpaulin over steel frame. <u>Example of SGT-800 covered with heavy duty PVC</u>
5.1.14	**GT Package Excluding Core Engine**	<u>SGT-A30 RB, SGT-A35 RB (full enclosure), SGT-65 TR (partial enclosure)</u> Preservation Desiccant in GT air intake and inside GT enclosure, VPCI only in end of skid control JB's and all I/O JB's, un-painted machined surfaces protected by corrosion inhibitor.

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		Packing Duct apertures steel blanks with plywood & gaskets plus Denso tape at joints. Metal frame & plywood end caps at each end of SGT-A30 RB, SGT-A35 RB packages to protect hydraulic starting system & control panel which are not included in a main enclosure. Other vulnerable areas are blocked with wood or metal frame. Tarpaulin over certain vulnerable areas, e.g. hydraulic start. Example of SGT-A65 TR

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6. Storage location and transportation environments classification codes

The following storage environment location classification codes are defined:

Storage Class	Location type	Definition of storage requirements	Comments	Approximate alignment with IEC 654-1 and IEC 60721-3-1 Climatic Classes (not for Customer and Supplier Packing Standards)
Class 1	*Indoors*, temperature control to 5 °C or greater.	Inside a building or tent where the temperature never drops below 5 °C (+41 °F). The goods shall be stored on a wooden base to allow air circulation and prevent accumulation of water. No contamination with dust, dirt, rain, snow or salt spray (splashing water). Max temperature limits: +5 °C and +40 °C (+41 °F and +104 °F). Sudden changes in temperature >20 °C/hour (36 °F/hour) is not allowed.	Packed equipment which is *very sensitive* to ambient conditions. Included for completeness, but seldom actually used.	B2 & B3 1K2
Class 2	*Indoors*, with no temperature control	Inside a building or tent. The goods shall be stored on a wooden base to allow air circulation and prevent accumulation of water. Protection against air pollution. Max temperature limits: -20 °C and +60 °C (-13 °F and +140 °F). Note - assembled units containing bearings can be sensitive to vibrations.	Packed equipment which is *relatively sensitive* to ambient conditions.	C1
Class 3	*Outdoors,* with additional weather protection	Covered by a tarpaulin or open building roof structure to provide protection against the direct effects of rain, snow, and salt-spray (splashing water), direct sunlight and sand storms. The goods shall be stored on a wooden base to allow air circulation and prevent accumulation of water. Max temperature limits: -40 °C and +60 °C (-13 °F and +140 °F).	Packed material is *relatively insensitive* to ambient factors. Below -40 °C, should not be stored outside	C2 & C3
Class 4	*Outdoors,* without any additional weather	Outdoors, raw materials and material wrapped in plastic from the Supplier does not need any additional protection. The goods shall be stored on a wooden	Packed material is insensitive to ambient climatic or meteorological	D1 & D2

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	protection	base to allow air circulation and prevent accumulation of water. Ambient temperature range -40 °C to +55 °C.	factors *Below -40 °C, should not be stored outside.* For LER's temperature limit is -20 °C For storage locations < 20 °C ambient, this is achieved by heating of the package or stored in a building.	

Note that for all of the above, the packed equipment shall be protected against excessive stacking pressure and mechanical damage.

Note also that if the equipment is unpacked, or partially unpacked, for inspection or Customs reasons during transportation, then the preservation and packing need to be re-implemented. Contact Siemens if further guidance is required. Similarly if packing appears damaged during transportation of storage, further advice from Siemens can be provided.

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Appendix 1: Equipment storage location classification codes after packing in line with this Packing Standard

Piece of Equipment	Packing Method Section 5	Storage Class. Section 6	Piece of Equipment	Packing Method Section 5	Storage Class. Section 6
Exhaust system - diffuser	5.1.6	3	Gas detection system, site [1]	5.1.3	2
Exhaust system - structure	5.1.9	4	Fire extinguishing system (CO2 extinguishing cabinet), site [2]	5.1.2	4
Exhaust system - silencer	5.1.6	4	Gas detection system, workshop	5.1.3	2
Exhaust system – flexible joint	5.1.6	4	Anti-icing system (GT air intake)	5.1.7	4
Ventilation system – inlet system	5.1.6	4	Purge air cooler, liquid cooled	5.1.5	4
Ventilation system – outlet system	5.1.6	4	Seal air cooler, air	5.1.4	4
Ventilation system - filter inserts	5.1.10	3	Purge air cooler, air cooled	5.1.4	4
Inlet silencer (Ventilation or combustion)	5.1.6		Instrument air unit	5.1.6	4
Gas turbine enclosure	5.1.8	3	Maintenance tools	5.1.6	3
Generator enclosure	5.1.8	3	Lube oil cooler air cooled	5.1.4	4
Noise reduction walls	5.1.8	3	Lube oil cooler water cooled	5.1.5	4
Inst. PT/Gear/EG	5.1.6	3	Removal frame for GT core engine/Electrical AC Gen rotor	5.1.9	4
Installation details at site	5.1.8	3	High voltage equipment	5.1.3	2
Piping at site	5.1.8	3	MCC	5.1.3	2
Embedded steel	5.1.8	4	DC-starter	5.1.3	2
Anti-vibration mount	5.1.8	4	UPS	5.1.3	2
Floor plates, stairs	5.1.6	4	UMD/UPS	5.1.3	2
GT Air intake system - structure	5.1.9	4	Battery Module (Cabinet)		4
GT Air intake system - filter house	5.1.7	4	Batteries [1]	5.1.3	2
GT Air intake system - filter inserts (elements)	5.1.10	3	Battery charger [1]	5.1.3	2
GT Air intake system - silencer	5.1.6	3	Frequency converters [1]	5.1.3	2
AC Generator	5.1.1	See Section 5.1.1	Control system [1]	5.1.3	2
Oil purification unit	5.1.6	3	Control panel [1]	5.1.3	2
De-humidifier	5.1.6	3	Auxiliary transformer	5.1.3	2
High speed quill shaft / main drive high speed couplings general	5.1.6	3	Auxiliary power supply diesel	5.1.3	2
SSS-coupling GT/ST//Low speed quill shaft / main drive low speed couplings general	5.1.6	3	Electrical installation material (cables, glands, cable tray etc)	5.1.6	3
Auxiliary gearbox	5.1.6		Spare parts mechanical	5.1.3	2
External gas fuel system	5.1.8	4	Spare parts mechanical, filters	5.1.10	3
Gas fuel unit	5.1.8	3	Spare parts electrical	5.1.3	2
External liquid fuel system	5.1.6	4	Spare parts core	5.1.3	2
Fire extinguishing system, workshop (nozzles & pipework)	5.1.8	2			
Gas detection system, site [1]	5.1.3	2			

[1] Items are installed in the control room or Battery Module, where applicable.

[2] Fire cabinet heater or similar shall be in operation during transportation or storage if ambient temperature is below -5°C.

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Appendix 2: Marking of packed equipment – Extracts from ISO 780, ISO 7000 and ISO 7010

All packed equipment is marked according to the International Standards ISO780, ISO7000 and ISO7010. The symbols are further explained in Table 1 below.

Display of symbols

- Symbols are stenciled directly on the package or on a label.
- Symbols are painted, printed or otherwise reproduced as specified in this International Standard.
- Symbols are not framed by border lines.
- The graphical design of each symbol has only one meaning; symbols are purposely designed so that they can also be stenciled without changing the graphics.

Color of symbols

- The color used for symbols is black.
- If the color of the package is such that the black symbol would not show clearly, a panel of a suitable contrasting color, preferably white, is provided as a background.
- Care is taken to avoid the use of colors which could result in confusion with the labelling of dangerous goods.
- The use of red, orange or yellow is avoided unless regional or national regulations require such use.

Size of symbols

- For normal purposes the overall height of the symbols are 100 mm, 150 mm or 200 mm.
- The size or shape of the package may, however, necessitate use of larger or smaller sizes for the symbols.

Number, location and position of symbols

- The number of identical symbols to be used for any one package depends on its size and shape.
- For symbols No. 1, 3, 7, 11 and 16 [see Table 1], the following rules are applied.
    - **Symbol No. 1**: "*Fragile*", is shown near the left-hand upper corner on all four upright sides of the packages [see example of application under No. 1 in Table 1].
    - **Symbol No. 3**: "*This way up*", appear in the same position as required for symbol No. 1 [see example of a) under No. 3 in Table 1]. Where both symbols are required, symbol No. 3 appear nearer to the corner [see example of application b) under No. 3 in Table 1].
    - **Symbol No. 7**: Where possible, "*Centre of gravity*" is placed on all six sides but at least on the four lateral sides relating to the actual location of the center of gravity [see example of application under No. 7 in Table 1].
    - **Symbol No. 11**: "*Clamp as indicated*".
        - Only appropriately marked packages are handled by clamps.
        - The symbol is positioned on two opposite faces of the package so that it is in the visual range of the clamp truck operator when approaching to carry out operation.
        - The symbol is not marked on those faces of the package intended to be gripped by the clamps.
    - **Symbol No. 16**: "*Sling here*", is placed on at least two opposite faces of the package [see example of application under No. 16 in Table 1].
        - When multiple packages are formed into a unit load, symbols are located so as to ensure they are visible [see example of application c) under No. 3 in Table 1].

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- Particular attention is paid to the correct application of the symbols, as faulty application may lead to misinterpretation.
- Symbols No. 7 and No. 16 are applied in their correct respective positions and in appropriate respective places in order to convey the meaning clearly and fully.

Table 1

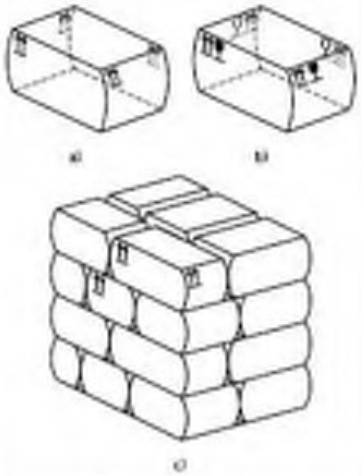
No.	Instruction/ Information	Symbol	Meaning	Reference/Remarks
1	FRAGILE		Contents of the transport package are fragile therefore it shall be handled with care.	ISO 7000, No. 0621 Example of application:
2	USE NO HAND HOOKS		Hooks are prohibited for handling the transport package.	ISO 7000, No. 0622
3	THIS WAY UP		Indicates correct upright position of the transport package.	ISO 7000, No. 0623 Example of application: 
4	KEEP AWAY FROM SUNLIGHT		Transport package shall not be exposed to sunlight.	ISO 7000, No. 0624

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Table 1 — *(Continued)*

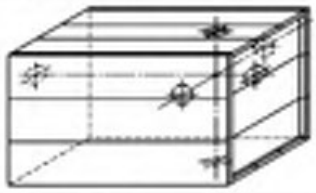
No.	Instruction/ Information	Symbol	Meaning	Reference/Remarks
5	PROTECT FROM RADIOACTIVE SOURCES		Contents of the package may deteriorate or may be rendered totally unusable by penetrating radiation.	ISO 7000, No. 2491
6	KEEP AWAY FROM RAIN		Transport package shall be kept away from rain.	ISO 7000, No. 0626
7	CENTRE OF GRAVITY		Indicates the centre of gravity of the transport package which will be handled as a single unit.	See 2.4.1 and 2.4.3 ISO 7000, No. 0627 Example of application: 
8	DO NOT ROLL		Transport package shall not be rolled.	ISO 7000, No. 2495
9	DO NOT USE HAND TRUCK HERE		Hand trucks shall not be placed on this side when handling the transport package.	ISO 7000, No. 0629
10	USE NO FORKS		Transport package should not be handled by forklift trucks.	ISO 7000, No. 2496

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Table 1 — (Continued)

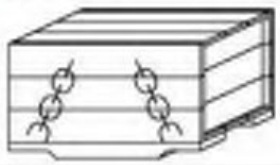
No.	Instruction/ Information	Symbol	Meaning	Reference/Remarks
11	CLAMP AS INDICATED		Clamps shall be placed on the sides indicated for handling the transport package.	See 2.4.1 ISO 7000, No. 0631
12	DO NOT CLAMP AS INDICATED		Transport package should not be handled by the clamps on the sides indicated.	ISO 7000, No. 2404
13	STACKING LIMIT BY MASS		Indicates the maximum stacking load permitted on the transport package.	ISO 7000, No. 0630
14	STACKING LIMIT BY NUMBER		Maximum number of identical packages which may be stacked on one another, where "n" is the limiting number.	See 2.4.4 ISO 7000, No. 2403
15	DO NOT STACK		Stacking of the transport package is not allowed and no load should be placed on the transport package.	ISO 7000, No. 2402
16	SLING HERE		Slings shall be placed where indicated for lifting the transport package.	See 2.4.1 and 2.4.3 ISO 7000, No. 0626 Example of application: 

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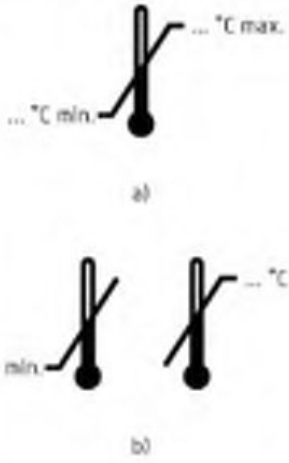
Table 1 — *(Concluded)*

No.	Instruction/ Information	Symbol	Meaning	Reference/Remarks
17	TEMPERATURE LIMITS		Indicates temperature limits within which the transport package shall be stored and handled.	ISO 7000, No. 0632 Examples of applications: 
18	NO STEP		Areas which are unsafe for people to walk or stand on.	ISO 7010

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PRELIMINARY **SITE COST ESTIMATIONS**

Draft Manpower calculations PVSC																														Drawing no.J8201332E Rev.B	
Project Month					1				2				3				4				5				6					Summary Site
SIT Site week					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
Installation/Commissioning																															
GT1 Preparation/Installation				Installation																											
GT1 Commissioning/Performance test/Trial run											Cold Commissioning				Hot Comm.																
GT2 Installation						Installation																									
GT1 Commissioning/Performance test/Trial run													Cold Commissioning				Hot Comm.														
GT3 Installation									Installation																						
GT1 Commissioning/Performance test/Trial run															Cold Commissioning					Hot Comm.										
DCS Installation/Commissioning																															
SCR1 installation																															
SCR1 Commissioning																															
SCR2 Installation																															
SCR2 Commissioning																															
SCR3 installation																															
SCR2 Commissioning																															
Fuel Gas compressor 1 Installation																															
Fuel Gas compressor 1 Commissioning																															
Fuel Gas compressor 2 Installation																															
Fuel Gas compressor 2 Commissioninmg																															
Fuel Gas compressor 3 Installation																															
Fuel Gas compressor 3 Commissioninmg																															
Black Start Diesel Generator Install./Commissioning																															
Lube oil Cooler Installation/Commissioning																															
Performance test																															
Trial run																															
TFA / Installation Specialists																														Manweeks	
																														0	
PM / Site Manager, Power plant																														*0*	
Site Manager, local																														*0*	
SIT GT Mechanical specialist				1	1	2	2	2	2	2	2	2	2	2	2	1	1													*24*	
SIT GT Electrical specialist					1	1	1	2	2	2	2	2	2	1	1	1														*18*	
SIT Inst. Specialist I&C (DCS)									1	1																				*2*	
External Installation SCR											1	2	1	2	1	2	0,5													*9,5*	
External Inst.Fuel Gas Compressor												1	1	1	1	1	1	1	1											*8*	
External Inst. Black Start Diesel														1	1															*2*	
External Installation Lube Oil Cooler														1	1															*2*	
Site Admin, local / secretary																														*0*	
HSE, local Not included in scope																														*0*	
QA/QC																														*0*	
SUBSUM on site	*0*	*0*	*0*	*1*	*2*	*3*	*3*	*4*	*5*	*5*	*5*	*7*	*6*	*8*	*7*	*5*	*2,5*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***65,5***	
Commissioning Specialists																															
Commissioning Manager site																														*0*	
External/DCS Commissioning Advisor																1	1	1	1	1	1	1	1							*8*	
BoP Advisor																														*0*	
GT Com. Engineer Cold Comm.											2	2	4	4	6	4	4	2	2											*30*	
GT Com. Engineer Hot Comm.																2	2	4	4	4	4	2	2	2	2					*28*	
Performance Engineers (& vibration)																				2		2		2						*6*	
External Commissioning SCR													1,0		1,0		1,0													*3*	
External Comm. Gas Compressor																1,0		1,0		1,0										*3*	
External Comm. Black Start Diesel															0,5															*0,5*	
External Comm. Lube Oil Cooler															1,0															*1*	
Spare																														*0*	
SUBSUM on site	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*2*	*5*	*4*	*8,5*	*8*	*8*	*8*	*7*	*8*	*5*	*5*	*3*	*4*	*2*	*0*	*0*	*0*	*0*	***79,5***
Workers for Inst. & Commissioning																															
GT Skilled Mechanical					5	5	10	10	15	15	15	13	12	9	7	4	2	1												*123*	
GT Skilled Electrical					1	2	4	4	6	6	6	6	6	6	4	3	1	1												*56*	
Skilled Welder						1	1	3	3	5	5	5	5	3	3	1	1													*36*	
Painter/Insulator												2	2	2	2	2	2													*12*	
																														0	
SUM Workers very draft figures	*0*	*0*	*0*	*0*	*6*	*8*	*15*	*17*	*24*	*26*	*26*	*26*	*25*	*20*	*16*	*10*	*6*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***227***	

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Customer obligations, Clarifications:

A: Foundations and cable routing ready for installation

Roads and site ready for heavy transport, site ready to receive heavy equipment.
Storage area, offices with telephone and internet connection, construction power and tool stores ready.
Installation manpower according to specification available at site.

B: Lubrication oil available on site

Lubricating oil according to GT Supplier specification available at site if first fill not included in contract.

C: Auxiliary power and internet

Permanent auxiliary power according to contract connected. Internet access for remote connection available.

D: Instrument air supply

Instrument air available at delivery point. (Customer-Siemens interface according to contract).

F: Generator feeding cable connection and interface customer-Siemens connection

High voltage cables connected, tested and ready for energizing. Customer CT and VT for optional relay-protection, synchronizing signals (including breaker signals and interlocks) connected and tested at delivery limit.

E: Fuel (Gas, Oil) connection

Fuel gas/oil according to specification available at delivery point. (Customer-Siemens interface according to contract).

NOTE!

External gas fuel piping (from last shut off valve on customer side) and electrical installation needs approval regarding safety by Siemens Product Acceptance Engineer before pressurization.

G: Load/Grid available

Grid available for synchronization and load tests of gas turbine.

H: Ready for hot gases

Exhaust ducting and HRSG/WHRU if applicable ready for hot commissioning of GT (Customer - Siemens interface according to contract)

NOTE!

The time schedule including manpower allocation is by no means fixed. The schedule is to be regarded as preliminary and the estimates are based on optimal site conditions. The time schedule may be subject to changes depending on the variation in scope of supply and site related information, such as local environmental conditions, site conditions or safety regulations. Deviations due to external and/or environmental conditions will be reported weekly by Siemens personnel on site.

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Commissioning tools

Tools and instruments included in the GT supplier commissioning tool set for the gas turbine unit.

The lists below are typical and may vary for each project depending on project setup, special test demands or requirements.

Common equipment basic kit

Item	#	Item	#
Laptop PC with control software	1	Vibration instrument incl. Transducer	1
Inkjet Printer	1	Phase order tester	1
Insulation tester 1000V	1	Communication kit (including wiring)	1
Adapter for isolation barrier calibration	1	Stop watch	1
Digital multimeter Fluke 179	1	Resistance decade box	1
Digital multimeter Fluke 185/287	1	Pressure calibration pump 0-20 MPa	1
Temp indicator Fluke 54 II	1	DPI104 Pressure transmitter 0-200 kPa(a)	1
Hand held temp instr. (incl. 3 thermometers)	1	DPI104 Pressure transmitter 0-70 kPa	1
Data acquisition logger	1	DPI104 Pressure transmitter 0-7 MPa	1
Temperature and current calibrator Unomat	1	WIKA Pressure indicator 2 channels	1
Oscilloscope	1	WIKA Pressure transmitter 0-250 kPa(a)	1
Process meter (4-20 mA)	1	WIKA Pressure transmitter 0-400 kPa	1
Current clamp (0-300 A)	1	WIKA Pressure transmitter 0-2,5 MPa	2
Sine wave generator	1	WIKA Pressure transmitter 0-6 MPa	1

Application dependant equipment

Item	Note	#
Relay test instrument 0-100A 10V	Power generation application	1
Laptop PC equipped with relay testing software	Power generation application	1
Potentiometer for relay test instrument	Power generation application	1
Earthing-clamps for generator testing	Power generation application	2
5000V Isolation tester	Power generation application	1
Analog multimeter	Power generation application	1
Extra earthing-clamps for generator testing	SGT-800	1
Gas indicator 0-100LEL	Gas fuel	1
Aerometer 0,75-0,95	Liquid fuel	1
Extra WIKA Pressure transmitter 0-6 MPa	SGT-500, liquid fuel	1
DPI104 Pressure transmitter 0-35 MPa	SGT-700/SGT-800 liquid fuel	1

BU / SGT-600(MD B, PG B, PG EX B) SGT-700(MD B, PG B, PG EX B)
SGT-750 (PG A)/&BE101 SGT-800(PG B, PG B2, PG Ex B2, PG B LS)/ &EC102

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Consumable kit

Item	#	Item	#
BNC-banana jack out 4mm	6	Sealing washer T3704-110	4
Reducing socket Phoenix	50	Resistor kit 60-158-08	1
Test pin black 40-4410-3	3	Electric torch	2
Test pin red 40-4412-9	3	Set of assorted fuses	1
Alligator clip red	4	Graduated cylinder 100ml	1
Alligator clip black	4	Graduated cylinder 500ml	1
Terminal, plastic 48-355-59	2	2 step ladder	1
Battery 1.5V R14	12	Padlock ABUS	15
Battery 9V	6	Lock fittings small	5
Battery 1.5V R20	12	Lock fittings large	5
Battery 1.5V LR6	12	Lock fitting operation blocker	10
Thread seal tape, Teflon	2	Padlock for MCB	10
Fabric tape width 38mm	2	Lock fittings for MCB	10
Electric isolation tape	2	Compressor detergent (Turbotect 950) 20l	2
Masking tape width 25mm	1	Conical Strainer 3” (Gas)	1
Locking wire 25m	1	Conical Strainer 4” (Gas)	2
Hearing protector	5	Conical Strainer 2” (Diesel)	1
Ferrule, Ø8mm	16	Protective gloves	20
Ferrule, Ø12mm	10	Roll of wiping cloth	2
Plug for pipe coupling Ø8mm	5	Emery cloth 100	1
Nipple NW4	5	Emery cloth 220	1
Seamless piping Ø8mm (1.5m)	2	Straps 4,7x200	200
Seamless piping Ø12mm (2m)	2	Straps 2,5x100	200
T-coupling Ø8mm	4	Bunting 1,5m	1
T-coupling NW4 (TEMETOXT6L)	4	Filter cloth 200x1300	1
Joint R ¼-NW4	7	Sealing material (klingerit 1mm) 2,5 kg	1
Joint 8mm-NW4	5	Protective gloves	4
Pipe coupling, straight 8-12mm	4	Filter element	2
Pipe coupling, straight 8-8mm	4	Transmitter adjustment key	3
Coupling 8mm-R1/4	3	Sealing (oil flowmeter) DN40	4
Coupling 8mm-R1/4 NPT	3	Sealing (oil flowmeter) DN25	4
Union NW4-NW4 Argus	5	Bolt (oil flowmeter) M16	8
Nipple NW4/R ¼	2	Bolt (oil flowmeter) M20	8
Tube nut	11	Sealing for 2” strainer	2
Tube nut NW4 Argus	5	Sealing for 3” strainer	4
Sealing washer Ø18x13.5x1	7	Sealing for 4” strainer	4
Sealing washer Ø26x17x2	5	Warning sign “energized”	5
Sealing washer copper Ø31x21x2	5	Warning sign “in operation”	5
Sealing washer Ø18.5x12x5	5	Warning sign “not operate”	5
Sealing washer Ø11.3x7x4.5	5	Protective helmets	3
Flexible tube, plastic 10m	1	Multiway socket 230V, 3-4 outlets	3
Sample bottle 1L	8	Extension cable 230V 10m	3
Needle valve	2	Coax cable, BNC-BNC-banana jack	2
Nipple 1CSA8048-1	2	Telescope test probe	2

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Nipple 1852422-1	2	Flexible tube, 1m 2TE5 A0A0-1000P	5
Flexible tube, 5m 2TE5 A0A0-5000P	2	Banana jack cable 50cm	10
Banana jack cable 100cm	10	Banana jack cable 200cm	20

Coupling kit Parker

Item	#	Item	#
Quick couplings	9	T-couplings	2
Ferrules	20	Pipe couplings	6
Plugs	16	Coupling nuts	7
Adapters	5	Intermediate piece to flexible tube	7
Straight couplings	6		

Coupling kit Swagelok

Item	#	Item	#
Plugs	8	T-connector	2
Pipe connectors	6	Unions	21

Hand tool kit

Item	#	Item	#
Tool box 500x200x300mm	1	Hand file medium 10"	1
Padlock	1	File half-round fine 10"	1
Style scissors 250mm	1	File round medium 8"	1
Screwdriver 0,5x3,0	1	Pin-file fine 6"	1
Screwdriver 0,8x4,0	1	Centre punch, Ø4mm	1
Terminal screwdriver Large	1	Driftpin, Ø2mm	1
Terminal screwdriver Small	1	Driftpin, Ø3mm	1
Set of U-Ring spanners, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 22, 24, 27, 32 and 36 mm.	1	Driftpin, Ø5mm	1
U-wrench 36mm	1	Gasket knife	1
U-wrench 41mm	1	Cold chisel	1
Combination pliers, insulated	1	Set of hollow punches 7, 11, 12 and 14mm	1
Crocodile spanner	1	Drill cassette Ø1.0-10.5mm	1
Polygrip wrench 250mm	1	Electric torch magnet	3
Retaining ring pliers, outer	1	Ball hammer 0,8kg	1
Retaining ring pliers, inner	1	Adjustable pin spanner Ø2.9m	1
Adjustable spanner 0-30mm	1	Adjustable pin spanner Ø3.8mm	1
Adjustable spanner 0-34mm	1	Hack saw 300mm	1
Set of Allen keys 8, 10, 11 and 12 mm	1	Hack saw blade, 24 teeth /inch	10
Torque wrench 10-100nm	1	Batteries 1,5 V r20	8
Socket wrench kit ½" 10-32 mm	1	Safety harness	1
Bevel	1	Torque Wrench (40-340 Nm)	1
Electric torch EX	1		

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Division of work – technical advisory services

Introduction

Siemens delivery is limited to *technical advisory services during installation.* The installation is carried out by the Customer supported by an advisory team provided by Siemens. If the geographical location of the installation is in an area or country classified as unsafe (risk country) by CSO (Siemens Corporate Security Office) Siemens reserves the right to have a minimum of 2 Siemens' personnel continuously during the installation and commissioning to avoid solitary work.

Siemens obligations

Siemens provides input for planning and specification of the site work related to the Siemens delivery. Further Siemens personnel acts as advisors during the installation work and performs commissioning of Siemens delivery. Siemens team consists of technical field advisors (mechanical and electrical) and commissioning engineers for commissioning activities. Siemens reserves the right to change site personnel to comply with local law, visa regulations, and terms of employment of Siemens' personnel or for operational reasons. Please refer to Time Schedule for Installation and Commissioning the estimated time required for installation and commissioning. All non-Siemens personnel including acts and work performed by such personnel is the sole responsibility of the customer. Under no circumstances shall Siemens bear any responsibility or be liable for any act or work performed by non-Siemens personnel.

Customer obligations

The Customer shall provide the necessary number and categories of skilled workers, cranes (including crane operators and appropriate insurance), tools, material handling equipment and general site facilities. The required manpower is listed in Time Schedule for Installation and Commissioning. Siemens reserves the right to request replacement of any workers and/or additional workers and other resources if necessary in order to achieve the required quality and efficiency of the site work

Further in order to enable the site work to proceed as smoothly and quick as possible, the customer shall make available all necessary tools and general site facilities, including but not limited to the items listed in the Division of Scope and Obligations.

Division of scope and obligations

Siemens = S Customer = C	Arranged by		Paid by		Reference code in time schedule	Additional information and comments
	S	C	S	C		
General:						
Permits		X		X	A	Including those required to build the plant and to dispose packing material and waste
Inspections required by regulations, authorities and statutory law		X		X		

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Siemens = S Customer = C	Arranged by		Paid by		Reference code in time schedule	Additional information and comments
	S	C	S	C		
Personnel:						
Installation technical advisors and commissioning engineers including travel to and from country of installation	X		X			
Transport of technical advisors and commissioning engineers in country of installation	X		X			
Accommodation for installation technical advisors and commissioning engineers	X		X			
Daily transports for installation technical advisors and commissioning engineers	X		X			
Labour for installation		X		X	A	
Assisting labour during commissioning if required		X		X	C	
Supervision and/or Technical Field Advisory Services for installation of equipment outside Siemens scope		X		X		

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Siemens = S Customer = C	Arranged by		Paid by		Reference code in time schedule	Additional information and comments
	S	C	S	C		
Site facilities:						
Health and safety requirements					A	According to K-9595-35
First aid material and medical facility		X		X	A	
Office with furniture Heated, air conditioned if required		X		X	A	2 x 10 m^2 (2x100ft^2) According to K-9595-36
Telephone, cell phone network		X		X	A	
Cell phones	X		X			
Internet connection		X		X	A	Min. 10Mbit/s
Ventilated changing-room and washing facilities		X		X	A	According to document K-9595-36
Ventilated sanitary facilities		X		X	A	According to document K-9595-36
Dining place/Canteen Heated, air conditioned if required		X		X	A	According to document K-9595-36
Cleaning of offices, changing rooms, sanitary facilities, dining places and stores		X		X	A	
Waste disposal/transportation		X		X	A	Including packing material
Site security and guarding the plant		X		X	A	
Firefighting and safety equipment		X		X	A	
Storage outdoor Clear and accessible hard standing site area		X		X	A	800m^2 (8000ft^2)
Store, indoor		X		X	A	70 m^2 (750ft^2) Heated, air conditioned if required

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Siemens = S Customer = C	Arranged by		Paid by		Reference code in time schedule	Additional information and comments
	S	C	S	C		
Installation and commissioning equipment:						
Tools for installation		X		X	A	According to document 1CS80303
Welding equipment		X		X	A	According to document 1CS80303
Tool storage		X		X	A	Equal to document 1CS80303
Load weight and equipment for proof load test of GT-unit lifting equipment		X		X	B	According to document 1CS102366
Special tools and instruments	X		X			According to document 1CS33784
Cranes (approx. sizes, actual size and duration pending on site conditions)		X		X	A	150-300 ton (165-350 USt) , 2-3 days for unloading 80 ton (90USt), 1 week 25 ton (30USt), 4 weeks
Other lifting equipment		X		X	A	Fork lift 3-4 ton (3-4,5 USt), 5 weeks MEWP 8 m (25 feet), 5 weeks
Lifting and transport aids		X		X	A	Jacks, blocks, struts, lifting beams etc.
Electrical supply and distribution equipment		X		X	A	
Scaffoldings		X		X	A	
Works:						
Ground and civil work incl. foundations		X		X		
Mechanical installation incl. alignments		X		X		
Piping installation		X		X		
Electrical installation		X		X		
Instrument installation		X		X		
Proof load test of GT-unit lifting equipment		X		X	B	According to document 1CS102366
Transport of goods and equipment on site		X		X	A	
Preparations of roads and unloading surfaces		X		X	A	14 ton (15USt) single axles 18 ton (20USt) double axles
Reception and unloading goods on site		X		X	A	
Touch-up painting		X		X	B	

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Siemens = S Customer = C	Arranged by		Paid by		Reference code in time schedule	Additional information and comments
	S	C	S	C		
Site utilities:						
Compressed air		X		X	A	7 bar, 3Nm³/min (100psi @100Sft³/min)
Water for drinking, washing		X		X	A	
Water for commissioning and hydro tests		X		X	B	
Auxiliary lighting		X		X	A	During site activities
Drainage		X		X	A	
Electrical power supply for installation		X		X	A	1 phase/3 phase, 50kW incl. cables for one GT unit
Electrical power supply for commissioning		X		X	C	According to project load list
Ventilation		X		X	A	
First lube oil fill of gas turbine		X		X	B	Siemens supply optional
First fill transformer cooling oil		X		X	B	
Fuel		X		X	E	

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SIEMENS	Installation & Commissioning SGT-600, SGT-700	GTI number		J840029E	
		Document number		1CS26652	
		Revision	L	Page	1

Installation procedure

Introduction

This document is valid for SGT-600/700, Power Generation Application.

Installation on site takes place when Customer's obligations according to the project time schedule are completed and the gas turbine generator unit arrives at the site.

Where Siemens delivery is limited to *Technical Advisory Services during installation* the installation is carried out by the Customer supported by an advisory team provided by Siemens. The Customer provides labor, tools, cranes and general facilities at his account.

The installation on site officially starts with a kickoff-meeting between the Customer and the Siemens advisory team concerning the installation procedure, time schedule, security rules etc. to clarify questions that either the customer or supplier may have.

1. Installation of gas turbine unit

Inspection and preparation of site

Dimensional check of foundation. Marking out of co-ordinates and zero-point and check together with boiler supplier (if applicable) that common centre line can be achieved.

Arrangement of personnel office and storage facilities.

Connection of electrical power for installation.

Unloading and reception of material

Unloading of material from Siemens and other suppliers.

Unpacking and inspection of material.

Reports to be made about any damages that may have occurred during the transport.

Installation of GT-unit

Installation of fixation details in position.

Placing of GT-unit (and generator) on foundation.

Installation of GT-unit and generator unit (Depending of transport condition).

Position complete GT-unit in relation to centre lines.

Installation of enclosure top half (Depending of transport condition).

BU / SGT-600(PG B, PG EX B), SGT-700(PG B, PG EX B)/&DC102	

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Installation of air intake system

Installation of steel support structure for air intake and exhaust duct.

Installation of silencer and air intake duct.

Assembly of air intake filter house before positioning on top of air intake duct.

For details refer to filter manufacturer's drawing.

Installation of AC Generator air intake and filter house.

Installation of GT-ventilation system

Installation of GT-ventilation ducts.

Installation of fans.

Installation of AC Generator outlet ventilation duct.

Installation of exhaust system

Installation of exhaust duct.

Installation of silencer and stack.

Mounting of sealing between exhaust duct and enclosure.

Insulation of exhaust system.

Walkways and stairs

Installation of platforms stairs and ladders for the complete gas turbine unit.

2. Auxiliary system

Installation of auxiliary units

Placing of gas fuel unit 1.

Installation of lube oil cooler.

Installation of purge air cooler (if applicable).

Installation of seal air cooler.

Connection of piping.

Piping

Fitting, welding, testing, insulation and cleaning of pipes for lube oil system, fuel supply system, sealing air system, water and anti-icing system etc. (if applicable).

Site fabrication and installation of small bore piping.

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Filling of lubricating oil

Filling of lubricating oil.

Oil samples to be taken.

Final alignment

Check final alignment of complete GT-unit after filling of lube oil.

3. Installation of electrical equipment

Installation of control module

Installation of control module to the GT skid.

Cabling, electrical connection and earthing

Installation of cable trays to air intake.

Pulling of control and power cables from control module to electrical units and equipment (extend equipment not included in main GT module which is complete with cabling from workshop).

Connection of control and power cables to its terminals in junction boxes, control cubicles and auxiliary equipment.

Earthing of buildings.

4. Completions

Final adjustment, touch up painting and cleaning.

Labelling.

Handing over installation tools (if included).

Handing over of spare parts (if included).

Site Termination.

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		Document number		1CS80303	
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Installation tools

Tools according to the list below are necessary in order to enable the installation to proceed without interruption. Depending on project-specific content or conditions, additional tools may be required. When Siemens delivery is limited to *technical advisory services during installation* the Customer is expected to provide all tools, or alternatively rent the tools from Siemens.

When the Siemens delivery includes complete installation, Siemens will provide the necessary tools.

Description	Dim / Size	Amount
Tool container 20 feet	-	1
Fire extinguisher CO2 (erected in container)	5 kg	1
Pad lock for container	-	1
Toolbox	-	1
Nail claw	-	1
Crow bar	600mm	2
Adjustable ladder alum.	2,85 - 5,0 m	1
Adjustable ladder alum.	5,70 - 10,0 m	1
Adjust. tap holder tool	4,5 - 11,2 mm	1
Adjust. tap holder tool	7,1 - 20,0 mm	1
Adjust. tap holder tool	16 - 32 mm	1
Allen key	8 - 19 mm	2 each
Allen key box	1,5 - 8 mm	2
Allen key box inch	1/16 - ¾	1
Angle drilling machine	-	1

Description	Dim / Size	Amount
Chain block	1500 kg	2
Chain block	2500 kg	1
Heavy duty ring spanner 32-36-41-46-55-65-75mm	32-75mm	1 each
Angle grinder + discs	5" and 7"	20 each
Argon welding set, full equip.	-	1
Besom	-	2
Bench Grinding machine	-	1
Scriber	-	5
Electric nut runner	-	1
Bench Brush	-	2
Bench cutting machine	-	1
Bench drilling machine + vice	-	1
Working bench with	800x1500	2
Centre punch	120 mm	3
Bow saw for wood	-	1

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Description	Dim / Size	Amount
Cold chisel	-	5
Combination pliers	180 mm	1
Compass saw for iron	-	1
Complete set of gas welding equip	-	1
Cord sling	800 kg/3m.	4
Core bar	450 mm	4
Degree angle	300 mm	1
Depth gauge	0-500 mm	1
Depth gauge micrometer	0-200 mm	1
Dial gauge	0-10 mm	4
Die plate	M24 x 1,5	1
Die plate	M3 - M30	1 each
Die Stocks for Ditto	different	1
Drifting mandrel	2,0 - 10 mm	2 each
Drill box	1,0 - 5,9 mm	3
Drill box	6,0 - 13,0	3
Fire extinguisher CO2	2 kg	2
Fire extinguisher CO2	5 kg	2
Flash light	-	4
Scraper high speed steel	620-25 mm	3
El. socket box	10/16 amp	2

Description	Dim / Size	Amount
El. socket box	10/32 amp	1
El. socket box	10/63 amp	1
El. socket box	5 x10 amp	2
Extension lead with socket	16 & 32 amp	3 each
Extension L=125 and 250 mm	1/2"	2 each
Extension	3/4-200mm	1
Extension	3/4-500mm	1
Extension lead	230 V 20m	6
Ex. lead with 2 sockets	230 V	4
Flat file 10"MGR, 10"MF, 10"F	-	2 each
Extension lead with socket	63 amp	5
Side cutter	150 mm	3
Eye bolt	M10-12-16-20	4 each
Flat nose pliers	L = 160 mm	2
Feeler gauge L = 100&200mm	0,05-1,0 mm	1 each
Figure cutter / right and left	280 mm	1 each
Filter for breathing	paper	10
Protection goggles	-	4
Iron bar	1500 mm	1
Knife	99mm	3
Ladder	3-5 m	1

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Description	Dim / Size	Amount
Reamer	30 mm 1/50	1
Drills	29-29,5-30mm	1 each
U-ring spanner	10-24 mm	4 each
U-ring spanner 27-30-32-36 mm	27-36 mm	2 each
Fluorescent light	-	4
Fluorescent light	24V	2
Gasket cutter	D = 200 mm	1
Gasket cutter	D =400 mm	1
Grinding pin	38 x 13 x 6	10
Hack saw	-	2
Hack saw blades	-	20
Half round file	10" MGR	3
Drilling machine	13mm chuck	1
Battery drilling machine	-	2
Round needle file	80 mm	3
Hearing protection	-	10
Plastic hammer	-	1
Machine spirit level	200 x 200 mm	1
Magnetic holder for dial gauge	complete	6
Marker string and Chalk	30 m	1

Description	Dim / Size	Amount
Ladder	5-8 m	1
Insp.lamp transf & flash lamp	-	1
Hydraulic jack	15 ton	4
Hollow punches	2-26 mm	1 each
Hydraulic jack	40 ton	2
Hydraulic jack	28 ton	2
Lifting sling	2 ton/4m	4
Lifting sling	4 ton/6m	4
Lifting sling	6 ton/8m	4
Lifting sling	8 ton/8m	4
Levelling instruments & stands	-	1
Lever pulley block	500/1000 kg	1
Pipe bending tools	8-25 mm	1
Pipe cutter	3-25/ 6-60 mm	1 each
Pipe wrench small & large	370 / 565 mm	1 each
Universal joint	1/2 - tap	1
Polygrip pliers	L = 240 mm	3
Rot file hard metal	6x12 with ball	2
Power sockets 30-36-46-55-65 mm	30-65 mm	1 each
Pulley bracket	20 ton	4

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Description	Dim / Size	Amount
Measure tape	0 - 2000 mm	10
Measure tape	0-30 m	1
Oil can	-	1
Oil filter pump trolley for oil flushing	spare filters 2	1
Pen hammer	-	1
Spare drills	10,5-11-12-13	5 each
Spare drills	3,3-4,5-5,0-5,4-6,8	30 each
Shovel long handle	-	1
Spirit level	300 mm	2
Spirit level	600 mm	1
Spirit level	1500 mm	1
Square angle	150 & 200 mm	1 each
Screw driver cross sm-m-large	8 x 150mm	2 each
Step ladder aluminium	2,0 m	2
Plump bob with line	-	2
Shackle with bolt	M12-M16-M30	4 each
Sledge hammer	1,5 kg	1
Socket set mm	1/2"mm	2
Sockets 1/2" mm	27-32	2 each
Steel straight edge	0-2000 mm	1

Description	Dim / Size	Amount
Ratchet handle	3/4 "- tap	1
Reducer joint	1/2- 3/4 "	2
Rivet pliers	240 mm	2
Screwdriver cross sm-m-large	4 x 150 mm	2 each
Rot. file hard metal	6x 12x 25 mm	6
Rot. file machine	220V	1
Spare Drills	6,8-8,5-10-10,2	10 each
Safety helmet (hard hat)	-	10
Safety wire	-	25m
Plate shears/straight	250 mm	1
Safety belt	-	1
ratchet handle	1/2 " - tap	1
Clamp ring pliers straight & bend	1,0x140 mm	1 each
Torch lamps	-	6
U-spanner 46-55-65-75 mm	46-75 mm	1 each
Tool holder with ratchet	0-8,0 mm	1
Torque converter	TD-1000-	1
Torque wrench	40-340 Nm	1
Torque wrench	200x800 Nm	1
Hydraulic torque wrench	Adjustable up to 4800 Nm	1

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Description	Dim / Size	Amount
Power sockets for hydraulic torque wrench	46, 55, 65, 75 mm	1 each
Hydraulic ring spanner (valid for Siemens generator)	65 or 75 mm, depending on applic.	1
Steel straight edge graduated	0-300 mm	2
Steel straight edge graduated	0-1000 mm	1
Welding gloves	2-fingers	4
T-handle	1/2" - tap	1
Tap 1/4" -1/2" - 5/8"-3/4" - 1 pipe	1/4" -1" pipe	1 each
Hammer drill machine	13 mm shuck	1
Drill for ditto 5,5-8-10-12-16-20 mm	L=100-180 mm	5 each

Description	Dim / Size	Amount
Turnable plate for pulley bracket	20 ton	4
Tap M3-4-5-6-8-10-12-16-20-24-30	M3-M30	2 each
Vacuum cleaner industrial type	-	1
Vernier gauge	0-150 mm	4
Welding clamp	50-225 mm	3
Welding plier	-	2
Welding machine, complete Pre-heating eqp. may be needed	-	1
Laser alignment equipment, Rotalign Ultra	-	1
Trolley 4 wheeled	small	1

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SIEMENS	Inspection, Erection, Testing SGT-600	GTI number		J852009E	
		Document number		1CS26653	
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Mechanical running test

General

This document describes how the mechanical running test of the SGT-600 gas turbines is conducted at Siemens test rig in Finspong, Sweden.

Mechanical running test of the SGT-600 gas generator and power turbine at the workshop test stand takes place after engine assembly is completed.

Main gearbox, generator, electrical and auxiliary systems needed for the test is part of the test facility. The electrical output is absorbed by a resistive load bank and partly by grid.

The test is run on liquid fuel, diesel oil.

The performance test will be carried out at two load points, approx. 75% and 100% load. Performance is evaluated according to ISO2314, where applicable.

Recalculation to any site condition and fuel composition can be done.

Test procedure

Idle tests

The following checks and tests are performed during the first test-run:

Start and check of the starting sequence.

Check of temperatures and accelerations during start.

Check of lubricating oil temperatures to and from bearings.

Check of running down times.

General visual check of the complete unit including auxiliary systems for tightness, pipe vibrations etc.

Measurements and evaluation according to the performance measurement and vibration analysis procedures and recording according to the instrumentation reading schedule.

Load and performance test

The load is increased in steps up to full load. At each step performance measurements and evaluations are carried out after stability is reached. Instrumentation reading and recording is carried out and the values are checked. When increasing the load between the steps the vibration levels are continuously monitored.

Load and performance test is normally carried out at two load steps. See also sheet 4 Running profile at load test.

Performance measurements and evaluation procedure

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The data logging system measures inlet air conditions, electric power output, fuel flow and temperatures and pressures in the gas turbine cycle with high accuracy. Also a number of supervision and check measurements are taken.

Evaluation of test data is done by using an evaluation program, which basically is a heat balance program.

At the mechanical running test the gas turbine is operated up to base load rating on liquid fuel in steps as described before. (See also section Measuring Stations).

The instrument calibration procedure is part of our Quality Instructions.

Vibration measurement and analysis procedure

Vibration measurements are made by using installed vibration transducers (L1, L2, L3 and L4), located in vertical direction on the bearing housings. Data collection is made by means of a PC computer system, and is evaluated in forms of tables, FFT spectra and graphs. The graphs consist of vibrations (RMS and rotor harmonics) versus speed, load and time.

Measurements are taken at all steady and transient conditions during the test.

The approval document contains basic vibration information, i.e. bearing vibration vs. time and load.

Instrumentation reading and recording schedule

At each step of the load test a reading and manual recording of all supervision instrumentation is carried out.

In connection with the manual recording at each load step a visual inspection of the unit is performed. Before increasing the load for the next load step a check of recorded values is completed by the test engineer.

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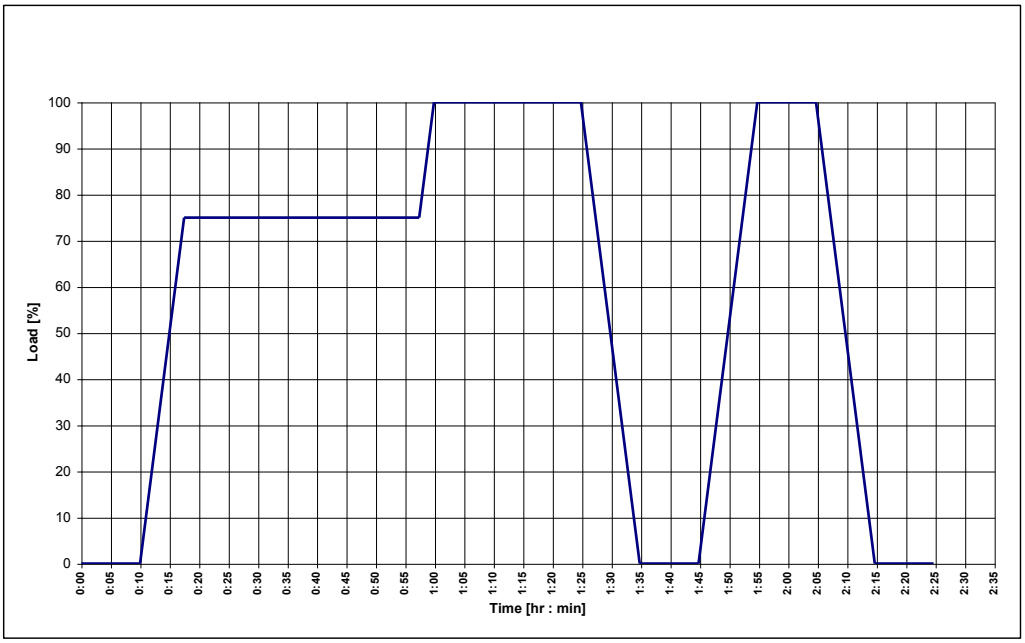
Running profile at load test



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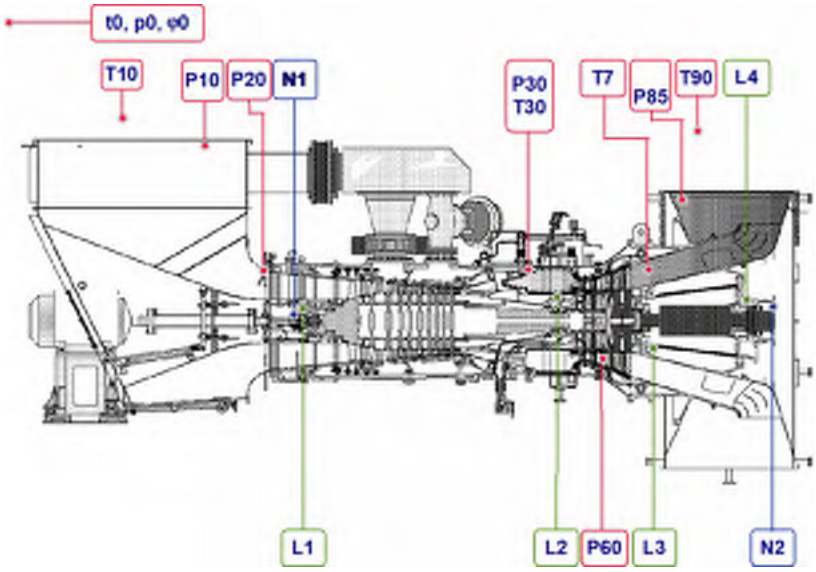
Measuring stations



Station number	Location	Unit	No points	Remarks
N1	Gas generator rotor speed	RPM	1	
N2	Power turbine rotor speed	RPM	1	
T0	Ambient air temperature	°C	1	Manual reading
P0	Ambient air pressure	bar(a)	1	
φ0	Ambient air humidity	%	1	
Pel	Generator output	kW	1	
Vf	Fuel volume flow	L/s	1	
Tf	Fuel temperature at flow meter	°C	1	
T10	Ambient air temperature	°C	9	At air intake
P10	Pressure before inlet casing	bar(g)	1	
T30	Temperature after compressor	°C	3	
P30	Pressure after compressor	bar(g)	3	
P60	Pressure after gas generator	bar(g)	3	
T7	Exhaust temperature	°C	16	From Master log sheet
P85	Pressure after power turbine	bar(g)	1	
T90	Exhaust temperature	°C	5x4	Mounted in 4 special probes
L1	Vibration bearing 1	mm/s	1	
L2	Vibration bearing 2	mm/s	1	
L3	Vibration bearing 3	mm/s	1	
L4	Vibration bearing 4	mm/s	1	

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		Document number		1CS176823	
		Revision	B	Page	1

Witnessing of unit control panel and package system FAT

Unit control panel and package FAT

Prior to witnessing of FAT the standard unit control panel and package system FAT is made according to W630054E.

Witness FAT

During a one day session a selection of checks according to "Protocol Witnessing of Unit Control Panel and Package System FAT Basic Scope" and "Protocol Witnessing of Unit Control Panel and Package System FAT Rotating Scope" are performed.

Upon request these tests can be witnessed, refer to factory inspections section in scope of supply for inclusion:

- Calibration check of transmitters/transducers
- Random check of control system I/O
- Test of alarm and shutdowns
- Function test lubrication oil system
- Function check of barring/purging system

The automatic start-up of the complete unit including installed auxiliary systems is function tested. The FAT is terminated with this sequence test when package systems and control system are verified to a level where the gas turbine is ready for ignition.

BU / SGT-600(PG B, PG Ex B), SGT-700(PG B, PG Ex B), SGT-750 (PG A)/&EC107	

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		Document number		1CS41421	
		Revision	E	Page	1

72 Hour reliability run

The GT installation shall be operated under normal commercial operation delivering electricity or process supply according to Customer's nominal demands.

Prior to the Reliability Run rotating commissioning including handling tests should be completed according to standard commissioning program.

The Reliability Run shall be a continuous period of operation demonstrating the reliability of the GT installation. The Reliability Run shall start with a cold unit, loaded with normal rate and continue for 72 hours at load according to Customer's demand. After 72 hours operation unit is unloaded with normal rate and stopped. Another start with warm unit will be done loading with normal rate to base load or maximum available load for 1 hour. The Reliability Run ends with unloading unit at normal rate and stop.

During the 72 hours operation period, the Contractor shall be allowed to make any minor adjustments which may be necessary, provided that such adjustments not result in shutdown of unit.

If a shutdown within the Contractors responsibility, occurs in the GT installation during 72 hour operation:

72 hours period shall be repeated after the Contractor has remedied the defect.

If a failure or shutdown within the Contractors responsibility, occurs in the GT installation during warm restart:

Warm start shall be repeated after the Contractor has remedied the defect.

If a shutdown outside the Contractors responsibility, occurs in the GT installation during 72 hour operation:

72 hours period shall continue at time counted when interruption occurred after the Customer has remedied the defect or analysed the reason.

If the shutdown occurred at load according to Customer's demand and restart is made within one hour, warm restart after 72 hours can be excluded.

If a failure or shutdown outside the Contractors responsibility, occurs in the GT installation during warm restart:

Warm start shall be repeated after the Customer has remedied the defect or analysed the reason.

BU / SGT-600(MD B,PG B, PG EX B) SGT-700(MD B,PG B, PG EX B) SGT-800(PG B, PG B2, PG Ex B2, PG B LS) / &EC107

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Commissioning procedure, power generation application

General

Commissioning on site takes place when the installation of the gas turbine unit is in the final phase. Installation of some external systems and customer options are completed in parallel with commissioning.

The commissioning procedure follows a set programme, consisting of a stationary test and a rotating test (pre-commissioning and hot commissioning).

The extent of site commissioning will depend upon the agreed scope of workshop test and whether a optional string test is carried out at the Siemens test facility. Some systems below are valid depending on application.

Stationary tests excluded from previous workshop tests are completed by checking components against P&ID´s and circuit diagrams, settings according to setting lists and functional checks according to checklists and circuit diagrams. For units without local control room, additional loop checks will be carried out for cabling installed on site.

The rotating test consists of checks and adjustments of the complete GT unit in order to achieve expected operating behaviour.

When the commissioning team arrives to site, the commissioning leader together with the customer shall go through the test program for rotating commissioning and trial run if included. The starts/tests that are subscribed in the program/contract is considered enough for take-over. All extra starts/tests that the customer requires have to be agreed with project manager preferably approved in written form.

The customer shall declare which starts/tests he wishes to witness prior to commissioning start up to keep number of starts as low as possible.

Stationary tests

Stationary commissioning start up

The work shop test reports are examined before start-up of each system.

The low voltage switchgear is tested regarding insulation and protective earthing before energising.

The auxiliary power phase sequence is checked and power to the control room is connected.

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Commissioning of systems

Gas turbine unit

The gas turbine system is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the Visual Display Unit (VDU).

Function test of starter motor, with gas-generator rotation.

Function tests of bleed-valves and inlet guide vane.

Function test of combustor by-pass valves if included.

Function check of flame detector.

Main gear

The main gear is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

Air intake system

The air intake is not subject to workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

The system is checked against system drawings and circuit diagram.

Instruments are tested according to component tests.

System functions are verified against system description.

Visual inspection and check of air intake filters, silencer and intake housing.

Functional test of any fans or motors related to the air intake filters.

Fire extinguishing, gas detection and ventilation system

The fire extinguishing, gas detection and ventilation system is not subject to workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

The system is checked against system drawings and circuit diagram.

Instruments are tested according to component tests.

System functions are verified against system description.

The pressure in the fire extinguishing agent bottle(s) is checked.

The function of the fire extinguishing system is tested, by simulating release signal from all detectors to verify alarms and function of fire dampers.

The function of the ventilation system is tested, and enclosure pressure checked.

If included, the function of the gas alarm equipment is tested, and alarm/shutdown functions are calibrated.

If included, the heaters are switched on.

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Instrument air system

The instrument air system is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

Instrument air supply is checked for cleanliness, and pressure checked.

If included, the instrument air compressor is started according to manufacturers instruction.

Lubricating oil system

The lubricating oil system is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

The lubricating oil level in the tank is checked.

The system is started up. The pressures after the pumps and vent fans are finally adjusted and the system is checked for leaks.

If external cooler(s) is/are connected to system at site clean flushing is carried out.

The oil cooler(s) is/are tested.

Safety check procedure is performed.

Cleaning system

The cleaning system is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

The system is started up. The pressure after the pump is verified and the system is checked for leaks.

Fuel, and ignition gas systems

Fuel systems are subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

Function check and tuning of ignition flame.

If included, the external fuel systems (pumps, filters, tanks etc.) are commissioned, and fuel lines cleaned by blowing or flushing. See workshop tests for fuel system.
If included, the fuel separators and fuel dosage equipment are commissioned.

If included, the gas fuel treatment equipment is commissioned

Cooling and sealing air

Cooling and sealing air systems are subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

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Dosage / steam- / water injection

If included in delivery these systems are subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

Dosage system is tuned according to system description.

Steam and water injection is tuned during rotating commissioning.

AC Generator and medium voltage equipment

The AC Generator and medium voltage equipment is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

General inspection of instrumentation concerning values on the VDU.

A visual check of all bolted joints, busbars, insulators etc.

Check of the protective earthing system.

Resistance measurement of all current transformers loops.

Insulation tests of the alternator stator and rotor and excitation equipment.

Auxiliary power AC-system

The auxiliary power system is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

The system is checked regarding busbar insulation resistance and protective earthing.

The system is energised and the phase sequence is checked.

Samples of feeders for motors are checked regarding insulation.

Switching between alternative incoming supplies if included.

DC-system and UPS

The DC-system and UPS are subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

The system is checked regarding insulation resistance and protective earthing.

The system is energised, batteries connected and charging current limit checked.

The capacity of the lube oil batteries is tested.

The UPS is energised and function-checked.

Relay protection

The relay protection is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

Verify that settings of relay protections are in accordance with electrical grid constellation.

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Synchronising equipment

The synchronising equipment is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

Grid measurement connected and checked against circuit diagram.

The function of the synchronising equipment is verified against the grid constellation for the breaker(s).

Control system and turbine governor

The control system is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

Energise and load software from workshop test. Verify correct software if already installed at workshop test.

Final function checks of sequences.

Communication with external control system verified, if included.

Checks of the sequence control and supervision software.

Check of function and setting of alarms and trips.

Functional check of the fuel valves together with the governor.

Re-check of certain functions of particular importance for the safe running of the gas turbine unit.

Adjustments of functions related to the specific fuel used on site.

For equipment included in contract but outside Siemens scope of supply, final adjustments may be required regarding:

Calibration of measurements shown on the VDU together with measuring equipment.

Check of function and setting of alarms and trips for the transducers not included in the workshop tests and transducers outside Siemens scope of supply.

Voltage regulator

The voltage regulator is subject to a workshop test procedure where functions and settings are tested before delivery. During site commissioning the following tests will be conducted:

Verify correct software from workshop test installed.

Verify that reference voltage and limiters are in accordance with electrical grid constellation, and relay protection settings.

Selected functions and settings are tested.

Protection system

All shutdown signals are simulated and the function of the protection system is verified.

Hard-wired signals are tested and operation of protection relay is checked.

Signals through control system are simulated and operation of protection relay is checked.

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Rotating test

Preparation before first start

The preparations are carried out according to a checklist.

Inspection and cleaning of the gas turbine unit including air intake duct, and preparation of test equipment.

All auxiliaries are checked to be in operational mode and all switches to be in automatic position. Generator and field breaker prepared for first start.

Recorder or data logger is connected for tuning of starts and various operation modes.

Start, idle speed and load test

The following checks and tests are performed according to a checklist:

Start sequence test up to fuel injection.

Start and check of the starting sequence up to idle speed. Check of accelerations and temperatures.

Check of lubricating oil temperatures to and from bearings and bearing casing vibration levels.

Test of emergency and normal stop procedures and recording of spinning down times.

Test of automatic cooling down sequence.

Test of power turbine over speed trip.

General visual check of the complete unit including auxiliary equipment for tightness, pipe vibrations etc.

Primary test of generator protections.

Check of voltage stability and range of adjustment.

Test of switchover from external to unit AC supply (if unit transformers are included).

Test of synchronising equipment.

Check of load/frequency stability and range of adjustment.

Synchronisation to the network.

Tests at 25%, 50% 75% and 100% load.

Additional test on dual fuel units

Idle and load tests will also be carried out for the second fuel.

Start sequence test up to fuel injection.

Start and check of the starting sequence up to idle speed. Check of accelerations and temperatures.

General visual check of the complete unit including auxiliary equipment for tightness, pipe vibrations etc.

Tests at 25%, 50%, 75%and 100% load.

Fuel changeover tests.

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Test on completion

Final check of temperature limit settings in the governor.

Final settings of fuel valves.

Test running against maximum limits.

Verify function of emission-reducing system.

If dual fuel, the tests will be carried out on both fuels.

Start with normal loading to full or available load.

Stop from full or available load with normal unloading.

Dead net start of the unit if a standby diesel unit is included.

Fuel changeover tests.

Performance and acceptance tests

Performance and acceptance test will be carried out in accordance with contract specification.

Wind up and report

Test equipment is removed and packed.

Customer is informed about importance of continuous reporting the operation statistics. An internal report will be written after site commissioning is completed.

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Performance test procedure

1. Introduction and purpose of the test

This document describes how the performance test of the gas turbine SGT-600 is conducted at site in power generation applications. This document does not include testing of emissions, noise or vibration.

The guidelines given in code ISO 2314 and ASME PTC 22-1997 are followed were applicable.

The main purpose of the performance test is to verify the guarantee performance data given in the contract. A secondary purpose is to obtain the parameters for the temperature limiter.

The measured performance will be corrected to the reference condition given in the contract.

Normally the three loads 100%, 85% and 65% will be tested. If there are different loads given for the guarantee conditions, these loads will also be tested.

2. Scope of tests

Siemens scope of tests includes the following items:

During preparations:

Preparation and organisation of the test.

Selection, delivery and installation of temporary test equipment.

Cleaning of the gas turbine.

During execution of the test:

Co-ordination of the measuring procedure with responsible parties.

Acquisition of measured values.

Processing and output of data.

During evaluation and reporting:

Removal of the temporary test equipment.

Detailed calculation of result.

Comparison of all available data.

Analysis of the fuel.

Test report.

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3. Instrumentation

The precision instrumentation for the tests will be furnished and installed by Siemens.

The calibration protocols for the precision instruments will be handed over to the customer at the time for the test. Calibration of the instruments is made either by our calibration laboratory or other calibration laboratory with recognised standard. Siemens calibration laboratory is supervised by Swedac (Swedish National Standard Laboratory) and has tractability to BIPM, Bureau International des Poids et Mesures.

Meas. point	Description	Instrument	Class	Exp. Un-certainty	Remark
Generator output					
P_e	Generator output	3 phase watt meter	0.1	0.3-0.5 % incl. transformers	
PF	Power factor	3 phase watt meter	0.1		
P_{aux}	Auxiliary power	Clamp on watt meter	2.0	-	
Ambient conditions					
T_0	Ambient air temperature	6*Pt-100 element	0.1 °C	0.2 °C	At air intake
p_0	Ambient air pressure	2*Barometer	0.03 %	0.1 %	
RH	Ambient air relative humidity	Hygrometer	2 %	< 4%	At air intake
Liquid fuel					
t_f	Fuel temperature	1*Pt-100 element	0.1 °C	0.2 °C	
V_m	Fuel volume flow	Screw volumeter	0.2 %	0.5 %	Resulting uncertainty for mass flow less than 0.5%
Gaseous fuel					
T_f	Fuel temperature	1*Pt-100 element	0.1 °C	0.2 °C	
p_f	Fuel pressure	Pressure transmitter	0.1 %	0.3 %	
m_{fg} or v_{fg}	Fuel volume flow or mass flow	Mass flow meter or turbine wheel flow meter	0.5-0.8 %	<1.0 %	Resulting uncertainty for mass flow less than 1%

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Meas. point	Description	Instrument	Class	Exp. Un-certainty	Remark
Water injection					
T_{wi}	Water temp.	1*Pt-100 element	0.1 °C	0.2 °C	
v_{wi}	Water flow	Calibrated flow-meter	1 %	<1.5 %	Resulting uncertainty for mass flow less than 1.5%
Steam injection					
t_{si}	Steam temp.	Pt-100 element	0.1 °C	0.4-0.5 °C	
Δp_{si}	Diff. pressure over orifice	Calibrated transmitter	0.1 %	0.3 %	Resulting uncertainty for mass flow less than 1.5 %
p_{si}	Pressure before orifice	Calibrated transmitter	0.1 %	0.3 %	
Temp. meas.					
t_{30}	Temperature after compressor	2*Type N thermo-couples	0.4 %	-	Mounted in 2 special probes
t_{85} or t_7[1]	After power turbine	t_{85}: 20*Type N t_7 : 48* Type N	0.4 %	-	t_{85}: mounted in 5 probes
Speed meas.					
N1	Gas generator speed	Electronic counter	-	-	Plant instrument
N2	Power turbine speed	Electronic counter	-	-	Plant instrument
Pressure meas.					
p_{30}	Pressure after compressor	2*Pressyre transmitter	0.1 %	0.3 %	Mounted in 2 special probes
p_0-p_{10}	Inlet pressure drop	1*differential transmitter	1 %	0.3 %	
p_{85}-p_0	Outlet pressure drop	1*differential transmitter	1 %	0.3 %	

[1] If t_7 consists of 48 elements in 16 probes, these will usually be used for evaluation. t_{85} will be used in all other machines. t_{85} consists of 5 probes with a total of 20 elements.

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Measuring sections SGT-600

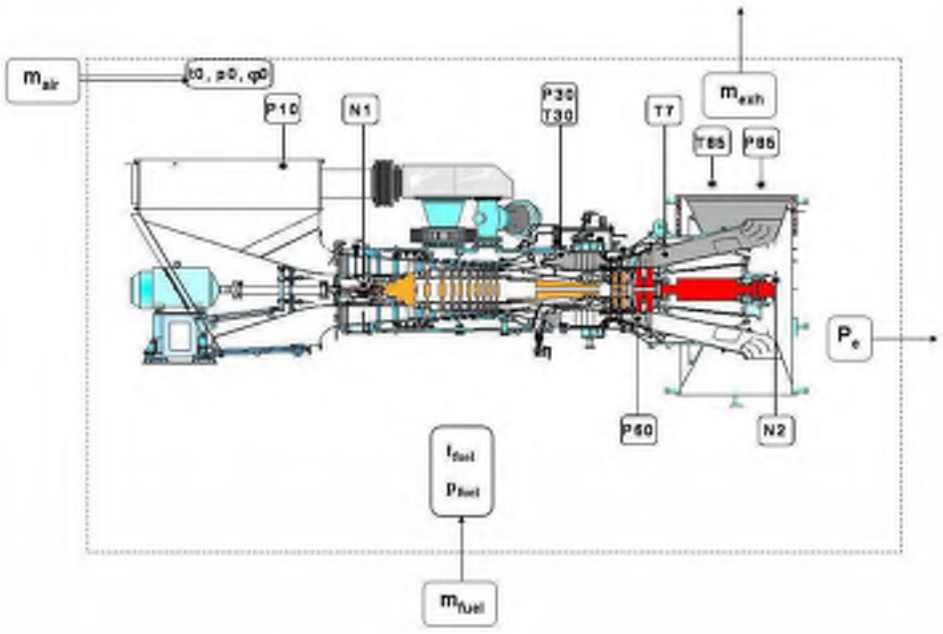

Fig. 1 Measurement sections on the SGT-600

Meas. point	Description	Unit	Number of points
T_0	Ambient air temperature	°C	6
p_0	Ambient air pressure	bar a	2
φ_0	Ambient air relative humidity	%	1
T30	Temperature after compressor	°C	2
T7	Temperature after Power Turbine	°C	16 or 48[2]
T85	Temperature after Power Turbine	°C	20[2]
N_1	Speed on gas generator	rpm	1
N_2	Speed on power turbine	rpm	1
P30	Pressure after compressor	bar a	2
p_0 - p_{10}	Inlet pressure drop	mbar	1
p_{85}-p_0	Outlet pressure drop	mbar	1

[2] Either T7 (with 48 elements) or T85 will be used for evaluation

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4. Methods of measurements

4.1 Output

The electrical output at the generator terminals will be measured by a calibrated three-phase wattmeter, class 0.1, connected to the plant current- and voltage transformers. The connection cables will have an area enough to give negligible voltage losses.

The power factor will be determined by the same instrument as for the electrical output.

The auxiliary power consumption will be measured by a wattmeter, class 2.0, of type clip on.

4.2 Heat consumption

Liquid fuel

The fuel flow will be measured by a calibrated screw volumeter.

The fuel temperature will be measured at the flow meter.

The lower heating value and the density will be determined from fuel samples. The density is determined according to ASTM D 4052-96. The lower heating value will be determined according to ASTM D 4868-90.

Three fuel samples will be taken during the test period, one for supplier, one for the Customer and a third sample to be sealed and in case of disagreement, analysed by a third part laboratory of recognised standard.

Gaseous fuel

The fuel flow will be measured by a calibrated mass flow meter or a turbine wheel flow meter.

For the turbine wheel flow meter, the fuel pressure will be measured by a calibrated pressure transmitter at the pressure point on the actual meter. The fuel temperature will be measured at the turbine wheel meter by a calibrated Pt-100.

The lower heating value and the density will be determined from a fuel sample. The composition analysis is according to ASTM D 1945, and the lower heat value calculation according to ASTM D 3588.

Three fuel samples will be taken during the test period, one for supplier, one for the Customer and a third sample to be sealed and in case of disagreement, analysed by a third part laboratory of recognised standard.

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4.3 Injection flows

Water injection (if applicable)

The injection water flow will be measured by a calibrated Vortex flow meter.

The water temperature will be measured at the flow meter.

Steam injection (if applicable)

The steam injection flow will be measured by an orifice, manufactured, installed and measured as described in ISO 5167:Edition 1991.

The differential pressure and static pressure will be measured on the flow meter by calibrated precision transmitters of class 0.1.

The steam temperature will be measured before the flow meter by a calibrated Pt-100.

4.4 Ambient air condition

The ambient temperature will be measured by six Pt-100 elements upstream the inlet air filters.

The ambient pressure will be measured by two precision barometer on the engine centreline level, outside the inlet air filters.

The relative humidity will be measured by a hygrometer upstream the inlet air filters.

5. Measuring uncertainties

The measuring uncertainties for power output and specific heat consumption will be calculated after the test and included in the test report. The calculation will be based on a confidence level of 95 %.

If the procedure/measurement described in this document can be followed, the total measuring uncertainties should fall within the range of 0.4-0.7 % for the power output.

The uncertainty for the specific heat consumption should be 0.8-1.0 % when running on liquid fuel and 1.0-1.2 % when running on gaseous fuel.

The measuring uncertainties are mainly based on the following individual uncertainties:

- Generator output	*- Fuel flow*	*- Lower Heating Value*
- Ambient temperature	*- Ambient pressure*	*- Outlet pressure losses*

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6. Execution of tests

Every reasonable effort will be made to test the gas turbine under conditions similar to the reference conditions given in the contract. If the machine is a dual fuel machine, performance on both fuels will be tested. The gas turbine shall be in new and clean condition.

Before readings are taken, the unit will be run for a sufficient time (at least 1 hour) to ensure that steady state conditions have been established. During this stabilisation period before the first test, a preliminary adjustment will be made of the temperature limiter in order to have the test as close as possible to the correct Turbine Inlet Temperature. The final setting of the temperature limiters will be made when the fuel analysis is at hand.

The fluctuations of the measured parameters shall be within the range given in ISO 2314.

The power factor will be adjusted as close as possible to the figure given as reference condition in the contract.

During the test, readings will be taken from all supervisory instruments.

All completed log sheets will include order number, date, time of day and part o test and shall be signed by both parties.

6.1 Data sampling

All measured data will be read either by hand or by a data logger. Readings will also be taken from all plant instruments, by hard copies or by manual readings.

Readings will be taken every 10^{th} second for all precision instruments read by data loggers. The interval of readings for instruments read by hand will be 5 minutes.

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7. Time schedule

Day	Time	Activity
1	-	Meeting regarding preparation and execution of the test. Shut down of gas turbine. Gas turbine compressor cleaning.
2	-	Installation of all instruments. Checking of all instruments.
3	00.00	Start time: Start and loading to 100% load.
	01.30-02.00	Test no. 1: 100% load. Readings during half an hour.
	02.05	First evaluation of the test. If the Turbine Inlet Temperature (TIT) at Test no 1 significantly deviates from design, Test no 2 will be carried out.
	02.30-03.00	Test no. 2: 100% load. Readings during half an hour.
	03.05	Decrease to 85 % load after confirmation by supplier representative.
	03.30-04.00	Test no. 3: 85% load. Readings during half an hour.
	04.05	Decrease to 65 % load after confirmation by supplier representative.
	04.30-05.00	Test no. 4: 65% load. Readings during half an hour.
	05.05	Increase to 100% load after confirmation by supplier representative.
	05.30-06.00	Test no. 5: 100% load. Readings during half an hour.

Preliminary calculation and evaluation on the first fuel. If the machine is a dual fuel machine, day no. 4 will be used for the next fuel. The time schedule for day no 4 will then be as for day no. 3.

4 (or 5 for dual fuel)	When the preliminary evaluations of the performance test is completed the test instrumentation will be removed from the unit. Shut down of the gas turbine is needed to remove instruments. Meeting regarding the preliminary result.

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8. Correction of test result

The correction curves will be handed over to the Customer before the test. Correction of performance test data to the reference conditions given in the contract will be made as follows:

8.1 Power output

The measured power output will be corrected for ambient temperature, ambient pressure, relative humidity and power factor. If reference values for inlet pressure drop and/or outlet pressure drop are included in the contract, corrections for those will be made. If water or steam injection is included also a correction for water/steam flow will be applied.

8.2 Heat rate (Specific heat consumption)

The measured heat rate will be corrected for ambient temperature and power factor. If reference values for inlet pressure drop and/or outlet pressure drop are included in the contract, corrections for those will be made. If water or steam injection is included also a correction for water/steam flow will be applied.

8.3 Exhaust gas mass flow

If the exhaust gas mass flow is guaranteed in the contract, the measured/evaluated exhaust gas mass flow will be corrected for ambient temperature, ambient pressure and relative humidity. If a reference value for inlet pressure drop is included in the contract, a correction for this will be made. If water or steam injection is included also a correction for water/steam flow will be applied.

8.4 Exhaust gas temperature

If the exhaust gas temperature is guaranteed in the contract, the measured exhaust gas temperature will be corrected for ambient temperature and relative humidity. If reference values for inlet pressure drop and/or outlet pressure drop are included in the contract, corrections for those will be made. If water or steam injection is included also a correction for water/steam flow will be applied.

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Gas turbine training programme - on-site training

Project NN

Availability and reliability are important economic factors that depend on the maintenance programme as well as on the quality and design of the turbine. To achieve high availability and optimised operating economy, skilled operation and maintenance staff is required. Skill is achieved by combining experience with training. Siemens on-site training is characterized by the combination of theory in combination with practical exercises. Your staff will participate in a training that is managed by competent and experienced trainers with high pedagogical skills. The training material of the Siemens gas turbine training is developed in a pedagogical and structured way. It is based on many years of experience and is easy to use.

After attending this training the staff will be able to operate and maintain the gas turbine plant. They will have a general understanding of basic gas turbine principles and their application to Siemens gas turbine plants. After the course the participants will be able to explain the main components and their function as well as the auxiliary systems. The participants will gain knowledge about documentation and KKS system.

BU / SGT-600(MD B, PG B, PG EX B) SGT-700(MD B, PG B, PG EX B) SGT-800(PG B, PG B2, PG Ex B2, PG B LS)	

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Training programme

The training programme is divided into three different courses:

Course 1 3 days basic course for all categories.

Course 2 1+1 days additional course for mechanical technicians.

Course 3 4 days additional course for operation and control

The training will be conducted in English and is to be carried out during normal working hours, six lessons per day.

The training material will be in English language.

The training consists of classroom lessons as well as practical exercises.

No audio or video recording of the training is permitted.

Purchaser is not entitled to hand over the training material to any third party.

The maximum number of participants is a recommendation from Siemens in order to achieve a good training result. If the number of participants exceeds the recommendation the additional participants will be charged accordingly.

Included in the training is:

- All costs for Siemens Industrial Turbomachinery AB personnel
- All costs for training manuals

All other costs for Client's personnel, to be borne by the Client

On site the client shall provide:

A suitable classroom equipped with a blackboard/whiteboard and a computer projector.

A SGT-XXX close to the classroom is needed for plant visits/studies and fault finding exercises. To carry out exercises in start and stop and compressor washing, a Gas Turbine unit has to be available for such mode of operation.

An interpreter with technical translation skills.

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Course programme

Course 1

Basic course for all categories

Duration: 3 days with maximum 18 participants

Day 1

1 Introduction

- Presentation of SIT
- Presentation of Trainer
- Course notes and course documentation

2 Gas turbine primer

- The Gas Turbine principle and its application on SGT-XXX
- SGT-XXX performance

3 Documentation

- Documentation Overview
- KKS designation system

4 Main components of the SGT-XXX, design and function

- Compressor
- Combustion Chamber
- Turbine

5 Site visit/walk around

Day 2

6 Location, function and operation of auxiliary systems

- Turbine system
- Lubricating oil system
- Fire fighting and ventilation system
- Fuel system

7 Site visit/walk around

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Day 3 **8** **Electrical system**

- Single line diagram
- Location of electrical equipment

9 **Control system**

- Control system configuration
- PC equipment

10 **Maintenance**

- Maintenance programme

11 **Personal safety**

Course 2
Additional course for mechanical technicians

Duration: 1+1 days with maximum 10 participants

Day 1 **1** **Introduction**

- Presentation of Trainer
- Course notes and course documentation
- Repetition of SGT-XXX Gas Turbine process

2 **Mechanical maintenance**

- Routine maintenance
- Inspections
- Overhauls

Day 2 **3** **Mechanical maintenance** (Requires unit available for washing)

- Compressor washing

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Course 3
Additional course for operators

Duration: 4 days with maximum 10 participants

Day 1 **1** **Introduction**

- Presentation of Trainer
- Course notes and course documentation
- Electrical documentation

2 **Electrical equipment**

- MCC
- UPS

Day 2 **3** **Generator**

- Generator system
- Excitation
- Synchronisation
- Relay Protection

Day 3 **4** **Control system**

- Control system layout
- Control station
- Process displays
- Human Machine Interface
- Alarm and Trip handling

Day 4 **5** **Operation**

- Checks before start up
- Start procedure
- Supervision during operation
- Emergency stop
- Stop procedure
- Operation records

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Customer Service Product Information

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Overhaul

Extended Intervals Maintenance Plan Fixed-B Package

SGT-600

2012-06-11 Scott Santamaria

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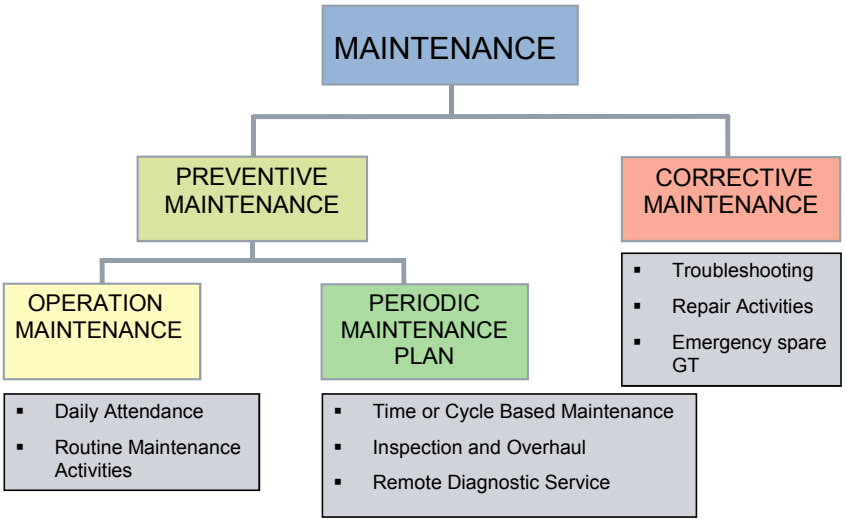
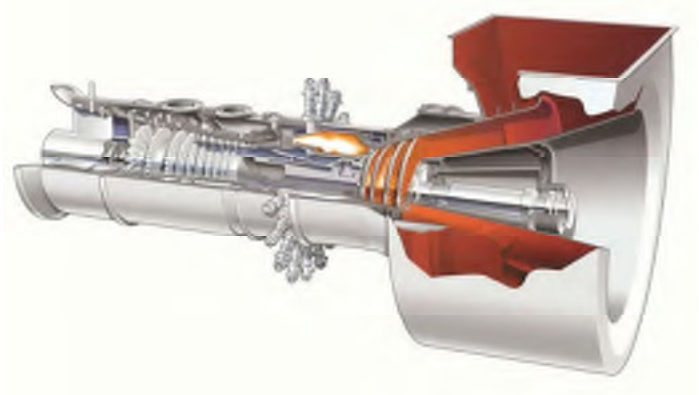
2012-07-09 Per Johansson

Maintenance General Information SGT-600





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1 INTRODUCTION

This document describes the required preventive maintenance for the Extended Intervals Maintenance concept for a SGT-600 gas turbine unit. The data given here reflects down time and replacement parts consumption for 120 000 equivalent operating hours with a maximum of 2400 equivalent operating cycles, i.e. approximately 15 years of base load operation.

1.1 TERMINOLOGY

The terminology used when discussing preventive maintenance in this document is as follows:

Maintenance	Tasks carried out to keep the equipment in normal operating condition or to restore it to such condition that operation can proceed without interruption.
On-site maintenance	Maintenance concept based on taking the customer's plant out of operation for service of installed equipment. Necessary maintenance activities are carried out in conjunction to the plant, either on site or in facilities nearby. The plant outage is determined by the time required to put the customer's original equipment back into operation.
Off-site maintenance	Maintenance concept based on a gas generator exchange program. The customer's gas generator is removed from the plant and the necessary maintenance activities are carried out off-site. Production continues using a reserve gas generator with the outage time determined by the time required to exchange gas generator and perform inspection/overhaul activities on the power turbine.
Preventive maintenance	Planned maintenance activities carried out to maintain the equipment in normal condition.
Operation maintenance	Tasks carried out by the site personnel mainly consisting of daily attendance and routine maintenance activities.
Maintenance plan	Plan based on equivalent operating hours or equivalent operating cycles, containing recommended activities at inspections, checks and overhauls. For SGT-600 gas turbines, recommended inspections and overhauls for base load operation with extended intervals are defined in a maintenance plan with maintenance levels labelled A, B and C.
Inspections and Overhauls	Inspections are defined as visual checks of the engine and its auxiliary systems after limited dismantling. Overhauls are defined as visual checks, change of parts with limited lifetime and controls of the unit after dismantling.
Equivalent Operating Hours (EOH)	A formula related to turbine condition with respect to operating hours, fuel, load and start/stop cycles, for further information see section 2.1.2.2.
Equivalent Operating Cycles (EOC)	A formula related to turbine condition with respect to number of start/stop cycles and stop sequence, for further information see section 2.1.2.2.

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Operation Consumables	Consumables and liquids necessary for normal operation such as different filters, cleaning agent and dosing chemicals.
Operation Back-up Parts	Spares representing a relatively low cost but essential for keeping the availability high. Examples of these parts are pressure switches, computer cards and thermocouples.
Replacement Parts	Spare parts identified in the Maintenance Plan to be replaced after a certain number of equivalent operation hours. Examples are turbine blades, heat segments and combustion chamber.
Maintenance Consumables	Consumables identified in the Maintenance Plan necessary to perform overhauls and/or repairs of the installation. Examples are locking washers, o-rings and gaskets
Contingency Parts	Spare parts that are not mandatory replaced during preventive maintenance but by experience are useful to have available in order to reduce down time. Examples are bolts, nuts, gaskets, sensors and bearing parts.
Emergency Spare Parts	Sophisticated spare parts, which represent a relatively high value. The customer has access to Siemens emergency spare parts “first comes first service”. Examples are bearings, gas turbine blades and complete gas turbine rotors.
Capital Spares	Sophisticated spare parts, owned by the customer, which can be used if an unexpected event occurs. This can lead to costly loss of production which makes it important to have these parts available at site. Examples are bearings, gas turbine blades and complete gas turbine rotors.
Reserve Gas Generator	A spare gas generator owned by the customer. Replaces the gas generator due for planned maintenance where an off-site maintenance plan is followed. Operated until next major inspection of the gas generator.
Emergency Gas Generator	Gas generator that replaces the removed gas generator in the event of a corrective maintenance requirement.
Remote online check	Remote analysis carried out prior to the inspection (approx. 3 months) to check functionality of auxiliaries and other gas turbine systems. Operational data are extracted from the data collector and remotely transferred for careful analysis by Siemens experts. Findings from the remote online check might result in additional activities recommended for the upcoming inspection scope.
Remote Diagnostic Services	Systems for remote diagnostics.

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2 MAINTENANCE

Economical operation of the power plant is affected by the operational performance and also by the availability and the reliability of the plant as a whole. The availability of a gas turbine is not guaranteed simply because the owner has originally invested in high quality reliable equipment. Successful and profitable operation also requires a well-prepared maintenance plan together with personnel trained to the appropriate level with the relevant engineering knowledge, experience and technical support.

Maintenance can be divided into two categories:

- Preventive maintenance
- Corrective maintenance

Siemens maintenance concept is focusing on optimizing the preventive maintenance with regards to cost and installation availability throughout the entire lifetime.

2.1 PREVENTIVE MAINTENANCE

The preventive maintenance is divided into two main categories:

- Operation maintenance
- Maintenance plan

2.1.1 OPERATION MAINTENANCE

The gas turbine requires regular attention in order to detect trends and to determine abnormalities at an early stage.
Operation Maintenance is to be carried out according to the operation maintenance manual, which is included in the plant documentation. Operation maintenance activities are performed on a daily, weekly, monthly and annual basis. These activities consist of daily checks that include instrument readings, visual inspections for general condition (i.e. check for leakage, abnormal noise, etc.) and also routine maintenance.
Routine maintenance activities are carried out on a calendar basis (lubrication oil sampling etc.) or as required (filter replacement, compressor washing etc.), including preventive maintenance of the auxiliary systems due to normal wear and tear.
These activities are normally carried out by site personnel.

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2.1.2 MAINTENANCE PLAN

The maintenance plan is defined for a SGT-600 operating on base load with certain number of starts. In order to optimize the overall maintenance cost and availability during the lifetime the maintenance plan includes necessary service activities for several important functions in the Gas Turbine system.

Table 1: Maintenance plan coverage

Maintenance Plan Coverage		
Gas Turbine Unit	**Gear System**	**Driven Equipment**
Gas Generator (GG)	Main Gear and Couplings	Electrical Generator
Power Turbine (PT)		Gas Compressor
Auxiliary Systems		Others

The overall availability of the gas turbine generating set is mainly determined by planned outages. Therefore such outages should be managed as efficiently as possible. This is possible under the following conditions:

- The Maintenance Plan activities are planned well in advance.
- The work to be performed and the spare parts required are purchased well in advance.
- The duration is kept as short as possible by comprehensive planning and expert execution.

This requires close communication and co-operation between the parties, starting well in advance of the preventive maintenance plan activities.

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2.1.2.1 MAINTENANCE LEVELS

The different activities in the preventive maintenance plan are structured in a system of levels. The gas turbine, driven equipment and related systems are split in five areas with maintenance levels classified as follows:

- A, B, C – Gas Generator, Power Turbine
- G1, G2 – Main Gear and Couplings
- L1, L2, L3, L4 – Electrical Generator
- Level I, Level II, Level III - Gas Compressor

Maintenance levels from each area are then coordinated into a periodic maintenance schedule with overall levels A, B and C controlled by either Equivalent Operating Hours (EOH) or Equivalent Operating Cycles (EOC).

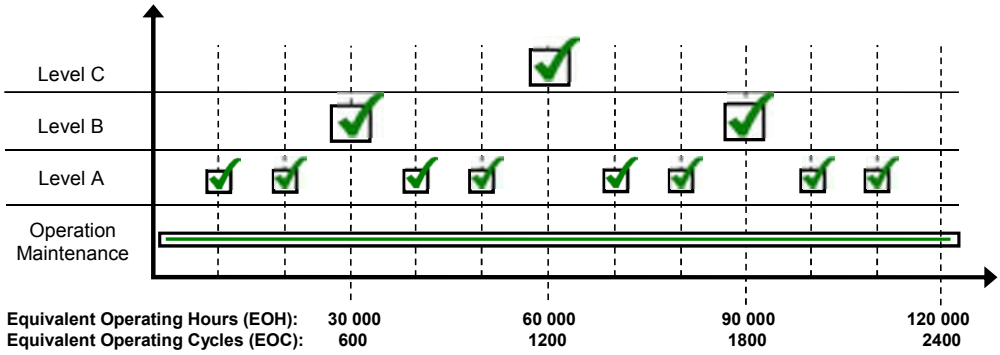

Figure 1: Maintenance schedule

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The coordination and periodic intervals for each level is presented in table 2.

Table 2: Coordination and scheduling of maintenance activities

Maintenance level	A	A	B	A	A	C	A	A	B	A	A	
EOH	**10'**	**20'**	**30'**	**40'**	**50'**	**60'**	**70'**	**80'**	**90'**	**100'**	**110'**	**120'**
EOC			**600**			**1200**			**1800**			**2400**
Gas generator	A	A	B	A	A	C	A	A	B	A	A	---
Power turbine	A	A	B	A	A	C	A	A	B	A	A	---
Main gear and couplings	G1	G1	G1	G1	G1	G2	G1	G1	G1	G1	G1	---
Electrical generator	L1	L1	L3	L1	L2	L4	L1	L1	L3	L1	L1	----
Driven Compressor	Level I	Level I	Level II	Level I	Level I	Level III	Level I	Level I	Level II	Level I	Level I	---

Irrespectively of the Equivalent Operating Hours a level A-inspection should be carried out a least every second year.

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Timing of Maintenance Levels

Equivalent Operating Hours (EOH) and Equivalent Operating Cycles (EOC) are used to determine the duration between maintenance inspections for the gas turbine. Equivalent Operating Hours covers time related damages such as creep, corrosion and oxidation whereas Equivalent Operating Cycles covers cyclic damage such as fatigue.
Remaining lifetimes of replacement components will be limited by either the number of EOH or the number of EOC. Frequent starting and stopping with few operation hours will make components run into the EOC limitation, while continuous operation with many operation hours and few starts will make components run into the EOH limitation.

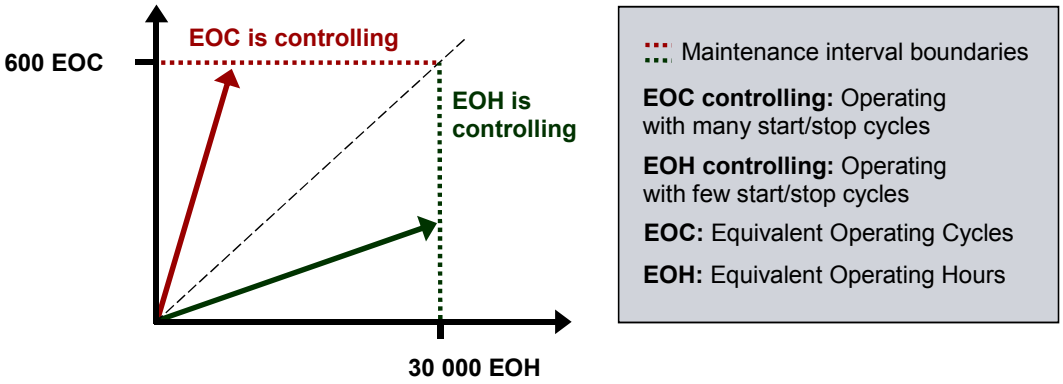

Figure 2: Timing of maintenance levels

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The formulas below describe how the equivalent operating hours and equivalent operating cycles are calculated. Both equations are automatically logged in the turbine control system.

Equivalent Operating Hours (EOH):

$$EOH = \Sigma(C_X \times C_f \times C_W \times H) + 5 \times EOC$$

EOH = Equivalent operating hours

C_X = Stress factor — C_X = 0.5 - 10 — depending on running condition

C_f = Fuel factor — C_f = 1.0 — for gas according to GTI J241013E; C_f = 1.2 — for liquid fuel according to GTI J242002E

C_W = Water and steam Injection factor — C_W = 1.0 — when no water or steam injection is used; C_W = 1.25 — when water or steam injection is used

H = Operating hours

Equivalent Operating Cycles (EOC):

$$EOC = \Sigma((C_{nStart} + C_{nStop}) \times N)$$

C_{nStart} = Start factor	C_{nStart} = 0	Start factor when T7 < 300°C
	C_{nStart} = 0,2	Start factor when T7 < 300°C, before GT in service
	C_{nStart} = 1	Start factor valid for normal start, if GT in service
	C_{nStart} = 4	Start factor valid for fast start, if GT in service
C_{nStop} = Stop factor	C_{nStop} = 0	Stop factor during normal stop
	C_{nStop} = 4	Stop factor if emergency shutdown from load > 50 %

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2.1.3 ON-SITE MAINTENANCE

On-site Maintenance is a standard concept for preventive gas turbine maintenance. All activities are carried out in conjunction to the customer plant, either direct on-site or in facilities nearby.

2.1.3.1 DOWNTIME AND SCOPE OF WORK

Table 3: Downtime and scope of work at various maintenance levels

		Level A	Level B	Level C
Expected downtime, incl. cooling down	1-shift	1 day	11 days	16 days
	2-shift	1 day	8 days	11 days
Inspection		**Remote Online check** (Prior to the inspection) **Borescope inspection of:** • Compressor • Combustion chamber • Turbine vanes and blades **Inspection of:** • Main gear and couplings • Driven equipment	**Remote Online check** (Prior to the inspection) **Borescope inspection of:** • Compressor **Inspection of:** • Compressor Turbine Blades • Main gear and couplings • Driven equipment	**Remote Online check** (Prior to the inspection) **NDT inspection of:** • Compressor vanes and blades **Inspection of:** • Power turbine vanes and blades • Compressor Turbine Disc 1 • Turbine Casing • Bearings • Auxiliaries • Main gear and couplings • Driven equipment
Replacement		See replacement schedule	See replacement schedule	See replacement schedule
Verification		Control system and instruments	Control system and instruments	Control system and instruments

Calculation of standard downtime is based on that a Remote Online Check has been successfully carried out prior to the inspection. If the terms for Remote Online Check are not met verification of specific equipment will be registered at site, downtime will be significantly increased.
The actual downtime can differ from the standard downtime. Reasons might be owner's requirements, work support from owner, site specific features, findings during inspections or remote online check, quality of workshop facilities, lifting tools etc.

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2.1.4 OFF-SITE MAINTENANCE

Using an off-site maintenance concept reduces total downtime for the gas turbine package to as low as 17 days in 15 years. This is made possible by using a gas generator exchange program including a lease or spare gas generator. Maintenance work of auxiliaries and driven equipment is performed in 2-shifts.

2.1.4.1 DOWNTIME AND SCOPE OF WORK

Table 4: Downtime and scope of work at various maintenance levels

	Level A	Level B	Level C
Expected downtime, incl. cooling down*	24 hours	48 hours	120 hours
Inspection	**Remote Online check** (Prior to the inspection) **Borescope inspection of:** • Compressor • Combustion chamber • Turbine vanes and blades **Inspection of:** • Main gear and couplings • Driven equipment	**Remote Online check** (Prior to the inspection) **Gas generator exchange** (The original gas generator is overhauled off-site) **Inspection of:** • Main gear and couplings • Driven equipment	**Remote Online check** (Prior to the inspection) **Gas generator exchange** (The original gas generator is overhauled off-site) **Inspection of:** • Power turbine vanes and blades • Bearings • Auxiliaries • Main gear and couplings • Driven equipment
Replacement	See replacement schedule	See replacement schedule	See replacement schedule
Verification	Control system and instruments	Control system and instruments	Control system and instruments

Calculation of standard downtime is based on that a Remote Online Check has been successfully carried out prior to the inspection. If the terms for Remote Online Check are not met verification of specific equipment will be registered at site, downtime will be significantly increased.
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Reserve Gas Generator

For reliability critical applications it is recommended that the customer owns a reserve gas generator. This option has the following advantages for planned inspections, unplanned outages and plant life such as:

- Smooth on-time exchange operation (no long distance transport, custom formalities, etc)
- RGG available on customer premises in case of unplanned outage
- Redundant configuration (M+1) extends overall plant operation time
- Maximizes availability and plant reliability

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2.1.5 REPLACEMENT AND RECONDITIONING SCHEME

Critical gas generator and power turbine components are replaced according to the following replacement scheme.

The expected parts intervals for critical gas generator and power turbine components are shown in table 5. The schedule is based on the design life and fleet experience of respective part. These values reflect current produced hardware. Many engineering judgments are built into this table including operation and maintenance of the unit, performed in accordance with all of the manufacturer's specifications and instructions.

Operation and maintenance factors can have a major impact on both replacement interval and life time of the unit. For this reason, the intervals given in table 5 should only be used as guidelines and not certainties, i.e. a replacement part will be assessed to be used for operation up to next decided inspection. Replacement parts can be new or reconditioned.

Table 5: Replacement and reconditioning scheme for major hot parts

Replacement Schedule												
Equivalent Operating Hours (EOH) x 1000	10	20	30	40	50	60	70	80	90	100	110	120
Equivalent Operating Cycles (EOC)			600			1200			1800			2400
Level Schedule						C						
			B						B			
	A	A		A	A		A	A		A	A	
Combustor Section												
Combustor chamber	Original			Repl.			Repl.			Repl.		
Injector shafts*	Original			Repl.			Repl.			Repl.		
*Only performed during on-site maintance												
Compressor Turbine												
Blade 1	Original			Repl.			Repl.			Repl.		
Blade 2	Original						Repl.					
Guide Vane 1	Original			Repl.			Repl.			Repl.		
Guide Vane 2	Original			Repl.			Repl.			Repl.		
Honeycomb Segment 1	Original			Repl.			Repl.			Repl.		
Honeycomb Segment 2	Original						Repl.					
Power Turbine												
Blade 3	Original						Repl.					
**Replacement (Repl.)												

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2.1.6 ELECTRICAL GENERATOR MAINTENANCE

Electrical generator maintenance is carried out according to four different levels that are coordinated with the maintenance plan. Table 6 shows the basic scope of work for each level.

Table 6: Scope of work at various electrical generator maintenance levels

Level	L1	L2	L3	L4
Scope of work	Visual inspection.	Visual inspection, electrical checks.	Acc. To L2 and bearing inspection, parts replacement on condition.	Acc. to L3 and rotor extraction.

2.1.7 MAIN GEAR AND COUPLINGS MAINTENANCE

Main gear and couplings maintenance is carried out according to two different levels that are coordinated with the maintenance plan. Table 7 shows the basic scope of work for each level.

Table 7: Downtime and scope of work at various maintenance levels

Level	G1	G2
Scope of work	Visual inspection of tooth mesh.	Inspection of seal, coupling, casing and bearings. Check of tooth contact pattern.

2.1.8 GAS COMPRESSOR MAINTENANCE

Gas compressor maintenance is carried out according to three different levels of inspection. Table 8 shows the basic scope of work for each level.

Table 8: Downtime and scope of work at various maintenance levels

Level	I	II	III
Scope of work	Inspection of instruments, oil system, filters, verification and functional tests of controls and safety devices.	Acc. to Level I, bearing inspection and dry gas seal change out.	Acc. to Level II and bundle swap/exchange.

The planning of scheduled maintenance intervals is depending on operating conditions and will be made project specific and aligned with gas turbine outages when a LTP (Long Term Program) is agreed.

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2.2 CORRECTIVE MAINTENANCE

Apart from the preventive maintenance it is also essential to have a philosophy for efficient back-up in case of emergency situations. By offering support services available for all our customers like spare gas generators, access to emergency store for sophisticated gas turbine parts and 24-hours telephone support, the cost for the back-up is divided on many hands without reducing the availability to the back-up functions for each customer.
When required in a specific situation, the following emergency service can be provided:

- Troubleshooting instructions
- Emergency mobilisation of service personnel
- Status assessment
- Access to gas turbine emergency spare part store
- Access to emergency gas turbine
- 24-hours gas generator exchange
- Repair activities
- Field balancing

3 PLANNING RECOMMENDATION FOR PREVENTIVE MAINTENANCE

At least 18 months prior to an overhaul, the customer together with Siemens, shall begin to plan/schedule the overhaul requirement, considering the following items:

3.1 SCOPE OF WORK

Based on standard time schedule, the results of earlier investigations and the customer's operational observations and requirements, a specific scope of work is to be decided.

3.2 SPARE PARTS REQUIREMENTS AND SPARE PART STOCK

In accordance with the scope of the work, it is possible to specify the spare parts likely to be needed. With respect to the demand, the customer spare part back up is to be checked for completeness and condition. Recommended spare parts should be procured well in advance.

3.3 TOOLS AND FIXTURES

Check if the specific necessary tools and fixtures are in the customer's possession or whether they have to be provided by Siemens.

3.4 LIFTING AND TRANSPORTATION

In case of preventive off-site maintenance or corrective maintenance involving a 24 hours exchange operation availability of all necessary lifting tools, transportation skids, vehicles, suitable roads and permits needs to be checked.

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3.5 INSPECTION AND ASSEMBLY WORK

All inspections and assembly work shall be performed or supervised by trained personnel in order to ensure quality of work performed.

3.6 CAPACITY PLANNING

The client together with Siemens should investigate well in advance that required workshop facilities are available.

3.7 WORK PLAN

A work plan has to be developed, specifying which activities to perform at site or in repair facilities.

3.8 CO-ORDINATION

For the co-ordination of activities, resources and work permits, a planning chart and critical path diagram should be prepared prior to the start of each inspection/overhaul.

3.9 SPARE PART MANAGEMENT

Well-balanced spare part management is essential for minimizing downtime of preventive and emergency maintenance and thus increases the availability of the unit. The selection of spare parts to be stored is mainly determined by:

- Failure probability
- Delivery time
- Repair or reconditioning time of capital components
- Time for replacement
- Investment cost versus cost of production losses

Consequently, available spare parts can considerably reduce the duration of an overhaul.

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4 REMOTE SERVICES

Siemens provides a comprehensive portfolio of remote access based services. Services that previously required on-site visits are now available by data transfer.
Siemens can provide remote support, remote updates and remote monitoring with diagnostics.

4.1 BASIC PACKAGE

For customers with a signed agreement Siemens provide 24-hour emergency telephone service from on-call service engineers backed by a network of on-call specialists. The 24-hour global helpdesk service provides technical advices and recommendations for operation and maintenance of the gas turbine installation.
If the problem cannot be solved with technical support by phone, Siemens can arrange for a qualified service engineer to go to site for further assistance.
Basic package also include remote connection which by customer approval gives full access to the gas turbine's control system. This allows service engineers to perform on-line troubleshooting and if required give advice for- or execute further actions.

4.2 ADVANCED PACKAGE

Advanced package includes all the features described for basic package. Advance package also include solutions for Proactive Event & Trending Response for advanced monitoring of vibration and combustion.

4.3 PREMIUM PACKAGE

Premium package includes all the features described for basic package. Premium package also include solutions for Proactive Event & Trending Response for advanced monitoring of vibration, combustion and performance. Providing premium package requires that the power output can be measured.

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5 SERVICE PROGRAMS

In order to meet our customers various demands, we can offer three different Long Term Program (LTP) levels, all of them with the Maintenance Plan as a solid base. The scope in the Long Term programs is gradually growing from only containing regular support services up to a level where both preventive and corrective maintenance is included.

- Support LTP
  - Tailor-made remote services and emergency support for your specific needs.
- Preventive LTP
  - Maintenance Plan activities negotiated once and for all.
- SAMS (Siemens Advanced Maintenance Services) LTP
  - Allows flexible operation with prescheduled outages.
- Corrective LTP
  - A comprehensive program for total maintenance coverage.

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SIEMENS

Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

Doc. No. J9401873E
Rev. ind.
Issued by
Håkan Pettersson

Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
BFA	Low voltage main distribution boards, normal system	Relay	1	PC		
BFA	Low voltage main distribution boards, normal system	Relay	1	PC		
BFA	Low voltage main distribution boards, normal system	Voltage regulator	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Motor protector switch	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Mini.circuit breaker	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Fuse knife 25A	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Knife fuse link	1	PC		
BPD	Motor drive system	Knife fuse link	1	PC		
BPD	Motor drive system	Knife fuse link	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Sinamics single motor module input	1	PC		
BPD	Motor drive system	Sinamics S120 single motor module input	1	PC		
BPD	Motor drive system	Fuse link	1	PC		
BPD	Motor drive system	Fuse link	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Thermal relay	1	PC		
BPD	Motor drive system	DI module	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Relay	1	PC		
CJA11	Unit control system (including cabinets)	Transducer	1	PC		
CJA11	Unit control system (including cabinets)	Communication card	1	PC		
CJA11	Unit control system (including cabinets)	DI module	1	PC		
CJA11	Unit control system (including cabinets)	AI module	1	PC		
CJA11	Unit control system (including cabinets)	AI module	1	PC		
CJA11	Unit control system (including cabinets)	AO module	1	PC		
CJA11	Unit control system (including cabinets)	DO module	1	PC		
CJA11	Unit control system (including cabinets)	DO module	1	PC		
CJA12	Unit control system (including cabinets)	AI module	1	PC		
CJD	Start up control	Transducer	1	PC		
CJD	Start up control	Communication card	1	PC		

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Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

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Håkan Pettersson

Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
CJD	Start up control	Filter fan EMC	1	PC		
CJD	Start up control	CPU	1	PC		
CJD	Start up control	Memory	1	PC		
CJD	Start up control	Rack	1	PC		
CJD	Start up control	Scalance S612	1	PC		
CJD	Start up control	Communication card	1	PC		
CJD	Start up control	Back plane	1	PC		
CJD	Start up control	AI Module	1	PC		
CJD	Start up control	AI module	1	PC		
CJD	Start up control	AO module	1	PC		
CJD	Start up control	DI module	1	PC		
CJD	Start up control	Network switch	1	PC		
CJP	Instrumentation control cabinets	DO module	1	PC		
CJP	Instrumentation control cabinets	Speed module	1	PC		
CJP	Instrumentation control cabinets	Speed module	1	PC		
CJP	Instrumentation control cabinets	Relay	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	AI module	1	PC		
CJP	Instrumentation control cabinets	DO module	1	PC		
CJP	Instrumentation control cabinets	Counter module	1	PC		
CJP	Instrumentation control cabinets	Contactor	1	PC		
CJP	Instrumentation control cabinets	Signal converter	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJV	Instrumentation control cabinets	AI module	1	PC		
CJV	Instrumentation control cabinets	DI module	1	PC		
MBB10CG005-B01	Turbine casing and rotor (Power turbine system)	Inductive Transducer	1	PC		
MBB10CG005-U01	Turbine casing and rotor (Power turbine system)	Position indicator	1	PC		
MBB10CG005-U02	Turbine casing and rotor (Power turbine system)	Cable Extension	1	PC		
MBB10CG010-U01	Turbine casing and rotor (Power turbine system)	Speed transducer	1	PC		
MBB10CG015-U01	Turbine casing and rotor (Power turbine system)	Amplifier	1	PC		
MBB10CG015-U02	Turbine casing and rotor (Power turbine system)	Control cable	1	PC		
MBB10CG015-U03	Turbine casing and rotor (Power turbine system)	Amplifier	1	PC		
MBB10CP005-B01	Turbine casing and rotor (Power turbine system)	Pressure transducer	1	PC		
MBB10CT085-B01	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		
MBB10CT095-B01	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		
MBB10CT105-B01	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		
MBB10CT110-B02	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		

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Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

Doc. No. J9401873E Rev. ind.

Issued by
Håkan Pettersson

Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
MBH10AA005-KA01	Cooling and sealing gas system	Ball valve	1	PC		
MBH10CT005-B01	Cooling and sealing gas system	Pt100-sensor	1	PC		
MBH20AA015-Y01	Cooling and sealing gas system	Solenoid valve	1	PC		
MBH20AA020-S11/S21	Cooling and sealing gas system	Limit switch	1	PC		
MBH20BS205-S004	Cooling and sealing gas system	Silencer	1	PC		
MBK10CY005-B01	Transmission gear between prime mover and driven machine	Vibration transducer	1	PC		
MBL30AA005-MS01	Intake air, cold gas system	Spring	1	PC		
MBL30AA010	Intake air, cold gas system	Valve	1	PC		
MBL30AA030	Intake air, cold gas system	Check valve	1	PC		
MBL30CM005-B01	Intake air, cold gas system	Transmitter	1	PC		
MBM10AV005-E01	Combustion chamber	Spark plug	1	PC		
MBM10AV005-T01	Combustion chamber	Ignition unit	1	PC		
MBM10CQ005-B01	Combustion chamber	Flame detector	1	PC		
MBP05AA215-S11	Fuel supply system (Gas fuel system)	Limit switch	4	PC		
MBP10AA005	Fuel supply system (Gas fuel system)	Valve aggregate	1	PC		
MBP10AA010-S11	Fuel supply system (Gas fuel system)	Limit switch	1	PC		
MBP10AA010-Y01	Fuel supply system (Gas fuel system)	Solenoid valve	1	PC		
MBP10AA205	Fuel supply system (Gas fuel system)	Ball valve	1	PC		
MBP10CP005-B01	Fuel supply system (Gas fuel system)	Pressure transducer	1	PC		
MBP10CP020-S01	Fuel supply system (Gas fuel system)	Pressure switch	1	PC		
MBP10CT005-B01	Fuel supply system (Gas fuel system)	Pt100-sensor	1	PC		
MBP20AA005-S31	Fuel supply system (Gas fuel system)	Limit switch	1	PC		
MBT10AA005-S11	Gas generator system	Bleed valve	1	PC		
MBT10AA005-Y01	Gas generator system	Solenoid valve	1	PC		
MBT10AA010-B01	Gas generator system	Bleed valve	1	PC		
MBT10AA010-KT01	Gas generator system	Valve	1	PC		
MBT10AA010-Y01	Gas generator system	Solenoid valve	1	PC		
MBT10AV005-B01	Gas generator system	Igniter	1	PC		
MBT10CG005-B01	Gas generator system	Inductive transducer	1	PC		
MBT10CP010-B01	Gas generator system	Transmitter - Pressure	1	PC		
MBT10CP015-B01	Gas generator system	Pressure transducer	1	PC		
MBT10CQ005-B01	Gas generator system	Flame detector	1	PC		
MBT10CQ005-B02	Gas generator system	Flame ampl.module	1	PC		
MBT10CS005-B02	Gas generator system	Transmitter	1	PC		
MBT10CT005-B01	Gas generator system	Temperature sensor	1	PC		
MBT10CT020-B01	Gas generator system	Temperature sensor	1	PC		
MBT10CT030-B01	Gas generator system	Thermocouple	1	PC		
MBT10CT045-B01	Gas generator system	Temperature sensor	1	PC		
MBT10CY005-B02	Gas generator system	Transmitter charge amplifier	1	PC		
MBT10CY010-B01	Gas generator system	Vibration transducer	1	PC		
MBV10AH005	Lubricant supply system	Heater	1	PC		

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Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
MBV10AN005-KN01	Lubricant supply system	Fan housing	1	PC		
MBV10AN005-M01	Lubricant supply system	Low voltage motor	1	PC		
MBV10CL010-B01	Lubricant supply system	Level gauge	1	PC		
MBV10CP010-QP01	Lubricant supply system	Instrumentation	1	PC		
MBV10CP015-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV10CT010-B01	Lubricant supply system	Pt100-sensor	1	PC		
MBV21CP005-S01	Lubricant supply system	Pressure switch	1	PC		
MBV40AA025-N01	Lubricant supply system	Limit switch	1	PC		
MBV40CP010-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV40CP015-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV40CP020-MR01	Lubricant supply system	Union	1	PC		
MBV40CT005-B01	Lubricant supply system	Pt100-sensor	1	PC		
MBV52AP005-M01	Lubricant supply system	Low voltage motor	1	PC		
MBV54CP015-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV60AA015-Y01	Lubricant supply system	Solenoid valve	1	PC		
QFA10AA170	Central control air generation system (Instrument air system)	Membrane valve	1	PC		
QFA10CP100-S01	Central control air generation system (Instrument air system)	Pressure switch	1	PC		
SAG10AB005-MS01	Ventilation system gas turbine	Spring	1	PC		
SAG10AB005-S11	Ventilation system gas turbine	Limit switch	1	PC		
SAG10AB005-Y01	Ventilation system gas turbine	Solenoid ventilation inlet/outlet	1	PC		
SAG10AN005-M01	Ventilation system gas turbine	Medium voltage motor	1	PC		
SAG10CP005-B01	Ventilation system gas turbine	Pressure transducer	1	PC		
SAG10CT005-B01	Ventilation system gas turbine	Pt100-sensor	1	PC		
SFY10CQ005-B01	Control and protection equipment (Gas detection system)	Gas detector	1	PC		
SFY10CQ005-B02	Control and protection equipment (Gas detection system)	Central unit	1	PC		
SGC30	Spray deluge system	Safety Valve	1	PC		
SGC30	Spray deluge system	Bottle Valve	1	PC		
SGC30	Spray deluge system	Smoke Detector	2	PC		
SGC30	Spray deluge system	Warning Light flashing red	1	PC		
SGC30	Spray deluge system	Limit Switch	1	PC		
SGC30	Spray deluge system	Push Button	1	PC		
SGC30	Spray deluge system	Blocking Valve	1	PC		
SGC30	Spray deluge system	Fan motor	1	PC		
SGC30	Spray deluge system	Warning Light flashing red	1	PC		
SGC30	Spray deluge system	Push Button	2	PC		
SGC30	Spray deluge system	Limit Switch	1	PC		
SGC30	Spray deluge system	Pneumatic Actuator	1	PC		
SGC30	Spray deluge system	Status Panel	2	PC		

Total: -

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Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

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Håkan Pettersson

Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price

Scope of spare parts listed is based on a generic spare part list adapted to project applications. It shall not be considered as the final scope of spare parts. The final scope of spare parts will be agreed upon during the project execution phase. Any changes in scope of spare parts may result in a price adjustment. This quotation may contain a discount as is valid only when ordering together with the main equipment within the validity period of this quotation.

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Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Consumables

Doc. No. J9401872E
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Consumables for 1 year

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
MBV	Lubricant supply system	Sheet gasket for oil mist filter	3	PC		
MBV	Lubricant supply system	Filter cartridge for oil mist filter	12	PC		
MBV	Lubricant supply system	1 lube oil filter element & 1 top seal O-ring	3	PC		
SAE	Ventilation system El generator	Filter cartridge F8	3	PC		
SAG	Ventilation system gas turbine	Filter cartridge G4	36	PC		
SDB	Compressor washing system	Compressor cleaning	208	PC		
SDB	Compressor washing system	Anti freeze/Rinse Liquid	208	PC		
Control cubicle	Control cubicle	Appliance battery	12	PC		
MBL10	Intake air, cold gas system	Prefilter M6	360	PC		
MBL10	Intake air, cold gas system	High efficiency filter E10	360	PC		

Scope of spare parts listed is based on a generic spare part list adapted to project applications. It shall not be considered as the final scope of spare parts. The final scope of spare parts will be agreed upon during the project execution phase. Any changes in scope of spare parts may result in a price adjustment. This quotation may contain a discount as is valid only when ordering together with the main equipment within the validity period of this quotation.

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Ingenuity for life

SGT-600 25MW

Extended Intervals Maintenance Plan Gas Fuel

Customer Service Product Information

1CS118959

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1. Introduction

This document describes the general maintenance concept and the required preventive maintenance for an SGT-600 gas turbine unit over approximately 15 years of operation. The information given in this document reflects the maintenance scope for 120 000 equivalent operating hours (EOH) in baseload operation, with a maximum of 600 equivalent operating cycles (EOC) between Hot Gas Path Inspection and Major Overhaul.

The maintenance concept is defined in terms of preventive and corrective maintenance, and all the other service products available which ensure a safe operation of your gas turbine unit. The main focus is given to the preventive maintenance. The scope of work in the maintenance schedule, presented in different levels, comprises a package of activities, including driven equipment such as electric generator, gearbox, and driven compressor.

Additional service products available are also presented such as spare part concept, remote diagnostic services, long-term programs, modernizations, and upgrades.

1.1 Downtime and time between overhaul

The gas turbine is scheduled for inspections with varied scope including core engine, auxiliaries, and driven equipment within the maintenance plan. The scope of the different inspections determines the downtime for the individual inspection depending on which kind of application, package, and machine configuration is in place. Inspections are classified as Remote Minor Inspection, Hot Gas Path Inspection, and Major Overhaul. As the gas turbine units can be used for different applications and be subject to inspection findings, variations in owner support, and other site-specific features, the downtime for the inspections could differ.

Standard downtimes:

1-shift

- Remote Minor Inspection 1 day on-site
- Hot Gas Path Inspection 11 days on-site
- Major Overhaul 16 days on-site

2-shift

- Remote Minor Inspection 1 day on-site
- Hot Gas Path Inspection 8 days on-site or 2 days off-site
- Major Overhaul 11 days on-site or 5 days off-site

EOH and EOC are used to determine the time between overhauls. The EOH and EOC uses a method to calculate the accumulated wear on the gas turbine parts during operation, setting the required time interval between overhauls.

1.2 Applicability and requirements

The applicability and requirements for this maintenance plan are:

- Active data collector
- Base load operation with limitation on cycles between major inspections
- Gas fuel operation
- Filter installation according to Siemens recommendation

This Maintenance Plan is built on 60 000 EOH between Major Overhauls.

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2. Maintenance

Economical operation is affected by the operational performance of the power plant and also by the availability and the reliability of the plant as a whole. Successful and profitable operation also requires a well-prepared maintenance plan, together with personnel trained to the appropriate level with the relevant engineering knowledge, experience, and technical support.

The maintenance plan described is adapted to coincide with the scheduled interval for the gas turbine activities. This document comprises the maintenance concept for equipment in the gas turbine drive train. There are individual maintenance concepts for each type of driven equipment, and those equipment activities are not fully explained and summarized in this document. Drive train equipment for the gas turbine could be electric generator, gearbox, and driven compressor.

Maintenance can be divided into two categories:

- Preventive maintenance
- Corrective maintenance

Siemens maintenance concept is focusing on optimizing the preventive maintenance with regards to cost and installation availability throughout the entire lifetime.

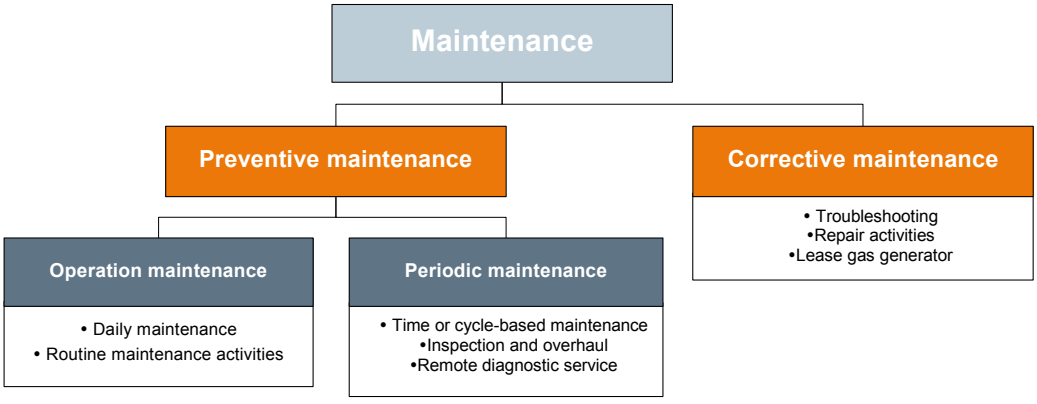

Figure 1. Maintenance overview

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2.1 Preventive maintenance

The preventive maintenance is divided into two main categories:

- Operation maintenance - continuous activities performed by the customer
- Periodic maintenance - reoccurring activities scheduled by the maintenance plan of the gas turbines and the driven equipment

2.1.1 Operation maintenance

The gas turbine requires regular attention to detect trends and to determine abnormalities at an early stage.

Operation maintenance is to be carried out according to the operation maintenance manual, which is included in the site-specific operation and maintenance documentation. Operation maintenance activities are performed on a daily, weekly, monthly, and yearly basis. As the maintenance is carried out on regular basis during operation, site personnel performs the operation maintenance.

Operation maintenance consists mainly of monitoring of the drive train operation. The monitoring includes daily checks with instrument readings, visual inspection for general condition – that is, checks for leakage, abnormal noise, and so on.

Routine maintenance activities are carried out on a calendar basis (such as compressor cleaning, lubrication oil sampling, calibration checks, function checks and so on) or as required (filter replacement, cleaning, and so forth), including preventive maintenance of the auxiliary systems due to normal wear and tear.

The recommendation is to plan and perform these activities in connection to planned preventive maintenance according to maintenance plan in order to avoid additional shut-down of the unit.

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2.1.2 Periodic maintenance

2.1.2.1 Maintenance plan

This maintenance plan is defined for an SGT-600 operating on base load with certain number of starts according to section 1. To optimize the overall maintenance cost and availability during the drive train lifetime, the maintenance plan includes necessary service activities for several important functions in the gas turbine system.

Maintenance plan coverage		
Gas turbine unit	**Gear system**	**Driven equipment**
Gas Generator (GG)	Main gear and couplings	Electric generator
Power Turbine (PT)		Compressor
Auxiliary systems		

Table 1: Maintenance plan coverage

The overall availability of the gas turbine is determined by planned outages. Therefore, such outages are to be managed as efficiently as possible.

The planned outages are possible under the following conditions:

- The maintenance plan activities are planned well in advance.
- The work to be performed and the spare parts required are purchased well in advance.
- The duration is kept as short as possible by comprehensive planning and expert execution.

This requires close communication and cooperation between the parties, starting well before the preventive maintenance plan activities.

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2.1.2.2 Scheduling of maintenance

Equivalent operating hours and equivalent operating cycles are used to determine the duration between maintenance inspections for the gas turbine.

Equivalent operating hours, EOH - a method to calculate the accumulated wear of engine from the operating hours and number of starts and stops.

Equivalent operating cycles, EOC - a method to calculate the accumulated wear from cycles, that is, from start to stop.

Remaining lifetimes of replacement components are limited by either the number of EOH or the number of EOC. Frequent starting and stopping with few operation hours makes components run into the EOC limitation. Continuous operation with many operation hours and few starts makes components run into the EOH limitation. Part load operation could extend the intervals between major inspections.

The formula to calculate the EOH and EOC factors depends on input from the gas turbine operation taken under consideration stress, fuel, and starts.

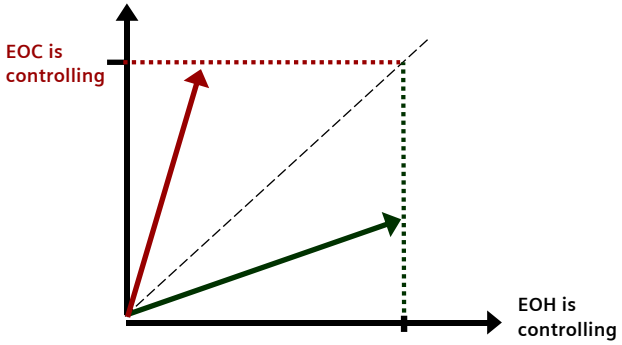

Figure 2. Maintenance interval boundaries

Irrespective of EOH, Siemens recommends that a Remote Minor Inspection is performed every two years.

Irrespective of EOH, a Hot Gas Path Inspection/Major Overhaul is to be carried out with maximum 600 EOC in between.

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2.1.2.3 Gas turbine maintenance

Scope of work at various maintenance levels

There are three different levels of inspections scope which are to be performed in scheduled interval. The inspection is defined by the amount of work that is performed at every inspection occasion.

- ***On-site maintenance***

On-site Maintenance is a standard concept for preventive gas turbine maintenance. All activities are carried out in conjunction to the customer plant, either direct on-site or in facilities nearby.

	Remote Minor Inspection*	Hot Gas Path Inspection*	Major Overhaul*
Scope of inspection	**Remote Inspection:** **Verification of:** • Control system and instruments • Performance **Site Inspection:** **Borescope inspection of:** • Compressor • Combustion section • Compressor turbine • Power turbine **Visual inspection of:** • Air inlet • Auxiliaries • General condition	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Site Inspection:** **Borescope inspection of:** • Compressor • Power turbine **Inspection of:** • Fuel injectors • Compressor turbine • Auxiliaries • Alignment controls **Verification of:** • Control system and instruments	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Site Inspection:** **Dismantling of:** • Compressor **NDT of:** • Compressor **Inspection of:** • Fuel injectors • Compressor turbine • Power turbine • Bearings • Auxiliaries • Alignment controls **Verification of:** • Control system and instruments

Table 2: Scope of work at various maintenance levels

**Remote Minor Inspection is also referred to as A-inspection, Hot Gas Path Inspection is also referred to as B-inspection. Major Overhaul is also referred to as C-inspection.*

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- ***Off-site maintenance***

Using an off-site maintenance concept reduces total downtime for the gas turbine package to as low as 14 days in 15 years. This is made possible by using a gas generator exchange. Maintenance work of auxiliaries and driven equipment is performed in 2-shifts.

	Remote Minor Inspection	Hot Gas Path Inspection	Major Overhaul
Scope of inspection	**Remote Inspection:** **Verification of:** • Control system and instruments • Performance **Site Inspection:** **Visual inspection of:** • Air inlet • Auxiliaries • General condition **Borescope inspection of:** • Compressor • Combustion section • Compressor turbine • Power turbine	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Gas generator exchange:** • Gas generator overhauled off-site **Site Inspection:** **Borescope inspection of:** • Power turbine **Inspection of:** • Auxiliaries • Alignment controls **Verification of:** • Control system and instruments	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Gas generator exchange:** • Gas generator overhauled off-site **Site Inspection:** **Inspection of:** • Power turbine • Power turbine bearings • Auxiliaries • Alignment controls **Verification of:** • Control system and instruments

Table 3: Scope of work at various maintenance levels

- ***Spare gas generator***

For reliability critical applications, it is recommended that the customer owns a spare gas generator. This option has the following advantages for planned inspections, unplanned outages, and plant life such as:

- Smooth on-time exchange operation (no long distance transport, custom formalities, and so on)
- Spare gas generator available on customer premises in case of unplanned outage
- Redundant configuration of having an extra gas generator extends overall plant operation time
- Maximized availability and plant reliability

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Replacement of gas turbine components

Since the intervals of the maintenance plan are dependent of the components lifetime, replacement of parts occurs at Hot Gas Path inspections or Major Overhaul.

Typical replacement parts for this maintenance plan are:

- Combustion chamber
- Compressor turbine guide vane 1
- Compressor turbine blade 1
- Compressor turbine guide vane 2
- Compressor turbine blade 2
- Heat shield 1
- Heat shield 2
- Power turbine blade 3

Replacement parts in the maintenance plan can be new, used or reconditioned. As continuous development and new engineering judgments are built into the replacement interval, including operation and maintenance of the unit, the maintenance is performed in accordance with specifications and instructions of Siemens. Therefore the intervals for the replacements are continuously updated according with the latest maintenance standard.

Environment and operation as well as maintenance factors can have a major impact on both replacement interval and lifetime of the unit as a whole.

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2.1.2.4 Gear maintenance

The gear box suppliers recommend that inspections are carried out according to the operating and maintenance manual, in order to monitor the status from the original installation. The maintenance plan is adapted to coincide with the gas turbine scheduled activities – see Table 7.

In this maintenance plan, the gear inspection activities are named G1 and G2. G1 inspection activities are to be performed every 15 000 EOH and G2 every 60 000 EOH.

	Remote Minor Inspection	Hot Gas Path Inspection	Major Overhaul
Scope of inspection	**Remote Inspection:** **Verification of:** • Control system and instruments **Site Inspection:** **Visual inspection of:** • Tooth mesh • Parallelism check of casing	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Site Inspection:** **Visual inspection of:** • Tooth mesh • Parallelism check of casing	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Site Inspection:** **Visual inspection of:** • Tooth mesh • Gear parts **Inspection of:** • Backlash and bearing clearance • Parallelism check of casing • Tooth contact pattern • Alignment gear to core

Table 4: Gear box scope of work at various maintenance levels

2.1.2.5 Generator maintenance

The generator inspection activities are named L1, L3, and L4. Inspection activities are coordinated with the gas turbine scheduled activities and be performed in line with Table 7.

Generator maintenance program interval:

- L1 every Remote Minor Inspection or every second year
- L3 every Hot Gas Path Inspection or maximum interval of six years
- L4 every Major Overhaul or maximum interval of twelve years

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	Remote Minor Inspection	Hot Gas Path Inspection	Major Overhaul
Scope of inspection	**Remote Inspection:** **Verification of:** • Control system and instruments **Site Inspection:** **Visual inspection of:** • External status • Earth brushes • Internals from manhole	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Site Inspection:** **Visual inspection of:** • External status • Earth brushes **Inspection of:** • Insulation resistance • Terminal box • Bearings	**Prior to site inspection:** **Remote Online Check** **Verification of:** • Instruments **Site Inspection:** **Visual inspection of:** • External status • Earth brushes **Inspection of:** • Insulation resistance • Winding • Stator/Rotor • Pole bolts • Bearings • Exciter

Table 5: Electric generator scope of work at various maintenance levels

2.1.2.6 Driven compressor maintenance

Also the driven compressor has got its individual maintenance schedule which is coordinated to the gas turbine schedule. The scopes for the inspections are labelled Level I, Level II and Level III.

The inspections are to be performed in accordance with table 7. (In mechanical drive applications, the maintenance plan may be adjusted to project specific conditions, such as frame size and type of driven compressor. The general recommendation is to have a Level II inspection carried out at least every 5 years and a Level III inspection at least every 10 years.)

	Remote Minor Inspection	Hot Gas Path Inspection	Major Overhaul
Scope of inspection	**Site Inspection:** **Visual inspection of:** • Instruments • Oil system • Filters **Verification and functional tests of:** • Controls • Safety devices	**Site Inspection:** • Change of dry gas seal **Visual inspection of:** • Instruments • Oil system • Filters • Bearings **Verification and functional tests of:** • Controls • Safety devices	**Site Inspection:** • Change of dry gas seal • Bundle exchange **Visual inspection of:** • Instruments • Oil system • Filters • Bearings **Verification and functional tests of:** • Controls • Safety devices

Table 6: Driven Compressor scope of work at various maintenance levels

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2.1.3 Maintenance levels

The different activities in the preventive maintenance plan are structured in a system of levels – see the maintenance schedule. The gas turbine, driven equipment, and related systems, are split into three areas with maintenance levels classified as follows:

As the maintenance is compiled to coincide with the gas turbine scheduled activities, the main activities for driven equipment are scheduled accordingly. The driven equipment and the activities of the gas turbine are comprised into one occasion; the overview is comprehensible and easy to follow. The inspection occasions are named Remote Minor Inspection, Hot Gas Path Inspection, and Major Overhaul.

The Remote Minor Inspection is focused on visual inspection of compressor and turbine parts, while the Hot Gas Path Inspection mainly contains inspection and/or replacement of parts in the hot section of the gas turbine. A total dismantle of the gas turbine is performed at the Major Overhaul, when both compressor and turbine are opened for inspection.

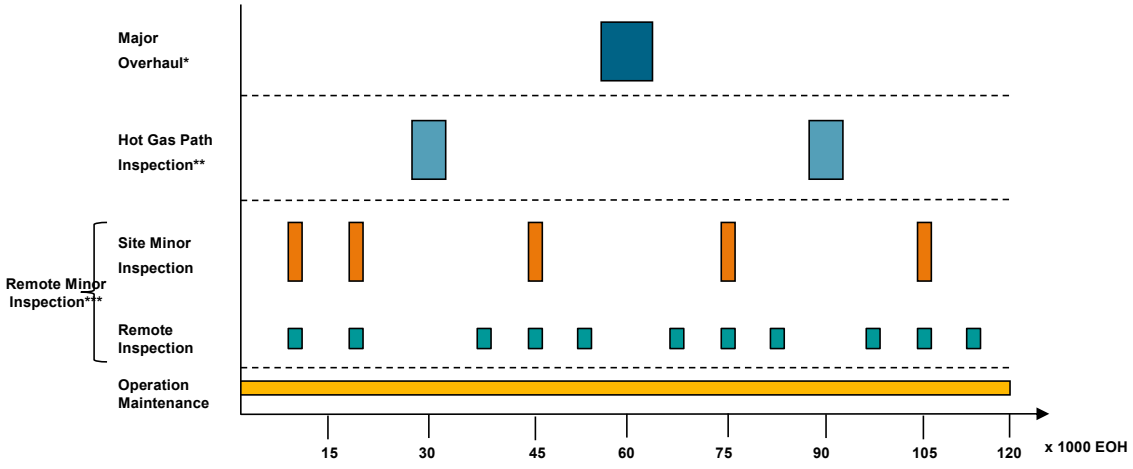

Figure 3: Maintenance schedule

**Major Overhaul was previously referred to as Level C Inspection*

***Hot Gas Path Inspection was previously referred to as Level B Inspection*

****Remote Minor Inspection was previously referred to as Level A Inspection*

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The maintenance coordination table 7 is used as a guideline for the maintenance plan overview. As the operation continues, individual equipment activities on each drive train can misalign over time.

Maintenance levels from each area are coordinated into a periodic maintenance schedule, with overall levels Remote Minor Inspection, Hot Gas Path Inspection, and Major Overhaul controlled by either EOH or EOC. The inspection levels of driven equipment are specified by the individual system's maintenance plan.

kEOH	10	20	30	45	60	75	90	105	120
Gas turbine	RMI	RMI	HGP	RMI	MO	RMI	HGP	RMI	-
Main gear and coupling	G1	G1	G1	G1	G2	G1	G1	G1	-
El. gen.	L1	L1	L3	L1	L4	L1	L3	L1	-
Driven compr.[1]	Level I	Level I	Level II	Level I	Level III	Level I	Level II	Level I	-
On-site downtime (days)*	1	1	11	1	16	1	11	1	-
Off-site downtime (days)	1	1	2	1	5	1	2	1	-

**The expected downtime is based on 10hours/day, 6 working days/week*

[1] In mechanical drive applications the maintenance plan may be adjusted to project specific conditions, such as frame size and type of driven compressor etc. The general recommendation is to have a Level II inspection carried out at least every 5 years and a Level III inspection at least every 10 years.

Table 7: Maintenance coordination

Calculation of standard downtime assumes that a Remote Online Check has been successfully carried out before the inspection.

The actual downtime can differ from the standard downtime. Reasons might be the owner's requirements, work support from the owner, site-specific features, findings during inspections or Remote Online Check, quality of workshop facilities, lifting tools, and so on.

In mechanical drive applications, actual downtime can differ from standard downtime; reasons may be project-specific adjustments, frame size, type of driven compressor, and so on.

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2.1.3.1 Planning recommendation for preventive maintenance

At least 18 months before an overhaul, the customer, together with Siemens, is to begin to plan/schedule the overhaul requirement, considering the following items:

Scope of work

Based on standard time schedule, earlier investigation results, customer operational observations, and requirements, a specific scope of work is to be decided.

Spare parts requirements and spare part stock

In accordance with the scope of the work, it is possible to specify the spare parts likely to be needed. Concerning the demand, the customer spare part backup is to be checked for completeness and condition. Recommended spare parts are to be procured well in advance.

Tools and fixtures

Tools and fixtures for maintenance activities are to be available when the activities commence, whether available through possession of the customer or provided by Siemens.

Lifting and transportation

If preventive off-site maintenance or corrective maintenance involves a gas generator exchange, operation availability of all necessary lifting equipment, transportation skids, vehicles, suitable roads, and permits, are to be checked before the inspection.

Inspection and assembly work

All inspections and assembly work are to be performed by, or supervised by, trained personnel to ensure quality of work performed.

Capacity planning

The client, together with Siemens, is to check well in advance that required workshop facilities are available.

Work plan

A work plan is to be developed, specifying which activities to perform at site or in repair facilities.

Coordination

For the coordination of activities, resources and work permits, a bar chart and critical path diagram are to be prepared before the start of each inspection/overhaul.

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2.2 Corrective Maintenance

Apart from the preventive maintenance it is also essential to have a philosophy for efficient backup in case of emergency situations. By offering support services available for all our customers such as emergency gas generators, access to emergency store for sophisticated gas turbine parts, and around the clock telephone support, the cost for the backup is divided without reducing the availability to the backup functions for each customer.

When required in a specific situation, the following emergency service can be provided:

- Troubleshooting instructions
- Emergency delegation of service personnel
- Status assessment
- Access to gas turbine emergency spare part store
- Access to emergency gas generator
- 24 h gas generator exchange
- Repair activities
- Field balancing group
- Root cause analysis

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3. Spare parts concept

Availability of spare parts plays a vital role in the reliability and availability of the machine. These purpose-specific spare part packages must be defined and procured on time to cover the operation maintenance activities, maintenance plan activities and corrective maintenance activities. The definition and scope of components depends on several criteria, including:

- Mode of operation
- Downtime
- Delivery time
- Duration of repairs, if necessary
- Number of identical components
- Failure probability

Therefore, available spare parts can considerably reduce the duration of an overhaul.

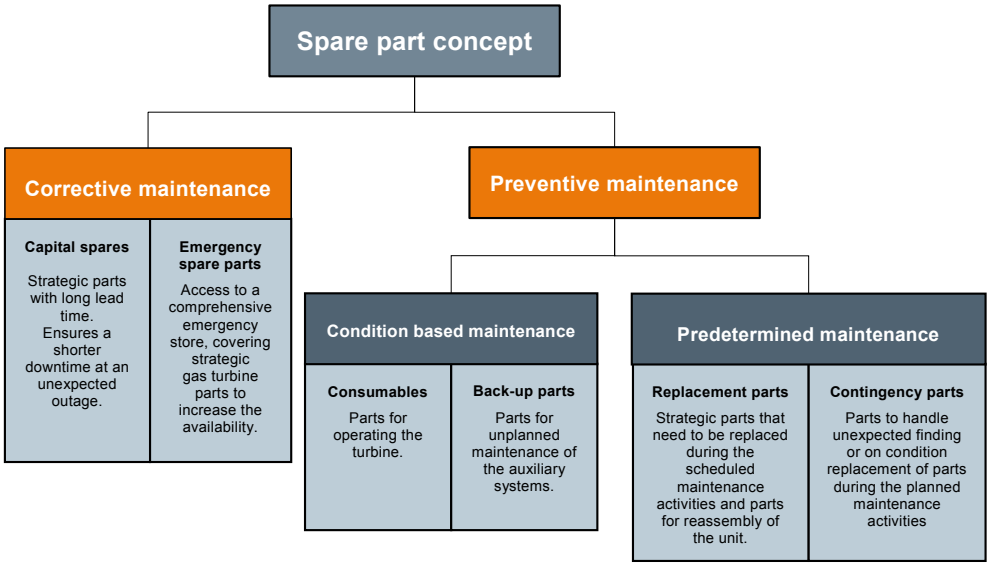

Figure 4. Spare part concept

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4. Remote diagnostic services

Siemens remote diagnostic services can assist you with the skilled professional management of the assets of your plant to help you to meet your investment goals. Through the daily monitoring of various operating statistics, trending and data analysis, tailored to your specific machine, Siemens RDS is designed to optimize the performance of your rotating equipment and maximize your gas turbine availability.

4.1 24-hour global helpdesk service

Real-time support from a Siemens technical support engineer that can remotely connect to your gas turbine control system.

- Emergency calls 24/7
- Dedicated telephone line
- Assurance of support as OEM
- Ability to connect remotely to the control system
- Case management system for all calls

4.2 Daily monitoring with early warning notification

Data are analyzed by specialist Siemens diagnostic engineer via connected data collector, and you are then contacted with associated notifications, through written communication.

- Key performance indicators
- Possible causes for loss of availability
- Daily monitoring observations and notifications
- Overview of gas turbine equipment operation

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5. Long-term program (FlexLTP)

Keeping our customers up to date with the latest in rotating equipment technology is key to Siemens' customer support philosophy. Our Long Term Service Agreements (FlexLTP) give you the opportunity to tailor maintenance and operation to suit your needs and requirements, and optimize it as your business evolves. All made to help you maximize operation. The long-term program agreement is a package of service products that are tailored to fit your needs:

- A tailored maintenance plan, based on your operating profile, needs and requirements.
- Value-added options through OEM know-how:
  - Performance guarantees
  - Spare part packages
  - Resident engineer
- Flexible contract and levels of support
  - Framework agreement: an agreement that allows the end user to work with one set of terms, conditions, and prices.
  - Managed call-off agreement: an agreement that allows the end user to budget the long-term operational costs without negotiating every transaction between the end user and a specific Siemens gas turbine contractor.
  - Preventive contract: all scheduled maintenance, Remote Minor Inspection, Hot Gas Path Inspection, and Major Overhaul, with a set of services.
  - Corrective contract: a comprehensive contract for total maintenance coverage.
- Flexible payment structures

When joining us in a Long Term Program, together we can make sure that operation and maintenance of your plant is always optimized, no matter what conditions prevail.

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6. Modernizations and upgrades

To meet various demands of our customers, we can offer various levels of modernization and upgrade solutions, tailored to the requirements of your specific equipment. Solutions are divided to meet different operational priorities.

- Availability
  - Maintainability
  - Obsolescence
  - Overhaul interval extension
  - Outage optimization
- Flexibility
  - Fuel flexibility
  - Profile flexibility
- Efficiency
  - System efficiency
  - Reparability
- Reliability
  - Operational reliability
  - Start reliability
- Environment
  - Emission compliance
  - Operational emissions
  - Operational waste
  - Sound emissions
- Power
  - Full load power output

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Appendix 1: terminology list

The terminology used when discussing preventive maintenance in this document is as follows:

Data collector	Unit that stores operational data over a period of time.
Emergency gas generator	If the unit has a corrective maintenance, an emergency gas generator replaces the removed gas generator.
Equivalent Operating Cycles (EOC)	A method to calculate the accumulated wear from cycles, that is, from start to stop.
Equivalent Operating Hours (EOH)	A method to calculate the accumulated wear of engine from the operating hours and number of starts and stops.
Hot Gas Path Inspection (HGP)	Site visit containing replacement of hot parts and borescope inspection of compressor, and check of auxiliaries. *Also referred to as B -inspection.*
Lease gas generator	Gas generator leased from Siemens. Replaces the gas generator due for planned off-site maintenance. Operated until the gas generator of the customer returns and is replaced in a 24-hours gas generator exchange operation.
Maintenance	Tasks carried out to keep the equipment in normal operating condition or to restore it to such condition that operation can proceed without interruption.
Maintenance plan	Plan based on equivalent operating hours or equivalent operating cycles, containing recommended activities at inspections, checks, and overhauls. For Siemens gas turbines, recommended inspections and overhauls for continuous load operation with basic intervals are defined in a maintenance plan with maintenance levels labeled Remote Minor Inspection, Hot Gas Path Inspection, and Major Overhaul.
Major Overhaul (MO)	Site visit containing a complete disassembly of the gas turbine with replacement of hot parts and on-condition parts, and check of auxiliaries. *Also referred to as C-inspection.*
Off-site maintenance	Maintenance concept based on a gas generator exchange. The gas generator is removed from the plant and the necessary maintenance activities are carried out off-site – in a workshop close to the customer or in a Siemens workshop. Production quickly continues using a spare gas generator. The plant outage is specified by the time required to exchange gas generator.
On-site maintenance	Maintenance concept based on taking the customer plant out of operation for service of installed equipment. Necessary maintenance activities are carried out inside the enclosure or in facilities nearby. The plant outage is specified by the time required to put the customer's original equipment back into operation.
Operation maintenance	Tasks carried out by the site personnel mainly consisting of daily attendance and routine maintenance activities.
Original Equipment Manufacturer (OEM)	An original equipment manufacturer (OEM) is a company whose goods are used as components in the products of another company, which then sells the finished item to users.
Preventive maintenance	Planned maintenance activities carried out to maintain the equipment in normal condition.

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Remote Inspection (RI)	The Remote Inspection includes verification of control system and Instruments, performance package and a Remote Inspection report.
Remote Minor Inspection (RMI)	Remote Minor Inspection consists of Remote Inspection and Site Minor Inspection carried out between Hot Gas Path Inspection and Major Overhaul. *Also referred to as A-inspection.*
Remote Online Check (ROC)	Remote analysis carried out before the inspection (approximately 3 months) to check functionality of auxiliaries and other gas turbine systems. Operational data are extracted from the data collector and remotely transferred for careful analysis by Siemens experts. Findings from the Remote Online Check could result in additional activities recommended for the upcoming inspection scope.
Site Minor Inspection (SMI)	Site visit containing borescope inspection of compressor and turbine, and check of auxiliaries.
Spare gas generator	Gas generator that replaces the removed gas generator which has been taken for off-site maintenance.
Time Between Overhaul (TBO)	The amount of time in equivalent operating hours between Major Overhauls.

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		Document number		1CS159505	
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Dual tagging information and requirements

In addition to the KKS-based tagging system, an additional tagging is possible. This document gives a brief description about how dual tagging on project design documentation, labelling of hardware and gas turbines Human Machine Interface is realized and what information is required from the client to implement this into the project with highest possible quality.

Dual tagging procedure

Siemens will, during the basic engineering of the project, hand over three different lists to the client. These lists are to be completed by the client and after completion to be implemented as stated below.

Lists in Microsoft EXCEL format provided by Siemens:

1. Cable table (cable number)
2. Hardware tags
3. Control system tags

Customer completes the lists above with project specific tags for all units which are applicable for specific project. Characters for the additional tags are limited to 14.

Submittal of lists with the additional tags shall be provided according to SDRL (Suppliers Document Registers List).

Documents showing dual tagging

Electrical system

- Circuit diagram (Loop diagram)
- Cable list
- Cable connection list
- Bus cable list
- Bus cable connection list

FO / SGT-600(MD B, PG B, PG EX B) SGT-700(MD B, PG B, PG EX B) SGT-750(PG A, MD A) SGT-800(PG B, PG B2, PG Ex B2, PG B LS)/&BE101	

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Control system

- Human Machine Interface (HMI)
- HMI screen printouts
- Signal transfer list for OPC / Modbus communication (if included)
- Signal lists
- Event, alarm and shutdown lists
- Fault procedure
- CFC logic (However the system is still structured according to KKS-system)
- Cause & Effect matrix (if included)

Mechanical system

- System P&ID's
- Lists (Instrument, settings etc)
- Instrument and motor data sheets (if included)
- Hook-up drawings (if included)

Physical components/equipment marked with dual tagging label

- Aggregate/components
- Instruments
- Valves
- Motors
- Pumps
- Junction boxes (front)
- Cabinets (front)
- Cables

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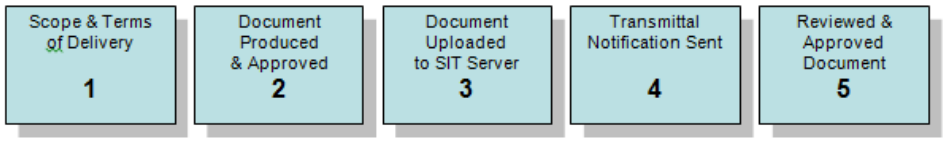
		Document number		1CS113721	
		Revision	F	Page	1

SDRL/CDL Processes and design freeze concept

This document provides information regarding Siemens Industrial Turbomachinery AB (SIT AB) management of Operation & Maintenance (O&M) documentation submission and Design Freeze Concept (DFC). It covers processes and tools for document submission. For details regarding O&M document turnaround times, status, life cycle state, etc. refer to separate Supplier Document Register List (SDRL) document.

SDRL outlines SIT AB standard document deliveries. If need occurs the SDRL is jointly adjusted to project specific requirements by customer and SIT AB. The adjusted and approved SDRL is named Customer Document List (CDL). The CDL is a critical process for project success and is used as base for all document controlling and submissions during project execution phase. This standardized process is supported by a tailor made application. During project execution phase, monthly reports are covering document status. The CDL process includes below listed key steps where steps 2 to 5 are repeated for each document.



Picture 1: Main steps in the CDL process

Design freeze concept

DFC is utilised within the engineering process. The purpose of DFC is to set the transitory stage from Basic Engineering (BE) to Detailed Engineering (DE) phases and to structure flow of information between SIT AB and customer to increase quality of information.

SIT AB's design process is split in a BE phase and a DE phase. The split between these two phases is the DFC date. At this date the functional design, locations and main dimensions are frozen. After this date changes affecting functionality, locations and main dimensions shall, as far as possible, be avoided. Suggested changes at this phase shall be discussed as soon as possible between SIT AB and customer.

There are in principle two releases of documents affected by DFC. The first is sent as For Engineering (FE); the second is sent after incorporation of agreed comments and updated with final information. The documents are then frozen and sent as For Construction (FC).

SIT AB produces documents as stated in the CDL and these are submitted via Siemens Sharepoint Server to the customer. For security and proprietary purposes, only authorized users are able to access their projects and/or contracts in Sharepoint application. Customers receive login information and user manual from SIT AB.

When SIT AB or a customer uploads documents an e-mail, including a transmittal note, is sent by the CDL application to following recipients:

For SIT AB uploads:

- Customer project manager
- CDL responsible at customer, if applicable
- Additional customer employees as stated in the agreement

Product: SGT-600, SGT-700, SGT-750, SGT-800	

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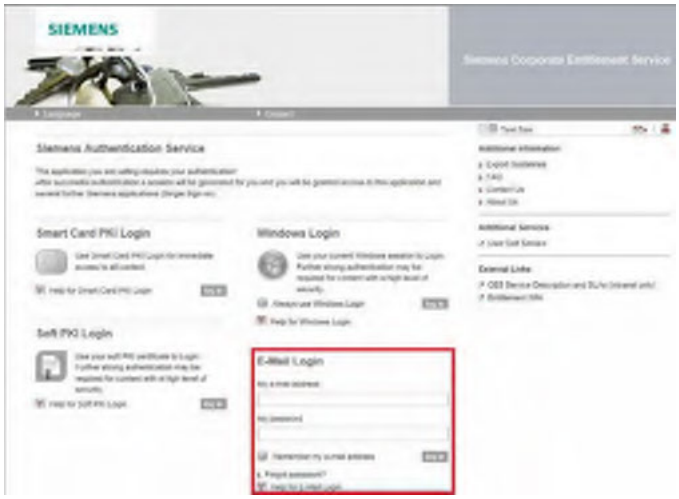
For Customer uploads:

- SIT AB project manager
- CDL responsible at SIT AB
- Additional SIT AB employees as stated in the agreement

For documents designated as "For Information" no further actions will be triggered by the CDL application.
For documents designated as "For Approval" the CDL application sends a reminder to the document owner(s) after the number of days as specified in the contract.

How to login to Siemens Sharepoint



- Enter your e-mail and one-time password received via e-mail to sign in. Password has to be changed after first log-on.

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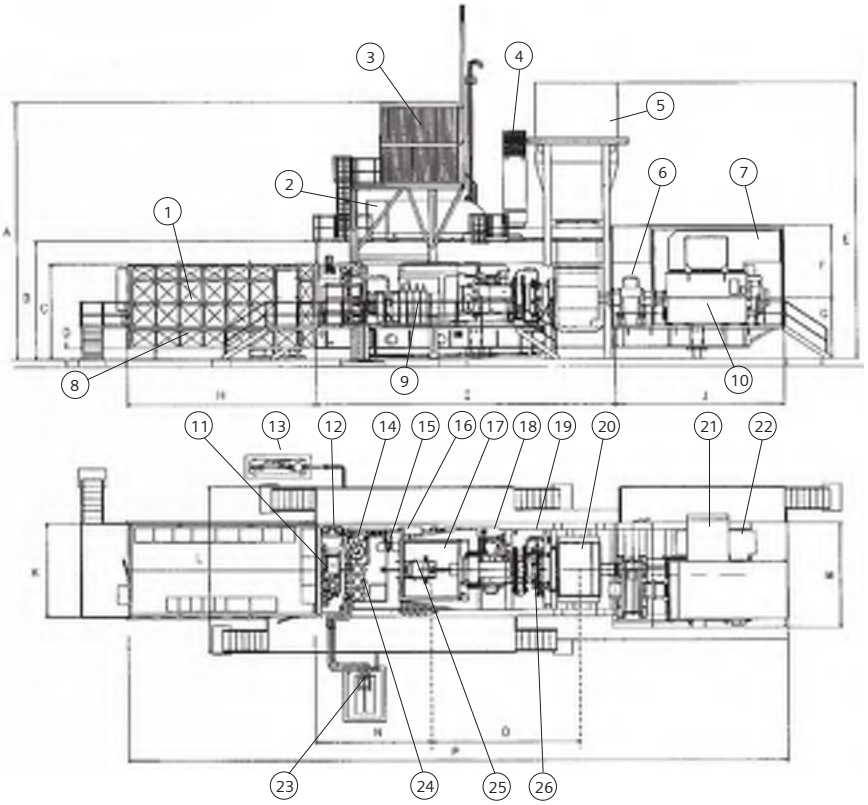
Layout & Terminal points power generation



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Meter	11,0	5,1	4,1	0,5	11,8	3,1	2,6	8,0	12,8	7,2	4,0	7,2	4,5	5,0	6,3	28,1
Feet	36,1	16,7	13,5	1,6	38,7	10,2	8,5	26,2	42,0	23,6	13,1	23,6	14,8	16,4	20,7	92,2

BO/FO / SGT-600 (MD B, PG B, PG EX B) / LD102 | Project name Siemens Sans 7

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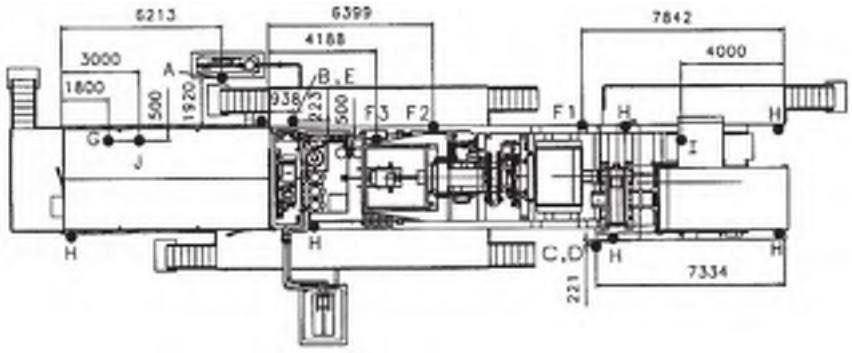
1. Electrical & Control module
2. Ventilation air inlet
3. Air intake filter
4. Ventilation air outlet
5. Exhaust silencer
6. Gear
7. Generator cooling, air inlet
8. Batteries
9. Fire suppress unit
10. Generator
11. Liquid fuel unit
12. Ignition gas bottles
13. Gas fuel unit 1
14. Oil ventilation filter
15. Lube oil filter
16. Compressor wash unit
17. Air intake plenum
18. Gas fuel unit 2
19. Purge air unit
20. Exhaust
21. Generator cooling, air outlet
22. Generator terminal box
23. Lube oil cooler
24. Lube oil unit
25. Starter motor
26. Seal air cooler

Terminal points



Mechanical

		Connection/Standard	*Above ground level*
A	Gas fuel supply	Flange, 3", ANSI B16.5, 300 lbs, RF	~490 mm
B	Liquid fuel supply	Flange, 2", ANSI B16.5, 300 lbs, RF	~878 mm
C	Cooling water supply	Flange, DN125, DIN 2633, PN 16 Option :Flange, 1 1/2", ANSI B16.5, 300 lbs, RF	~580 mm
D	Cooling water return	Flange, DN125, DIN 2633, PN 16 Option :Flange, 1 1/2", ANSI B16.5, 300 lbs, RF	~285 mm
E	Instrument air supply	ISO G ¾" FEMALE (Tube Ø 20)	~881 mm
F	Drains		
1	Exhaust outlet casing drain	Flange, DN50, DIN 2635, PN40 Option :Flange, 2", ANSI B16.5, 300 lbs, RF	~1027 mm
2	Turbine drain	Flange, DN50, DIN 2635, PN40 Option :Flange, 2", ANSI B16.5, 300 lbs, RF	~730 mm
3	Compr. washing unit drain	Hose, 3/8"	~2325 mm

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Electrical

		Connection/Standard	*Above ground level*
G	Secondary PT for synchronising equipment	-	~3000 mm
H	Earthing	95 mm^2 copper wire, six in number	~500 mm
I	Medium voltage	-	~3400 mm
J	Auxiliary power supply	-	~2500 mm

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SIEMENS **Installation & Commissioning Manual** GT-G01-11

For Information Only
Reference Copy

General

Installation & Commissioning Manual Instruction

SUMMARY

The *Installation & Commissioning Manual* is valid for Siemens Medium Gas Turbines (MGT) in different applications, i.e. Power Generation or Mechanical Drive applications, and covers the standard workshop test, site installation and site commissioning scope of work for the gas turbine and the equipment included in the delivery.

The manual consists of five main parts. Each part can be split into several binders if necessary.

- *Installation Manual*
- *Commissioning Manual*
- *EHS Manual**
- *Updates*
- *Reports & Data**

**Normally applies for Siemens and its sub contractors*

The general procedures for installation and commissioning are described in sequences and – in general – each sequence has its specific *Work Module*, which contains checklists and instructions, forms, records etc. needed for carrying out all necessary steps towards completion.

The *Installation & Commissioning Manual* shall be used together with the project specific technical documentation (i.e. drawings, layouts, circuit diagrams, etc.) that is referred to in the manual.

The Installation & Commissioning Coordination Office is responsible for the *Installation & Commissioning Manual* and revises and distributes the manual and its content.

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Installation & Commissioning Manual Instruction

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1 REFERENCE DOCUMENTS

See chapter *10.3 List of Documents*.

2 MANUAL STRUCTURE

The *Installation & Commissioning Manual* consists of five main parts that can be split into several binders if necessary.

- *Installation Manual*
- *Commissioning Manual*
- *EHS Manual**
- *Updates*
- *Reports & Data**

**Normally applies for Siemens and its sub contractors*

2.1 *Installation Manual / Commissioning Manual*

The *Installation Manual* and the *Commissioning Manual* each consists of three main chapters:

- **General** – contains the *Installation & Commissioning Manual Instruction* as well as all general documents valid for the process i.e. sequence descriptions, signature records, general forms etc.
- **QA/QC** – contains the Quality Assurance and Quality Control documentation, e.g. the *Inspection & Test Plan* valid for the project. System specific quality documentation issued by Siemens is filed under respective Work Module (see below). quality documentation, e.g. NDT protocols, certificates etc, issued by third party is filed under the QA/QC section.
- **Work Module** – contains the technical checklists, instructions, settings, protocols and certificates, etc. needed for each applicable system.

2.2 *EHS Manual*

The *EHS Manual* contains the complete Environment, Health & Safety structure, i.e. all applicable EHS documents:

- **Environment, Health & Safety Plan** – contains the project specific EHS plan.
- **EHS Instructions** – contains all applicable Siemens EHS instructions.
- **Risk Assessment** – contains the generic risk assessment.
- **Method Statements** – contains the generic method statements.
- **EHS Forms** – contains necessary and applicable EHS forms to be used at site.

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2.3 *Updates*

The *Updates* section consists of technical documents, i.e. P&ID's, Circuit Diagrams, Setting Lists, Connection Tables, etc, that shall be handed over to the Design Office after the site activities are completed. This is done when the commissioning is terminated.

Note! **All red marked sheets shall be copied and the original shall be placed in the binder *Updates*, and the copy to be placed as a replacement in the technical binder!**

2.4 *Reports & Data*

The *Report & Data* section consists of daily and weekly reports, EHS reports, data readings, modification order lists, punch lists, etc. produced throughout the complete installation and commissioning phases.

3 COMPILING THE INSTALLATION & COMMISSIONING MANUAL

The *Installation & Commissioning Manual* covers all Siemens Medium Gas Turbines (MGT) applications. The project scope determines which systems are applicable. Based on this, a project specific *Installation & Commissioning Manual* is compiled, assigned and stamped with the unit project name and number on all included documents.

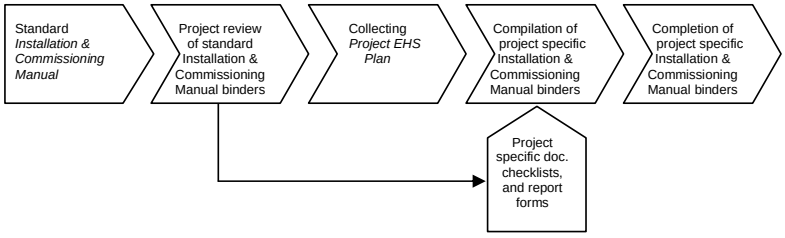
A complete set of project specific technical report forms can be printed out from the design tool *COMOS*, or blank forms can manually be filled in and enclosed in the manual.

Optional gas turbine and process systems included in the delivery are added in the *Installation & Commissioning Manual* and checklists **GT-I16-11** and **GT-C15-11** will be used.

The *Project EHS Plan* **GT-H01-11** is a part of the *Installation & Commissioning Manual* and is prepared for each project and continuously updated throughout the project execution phase.

The *Inspection & Test Plan* (ITP) **GT-Q01-11** is used in the project and covers the QA/QC demands for a Siemens medium gas turbine standard delivery. If a project requires a specific ITP, this will be issued by the Quality Department and replace **GT-Q01-11** in the *Installation & Commissioning Manual* and in the *Quality Control Plan*.

Where Siemens instructions and settings do not apply, sub supplier documentation applies and is referred to as *sub supplier documentation* in the reference lists.



Note! **If the compiling is not included in Siemens scope and instead is to be performed by the Customer or Sub contractor, separate project specific routines for compiling may be used!**

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4 INSTALLATION PROCEDURE

4.1 *General Procedures*

The general procedures for the installation sequence are described in the documents

Installation Sequence **GT-G02-11** (Power Generation applications) or *Installation Sequence* **GT-G02-12** (Mechanical Drive applications).

The sequences described are not fixed and can be altered to suit the specific site conditions and requirements.

The responsible Installation Technical Field Advisor shall upon arrival on site attend/call for a *Site Start-up Meeting* where site rules and EHS issues are raised. During the *Site Start-up Meeting*, general issues regarding the installation and its sequence shall be discussed. Issues regarding Customer witness points and routines for inspections shall be cleared and finalized. If special reporting and/or work permit routines or specific site rules applies for Siemens installations activities, it should be discussed and formalized at the *Site Start-up Meeting*.

Throughout the installation, reporting shall be done according to *Daily & Weekly Reporting Instruction* **GT-G03-31**.

- The reporting to project for the installation is written daily. The *MS Word* template **GT-G03-21** is used for the *Daily/Weekly Report*. The *Daily/Weekly Report* can also be issued to the Customer for information if required.

During the installation the checklists and other applicable documents (referred to in the checklist reference list) for each system and/or sequence shall be filled in and signed by the responsible Installation Technical Field Advisor. Reports and protocols issued or filled in during the installation shall be filed under the corresponding sequence step/work module.

Reports, protocols and certificates issued by a third party shall be filed under *Certificates & Protocols* **Q02**.

If a component is exchanged this should be recorded in the *Material Request & Component Change out Record* **GT-G04-22**.

Hand over to commissioning can not take place until the system/sequence checklist has been completed.

Note! **The Customer signature is not mandatory for the Installation completion of a system!**

4.2 *Site Installation*

Depending on the specific project requirements the installation scope may vary. Siemens have the following standard options for gas turbine sites:

- **Technical Field Advisory Services**
  Siemens provides technical advice during installation. The Customer is primarily responsible for workers, EHS, time schedules, installation sequences at site and supplies manpower, tools etc. necessary for the installation. The advisor will support and instruct the Customer so that the installation of Siemens delivery is performed according to the *Installation & Commissioning Manual* and to the contractual requirements. The advisor reports technical issues to the Customer.

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- **Complete Installation Services**
  Siemens supplies manpower, tools etc., and is responsible for time schedule and installation sequences as well as EHS, waste handling etc. on the gas turbine construction area and its related activities and for the sub contractors employed by Siemens. Over all Site EHS management will be in the Customers' scope for activities in or outside the gas turbine construction area not controlled by Siemens.

Note! **Legal definitions may differ between contracts! The text above is for information only! The scope of installation shall be defined for each project!**

4.3 *As-designed Document Handling during Installation*

As-designed documents and drawings collected from the Design Office such as drawings, isometrics, circuit diagrams, cable connection tables etc. will be used as *working copy of as-built* drawings throughout the installation. Changes to the drawings initiated on site will be verified by the design office before implementation. Minor changes such as positioning of pipe supports or cable routing may be initiated and made on site without approval from the design office as long as the function and the design strength are not altered.

After installation the *working copy of as-built* documents shall be handled according to *Report & Document Handling* **GT-G03-11**.

All changes must be documented in all documents that involve the change. E.g. circuit diagram; cable list, internal winding table, layouts, P&ID's, pipe isometrics etc.

All changed documents shall be copied and the original shall be placed in the binder *Updates* and the copy to be placed as a replacement in the technical binder.

The responsible Installation Technical Field Advisor, either electrical or mechanical, shall ensure that the changes made have been received by the design office after the installation is terminated on site to enable the design office to issue correct *as-built* documentation.

The changes made on site to the as-designed documentation are part of the continuous improvement process and will ensure that faults in the design are not repeated.

5 HAND OVER FROM INSTALLATION TO COMMISSIONING

When a system has been completed and inspected both electrically and mechanically it can be handed over from installation to commissioning.

The hand over process is controlled in checklist *Hand over Systems to Commissioning* **GT-I27-11** and the Commissioning Leader/Engineer accepts the hand over by signing off each system. Acceptance of a system shall only be made after a joint inspection by the responsible Installation Technical Field Advisor or Commissioning Leader/Engineer.

Remaining work such as late modifications or warranty issues must be documented in form *Hand over Punch List* **GT-G04-23**. The scope and extent of the remaining work must be known and agreed upon by both the responsible Installation Technical Field Advisor and Commissioning Leader/Engineer before hand over of a system is done.

After the hand over is completed the Commissioning Leader/Engineers are responsible for the system and no installation activities can be done on the handed over system unless it has been approved by the responsible Commissioning Leader/Engineer. Approval is done according to the work permit routines (see the *EHS Manual*), or verbally depending on in

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which phase the commissioning is in. During the hot/rotating commissioning phase, work permit rules apply.

6 COMMISSIONING PROCEDURE

6.1 *General Procedures*

The general procedures for the commissioning sequence are described in *Workshop Test Sequence* **GT-G02-13**, and *Commissioning Sequence for Site (Power Generation)* **GT-G02-14** or *Commissioning Sequence for Site (Mechanical Drive)* **GT-G02-15**.

The sequences described are not fixed and can be altered by the responsible Commissioning Leader/Engineer to suit the site conditions and requirements.

Throughout the commissioning, reporting shall be done according to *Daily & Weekly Reporting Instruction* **GT-G03-31**.

- During the Commissioning, *Daily Log Sheet* **GT-G03-22** shall be written. The *Daily Log Sheet* is logging events connected to the tests during commissioning. *Daily Log Sheet* is internal and shall not be issued to the Customer but selected events may be used for the *Daily/Weekly Report.*
- When the installation is terminated, the reporting to project is taken over by the commissioning. The *MS Word* template **GT-G03-21** is used for the *Daily/Weekly Reports*. The *Daily/Weekly Report* can also be issued to the Customer for information if required.

During the commissioning the checklists and other applicable documents (referred to in the checklist's reference list) for each system and/or sequence shall be filled in and signed by the responsible Commissioning Leader/Engineer. Reports and protocols issued or filled in during the commissioning shall be filed under the corresponding sequence step/work module.

Reports, protocols and certificates issued by a third party shall be filed under *Certificates & Protocols* **Q02**.

Commissioning report forms covering loop checks and calibrations will be used for each instrument and object connected to the control system. Data from previous calibrations may be used or referred to. The *Commissioning Report Matrix* shall be used as a checklist. Tick off (✓) each instrument or object, so that it is clear what has been done. The reports are then enclosed in the corresponding sequence step.

- The component testing has references from checklist *Check Components & P&ID* **GT-C03-11** and is ticked off for each system.
- System checklists refer to detailed instructions, setting lists, drawings and special test records that are enclosed to the corresponding system.

If a component is exchanged this should be recorded in the *Material Request & Component Change-out Record* **GT-G04-22**.

After the commissioning, the manual will be handled according to **GT-G03-11**.

Note! **All control system changes at workshop test and at site commissioning affecting safety function must be verified with design office for the delivery project!**

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Following are considered as safety functions:

Shutdown system, turbine governor, AVR, anti-surge control, synchronizing control, interlock/interface with exhaust ducting, interlocks for low and medium voltage system, Eex and ATEX classified equipment.

6.2 *Workshop Test*

The auxiliary systems are tested at the sub supplier workshop after assembly. The available auxiliary systems are, after installation in the package, subjects to additional workshop tests at final assembly. The main objectives of the latter tests are to verify the settings, check adjustments and to carry out wiring checks as well as clean flushing, tuning and functional checks of the complete systems together with the control system.

For units without control room connected to the skid, or with loose panels, temporary cabling will be used between the gas turbine package and the control equipment. Temporary feeders are isolation tested outside the *Installation & Commissioning Manual* test record procedures.

The commissioning during the workshop test is to some extent depending upon the availability of external systems. Some equipment can only be commissioned during a load test or on site due to contractual or logistical reasons.

The level of workshop test is also depending on product and is described in document *Workshop Test Sequence*.

Signing of component testing on checklist *Check Components & P&ID* **GT-C03-11** for workshop test will cover the components installed at workshop. Some systems will have additional components installed at site and will require another signature.

Some measurements and calibrations from core engine assembly and core engine test needs to be collected and attached to the *Installation & Commissioning Manual.*
Example: IGV calibration and axial bearing clearances.

6.3 *Site Commissioning*

Depending on the specific project requirements the commissioning scope may vary. Siemens have the following standard options for gas turbine sites:

- **Commissioning when Advisory Services**
  Siemens provides a commissioning team and necessary commissioning instruments and is responsible for commissioning sequences. The Customer is primarily responsible for EHS, time schedules and for providing Siemens commissioning team with necessary facilities and utilities according to contract. The commissioning team will perform commissioning according to the *Installation & Commissioning Manual*. The commissioning engineers reports technical issues to the Customer.
- **Commissioning when Complete Installation Services**
  Siemens provides a commissioning team, necessary commissioning instruments, etc., and is responsible for time schedule and commissioning sequences. Siemens will be responsible for the EHS, waste handling etc. on the gas turbine construction area and its related activities and for the sub contractors employed by Siemens. Over all Site EHS management will be in the Customers' scope for activities in or outside the gas turbine construction area not controlled by Siemens.

Note! **Legal definitions may differ between contracts! The text above is for information only! The scope of commissioning shall be defined for each project!**

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Commissioning on site takes place when the installation of the gas turbine unit is completed. Installation of some external systems and Customer options are completed in parallel with the Commissioning.

The commissioning procedure follows a program, consisting of a stationary and a rotating test part (pre-commissioning and hot commissioning). The scope of the site commissioning will depend upon the extent of previous workshop test and if a string test is carried out.

Stationary tests excluded from previous workshop tests are completed on site according to the checklists. For units without control room connected to skid or with loose panels, additional loop checks for cabling installed on site, will be carried out.

The rotating commissioning checklist covers the standard gas turbine delivery for *Power Generation* or *Mechanical Drive* application.

The responsible Commissioning Leader/Engineer shall upon arrival on site attend/call for a *Commissioning Start-up Meeting* where the rotating commissioning program and the trial run are reviewed together with the Customer. The Customer shall declare which starts/tests the Customer will witness (see also the *Inspection & Test Plan*). If special reporting and/or work permit routines or specific site rules applies for Siemens commissioning activities, it should be discussed and formalized at the *Commissioning Start-up Meeting*.

The starts/tests that are described in the program/contract are sufficient for the Customer take-over (*Preliminary Acceptance Certificate*, PAC). All extra starts/tests that the Customer requires have to be agreed upon with - Siemens Project Manager. This is to minimize the number of starts. In order to reduce the number of starts during the commissioning, it is recommended to keep the internally requested starts at the lowest possible level.

When performing special tests during load operation and power is critical for plant or customer, evaluation and analyze is required to minimize risk of shutdown. Plant commissioning team or customer must be aware of the test and the precautions made.

When the turbine control parameters or turbine protections need to be adjusted outside the *Engine Control Specification* or *Setting List*, acceptance from Siemens Product Coordinator or Product Manager and a fault report is required.

Note! **The Customer signature is not mandatory for the Commissioning completion of a system!**

6.4 *Document Handling during Commissioning*

As-designed technical documents collected from Design Office such as P&ID's, circuit diagram, cable connection table, project setting list, control system documents etc. will be used as *working copy of as-built* drawings during commissioning. One set of these documents must be used for each unit on sites with more than one gas turbine unit.

After the commissioning the *working copy of as-built* documents – as well as software copies – will be handled according to *Report & Document Handling* **GT-G03-11**.

Note! **Only red marked sheets for Siemens as well as Sub Supplier produced documents should be returned in the binder "*Updates*"**

It is important that the green and red update markings in the documents are done in a standardized way and according to the instructions below. The reason to keep a strict routine is to avoid misunderstandings and to:

- Facilitate the hand over between personnel.

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- Assure that the design office can transfer the changes from the as-designed to the as-built documentation.

6.4.1 Update Marking and Verification

Changes and updates must be clearly marked in **red** color. If possible; use a pen < 0.5 mm and sign next to the change. It is allowed to make notes in the documentation if using a pencil.

All changes must be documented in all files that involve the change, e.g. circuit diagram; cable list, internal winding table, apparatus list, lay-outs, P&ID's, instrument list, aggregate list and electrical load list. Though, there are a few exceptions:

- Cable number in the circuit diagrams does not need to be updated since this is not included in the as-built document.
- Terminal lists do not need to be updated. These will not be included in the *as-built* documentation.

Indicate that systems are checked with a **green** marker in the P&ID's, circuit diagrams, etc.

- Tick off the contact symbol of a mechanical relay only if the relay function has been tested. If jumpers are used over the connection points of the relay the relay can not be ticked off.
- Tick off the input of an AI or DI channel if the signal is visual on the operator station.
- Tick off the output of a DO channel when it is tested from the PC logic.
- Tick off the solenoid valve symbol when the solenoid function is verified. Tick off the valve symbol when the valve function is verified.
- Tick off the relay coil to a relay when the relay function is verified. Tick off the relay function when the function is verified.
- A green line through a terminal connection point means that a terminal point is not disconnected. These terminal connection points shall only be isolated again if a *work permit* has been assigned.

Note! **Do not tick off (green mark) components unless the function has been verified!**

Change signal names and descriptions in the circuit diagram if necessary. The names shall correspond to the names in the PC logic.

New wirings shall be documented in alpha-numerical order in the connection and cable tables. If there is not enough space in the table, document the new wring in the end of the table with a note of the correct position.

6.4.2 Marking Transfer from Supplier

Internal electrical circuits in *Energize Low Voltage Switchgear* **GT-C2**, *Energize UPS & Battery System* **GT-C4**, *Energize & Load Gas Turbine Control System* **GT-C5,** *Perform Generator & Main Terminal Box Checks* **GT-C16** and *Perform Relay Protection, AVR & Synchronizing System Checks* **GT-C17**, must be checked before energizing. This check is normally performed by supplier before delivery and markings can in those cases be transferred to the *Working Copy of As-built* documentation without rechecking. If no supplier documentation has been handed over, the check must be done during commissioning.

Transferred markings are done in **yellow** color and deviations between the sub supplier documentation and the *working copy of as-built* documentation, must be clarified with the design office.

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If circuits are hidden as *"black boxes"* in the project *working copy of as-built* documentation, the box may be ticked off after confirmation that circuit checks have been performed by the sub supplier with reference to an available standard drawing.

7 TOOLS & INSTRUMENTS

All tools and instruments to be used during the installation and commissioning phases must have a valid certificate and must be in safe and working condition according to the *Project EHS Plan* **GT-H01-11**.

For tools and instruments supplied by Siemens, used during installation and commissioning, testing and calibration follows the requirements according to ISO 9001, ISO 14001 and OHSAS.

8 ENVIRONMENT, HEALTH & SAFETY

8.1 *Environment, Health & Safety Plan*

The *Project EHS Plan* **GT-H01-11** is based on 100 130 10 - E O Health, Safety & Environment Plan and Siemens Energy Oil & Gas and Industrial Applications (E O) Health, Safety and Environmental (EHS) Policy and is in line with E EHS Policy Principles.

It is an integral part of the overall projects Environment, Health & Safety (EHS) program.

The *Project EHS Plan* is written in compliance with the European Legislation such as:

"Council Directive 89/391/EEC" *Introduction of measures to encourage improvements in the safety and health of workers at work*.

"Council Directive 92/57/EEC" *Implementation of minimum safety and health requirements at temporary or mobile construction Sites.*

The EHS plan shall also comply with:

- Local laws and legislation
- Contract and Customer EHS rules
- Siemens K-9595-36 *Minimum occupational Health and Safety and security requirements for Project/Site contracts*.

In case of duplicate or contradictable EHS rules it is contractually regulated that the strictest rule shall always be complied with.

8.2 *Siemens EHS Instructions*

Siemens EHS instructions shall be used on site or string test to ensure that the work and other activities fulfills Siemens minimum requirements of occupational health and safety and minimizes environmental impact.

8.3 *General Risk Assessment for Site Activities*

General Risk Assessment for Site Activities **GT-H03-11** is a generic risk assessment based upon good practice and standard procedures for Siemens installation and commissioning on site, performed by trained and experienced personnel. The risk assessment covers

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Installation and commissioning activities on site. It describes the standard control measures to be implemented to control risks and hazards on site.

If local legislation and/or site specific EHS plans or conditions calls for risk assessments and method statements they shall be made by the Contractor performing the task.

8.4 *Generic Method Statements*

The generic method statements are based upon good practice and standard procedures for Siemens installation and commissioning on site; generic risks have been identified in *General Risk Assessment for Site Activities*.

If local legislation and/or site specific EHS plans or conditions call for risk assessments and method statements they shall be made by the contractor performing the task.

8.5 *Forms and Reports for Site Use*

This is a collection of standardized forms and reports which shall be used on site for the EHS work during the installation and commissioning phases of the project.

9 QUALITY ASSURANCE / QUALITY CONTROL ON SITE

9.1 *Inspection & Test Plan*

The *Inspection & Test Plan* **GT-Q01-11** is a common list of inspections done during installationand commissioning on site. The document is part of the *Quality Control Plan* (QCP) for a project.

The inspection list refers to checks in the *Installation & Commissioning Manual* Work Modules and in some cases to company standard instructions.

If the project specific QA/QC requirements are not fulfilled by the *Inspection & Test Plan*, the responsible Quality Department issues a project specific *Inspection & Test Plan* that ensures that the requirements of the inspections and tests are met.

When inspecting the gas fuel system installation, the *Safety Assessment Certificate* **GT-Q01-21** shall be filled out and attached in the *Report* binder.

9.2 *Certificates & Protocols*

Quality documentation issued by third parties are to be collected and filed in chapter **Q02**.

9.3 *Modification order*

If a modification order is extensive, rework is to be performed or considered.

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10 DOCUMENTATION STRUCTURE

10.1 *Document Signing*

General

All grey fields are mandatory to fill in with values and/or signatures. Possible exceptions or more detailed explanations will be found in respective document.

Signature Record

The *Signature Record* **GT-G04-21** in the *Installation & Commissioning Manual* must be filled in for all Installation Technical Field Advisors and Commissioning Engineers who are signing the *Installation & Commissioning Manual*.

Checklists

The checkboxes are signed by the executing Installation Technical Field Advisors and Commissioning Engineers.

When the checklist is completed, the responsible engineer signs the checklist completion field with date and signature.

Note! **The Customer signature is not mandatory for completion!**

Test Records / Setting Lists

Each record is signed with date by the performing Installation Technical Field Advisors and/or Commissioning Engineers.

Hand over Commissioning Manual

The document *Hand over of Commissioning Manual* **GT-G01-21** will be signed with date by the Customer for acceptance of the *Commissioning Manual* when handed over.

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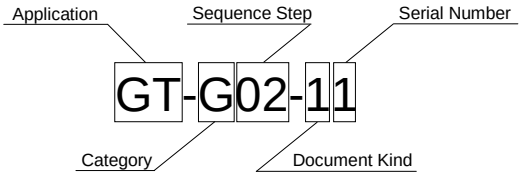
10.2 *Document Number Structure*



Application (GT, ST, PP, etc.)

GT	Gas Turbine package delivery
ST	Steam Turbine
PP	Power Plant (BoP)

Category

G	General documents
I	Work Module installation documents
C	Work Module commissioning documents
P	Work Module performance verification documents
H	EHS (Environment, Health & Safety)
Q	QA/QC (Inspection & Test Plan)

Chapter / Sequence Step Number

Two digit sequence step or chapter number follows the category letter, starting on 01.

Document Kind

1	Main documents, Sequences and Checklists
2	Records, Protocols, Reports and Forms
3	Instructions
4	Setting Lists
5	Drawings

Serial Number

The serial number follows the document kind number, starting on 1.

(ex. GT-G03-21 / GT-I04-11 / GT-C05-21 / GT-H02-310)

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10.3 *List of Documents*

10.3.1 Installation Manual

General

- GT-G01-11 Installation & Commissioning Manual Instruction
- GT-G02-(11-12) Installation Sequence
- GT-G03-11 Report & Document Handling
- GT-G03-31 Daily & Weekly Reporting
- GT-G03-32 Final Report Instruction
- GT-G03-(21-22) Report Forms
- GT-G04-(21-23) Record Lists
- GT-G05-(21-23) Report Forms (Component Test Sheets)

Quality Assurance / Quality Control

- GT-Q01-11 Inspection & Test Plan
- GT-Q01-21 Safety Assessment Certificate
- GT-Q02 Certificates & Protocols

Work Modules

Checklists for SGT-500, SGT-600, SGT-700, SGT-750, SGT-800 (PG Application)

- GT-I01-11 Prepare Installation
- GT-I02-11 Inspect & Check Foundations & Embeds
- GT-I03-11 Receive & Store Equipment
- GT-I04-11 Connect Gas Turbine & Driven Equipment Skids
- GT-I05-11 Position & Level Gas Turbine Skid
- GT-I06-11 **(SGT-800)** Position Generator, Start Motor, Auxiliary Unit & Diffuser
- GT-I08-11 Pre-align Gas Turbine, Generator & Gearbox
- GT-I09-11 Position Control & Battery Module
- GT-I10-11 Install Walkways & Stairs
- GT-I11-11 Install Electrical Cabinets & Batteries
- GT-I12-11 **(SGT-800)** Install Enclosure
- GT-I13-11 Install Ventilation System
- GT-I14-11 Install Air Intake System
- GT-I15-11 Install Exhaust System

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- GT-I16-11 Install Auxiliary & Process Systems
- GT-I17-11 Install Fire Extinguishing Equipment
- GT-I18-11 Install Instrumentation
- GT-I19-11 Install Piping
- GT-I20-11 Install Electrical Equipment & Cables
- GT-I21-11 **(SGT-800)** Install Electrical Equipment inside Enclosure
- GT-I22-11 Fill Lubrication Oil
- GT-I23-11 Align String (Power Generation)
- GT-I25-11 Inspect Mechanical Installation
- GT-I26-11 Inspect Electrical Installation
- GT-I27-11 Hand Over of Systems to Commissioning
- GT-I28-11 Terminate Installation

Checklists for SGT-500, SGT-600, SGT-700, SGT-750 (MD Application)

- GT-I01-11 Prepare Installation
- GT-I02-11 Inspect & Check Foundations & Embeds
- GT-I03-11 Receive and Store Material
- GT-I04-11 Connect Gas Turbine & Driven Equipment Skids
- GT-I05-11 Position & Level Gas Turbine Skid
- GT-I07-11 Position & Level Mechanical Drive Equipment
- GT-I09-11 Position Control & Battery Module
- GT-I10-11 Install Walkways & Stairs
- GT-I11-11 Install Electrical Cabinets & Batteries
- GT-I13-11 Install Ventilation System
- GT-I14-11 Install Air Intake System
- GT-I15-11 Install Exhaust System
- GT-I16-11 Install Auxiliary & Process Systems
- GT-I17-11 Install Fire Extinguishing Equipment
- GT-I18-11 Install Instrumentation
- GT-I19-11 Install Piping
- GT-I20-11 Install Electrical Equipment & Cables
- GT-I22-11 Fill Lubrication Oil
- GT-I24-11 Align String (Mechanical Drive)
- GT-I25-11 Inspect Mechanical Installation
- GT-I26-11 Inspect Electrical Installation

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- GT-I27-11 Hand Over of Systems to Commissioning
- GT-I28-11 Terminate Installation

10.3.2 Commissioning Manual

General

- GT-G01-11 Installation & Commissioning Manual Instruction
- GT-G01-21 Hand over of Commissioning Manual
- GT-G02-13 Commissioning Sequence for Workshop Test
- GT-G02-14 Commissioning Sequence for Site (Power Generation)
- GT-G02-15 Commissioning Sequence for Site (Mechanical Drive)
- GT-G03-11 Document Handling & Reporting
- GT-G03-31 Daily & Weekly Reporting
- GT-G03-32 Final Report Instruction
- GT-G03-(21-22) Report Forms
- GT-G04-(21-23) Record Lists
- GT-G05-(21-29) Report Forms (Component Test Sheets)

Quality Assurance / Quality Control

- GT-Q01-11 Inspection & Test Plan
- GT-Q02 Certificates & Protocols

Work Module

Checklists for SGT-500, SGT-600, SGT-700, SGT-750, SGT-800 (PG Application)

- GT-C01-11 Prepare Commissioning
- GT-C02-11 Energize Low Voltage Switchgear
- GT-C03-11 Check Components & P&ID
- GT-C04-11 Energize UPS & Battery System
- GT-C05-11 Energize & Load Gas Turbine Control System
- GT-C06-11 Perform Lubrication Oil System Checks
- GT-C07-11 Perform Instrument Air System Checks
- GT-C08-11 Perform Gas Fuel System Checks
- GT-C11-11 Perform Gas Turbine, Secondary Air, Starting & Gear System Checks
- GT-C12-11 Perform Ventilation System Checks
- GT-C13-11 Perform Air Intake System Checks

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Installation & Commissioning Manual Instruction

- GT-C14-11 Perform Compressor Cleaning System Checks
- GT-C16-11 Perform Generator & Main Terminal Box Checks
- GT-C17-11 Perform Relay Protection, AVR & Synchronizing System Checks
- GT-C19-11 Perform Fire Extinguishing & Gas Detection System Checks
- GT-C20-11 Perform Protection & Logic Tests
- GT-C21-11 Prepare for Start
- GT-C22-11 Perform Start Tests
- GT-C23-11 Perform Idle Tests
- GT-C24-11 Perform Load Tests
- GT-C25-11 Perform Tests on Completion
- GT-C29-11 Terminate Commissioning

Checklists for SGT-500, SGT-600, SGT-700, SGT-750 (MD Application)

- GT-C01-11 Prepare Commissioning
- GT-C02-11 Energize Low Voltage Switchgear
- GT-C03-11 Check Components & P&ID
- GT-C04-11 Energize UPS & Battery System
- GT-C05-11 Energize & Load Gas Turbine Control System
- GT-C06-11 Perform Lubrication Oil System Checks
- GT-C07-11 Perform Instrument Air System Checks
- GT-C08-11 Perform Gas Fuel System Checks
- GT-C11-11 Perform Gas Turbine, Secondary Air, Starting & Gear System Checks
- GT-C12-11 Perform Ventilation System Checks
- GT-C13-11 Perform Air Intake System Checks
- GT-C14-11 Perform Compressor Cleaning System Checks
- GT-C18-11 Perform Mechanical Drive System Checks
- GT-C19-11 Perform Fire Extinguishing & Gas Detection System Checks
- GT-C20-11 Perform Protection & Logic Tests
- GT-C21-11 Prepare for Start
- GT-C22-11 Perform Start Tests
- GT-C26-11 Perform Minimum Load Tests
- GT-C27-11 Perform Load Tests
- GT-C28-11 Perform Tests on Completion
- GT-C29-11 Terminate Commissioning

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Optional Systems Power Generation and Mechanical Drive

- GT-C09-11 Perform Liquid Fuel & Purge Air System Checks
- GT-C10-11 Perform Dosage / Steam / Water Injection System Checks
- GT-C15-11 Perform Auxiliary & Process System Checks

10.3.3 EHS Manual

- GT-H01-11 Environment, Health & Safety Plan
- H02 Siemens Company EHS Instructions
- H03 Risk Assessments
- H04 Method Statements
- H05 Forms, Reports & Checklists

10.3.4 Updates

- P&I Drawings
- Project Setting Lists
- Changes in Installation Documentation, Isometrics, Drawings etc.
- Changes in Circuit Diagrams
- Changes in Cable Connection Lists, List of Apparatus etc.
- Changes in System Descriptions

10.3.5 Reports & Data

- Weekly Reports
- Daily Reports
- Safety Statistics Reports
- Work Permits
- EHS Inspections & Checklists
- Modification Orders
- Punch Lists
- Tools & Instruments including Certificates
- Analysis (Lubrication Oil, Fuel etc.)
- MSDS – Material Safety Data Sheets
- Software License Agreement
- Operation Readings (Hard copies etc.)
- ECS Drawing
- Contract Performance
- Reports (Workshop Test and/or String Test and Sub Supplier Reports)

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Proposal Section	Redacted Documents
1 - General Proposal Information	Executive Summary - redact price only
2 - Technical Proposal	160_1603090E_A_Exceptions & Clarifications Gas turbine scope
2 - Technical Proposal	171_J1711871E_C_PVSC Performance Guarantee_signed
2 - Technical Proposal	171_J1711882_A PVSC Performance
2 - Technical Proposal	210_J2105873_-_Performance Runs Fuel gas compressor
2 - Technical Proposal	210_J2105874E_-_Performance Black start Generators
2 - Technical Proposal	262_J262326E_-_SCR Performance
2 - Technical Proposal	220_J2203017E_A_Utility schedule Prelminary SGT-600
2 - Technical Proposal	300_TCS-022673P&ID01-1_A_P&ID GAS TURBINE SYSTEM
2 - Technical Proposal	300_TCS-022673P&ID19-1_A_P&ID GAS GENERATOR SYSTEM
2 - Technical Proposal	300_TCS-022673P&ID19-2_A_P&ID GAS GENERATOR SYSTEM
2 - Technical Proposal	305_TCS-022673P&ID18_A_P&ID GAS TURBINE ENGINE SYSTEM
2 - Technical Proposal	330_TCS-022673P&ID04_A_P&ID GEAR ELECTRIC GENERATOR SYSTEM
2 - Technical Proposal	400_J400303E_-_P&ID SCR
2 - Technical Proposal	400_TCS-022673P&ID17-1_A_P&ID LEGEND FOR SYMBOLS
2 - Technical Proposal	400_TCS-022673P&ID17-2_A_P&ID LEGEND FOR SYMBOLS
2 - Technical Proposal	402_TCS-022673P&ID02_A_P&ID COOLING SEALING AIR SYSTEM
2 - Technical Proposal	403_TCS-022673P&ID03-1_A_P&ID STARTING SYSTEM
2 - Technical Proposal	410_TCS-022673P&ID08-1_A_P&ID LUBE OIL GAS TURBINE SYSTEM
2 - Technical Proposal	410_TCS-022673P&ID08-2_A_P&ID LUBE OIL GAS TURBINE SYSTEM
2 - Technical Proposal	410_TCS-022673PID08-1_A_PID LUBE OIL GAS TURBINE SYSTEM(2)
2 - Technical Proposal	423_TCS-022673P&ID13_A_P&ID VENTILATION SYSTEM GAS TURBINE ENCLOSURE
2 - Technical Proposal	424_TCS-022673P&ID15_A_P&ID GAS DETECTION SYSTEM
2 - Technical Proposal	425_TCS-022673P&ID16-1_A_P&ID FIRE DETECTION AND EXTINGUISHING SYSTEM H2O
2 - Technical Proposal	425_TCS-022673P&ID16-2_A_P&ID FIRE DETECTION AND EXTINGUISHING SYSTEM H2O
2 - Technical Proposal	431_TCS-022673P&ID07_A_P&ID GAS FUEL SYSTEM
2 - Technical Proposal	481_TCS-022673P&ID14_A_P&ID WASHING SYSTEM
2 - Technical Proposal	482_TCS-022673P&ID10-2_A_P&ID INSTRUMENT AIR SYSTEM
2 - Technical Proposal	731_TCS-022673P&ID06_A_P&ID COMBUSTION AIR INTAKE SYSTEM
2 - Technical Proposal	700_E1B100333266_A_Preliminary Layout
2 - Technical Proposal	700_J700416E_-_Genaral Layout Fuel Gas compressor
2 - Technical Proposal	700_J700417E_-_General Layout Black Start Generator
2 - Technical Proposal	720_2089924_D_GT Foundation General Layout
2 - Technical Proposal	720_J720267E_A_Preliminary Foundation loads intensity PVSC
2 - Technical Proposal	J630051E_1CS136711_C_Reliability and Availability - Simatic PCS7 Control System
2 - Technical Proposal	J960002E_1CS26665_E_Availability and Reliability
2 - Technical Proposal	820_J820776E_A_Quality Control plan
2 - Technical Proposal	501_J501SET18251ITP_A_Generator Inspection &test plan
3 - Contract Forms	P--500/700/800 - redacted due to confidential information and final contract version not yet negotiated
3 - Contract Forms	Commercial Comments and Clarifications
3 - Contract Forms	Technical Comments and Clarifications
4 - Pricing	Cost Proposal Form
4 - Pricing	Option Price List
4 - Pricing	P20180817-01- MA-Passaic Valley Sewer Plant_T3000_Rev.1
4 - Pricing	980_J980878E_A_Standard Supplier Document Register List
5 - Alternate Proposal	Alternate Proposal Cost Proposal Forms
5 - Alternate Proposal	Alternate Bid Conceptual and Preliminary GA Dwg for 5MOS1 Compressor and 200hp Motor quoted to Siemens for the PVSC Proje
5 - Alternate Proposal	200hp 460-3-60 VFD Details for Siemens PVSC project
5 - Alternate Proposal	Q7281-UEC, PVSC FGB (250-310 psig Case) 5MOS1

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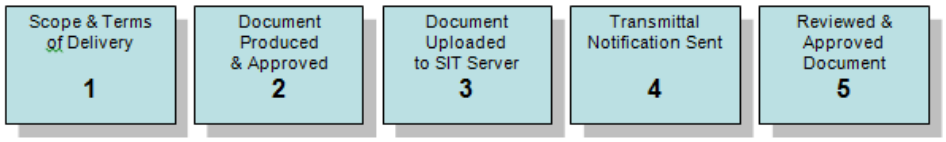
SIEMENS	Operation & Maintenance SGT-600, SGT-700, SGT-750, SGT-800	GTI number		W980041E	
		Document number		1CS113721	
		Revision	F	Page	1

SDRL/CDL Processes and design freeze concept

This document provides information regarding Siemens Industrial Turbomachinery AB (SIT AB) management of Operation & Maintenance (O&M) documentation submission and Design Freeze Concept (DFC). It covers processes and tools for document submission. For details regarding O&M document turnaround times, status, life cycle state, etc. refer to separate Supplier Document Register List (SDRL) document.

SDRL outlines SIT AB standard document deliveries. If need occurs the SDRL is jointly adjusted to project specific requirements by customer and SIT AB. The adjusted and approved SDRL is named Customer Document List (CDL). The CDL is a critical process for project success and is used as base for all document controlling and submissions during project execution phase. This standardized process is supported by a tailor made application. During project execution phase, monthly reports are covering document status. The CDL process includes below listed key steps where steps 2 to 5 are repeated for each document.



Picture 1: Main steps in the CDL process

Design freeze concept

DFC is utilised within the engineering process. The purpose of DFC is to set the transitory stage from Basic Engineering (BE) to Detailed Engineering (DE) phases and to structure flow of information between SIT AB and customer to increase quality of information.

SIT AB's design process is split in a BE phase and a DE phase. The split between these two phases is the DFC date. At this date the functional design, locations and main dimensions are frozen. After this date changes affecting functionality, locations and main dimensions shall, as far as possible, be avoided. Suggested changes at this phase shall be discussed as soon as possible between SIT AB and customer.

There are in principle two releases of documents affected by DFC. The first is sent as For Engineering (FE); the second is sent after incorporation of agreed comments and updated with final information. The documents are then frozen and sent as For Construction (FC).

SIT AB produces documents as stated in the CDL and these are submitted via Siemens Sharepoint Server to the customer. For security and proprietary purposes, only authorized users are able to access their projects and/or contracts in Sharepoint application. Customers receive login information and user manual from SIT AB.

When SIT AB or a customer uploads documents an e-mail, including a transmittal note, is sent by the CDL application to following recipients:

For SIT AB uploads:

- Customer project manager
- CDL responsible at customer, if applicable
- Additional customer employees as stated in the agreement

Product: SGT-600, SGT-700, SGT-750, SGT-800	

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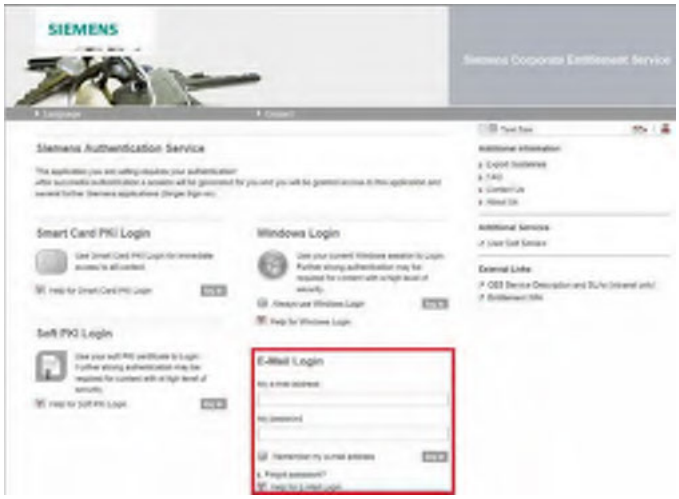
For Customer uploads:

- SIT AB project manager
- CDL responsible at SIT AB
- Additional SIT AB employees as stated in the agreement

For documents designated as "For Information" no further actions will be triggered by the CDL application.
For documents designated as "For Approval" the CDL application sends a reminder to the document owner(s) after the number of days as specified in the contract.

How to login to Siemens Sharepoint



- Enter your e-mail and one-time password received via e-mail to sign in. Password has to be changed after first log-on.

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SIEMENS

Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

Doc. No. J9401873E
Rev. ind.
Issued by Håkan Pettersson

Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
BFA	Low voltage main distribution boards, normal system	Relay	1	PC		
BFA	Low voltage main distribution boards, normal system	Relay	1	PC		
BFA	Low voltage main distribution boards, normal system	Voltage regulator	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Motor protector switch	1	PC		
BFA	Low voltage main distribution boards, normal system	Contactor	1	PC		
BFA	Low voltage main distribution boards, normal system	Mini.circuit breaker	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Fuse knife 25A	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Knife fuse link	1	PC		
BPD	Motor drive system	Knife fuse link	1	PC		
BPD	Motor drive system	Knife fuse link	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Sinamics single motor module input	1	PC		
BPD	Motor drive system	Sinamics S120 single motor module input	1	PC		
BPD	Motor drive system	Fuse link	1	PC		
BPD	Motor drive system	Fuse link	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Contactor	1	PC		
BPD	Motor drive system	Thermal relay	1	PC		
BPD	Motor drive system	DI module	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Relay	1	PC		
BPD	Motor drive system	Relay	1	PC		
CJA11	Unit control system (including cabinets)	Transducer	1	PC		
CJA11	Unit control system (including cabinets)	Communication card	1	PC		
CJA11	Unit control system (including cabinets)	DI module	1	PC		
CJA11	Unit control system (including cabinets)	AI module	1	PC		
CJA11	Unit control system (including cabinets)	AI module	1	PC		
CJA11	Unit control system (including cabinets)	AO module	1	PC		
CJA11	Unit control system (including cabinets)	DO module	1	PC		
CJA11	Unit control system (including cabinets)	DO module	1	PC		
CJA12	Unit control system (including cabinets)	AI module	1	PC		
CJD	Start up control	Transducer	1	PC		
CJD	Start up control	Communication card	1	PC		

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SIEMENS

Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

Doc. No. J9401873E
Rev. ind.
Issued by Håkan Pettersson

Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
CJD	Start up control	Filter fan EMC	1	PC		
CJD	Start up control	CPU	1	PC		
CJD	Start up control	Memory	1	PC		
CJD	Start up control	Rack	1	PC		
CJD	Start up control	Scalance S612	1	PC		
CJD	Start up control	Communication card	1	PC		
CJD	Start up control	Back plane	1	PC		
CJD	Start up control	AI Module	1	PC		
CJD	Start up control	AI module	1	PC		
CJD	Start up control	AO module	1	PC		
CJD	Start up control	DI module	1	PC		
CJD	Start up control	Network switch	1	PC		
CJP	Instrumentation control cabinets	DO module	1	PC		
CJP	Instrumentation control cabinets	Speed module	1	PC		
CJP	Instrumentation control cabinets	Speed module	1	PC		
CJP	Instrumentation control cabinets	Relay	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	AI module	1	PC		
CJP	Instrumentation control cabinets	DO module	1	PC		
CJP	Instrumentation control cabinets	Counter module	1	PC		
CJP	Instrumentation control cabinets	Contactor	1	PC		
CJP	Instrumentation control cabinets	Signal converter	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJP	Instrumentation control cabinets	Insulator	1	PC		
CJV	Instrumentation control cabinets	AI module	1	PC		
CJV	Instrumentation control cabinets	DI module	1	PC		
MBB10CG005-B01	Turbine casing and rotor (Power turbine system)	Inductive Transducer	1	PC		
MBB10CG005-U01	Turbine casing and rotor (Power turbine system)	Position indicator	1	PC		
MBB10CG005-U02	Turbine casing and rotor (Power turbine system)	Cable Extension	1	PC		
MBB10CG010-U01	Turbine casing and rotor (Power turbine system)	Speed transducer	1	PC		
MBB10CG015-U01	Turbine casing and rotor (Power turbine system)	Amplifier	1	PC		
MBB10CG015-U02	Turbine casing and rotor (Power turbine system)	Control cable	1	PC		
MBB10CG015-U03	Turbine casing and rotor (Power turbine system)	Amplifier	1	PC		
MBB10CP005-B01	Turbine casing and rotor (Power turbine system)	Pressure transducer	1	PC		
MBB10CT085-B01	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		
MBB10CT095-B01	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		
MBB10CT105-B01	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		
MBB10CT110-B02	Turbine casing and rotor (Power turbine system)	Temperature sensor	1	PC		

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SIEMENS

Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

Doc. No. J9401873E
Rev. ind.
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Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
MBH10AA005-KA01	Cooling and sealing gas system	Ball valve	1	PC		
MBH10CT005-B01	Cooling and sealing gas system	Pt100-sensor	1	PC		
MBH20AA015-Y01	Cooling and sealing gas system	Solenoid valve	1	PC		
MBH20AA020-S11/S21	Cooling and sealing gas system	Limit switch	1	PC		
MBH20BS205-S004	Cooling and sealing gas system	Silencer	1	PC		
MBK10CY005-B01	Transmission gear between prime mover and driven machine	Vibration transducer	1	PC		
MBL30AA005-MS01	Intake air, cold gas system	Spring	1	PC		
MBL30AA010	Intake air, cold gas system	Valve	1	PC		
MBL30AA030	Intake air, cold gas system	Check valve	1	PC		
MBL30CM005-B01	Intake air, cold gas system	Transmitter	1	PC		
MBM10AV005-E01	Combustion chamber	Spark plug	1	PC		
MBM10AV005-T01	Combustion chamber	Ignition unit	1	PC		
MBM10CQ005-B01	Combustion chamber	Flame detector	1	PC		
MBP05AA215-S11	Fuel supply system (Gas fuel system)	Limit switch	4	PC		
MBP10AA005	Fuel supply system (Gas fuel system)	Valve aggregate	1	PC		
MBP10AA010-S11	Fuel supply system (Gas fuel system)	Limit switch	1	PC		
MBP10AA010-Y01	Fuel supply system (Gas fuel system)	Solenoid valve	1	PC		
MBP10AA205	Fuel supply system (Gas fuel system)	Ball valve	1	PC		
MBP10CP005-B01	Fuel supply system (Gas fuel system)	Pressure transducer	1	PC		
MBP10CP020-S01	Fuel supply system (Gas fuel system)	Pressure switch	1	PC		
MBP10CT005-B01	Fuel supply system (Gas fuel system)	Pt100-sensor	1	PC		
MBP20AA005-S31	Fuel supply system (Gas fuel system)	Limit switch	1	PC		
MBT10AA005-S11	Gas generator system	Bleed valve	1	PC		
MBT10AA005-Y01	Gas generator system	Solenoid valve	1	PC		
MBT10AA010-B01	Gas generator system	Bleed valve	1	PC		
MBT10AA010-KT01	Gas generator system	Valve	1	PC		
MBT10AA010-Y01	Gas generator system	Solenoid valve	1	PC		
MBT10AV005-B01	Gas generator system	Igniter	1	PC		
MBT10CG005-B01	Gas generator system	Inductive transducer	1	PC		
MBT10CP010-B01	Gas generator system	Transmitter - Pressure	1	PC		
MBT10CP015-B01	Gas generator system	Pressure transducer	1	PC		
MBT10CQ005-B01	Gas generator system	Flame detector	1	PC		
MBT10CQ005-B02	Gas generator system	Flame ampl.module	1	PC		
MBT10CS005-B02	Gas generator system	Transmitter	1	PC		
MBT10CT005-B01	Gas generator system	Temperature sensor	1	PC		
MBT10CT020-B01	Gas generator system	Temperature sensor	1	PC		
MBT10CT030-B01	Gas generator system	Thermocouple	1	PC		
MBT10CT045-B01	Gas generator system	Temperature sensor	1	PC		
MBT10CY005-B02	Gas generator system	Transmitter charge amplifier	1	PC		
MBT10CY010-B01	Gas generator system	Vibration transducer	1	PC		
MBV10AH005	Lubricant supply system	Heater	1	PC		

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Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price
MBV10AN005-KN01	Lubricant supply system	Fan housing	1	PC		
MBV10AN005-M01	Lubricant supply system	Low voltage motor	1	PC		
MBV10CL010-B01	Lubricant supply system	Level gauge	1	PC		
MBV10CP010-QP01	Lubricant supply system	Instrumentation	1	PC		
MBV10CP015-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV10CT010-B01	Lubricant supply system	Pt100-sensor	1	PC		
MBV21CP005-S01	Lubricant supply system	Pressure switch	1	PC		
MBV40AA025-N01	Lubricant supply system	Limit switch	1	PC		
MBV40CP010-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV40CP015-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV40CP020-MR01	Lubricant supply system	Union	1	PC		
MBV40CT005-B01	Lubricant supply system	Pt100-sensor	1	PC		
MBV52AP005-M01	Lubricant supply system	Low voltage motor	1	PC		
MBV54CP015-B01	Lubricant supply system	Pressure transducer	1	PC		
MBV60AA015-Y01	Lubricant supply system	Solenoid valve	1	PC		
QFA10AA170	Central control air generation system (Instrument air system)	Membrane valve	1	PC		
QFA10CP100-S01	Central control air generation system (Instrument air system)	Pressure switch	1	PC		
SAG10AB005-MS01	Ventilation system gas turbine	Spring	1	PC		
SAG10AB005-S11	Ventilation system gas turbine	Limit switch	1	PC		
SAG10AB005-Y01	Ventilation system gas turbine	Solenoid ventilation inlet/outlet	1	PC		
SAG10AN005-M01	Ventilation system gas turbine	Medium voltage motor	1	PC		
SAG10CP005-B01	Ventilation system gas turbine	Pressure transducer	1	PC		
SAG10CT005-B01	Ventilation system gas turbine	Pt100-sensor	1	PC		
SFY10CQ005-B01	Control and protection equipment (Gas detection system)	Gas detector	1	PC		
SFY10CQ005-B02	Control and protection equipment (Gas detection system)	Central unit	1	PC		
SGC30	Spray deluge system	Safety Valve	1	PC		
SGC30	Spray deluge system	Bottle Valve	1	PC		
SGC30	Spray deluge system	Smoke Detector	2	PC		
SGC30	Spray deluge system	Warning Light flashing red	1	PC		
SGC30	Spray deluge system	Limit Switch	1	PC		
SGC30	Spray deluge system	Push Button	1	PC		
SGC30	Spray deluge system	Blocking Valve	1	PC		
SGC30	Spray deluge system	Fan motor	1	PC		
SGC30	Spray deluge system	Warning Light flashing red	1	PC		
SGC30	Spray deluge system	Push Button	2	PC		
SGC30	Spray deluge system	Limit Switch	1	PC		
SGC30	Spray deluge system	Pneumatic Actuator	1	PC		
SGC30	Spray deluge system	Status Panel	2	PC		

Total: -

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Operation & Maintenance
SGT-600
Passaic Valley Sewerage Commissioning, PVSC
Operation Back-up

Doc. No. J9401873E
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Medium level

Spare parts Scope based on (No. of units): **3** All prices are in SEK.

Designation	Applicable for system(s)	Material Description	Quantity	Unit	Price per unit	Total price

Scope of spare parts listed is based on a generic spare part list adapted to project applications. It shall not be considered as the final scope of spare parts. The final scope of spare parts will be agreed upon during the project execution phase. Any changes in scope of spare parts may result in a price adjustment. This quotation may contain a discount as is valid only when ordering together with the main equipment within the validity period of this quotation.

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Alternate Technical Proposal

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Standby Powe . xxxxxxx Rev.A

SECTIONP-00350-1

Technical Documents Required withProposal Schedule

		Check if complete
Reference Document	Submittal Item	
15220	**Reciprocating Fuel Gas Compressor**	
15220	Equipment outline drawing	Alternate Bid Conceptual and Preliminary GA Dwg for 5MOS1 Compressor and 200hp Motor quoted to Siemens for the PVSC Project
15220	Compressor performance data & power requirements	Q7281-UEC, PVSC FGB (250-310 psig Case)
15560	**Small Combustion Turbine/Generators**	120_SCS22673
15560	Combustion turbine generator performancedata	J210129E
15910	**BlackstartGenerator**	J1204937E
15910	Engine performance data	J2105874E
15910	Preliminary arrangement drawings indicating overall dimensions, estimated weights, component locations, and external connection information.	J700417E
15910	Exhaust gas emission data, maximum valves at loads of 1/2, 3/4, and full load.	J2105874E
TBD	**Fuel Gas Heater (if Required)**	N/A
TBD	Heater performance data and power requirements	N/A
TBD	Preliminary arrangement drawings indicating overall dimensions, estimated weights, component locations, and external connection information.	N/A
TBD	Exhaust gas emission data, maximum valves at loads of 1/2, 3/4, and full load.	N/A
17053	**Subsystem - Programmable Logic Control System (Gas Compressors)**	
17053	Description of proposed PLC equipment, including manufacturer, model, memory type and capacity, types and quantities of I/O modules provided, and preliminary PLC system architecture andlayout.	J1204938E
17053	Description of proposed interface to plant DCS, including communication standard, protocol, andmedia.	J640219E
17053	**Subsystem - Programmable Logic Control System (Gas Heater) - if required**	J1204937E
17053	Description of proposed PLC equipment, including manufacturer, model, memory type and capacity, types and quantities of I/O modules provided, and preliminary PLC system architecture andlayout.	J1204937E
17053	Description of proposed interface to plant DCS, including communication standard, protocol, andmedia.	J640219E
17101	**Distributed ControlSystem**	
17101	Preliminary Engineering/Production/Shipping Schedule. This schedule shall be based on the milestone dates listed in the preliminary project schedule, and shall include the dates for database, hardware, and software cutoff, for Seller issue of each logic system configuration package for review, and for Seller issue of the graphic configuration package forreview.	J150584E
17101	System configuration drawing. The system configuration drawing shall include details on the control network, the operator work station network, and any network securitycomponents.	J640219E
17101	Proposer s listing and description of the software (graphics configurator, alarm manager, etc.).	PCS7 system
17101	Bill of Material including the following: 1) Cabinet quantity and size 2) Processor (control/link/other) quantity, manufacturer & model/series 3) Workstations quantity, manufacturer & model/series 4) I/O card quantity by type and cabinet, manufacturer & model/series 5) Network hardware (switches, routers, etc.) quantity, manufacturer & model	1)doc 120_SCS22673+ J693007E 2)doc J693007E 3)120_SCS22673 + W635033E 4&5) To be defined during detailed engineering incl 20%spare

Technical DocumentSchedule P-00350.1

Source: 00300, 2009,v1.2 A-1

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Alternate Reciprocating Fuel Gas Compressor
3 x 50% Design

SCOPE OF WORK

PACKAGED MOTOR DRIVE RECIPROCATING COMPRESSOR

Complete UEC reciprocating compressor package(s), each with a single compressor and driver mounted on a steel skid and containing necessary on-skid wiring, piping, and controls, as described below.

CONDITIONS OF SERVICE

Location	New Jersey
Elevation (FASL)	12
Ambient Temperature	-5°F to 108°F

	Guarantee Case	**Range**
Service:	Fuel Gas	Fuel Gas
Unit Design:	3 x 50%	3 x 50%
Gas composition:	0.58	0.58
Flow rate per unit (SCFM):	6,000	3,433
Inlet pressure at skid edge (PSIG):	5	5 – 45*
Discharge pressure at skid edge (PSIG):	310	250 – 310
Suction temperature (°F):	50	50 – 120

PACKAGE STUDIES

The following package studies are typically performed by a 3rd party consulting firm:

1.	Acoustical & mechanical studies (API 618 Design Approach 3a)	Included
2.	Torsional analysis	Included

Acoustical studies – The outcome of this study will examine the suitability of the pulsation bottles and piping system, and determine if any changes are required. Typical changes include pulsation bottle sizing, adding of internals (choke tubes and baffles), orifice plates, main skid beam or pedestal sizes and additional pipe supports. If off-skid piping (including to suction/discharge headers, other compressor equipment, etc.) is to be included in studies, customer must supply drawings in timely manner or it will affect the delivery schedule. See the standard notes on gas compressor applications section for further details.

Torsional study – The outcome of this study will examine the suitability of the driver and coupling, and determine if a flywheel or others charges are required. A flywheel, if required, is not included in the compressor pricing.

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EQUIPMENT DESCRIPTION

COMPRESSOR

Dresser-Rand reciprocating compressor, double acting, horizontally opposed as described below:

Compressor Model 5MOS1
Rated Frame BHP 975
Rated Frame RPM 1500
Stroke (in.) 5.00
Max Rod Load – Total 45,000

- Force feed cylinder lubricator with divider blocks and no flow shutdown
- Meets the requirements of API 11P with Dresser-Rand standard comments and exceptions
- Subject to Dresser-Rand's standard comments and exceptions for API 618, provided upon request
- 304/304L stainless steel tubing with zinc plated steel fittings
- Compressor mounted with sole plates and shims in grout box
- Compressor distance pieces mounted with Rotachock (or equal) mounts
- Compressor manufacturer's standard unwitnessed run test – witnessed upon request as adder
- Manufactured in Painted Post, NY USA

CYLINDERS

Double acting, unlined, and lubricated cylinders as described below:

Service	Stage	Qty	Class	Bore (in.)	MAWP	Pockets	Unloaders
1	1	1	G5121	8.500	1150 PSIG	VVCP	N/A

VVCP – Variable volume clearance pockets for manual capacity control

- Cylinder bodies are ductile iron unless otherwise specified
- Air cooled cylinders, water cooled packing not required on any cylinders
- Carbon steel, Ion Nitride piston rods
- Compressor manufacturer's standard unwitnessed cylinder hydrotest

DISTANCE PIECE, VENTS & DRAINS

- Standard (single compartment) distance piece for all throws
- Vents and drains brought to skid edge

COMPRESSOR OIL SYSTEM

Closed loop oil system, each package, as described below:

- Shaft driven primary oil pump with suction strainer
- Simplex oil filter
- Electric pre-lube pump with check valve downstream of pump
- Crankcase immersion heater
- Direct oil cooled heat exchanger, radiator style mounted on-skid (480V)
- Thermostatic lube oil temperature control valve
- Automatic oil level make-up controller
- Compressor oil day tank not included (by others)

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COMPRESSOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) vibration transmitter
- One (1) compressor oil pressure transmitter
- One (1) compressor oil pressure indicator
- One (1) compressor oil temperature element, downstream of oil cooler
- Two (2) compressor oil temperature gauges, upstream and downstream of oil cooler

COUPLING AND GUARD

- Double-flexing spacer coupling (or equal) with standard carbon steel hubs and dry type, carbon steel flex pack initially sized for a minimum 3.0 service factor.
- OSHA compliant full drive guard covering flywheel and coupling, with view port for determining unit rotation and designed for ease of removal

MOTOR

Siemens or equal electric motor driver:

HP rating	200
Speed	1200 RPM
Power rating	4160V/3Ph/60Hz
Enclosure Type	TEFC
Air Filters	Stainless Steel
Differential Pressure Switch	Yes
Insulation Class	F
Temperature Rise	B
Service Factor	1.15
Elevation	3300 FASL
Maximum Ambient Temperature	40°C
Fixed Speed Operation	No
VFD Compatible	Yes
Starting Method	VFD

Additional features include:

- Space heater (120/240V)
- Rotachock (or equal) mounts
- Manufacturer's routine non-witnessed tests only are included
- Suitable for installation in a Class 1 Division 2 Group D hazardous area, T2B temp code (area classification and temp code to be confirmed by customer)
- Manufactured in Norwood, OH USA
- Variable Frequency Drive (VFD) manufactured by Siemens Model #6SR42020DG422AJ0-Z, shipped loose.

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MOTOR INSTRUMENTATION

In addition to manufacturer's standard instrumentation, the following additional instrumentation is included:

- One (1) Metrix vibration transmitter
- Winding RTDs, 100 Ohm platinum, 2 per phase
- Bearing RTDs, 100 Ohm platinum, 1 per bearing
- Wired by others to customer provided MCC

Note – Motor starter to be installed off-skid by others with power wiring between starter and main drive motor by others. Electrical design for power systems and subsystems supplying the compressor main drive motor is the responsibility of the contractor.

PROCESS AIR COOLER

Air-X-Changers (or equivalent) box header heat exchanger for process gas cooling as described below:

- One cooler per package, 3 x 50% design
- Mounted off-skid, interconnecting piping from skid edge to cooler is by others
- Cooler driven by VFD compatible, 480V 30hp electric motor with space heater
- Murphy VS-2EX vibration switch
- Standard enamel paint with tint to match as required
- Manufactured in Tulsa, OK USA
- Fan motor starter by others, power wiring by others.

PROCESS GAS SECTION(S)

- IC section temperatures 119°F (20°F approach, based on 99°F ambient performance)
- Recycle section temperature 119°F (20°F approach, based on 99°F ambient performance)
- Fouling factor 0.001
- Corrosion allowance 0"
- Tubes SA-214 (welded carbon steel)
- Headers SA-516-70 (carbon steel)
- (3) sets automatic discharge louvers with pneumatic actuators and Kimray T12 temperature controllers, individual per stage
- Spot RT examined headers
- 1" npt thermowell connection opposite outlet nozzles
- ASME code stamp with national board registration

SUCTION SCRUBBERS

Scrubbers have been provided at the inlet of each stage of compression for removal of liquids (bulk liquid removal such as slugs has not been considered for design) as described below:

Scrubber	O.D.	S/S	MAWP	Temp.	Internals	C.A.	Material
Stage 1	20"	82"	400 PSIG	150°F	Vane Pack	0"	Carbon Steel

- Vane Mist Extractors and mesh type mist eliminators are designed to remove 99.9% of all liquid entrainment 8 microns and larger which is present in the processed gas stream, carry-over of 8 micron and larger entrained liquids will be less than 1/10 gallon per million standard cubic feet of processed gas

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- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell
- Flange bolt-holes shall straddle the bottle centerline
- Located on-skid, each scrubber cascaded to previous scrubber and brought to single skid edge connection

SUCTION SCRUBBER TRIM

- **Level gauge**, reflex style – Penberthy RL (3/4" NPT)
- **Level switch** (high shutdown), electric – Murphy LS200 (2" NPT)
- **Level controller**, pneumatic – Murphy LS200NDVOR (2" NPT)
- **Automatic dump valve**, pneumatic – Murphy DVU150 (1" NPT)
- **Manual drain valve** – 1" NPT ball valve
- **Check valve** – 1" NPT piston check

PULSATION BOTTLES

Pulsation bottles have been provided at the suction and discharge of each stage of compression based on the sizing criteria of **API 11P** with no vessel internals with preliminary sizing as described below:

Bottle	O.D.	S/S	MAWP	Temp.	C.A.	Material
1st Stage Suction	8.625"	12"	400 PSIG	150°F	0"	Carbon Steel
1st Stage Discharge	8.625"	12"	645 PSIG	350°F	0"	Carbon Steel

- Vessels designed and built in accordance with ASME Section VIII Division 1 Pressure Vessel Code and shall each be supplied with an ASME Code Stamp and national board number
- Non Destructive Examination shall be per code (radiography or phased array)
- Hydrotest to 1.3 times design pressure
- Instrument connections 2" and smaller shall be threaded
- Piping and cylinder nozzle connections shall be XH material (minimum), flanged and reinforced
- Pipe nozzles shall extend a minimum of 1" into the inner diameter of the shell
- All suction bottles have "Vee" notch connection to the cylinder to prevent puddling of any liquids that could accidently exist
- Pulsation bottles include two inspection openings, vent, drain, pressure and temperature connections, per spec items#54 & #55
- Base price includes API 618, 5th Edition Design Approach 3a studies (formerly M2-M5)

PIPING SYSTEMS & DESIGN

All piping provided on skid shall be designed and built in accordance with below:

PROCESS PIPING

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Process piping provided per preliminary sizing and general criteria as described below:

Pipe Run	Nominal Size	Flange	Material	Rating
1st Stage Suction	6"	300#RF	Carbon Steel	400 PSIG @ 150°F
1st Stage Discharge	6"	300#RF	Carbon Steel	400 PSIG @ 350°F
Final Discharge	6"	300#RF	Carbon Steel	400 PSIG @ 350°F

- Process Piping Code: B31.3
- Non Destructive Examination: Per Code (Radiography or Phased Array)
- Corrosion Allowance: 0.000”
- Hydrotest: 1.5 times design pressure
- Carbon Steel Material: SA-106B
- Suction Connection: Suction scrubber flange
- Discharge Connection: Skid edge

PIPING DESIGN

Design of the piping systems shall be as follows:

- The process pipe shall be sized based on a maximum gas velocity of 3000ft/min or by pressure drop calculations where applicable
- All piping greater than 2” nominal shall be buttweld and schedule STD minimum
- All piping 2” and smaller shall be socketweld or threaded and schedule 80 minimum
- All process and auxiliary gas piping 1” shall be socketweld or threaded and schedule 160
- Socketweld piping to be visually inspected, radiography not provided
- Flanges shall be raised face and rated in accordance with ANSI B16.5
- Flange gaskets shall be flexitallic and bolting studs shall be grade B7
- Pipe fittings shall be 3000 PSI for gas and auxiliary piping as a minimum, and may be socketweld or threaded
- All welded pipe is hydrotested

PROCESS INSTRUMENTATION

In addition to manufacturer’s standard instrumentation, the following additional instrumentation is included:

- Suction pressure transmitter at inlet of package
- Suction pressure gauge at inlet of package
- Discharge pressure transmitter, per stage
- Discharge pressure gauge, per stage
- Temperature element, per cylinder discharge
- Temperature gauge, per discharge of each stage
- Please advise if additional instrumentation is required

GENERAL TUBING

General tubing, typical, as described below:

- Threaded carbon steel instrument air manifold with isolation valves for each device
- All tube fittings shall be stainless steel compression fittings
- All tubing shall be stainless steel

CAPACITY CONTROL SYSTEMS

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The following methods of capacity control have been included:

1. Variable volume clearance pockets (VVCP) on the compressor cylinder(s)
2. Automatic recycle capacity control valve
3. Motor speed turndown (VFD)

SYSTEM VALVES

System valves included in UEC scope of supply as described below:

- Suction pressure control valves – see Suction Pressure Control Valve Skid below for details
- Automatic recycle valve, 2”-300#RF Fisher V200 with Fisher DVC6200 digital positioner for capacity control and startup
- Manual blowdown valve, 1”-300#RF ball valve
- Contractor to provide inlet and outlet isolation valves in interconnecting piping.

System valves shall be provided as per the following guidelines:

- Ball valves to be full port with carbon steel body and carbon trim (ball & stem)
- Large bore (greater than 2”) ball valves to be KF or equal
- Small bore ball valves to be KF, Apollo or equal
- Small bore globe valves, check valves to be Bonney Forge or equal

RELIEF VALVES

Process relief valves as described below:

- Farris, Mercer or equal
- Thermal relief valve for suction scrubber
  - Threaded conventional spring type valve
  - Full flow relief protection sized for any upset conditions upstream of package by others
- Full flow relief valves for discharge of each stage of compression
  - Flanged conventional spring type or pilot type valve(s)
- Relief valves and blowdown manifolded and brought to single common skid edge connection

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CONTROL PANEL & ELECTRICAL

Each compressor package shall have controls and electrical as outlined below:

CONTROL PANEL

Complete compressor logic control panel rated for Class 1, Division 2, Group D with alarm, shutdown and control items as described below:

- Allen Bradley ControlLogix – *Simplex Processor*
- PanelView Plus 19" HMI (maximum screen size available)
- Collapsible HMI Sun shield
- Ethernet switch for Modbus communications with Fiber Optic
- Enclosure built to NEMA 4 specifications
- Panel mounted and wired on-skid
- 20% spare terminal blocks for future connections
- UL698B listed assembled control panel for installation in a classified area
- Individual fuses for all PLC modules and HMI
- Notifications of alarms and shutdowns to protect compressor package
- Common relay contacts for dry contact remote start, run enabled and annunciation
- Suitable for customer-supplied primary power of 125 VDC and customer-supplied secondary power of 120 VAC. Our panel has this capability by including separate/redundant 24VDC Power Supply modules, with one accepting 125VDC and the second accepting 120VAC.
- One set of licensed software for the ControlLogix PLC & PanelView Plus HMI included for all three panels. If additional copies are required, they are available for a price adder.

INSTRUMENTATION

Instruments as described below:

- All instruments and electrical devices shall be suitable for installation in a Class 1 Group D Division 2 hazardous area
- In general, installation of pressure and temperature devices as follows:
    - Instrument connections in piping provided by thredolet unless otherwise noted
    - Pressure instrument shall be supplied with threaded instrument valve when installed in piping. Pressure gauges shall be mounted at or near the valve, pressure transmitters may be rack mounted near control panel or junction box (if provided).
        - Instrument valves to be threaded stainless steel gauge (needle) type block and bleed valve – Anderson Greenwood (M25VIS) or equal
        - Root valve provided upstream of instrument valve, socketwelded carbon steel ball valve
        - Pulsation dampeners provided for pressure instrumentation
    - Temperature instrument shall be supplied with a stainless steel threaded thermowell when installed in piping. The instrument shall be mounted at the thermowell. Temperature elements are to be wired directly to control system (no transmitter).
- UEC standard P&ID tagging with wire can be provided for instrumentation upon request
- Instrumentation has been provided as follows (or approved equivalent):

Instrument	**Make**	**Model**
Pressure Transmitter	Rosemount	3051T with LCD display
Pressure Indicator	Ashcroft	1279
Differential Pressure Indicator	Orange Research	1201/1203/1516

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Temperature Element	Thermocouple	Type K
Temperature Indicator	Ashcroft	EL
Vibration Transmitter	Metrix	ST5484E
Vibration Switch	Murphy	VS2EX
Level Switch	Murphy	LS200
Level Control	Murphy	LS200NDVOR
Level Gauge	Penberthy	RL
Oil Controller / Gauge / Switch	Kenco	LCE
No Flow Switch	Dresser-Rand	DNFT 24 VDC

CONDUIT AND WIRING

General conduit and wiring, typical, as described below:

- All conduit and wiring shall be installed in accordance with the NEC for installation in a Class 1 Group D Division 2 hazardous area
- Weather-tight, rigid conduit with liquid-tight, flexible conduit pigtails and THHN or MTW #14 copper stranded internal wiring
- Armored cable and cable trays available upon request for optional price adder

CONTROL TUBING

All tubing is 316L stainless steel with Parker or Swagelok 316L stainless steel compression fittings.

STRUCTURAL STEEL FRAME

Structural steel frame with preliminary dimensions as described below:

- Estimated Skid Width: 10’0”
- Estimated Skid Length: 20’0”
- Estimated Package Height: 12’6”
- Estimated Shipping Weight: 80,000 LBS
- Frame is welded using A-36 steel in accordance with AWS D1.1
- All welders are certified and all procedures are qualified
- Pipe drawbars or lifting lugs at each end of skid
- 2” drip lip around compressor package
- (2) grounding lugs provided on opposite corners of skid

SOUND ENCLOSURE

Sound enclosure with equipment as described below:

- Single enclosure mounted on concrete around perimeter of all three compressor skids
- All equipment to be Class 1, Division 2, Group D
- Noise level outside enclosure guaranteed to be 85dBA or less at 3 feet
- Preliminary dimensions of 30’x40’x20’ high
- Blow out panels
- Forced air ventilation system
- Temperature element wired to control panels to shutdown on high air temp inside building
- Electric heater
- UV Fire Detection & gas detectors
- Control panel with battery back-up for fire and gas detectors

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- Control panel has a Z-purge and is mounted on the exterior of the enclosure

PAINTING AND PREPARATION

Painting and preparation as described below:

- Standard UE Compression Type 4 paint system as follows:
  - SSPC-SP6 sandblast of non-painted items, including skids, vessels and process piping. Pre-painted items will be cleaned and top coated only. All other piping will be prepped by SSPC-SP1, 2 or 3, primed and top coated.
  - Tnemec or equal high build epoxy primer, 4-6 mils (dry).
  - Tnemec or equal Series 73 polyurethane enamel top coat, 2-3 mils (dry).
- Color: UE standard paint color gray, single monolithic color only

SHOP TESTING

Shop testing described below:

- Functional checkout of all end devices
- Leak testing of gas and pneumatic control systems
- Full shop alignment of motor and compressor
- No load run test of compressor package not provided as adequate power is not available

MATERIAL COUNTRY OF ORIGIN

Unless otherwise agreed to, standard country of origin shall apply for all directly sourced materials. 3rd party equipment (compressor, driver, etc.) subject to vendor's standard country of origin.
Standard countries: USA, Canada, Mexico, Great Britain, Spain, Germany, France, Austria, Switzerland, Portugal, Italy, Belgium, South Africa, South Korea, and Japan.

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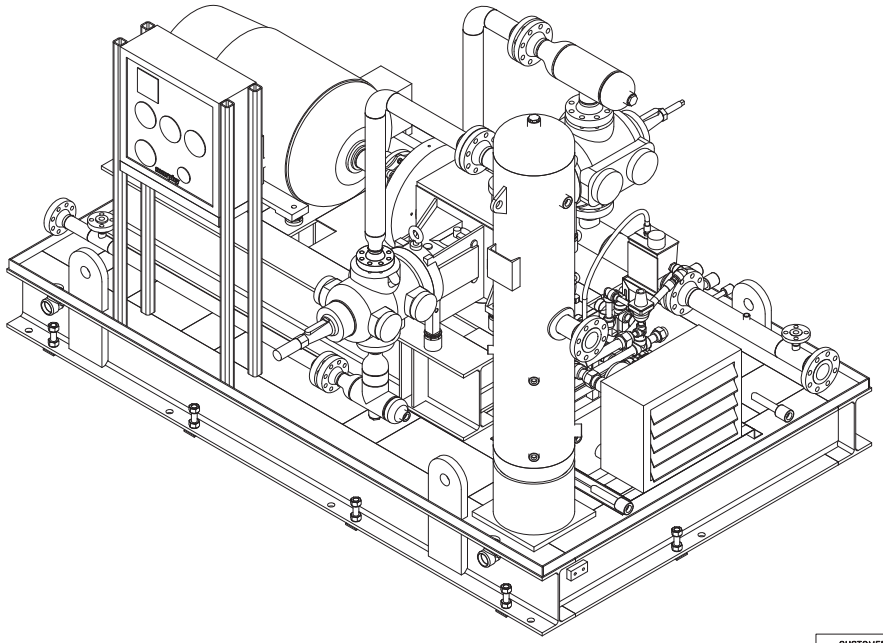
CONCEPTUAL AND PRELIMINARY DRAWING WITH D-R 5MOS1 AND 200HP MOTOR FOR SIEMENS BID ON PVSC PROJECT



REVISIONS				
REV.	DESCRIPTION	REVISED BY	DATE	APPROVED
A	ISSUED FOR CUSTOMER REVIEW	DES	12/17/2013	JK
B	RE-ISSUED FOR CUSTOMER REVIEW	DES	1/30/2014	JK
C	RE-ISSUED FOR CUSTOMER REVIEW	DES	2/12/2014	JK
D	ISSUED FOR FABRICATION	DES	3/17/2014	JK
E	ACOUSTICAL CHANGES	DES	4/1/2014	JK
F	AS BUILT	DES	7/21/2014	JK

GENERAL NOTES:

1. ESTIMATED UNIT WEIGHT 16,364#.
2. ALL CUSTOMERS PIPING THAT IS ATTACHED TO SKID CONNECTIONS SHALL BE SELF SUPPORTING.
3. EXACT LOCATION OF NOTED ITEMS ARE TO BE DETERMINED AT FINAL ASSEMBLY.
4. NOTED CONNECTIONS MUST BE VENTED TO A SAFE LOCATION.
5. PIPING CONNECTIONS TO THIS PACKAGE SHALL NOT BE COMPLETED WITH PRE-FABRICATED PIPING SPOOLS. THE MANUFACTURING TOLERANCES OF THE COMPONENTS INVOLVED ARE NOT SUFFICIENT TO ALLOW PRE-FABRICATED PIPE SPOOLS WITHOUT UNACCEPTABLE PIPING STRAINS. UE COMPRESSION WILL NOT BE HELD LIABLE FOR RE-WORK TO PRE-FABRICATED COMPONENTS ATTACHING TO THIS PACKAGE.
6. SEE UE COMPRESSION DRAWING #(31232) FOR ANCHOR BOLT LOCATIONS, LIFTING PROVISIONS, LIFTING LUG SIZE AND LOCATION, AND FOUNDATION REQUIREMENTS.
7. USE LIFTING LUGS ON MAIN SKID ONLY. DO NOT USE LUGS ON VESSELS OR OTHER COMPONENTS FOR LIFTING UNIT.
8. GUARDS ARE NOT SHOWN FOR CLARITY. GUARDS WILL BE PROVIDED BY UE COMPRESSION INC. ON ALL ROTATING SHAFTS, COUPLINGS, SHEAVES AND BELTS.
9. THE COMPLETE PACKAGE SHALL BE PAINTED PER UEC STANDARD SDF008, TYPE 4 PAINT SYSTEM. THE FINAL COLOR SHALL BE ANSI 70 GREY.
10. NOTED ITEMS ARE TO SHIP LOOSE AND BE INSTALLED IN THE FIELD BY CUSTOMER. SHIP LOOSE ITEMS INCLUDE:
    - CONE STRAINERS
    - ORIFICE PLATE
    - COOLER

CUSTOMER CONNECTIONS TOLERANCE UNLESS OTHERWISE SPECIFIED	STANDARD TOLERANCE UNLESS OTHERWISE SPECIFIED	UECS WORK ORDER NUMBER: P29480-1-1 2 UNIT(S)	UECompression Gas Compression and Power Generation Parts and Service DENVER, COLORADO
FRACTIONAL: FRACTION ± 1" DECIMAL: 1 PLACE ± .1 2 PLACE ± .06 3 PLACE ± .031 BREAK SHARP EDGES	FRACTIONAL: FRACTION ± 3/8" DECIMAL: 1 PLACE ± .1 2 PLACE ± .06 3 PLACE ± .031 BREAK SHARP EDGES	901850 70960 901763 70959 901762 40600 901759 31232 74370 31231 74369 10616 RELATED DWGS	DRAWN BY: DAVE STARNES 12/11/13 · CHECKED BY: JAMES KIM 12/17/13 · SCALE: 1:8 · SIZE: D · ALL DIMENSIONS IN INCHES · TITLE: GENERAL ARRANGEMENT · DRAWING NUMBER: 10616 SHEET 1 OF 6 · REVISION: F

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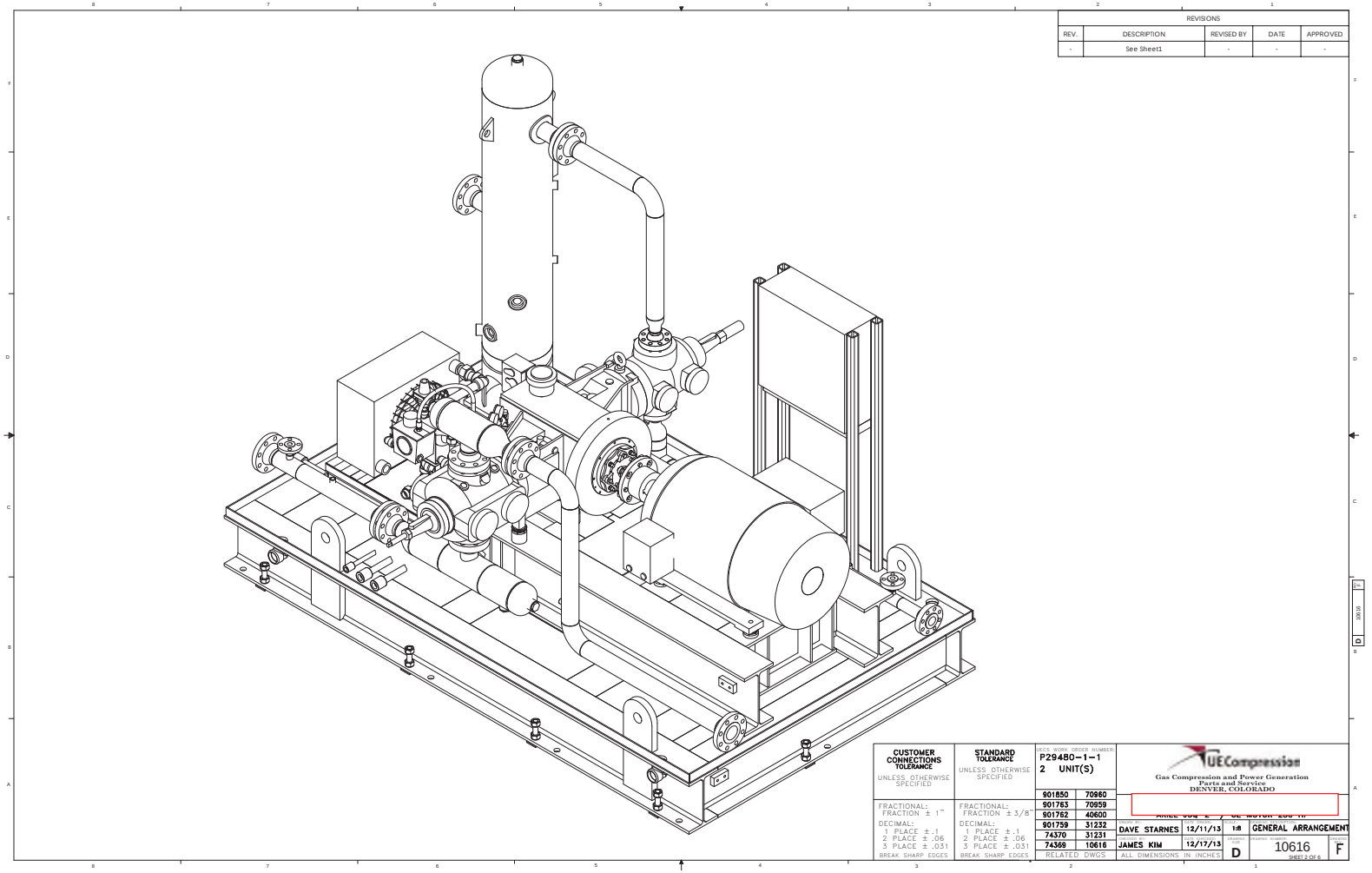

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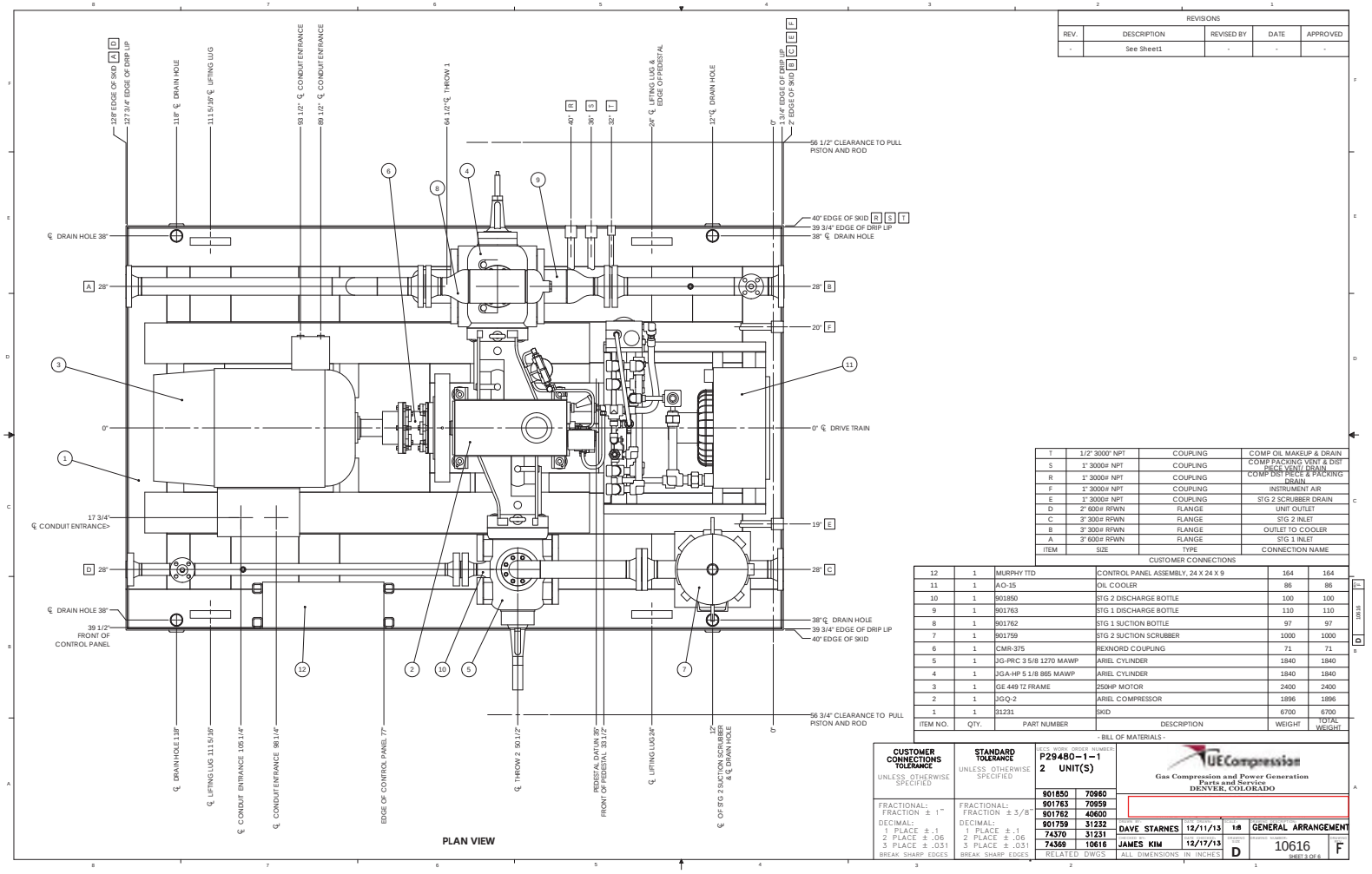

REVISIONS				
REV.	DESCRIPTION	REVISED BY	DATE	APPROVED
-	See Sheet1	-	-	-

ITEM	SIZE	TYPE	CONNECTION NAME
T	1/2" 3000# NPT	COUPLING	COMP OIL MAKEUP & DRAIN
S	1" 3000# NPT	COUPLING	COMP PACKING VENT & DIST PIECE VENT DRAIN
R	1" 3000# NPT	COUPLING	COMP DIST PIECE & PACKING DRAIN
F	1" 3000# NPT	COUPLING	INSTRUMENT AIR
E	1" 3000# NPT	COUPLING	STG 2 SCRUBBER DRAIN
D	2" 600# RFWN	FLANGE	UNIT OUTLET
C	3" 300# RFWN	FLANGE	STG 2 INLET
B	3" 300# RFWN	FLANGE	OUTLET TO COOLER
A	3" 600# RFWN	FLANGE	STG 1 INLET

CUSTOMER CONNECTIONS

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION	WEIGHT	TOTAL WEIGHT
12	1	MURPHY TTD	CONTROL PANEL ASSEMBLY, 24 X 24 X 9	164	164
11	1	AO-15	OIL COOLER	86	86
10	1	901850	STG 2 DISCHARGE BOTTLE	100	100
9	1	901763	STG 1 DISCHARGE BOTTLE	110	110
8	1	901762	STG 1 SUCTION BOTTLE	97	97
7	1	901759	STG 2 SUCTION SCRUBBER	1000	1000
6	1	CMR-375	REXNORD COUPLING	71	71
5	1	JG-PRC 3 5/8 1270 MAWP	ARIEL CYLINDER	1840	1840
4	1	JGA-HP 5 1/8 865 MAWP	ARIEL CYLINDER	1840	1840
3	1	GE 449 TZ FRAME	250HP MOTOR	2400	2400
2	1	JGQ-2	ARIEL COMPRESSOR	1896	1896
1	1	31231	SKID	6700	6700

- BILL OF MATERIALS -

CUSTOMER CONNECTIONS TOLERANCE: UNLESS OTHERWISE SPECIFIED
FRACTIONAL: FRACTION ± 1"
DECIMAL: 1 PLACE ± .1, 2 PLACE ± .06, 3 PLACE ± .031
BREAK SHARP EDGES

STANDARD TOLERANCE: UNLESS OTHERWISE SPECIFIED
FRACTIONAL: FRACTION ± 1/8"
DECIMAL: 1 PLACE ± .1, 2 PLACE ± .06, 3 PLACE ± .031
BREAK SHARP EDGES

BLACK WORK ORDER NUMBER: P29480-1-1
2 UNIT(S)

RELATED DWGS.	
901850	70960
901763	70959
901762	40600
901759	31232
74370	31231
74369	10616

Gas Compression and Power Generation Parts and Service DENVER, COLORADO

DRAWN BY	DATE DRAWN	SCALE	DRAWING TITLE
DAVE STARNES	12/11/13	1:8	GENERAL ARRANGEMENT
JAMES KIM	12/17/13	DRAWING SIZE D	DRAWING NUMBER 10616 SHEET 3 OF 6 REV F

ALL DIMENSIONS IN INCHES

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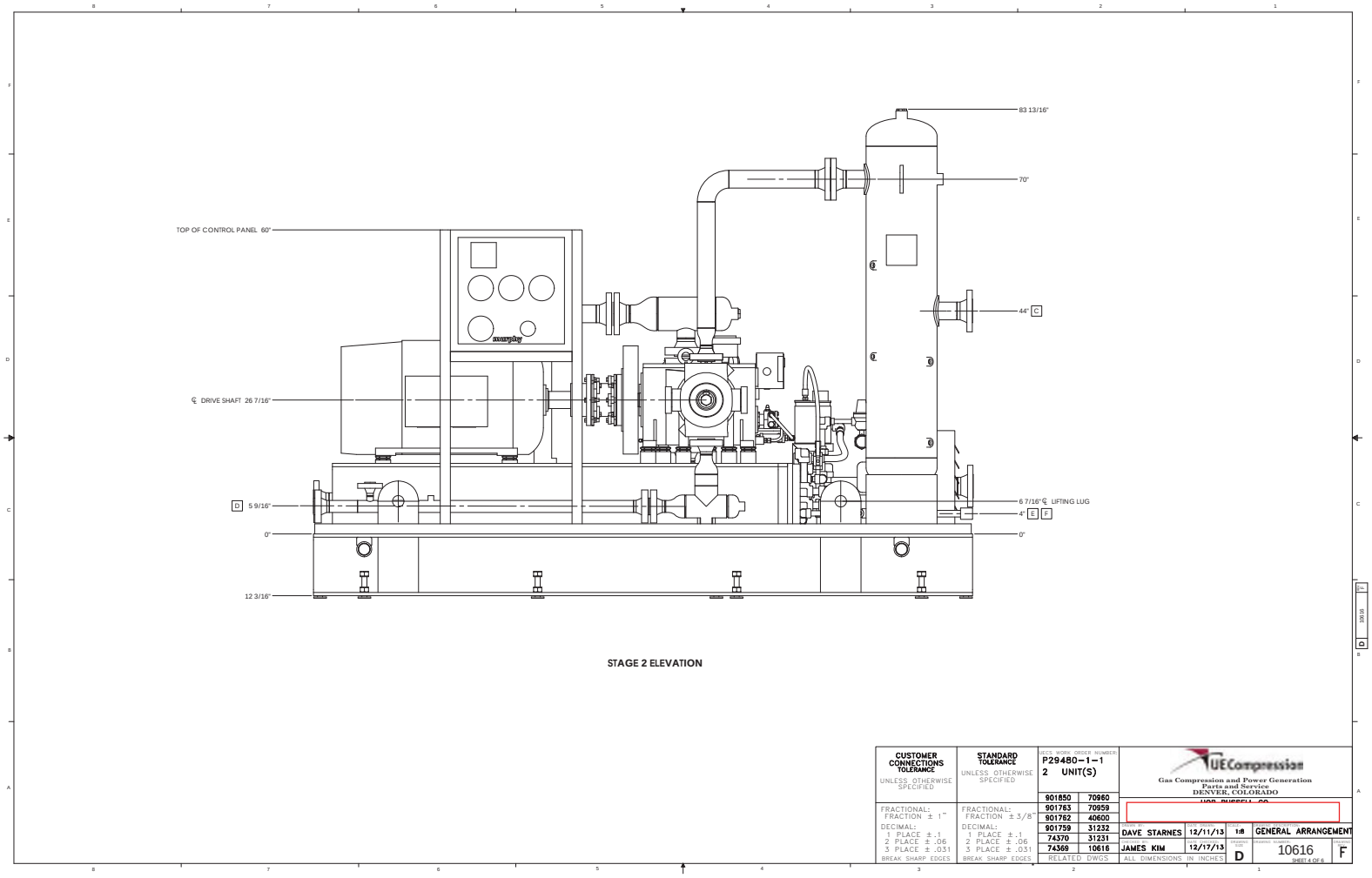

STAGE 2 ELEVATION

CUSTOMER CONNECTIONS TOLERANCE UNLESS OTHERWISE SPECIFIED	STANDARD TOLERANCE UNLESS OTHERWISE SPECIFIED	UECS WORK ORDER NUMBER: P29480-1-1 2 UNIT(S)	UEC Compression Gas Compression and Power Generation Parts and Service DENVER, COLORADO
FRACTIONAL: FRACTION ± 1" DECIMAL: 1 PLACE ± .1 2 PLACE ± .06 3 PLACE ± .031 BREAK SHARP EDGES	FRACTIONAL: FRACTION ± 3/8" DECIMAL: 1 PLACE ± .1 2 PLACE ± .06 3 PLACE ± .031 BREAK SHARP EDGES	901850 70960 901763 70959 901762 40600 901759 31232 74370 31231 74369 10616 RELATED DWGS	DRAWN BY: DAVE STARNES 12/11/13 1:8 GENERAL ARRANGEMENT CHECKED BY: JAMES KIM 12/17/13 SCALE: D DRAWING NUMBER: 10616 SHEET 4 OF 6 REVISION: F ALL DIMENSIONS IN INCHES

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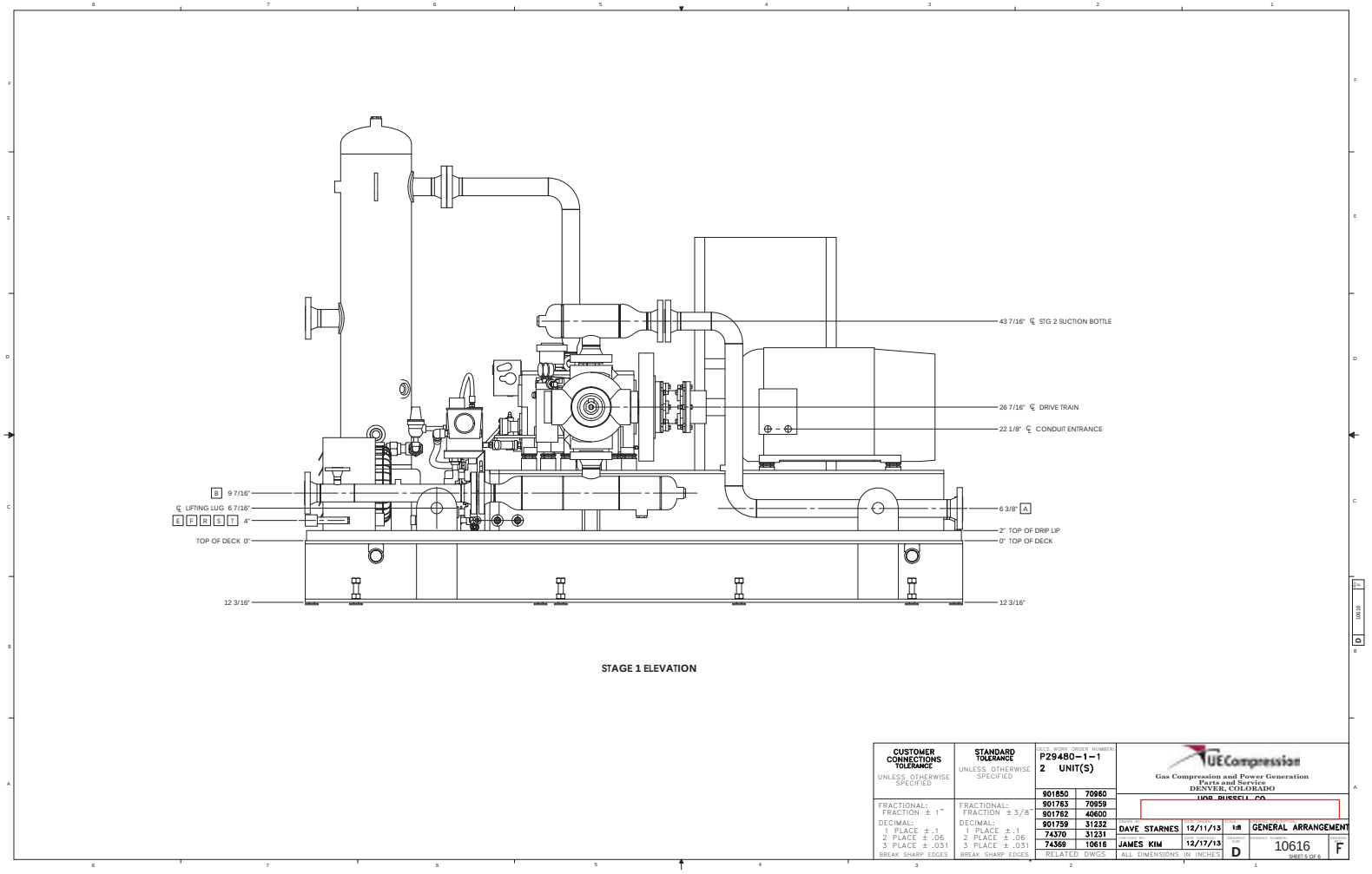

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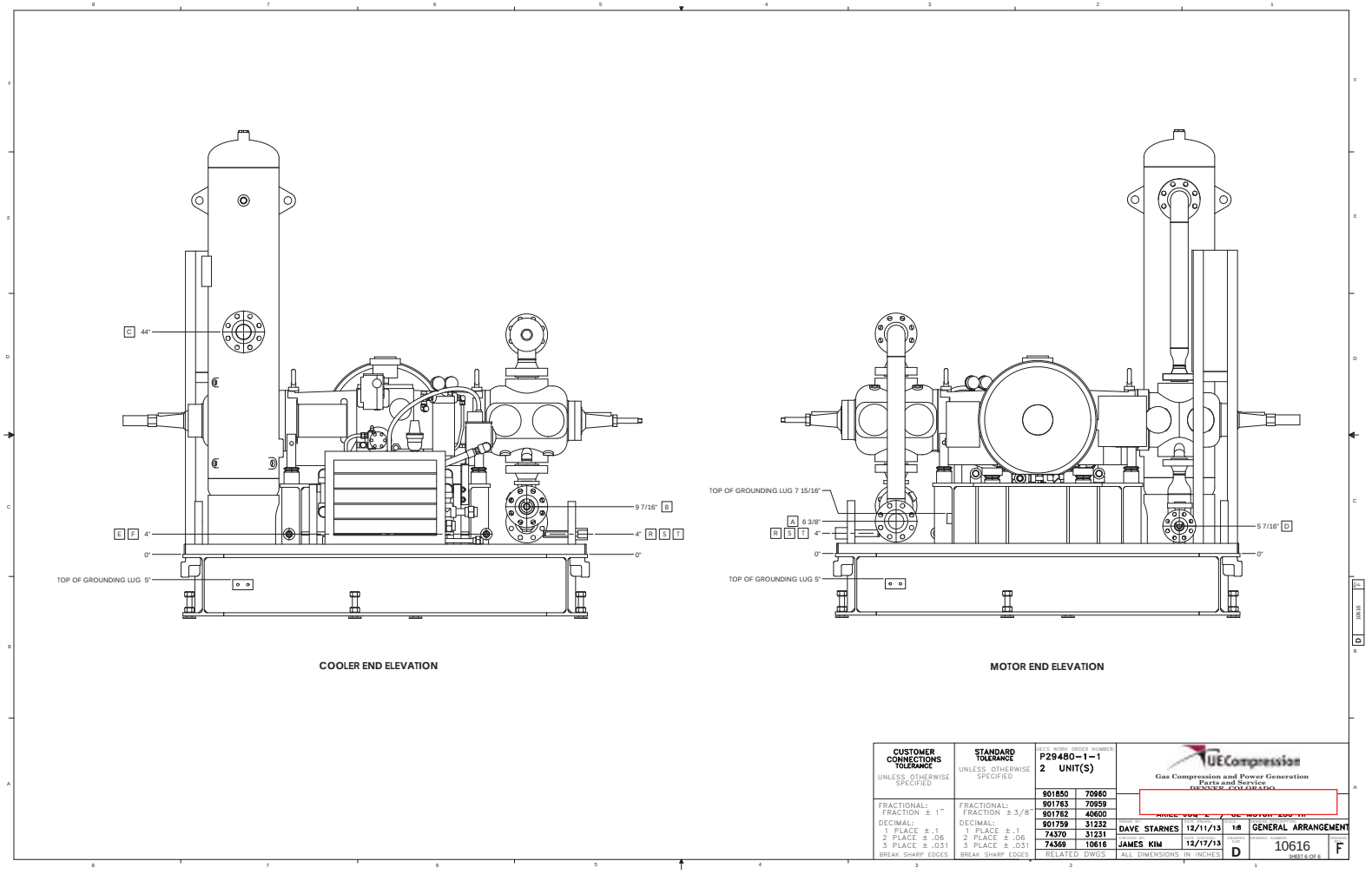

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D-R Size Version 6.5.16.727

PACKAGER:
LOCATION:
JOB/REF:

DRESSER-RAND
A Siemens Business

DESIGN POINT

AMBIENT T (F) :	108.0	ALTITUDE (FT)	12	ATM PRESS (PSIA)	14.6896
REF TEMP. (F) :	60.0	REF PRESS (PSIA)	14.6960	LUBRICATED	

COMPRESSOR DATA				DRIVER DATA			
MODEL	5MOS2	**RATED RPM**	1500	**TYPE**	Motor	**DRIVER (HP)**	0
STROKE (IN)	5.000	**CALC RPM**	1188	**MANUF**		**COOLER (HP)**	0
ROD DIA (IN)	2.250	**Calc PS (FPM)**	990.00	**MODEL**			

Stage Number		1		
Gas		Average		
Dry Gas Mol. Weight		16.740		
Dry Gas Spec. Gravity		0.578		
Cp/Cv @ 14.7/60		1.303		
Avg. Temp. Expon. (K)		1.300		
Avg. Vol. Expon. (N)		1.294		
Gas Crit. Temperature	F	-109.133		
Gas Crit. Pressure	PSIA	665.096		
Z Standard		0.998		
Z Suction		0.963		
Z Discharge		0.962		
Inlet Temperature	F	50.00		
Inlet Line Pressure	PSIG	250.00		
Inlet Press. @ Cyl Flg	PSIG	248.65		
Interstage Press. Drop	%	0.00		
Disch. Press. @ Cyl Flg	PSIG	311.27		
Disch. Line Pressure	PSIG	310.00		
Ratio of Compression		1.238		
Adiabatic Disch. Temp.	F	81.50		
Est Actual Disch Temp	F	95.35		
Stg. Piston Displ.	CFM	376.5		
REQUIRED CAPACITY PER API 618(TOLERANCE: CAPACITY +6/-0%)				
Stg. Inlet Capacity	CFM	320.2		
CAPACITY ACTUAL WET	SCFM	6004.06		
CAPACITY ACTUAL DRY	SCFM	6000.00		
MGFR'S RATED CAPACITY (TOLERANCE: CAPACITY +/-3% POWER +/-3%)				
Stg. Inlet Capacity	ACFM	330.2		
CAPACITY ACTUAL WET	SCFM	6189.75		
CAPACITY ACTUAL DRY	SCFM	6185.57		
TOTAL COMPRESSOR POWER	HP	152.69		
Stage number at (HE/CE)		1/1	0/0	
Frame Ext/Cyl. Bore	#/IN	1/ 8.500	2/10.000	
Cylinder Pattern		MOS-8.50	BALANCE	
RDP	PSIG	1045.0	0.0	
MAWP	PSIG	1150.0	0.0	
Cyl. Action/HE Rod Dia.	Act./IN	DA/ 0.00	NA/ 0.00	
Brake power / Cylinder	HP	131.8	0.0	
Capacity Wet/ Cylinder	SCFM	6189.75	0.00	
HE Disch. Vol. Eff.	%	70.99	0.00	
CE Disch. Vol. Eff.	%	78.01	0.00	
HE Inlet Vol. Eff.	%	83.71	0.00	
CE Inlet Vol. Eff.	%	91.99	0.00	
Avg. Inlet Vol. Eff.	%	87.85	0.00	
HE Clearance Reqd.	%	72.39	0.00	
HE Clearance Min.	%	21.22	0.00	
HE Pocket Open	%	84.59	0.00	
HE Clearance Added	IN3	145.2	0.0	
CE Clearance Reqd.	%	26.17	0.00	
CE Clearance Min.	%	26.17	0.00	
CE Clearance Added	IN3	0.0	0.0	
Valve Model - HE		HH 60-105	BALANCE	
Valve Model - CE		HH 60-105	BALANCE	
Valves/Corner (HES/HED/CES/CED)		1/1/1/1	0/0/0/0	
Valve Lift - HE	IN	0.105	0.000	
Valve Lift - CE	IN	0.105	0.000	
Valve Lift Area - HE	SQIN	7.420	0.000	
Valve Lift Area - CE	SQIN	7.420	0.000	
API Inlet Vlv Vel Avg.	FPM	7305.9	0.0	
Internal Gas Load - T	%	9.7	0.0	
Internal Gas Load - C	%	14.2	0.0	
MACGL	LBF	54000	54000	
Combined Rod Load - T	%	57.6	67.7	
Combined Rod Load - C	%	49.1	47.8	
MACCRL	LBF	45000	45000	
Recip. Weight @ XHD Pin	LB	259.5	259.5	
Reversal @ XHD Pin	DEG	165.0	170.0	

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Quotation Summary

SHIPMENTS

Shipment is contingent upon when an acceptable purchase order is received by Siemens Industry, Inc., when drawings approval is completed and/or when the customer releases the job to start manufacturing the equipment. Actual ship dates are subject to factory availability at the time the order is entered. Partial shipments shall be allowed.

All equipment is domestically packed per Siemens standard practices with no freight or crating unless otherwise stated. Freight is prepaid by Siemens and added to customer's invoice. Siemens Shipping & Handling Guidelines shall apply. Freight prices, if quoted, are based on means of transport selected by Siemens. Special means of transport directed by customer purchase order will incur additional freight charges.

Siemens requires the unpacking of the equipment at customer's destination, as well as, visual inspection by customer. Siemens requires that any claims for transportation damage be reported, in writing, within 5 business days from receipt at the named destination and/or title/risk transfer point per contractual INCO terms. Claim must include written documentation of the damage, as well as, supporting photographic evidence. Any claims issued after the 5 day period mentioned above will not be the responsibility of Siemens. Once equipment is received at named facility and inspection is completed, the equipment then becomes the responsibility of the customer which includes risk of any other damage or loss from that point forward until the equipment reaches its final destination.

ADDITIONAL COMMENTS

1. Drive commissioning and site training are not included in this proposal.
2. Power cable entry from top or below. Motor cable exit from below.

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Variable Frequency Drive Specifications

Variable Frequency Drive System

Item	Quantity	Description
1	1	**6SL3710-3GJ33-1AS3-z** z=G52+K20+K21+L56+X30.1 SINAMICS W150CP NEMA 1 enclosed 18-Pulse Clean Power drive Meets IEEE519-1992 at the point of common coupling 460-480V, Nominal 250HP, FLA 310 continuous at 40°C Low Overload 250HP, 302Amps, 110%/60s or 150%/10s High Overload 200HP, 277Amps, 150%/60s Circuit breaker disconnect, input line reactor/autotransformer Semiconductor fuses, SCCR per UL 65 kA IC AOP30 Advanced Operator Panel Maximum cable lengths between motor and drive: 985 ft (shielded cable), 1475 ft (unshielded cable)

Options Defined

G52	Qty. two (2) RTD monitor module TM150 (Pt100, 12x 2 or 6x 3-wire)
K20	Pilot lights (qty. 3), door mounted – Ready, Run, Fault
K21	Additional local controls (L-R & H-O-A, speed pot, Start/Stop p/b)
L56	Motor space heater supply
X30.1	SINAMICS label

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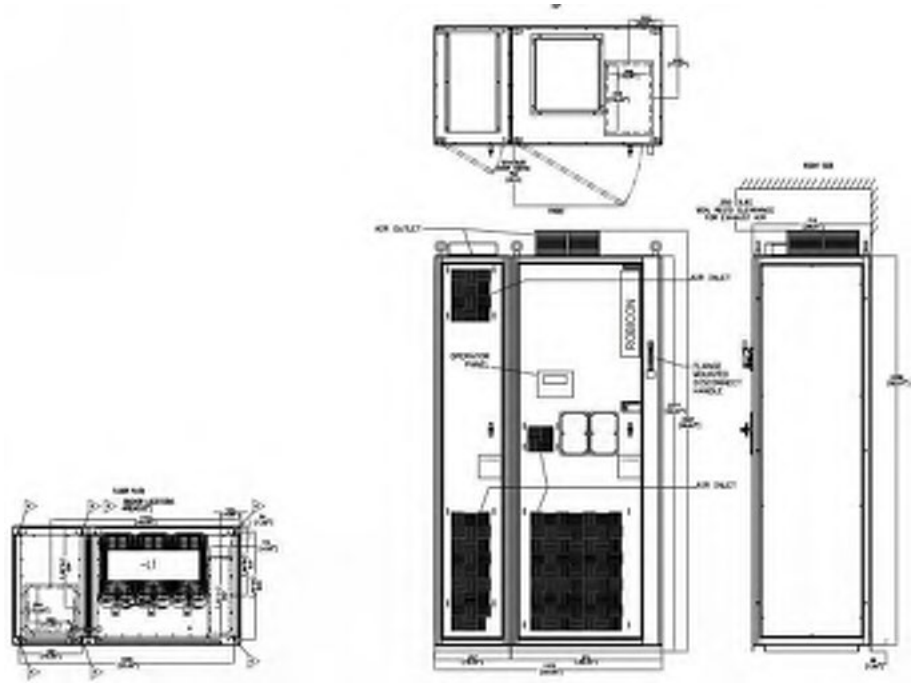
Variable Frequency Drive Specifications

Approximate Enclosure Outline (without options)



Approximate VFD Dimensions, Weight and Heat Loss

Drive Solution	Drive Part Number	Dimensions (in)			Weight (lbs)	Heat Loss (kW)
		Height	Width	Depth		
Clean Power 18-Pulse	6SL3710-3GJ33-1AS3	100	54	28	2420	6.9

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Commercial Items

VFD Spare Parts Kit

Spare Part Kit	Description	Quantity
Spare Parts Kit – Not included in this proposal		N/A
Total Spare Parts Kit Cost		$ 0.00

VFD Commissioning

Part	Pricing	Quantity
Commissioning – Not included in this proposal		N/A
Total Expected Commissioning Cost		$ 0.00

General Comments

- Cabling between the VFD and motor, incoming power and motor cable termination lugs, as well as anchor bolts, are the responsibility of the purchaser.
- The VFD is normally configured with main incoming power cables and outgoing motor cables for bottom entry. Top entry for incoming power cables can usually be accommodated depending on the horsepower rating, but top motor cable exit requires an additional option code.
- All interior buswork is nickel-plated bus.
- The typical drawings supplied with this proposal are for reference only and are not to be used for construction.
- Documentation and software will be to Siemens standard format unless expressly negotiated and entered as a separate line item on the purchase order.
- Equipment quoted has not been designed to be arc flash resistant. Siemens makes no claim of conformance to any arc flash requirements or specifications, as no standard exists for VFDs.
- Specifically not included in this proposal are: special crating, offloading at jobsite, storage, installation and testing equipment, foundations, anchor bolts, templates, system controls, external wiring, field testing, independent analysis, seismic calculations and video taping of seminars. NOTE: These items are the sole responsibility of the purchaser.
- Siemens Industry is acting as an equipment supplier only, not as a contractor or subcontractor. The listed specifications, (see Applicable Specifications of this proposal) are applicable only to the extent of the Siemens Industry, Inc. "Equipment Provider" scope of supply as described.
- If motor details are not supplied by the customer, then the drive will be sized according to industry standard motor power factor and efficiency performance data.
- Unless otherwise indicated, the drives are to be used for standard, on-shore, non-hazardous, industrial applications. Drive must be stored in a climate controlled indoor environment at all times.
- Unless specified by the customer, the drive and its accessories will be manufactured using parts and components per Siemens common practice and standard core design in effect at the time of manufacturing.
- In the event there is a change required to the scope of this project after the purchase order is received and accepted by Siemens, each change will need to be evaluated for its impact on schedule and price following the Siemens change order request and evaluation process. It is Siemens' recommendation that any change be communicated and finalized as soon as possible, but no later than two weeks after purchase order acceptance by Siemens so price and schedule impacts can be minimized. If changes are requested after the two-week period, the impacts could include, but are not limited to, price changes, cancellation charges for material on order and a change in the drawing submittal and shipping schedule because of holds placed on subcontractors and manufacturing. Siemens will make every effort to work with the customer to incorporate the desired changes. However, Siemens will not be responsible for additional pricing and delays due to these changes or liquidated damages, if applicable.

EXPORT COMPLIANCE CLAUSE

Purchaser acknowledges that Siemens Industry is required to comply with applicable export laws and regulations relating to the sale, exportation, transfer, assignment, disposal, and usage of the equipment / services provided under the contract, including any export license requirements. Purchaser agrees that such equipment / services shall not at any time directly or indirectly be used, exported, sold, transferred, assigned, or otherwise disposed of in a manner which will result in non-compliance with such applicable export laws and regulations. It shall be a condition of the continuing performance by Siemens Industry of its obligations hereunder that compliance with such export laws and regulations be maintained at all times.

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State of New Jersey
Division of Purchase and Property
Two-Year Chapter 51 / Executive Order 117 Vendor Certification and Disclosure of Political Contributions

CHAPT 51/EO 117-1

For AGENCY USE ONLY

General Information Goods and Special Services

Solicitation, RFP or Contract No. Power Generation System Award Amount

Description of Services Procurement Contract

Agency Contact Information

Agency Passaic Valley Sewerage Commission Contact Person Thomas A. Fuscaldo

Phone Number 973-817-5702 Agency Email tfuscaldo@pvsc.com

Part 1: Vendor Information

Full Legal Business Name Siemens Energy Inc.
(Including trade name if applicable)

Business Type [X] Corporation [ ] Limited Partnership [ ] Professional Corporation [ ] General Partnership [ ] Limited Liability Company [ ] Sole Proprietorship [ ] Limited Liability Partnership

Address 1 4400 Alafaya Trail Address 2

City Orlando, State FL Zip 32826 5 Phone (407) 736-2000

Vendor Email andrew.gagin@siemens.com Vendor FEIN 13-3987280

Part 2: Public Law 2005, Chapter 51/ Executive Order 117 (2008) Certification

I hereby certify as follows:

1. On or after October 15, 2004, neither the below-named entity nor any individual whose contributions are attributable to the entity pursuant to Executive Order 117 (2008) has solicited or made any contribution of money, pledge of contribution, including in-kind contributions, company or organization contributions, as set forth below that would bar the award of a contract to the vendor, pursuant to the terms of Executive Order 117 (2008).

   a) **Within the preceding 18 months**, the below-named person or organization has not made a contribution to:

      (i) Any candidate committee and/or election fund of any candidate for or holder of the public office of Governor or ***Lieutenant Governor***;
      (ii) Any State, county, ***municipal*** political party committee; OR
      (iii) Any ***legislative leadership committee***.

   b) **During the term of office of the current Governor(s)**, the below-named person or organization has not made a contribution to

      (i) Any candidate, committee and/or election fund of the Governor or ***Lieutenant Governor***; OR
      (ii) Any State, county or ***municipal*** political party committee nominating such Governor in the election preceding the commencement of said Governor's term.

   c) **Within the 18 months immediately prior to the first day of the term of office of the Governor(s)**, the below-named person or organization has not made a contribution to

      (i) Any candidate, committee and/or election fund of the Governor or ***Lieutenant Governor***; OR
      Any State, county, ***municipal*** political party committee of the political party nominating the successful gubernatorial candidate(s) in the last gubernatorial election.

PLEASE NOTE: Prior to November 15, 2008, the only disqualifying contributions include those made by the vendor or a principal owning or controlling more than 10 percent of the profits or assets of a business entity (or 10 percent of the stock in the case of a business entity that is a corporation for profit) to any candidate committee and/or election fund of the Governor or to any state or county political party within the preceding18 months, during the term of office of the current Governor or within the 18 months immediately prior to the first day of the term of Office of Governor.

CH51.1 R1/21/2009 Page 1 of 3

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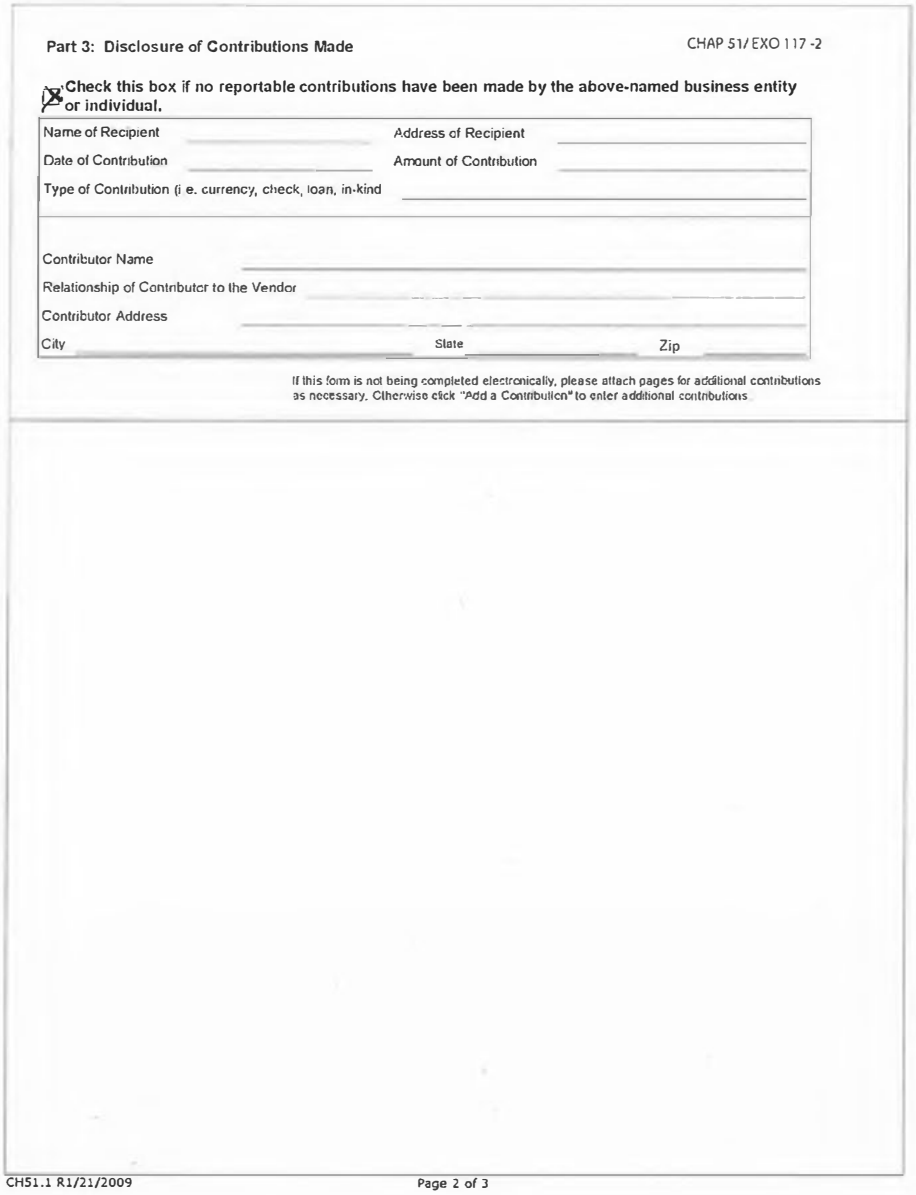

Part 3: Disclosure of Contributions Made

CHAP 51/ EXO 117 -2

☒ Check this box if no reportable contributions have been made by the above-named business entity or individual.

Name of Recipient	Address of Recipient
Date of Contribution	Amount of Contribution
Type of Contribution (i e. currency, check, loan, in-kind	

Contributor Name

Relationship of Contributor to the Vendor

Contributor Address

City State Zip

If this form is not being completed electronically, please attach pages for additional contributions as necessary. Otherwise click "Add a Contribution" to enter additional contributions

CH51.1 R1/21/2009 Page 2 of 3

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Part 4: Certification CHAPT 51/EO 117-3

I have read the instructions accompanying this form prior to completing this certification on behalf of the above-named business entity. I certify that, to the best of my knowledge and belief, the foregoing statements by me are true. I am aware that if any of the statements are willfully false, I am subject to punishment.

I understand that this certification will be in effect for two (2) years from the date of approval, provided the ownership status does not change and/or additional contributions are not made. If there are any changes in the ownership of the entity or additional contributions are made, a new full set of documents are required to be completed and submitted. By submitting this Certification and Disclosure, the person or entity named herein acknowledges this continuing reporting responsibility and certifies that it will adhere to it.

(CHECK ONE BOX A, B or C)

(A) ☐ I am certifying on behalf of the above-named business entity and all individuals and/or entities whose contributions are attributable to the entity pursuant to Executive Order 117 (2008).

(B) ☒ I am certifying on behalf of the above-named business entity only.

(C) ☐ I am certifying on behalf of an individual and/or entity whose contributions are attributable to the vendor.

Signed Name _____ Print Name Andrew Goggin

Phone Number 407-580-3981 Date 9/14/18

Title/Position Vice President North American Sales

Agency Submission of Forms

The agency should submit the completed and signed Two-Year Vendor Certification and Disclosure forms, together with a completed Ownership Disclosure form, either electronically to cd134@treas.state.nj.us, or regular mail at Chapter 51 Review Unit, P.O. Box 039, 33 West State Street, 9th Floor, Trenton, NJ 08625. The agency should save the forms locally and keep the original forms on file, and submit copies to the Chapter 51 Review Unit.

CH51.1 R1/21/2009 Page 3 of 3

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State of New Jersey
Department of Treasury: Division of Revenue & Enterprise Services

Business Record Service

Standing Certificates

Search Summary

Search Type: Business Name
Business Name: Siemens Energy, Inc

Short Form ?	Long Form w/Filing History ?	Long Form w/Officers ?	Business Name	Entity ID	City	Type	Original Filing Date
☐	☐	☐	SIEMENS ENERGY, INC.	0100757511	ORLANDO	FR	09/1998

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SECTION P-00301

PROPOSAL BOND

KNOW ALL MEN BY THESE PRESENTS that we, the undersigned, Siemens Energy Inc., as Principal; and Federal Insurance Company, as Surety, are hereby held and firmly bound unto the Passaic Valley Sewerage Commission in the penal sum of Ten Percent of Amount Bid Not to Exceed Twenty Thousand and 00/100 Dollars (10% of Amount Bid NTE $20,000.00) for the payment of which, well and truly to be made, we hereby jointly and severally bind ourselves, our heirs, executors, administrators, successors and assigns.

Signed this 19th day of September 20 18 .

The condition of the above obligation is such that whereas the Principal has submitted to the Passaic Valley Sewerage Commission an accompanying Proposal, attached hereto, and hereby made a part hereof, to enter into a contract in writing, to:

CONTRACT NO. B129 – POWER GENERATION SYSTEM PROCUREMENT

NOW THEREFORE,

A. If said Proposal shall be rejected, or, in the alternate,

B. If said Proposal shall be accepted and the Principal shall execute and deliver a contract in the form of CONTRACT attached hereto (properly completed) and shall furnish a bond for his faithful performance of said CONTRACT, and shall in all other respects perform the agreement created by the acceptance of said Proposal.

Then, this obligation shall be void, otherwise the same shall remain in force, and effect; it being expressly understood and agreed that the liability of the Surety for any and all claims hereunder shall, in no event, exceed the penal amount of this obligation as herein stated.

The Surety, for value received, hereby stipulates and agrees that the obligations of said Surety and its bond shall be in no way impaired or affected by any extension of time within which the Principal may accept such Proposal; and said Surety does hereby waive notice of any such extension.

IN WITNESS WHEREOF, the Principal and the Surety have set their hands and seals, and such of them as are corporations having caused their corporate seals to be hereto affixed and these presents to be signed by their proper officers, the day and year first set forth above.

Siemens Energy Inc.

Principal: _____

Surety: Federal Insurance Company by: _____

Jessica Antiotta, Attorney-in-Fact

5063-99634

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SECTION P-00302

CONSENT OF SURETY

KNOW ALL MEN BY THESE PRESENTS, that for and in consideration of the sum of $1.00, lawful money of the United States, the receipt whereof is hereby acknowledged, paid the undersigned corporation, and for other valuable consideration, the Federal Insurance Company (Name of Surety) corporation organized and existing under the laws of the State of Indiana and licensed to do business in the State of New Jersey, certifies and agrees, that if CONTRACT NO. B129 – POWER GENERATION SYSTEM PROCUREMENT is awarded to Siemens Energy Inc. undersigned corporation will execute the Bond or Bonds as required by the CONTRACT Documents and will become surety in the full amount of the CONTRACT price for the faithful performance of the contract and for payment of all persons supplying labor or furnishing materials in connection hence with.

Signature of Surety by: _____

Print Name: Jessica Iannotta

Title: Attorney-in-Fact

Address: 202B Halls Mill Road

Whitehouse Station, NJ 08889-3454

(To be accompanied by the usual proof of authority of officers of surety company to execute the same.)

5063-99634

P-00302-1

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CORPORATE ACKNOWLEDGMENT

STATE OF _____

COUNTY OF _____

On this 19th day of September, 2018 before me personally came

_____ to me known, who, being by me duly sworn, did depose and say that he/she resides in

_____ that he/she is the

_____ of Siemens Energy Inc.

that corporation described in and which executed the above instrument; that he/she knows the seal of said corporation; that the seal affixed to said instrument is such corporate seal; that it was so affixed by order of the Board of Directors of said corporation, and he/she signed his/her name thereto by like order.

(SEAL)

_____

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State of NJ
County of Morris } ss:

On September 19, 2018, before me, a Notary Public in and for said County and State, residing therein, duly commissioned and sworn, personally appeared

Jessica Iannotta

known to me to be Attorney-in-Fact of Federal Insurance Company
the corporation described in and that executed the within and foregoing instrument, and known to me to be the person who executed the said instrument in behalf of the said corporation, and he duly acknowledged to me that such corporation executed the same.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal, the day and year stated in this certificate above.

My Commission Expires 4/21/2021

Kristin S. Bender Notary Public

KRISTIN S BENDER
NOTARY PUBLIC-STATE OF NEW JERSEY
MY COMMISSION EXPIRES
APRIL 21, 2021

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CHUBB

Power of Attorney

Federal Insurance Company | Vigilant Insurance Company | Pacific Indemnity Company

Know All by These Presents, That **FEDERAL INSURANCE COMPANY**, an Indiana corporation, **VIGILANT INSURANCE COMPANY**, a New York corporation, and **PACIFIC INDEMNITY COMPANY**, a Wisconsin corporation, do each hereby constitute and appoint Kristin S. Bender, Jessica Iannotta, Annette M. Leuschner, Kelly O'Malley and April D. Perez of Morristown, New Jersey; Megan Schlueter of Raleigh, North Carolina----------

each as their true and lawful Attorney-in-Fact to execute under such designation in their names and to affix their corporate seals to and deliver for and on their behalf as surety thereon or otherwise, bonds and undertakings and other writings obligatory in the nature thereof (other than bail bonds) given or executed in the course of business, and any instruments amending or altering the same, and consents to the modification or alteration of any instrument referred to in said bonds or obligations.

In Witness Whereof, said **FEDERAL INSURANCE COMPANY, VIGILANT INSURANCE COMPANY**, and **PACIFIC INDEMNITY COMPANY** have each executed and attested these presents and affixed their corporate seals on this **21st** day of **August, 2018**.

Dawn M. Chloros, Assistant Secretary

Stephen M. Haney, Vice President

STATE OF NEW JERSEY

County of Hunterdon ss.

On this **21st** day of **August, 2018**, before me, a Notary Public of New Jersey, personally came Dawn M. Chloros, to me known to be Assistant Secretary of FEDERAL INSURANCE COMPANY, VIGILANT INSURANCE COMPANY, and PACIFIC INDEMNITY COMPANY, the companies which executed the foregoing Power of Attorney, and the said Dawn M. Chloros, being by me duly sworn, did depose and say that she is Assistant Secretary of FEDERAL INSURANCE COMPANY, VIGILANT INSURANCE COMPANY, and PACIFIC INDEMNITY COMPANY and knows the corporate seals thereof, that the seals affixed to the foregoing Power of Attorney are such corporate seals and were thereto affixed by authority of said Companies; and that she signed said Power of Attorney as Assistant Secretary of said Companies by like authority; and that she is acquainted with Stephen M. Haney, and knows him to be Vice President of said Companies; and that the signature of Stephen M. Haney, subscribed to said Power of Attorney is in the genuine handwriting of Stephen M. Haney, and was thereto subscribed by authority of said Companies and in deponent's presence.

Notarial Seal

KATHERINE J. ADELAAR
NOTARY PUBLIC OF NEW JERSEY
No. 2316886
Commission Expires July 18, 2019

Notary Public

CERTIFICATION

Resolutions adopted by the Boards of Directors of FEDERAL INSURANCE COMPANY, VIGILANT INSURANCE COMPANY, and PACIFIC INDEMNITY COMPANY on August 30, 2016:

"RESOLVED, that the following authorizations relate to the execution, for and on behalf of the Company, of bonds, undertakings, recognizances, contracts and other written commitments of the Company entered into in the ordinary course of business (each a "Written Commitment"):

(1) Each of the Chairman, the President and the Vice Presidents of the Company is hereby authorized to execute any Written Commitment for and on behalf of the Company, under the seal of the Company or otherwise.

(2) Each duly appointed attorney-in-fact of the Company is hereby authorized to execute any Written Commitment for and on behalf of the Company, under the seal of the Company or otherwise, to the extent that such action is authorized by the grant of powers provided for in such person's written appointment as such attorney-in-fact.

(3) Each of the Chairman, the President and the Vice Presidents of the Company is hereby authorized, for and on behalf of the Company, to appoint in writing any person the attorney-in-fact of the Company with full power and authority to execute, for and on behalf of the Company, under the seal of the Company or otherwise, such Written Commitments of the Company as may be specified in such written appointment, which specification may be by general type or class of Written Commitments or by specification of one or more particular Written Commitments.

(4) Each of the Chairman, the President and the Vice Presidents of the Company is hereby authorized, for and on behalf of the Company, to delegate in writing to any other officer of the Company the authority to execute, for and on behalf of the Company, under the Company's seal or otherwise, such Written Commitments of the Company as are specified in such written delegation, which specification may be by general type or class of Written Commitments or by specification of one or more particular Written Commitments.

(5) The signature of any officer or other person executing any Written Commitment or appointment or delegation pursuant to this Resolution, and the seal of the Company, may be affixed by facsimile on such Written Commitment or written appointment or delegation.

FURTHER RESOLVED, that the foregoing Resolution shall not be deemed to be an exclusive statement of the powers and authority of officers, employees and other persons to act for and on behalf of the Company, and such Resolution shall not limit or otherwise affect the exercise of any such power or authority otherwise validly granted or vested."

I, Dawn M. Chloros, Assistant Secretary of FEDERAL INSURANCE COMPANY, VIGILANT INSURANCE COMPANY, and PACIFIC INDEMNITY COMPANY (the "Companies") do hereby certify that

(i) the foregoing Resolutions adopted by the Board of Directors of the Companies are true, correct and in full force and effect.

(ii) the foregoing Power of Attorney is true, correct and in full force and effect.

Given under my hand and seals of said Companies at Whitehouse Station, NJ, this September 19, 2018.

Dawn M. Chloros, Assistant Secretary

IN THE EVENT YOU WISH TO VERIFY THE AUTHENTICITY OF THIS BOND OR NOTIFY US OF ANY OTHER MATTER, PLEASE CONTACT US AT:
Telephone (908) 903-3493 Fax (908) 903-3656 e-mail: surety@chubb.com

FED- VIG-PI (rev. 08-18)

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FEDERAL INSURANCE COMPANY

STATEMENT OF ASSETS, LIABILITIES AND SURPLUS TO POLICYHOLDERS

Statutory Basis

DECEMBER 31, 2017

(in thousands of dollars)

ASSETS		*LIABILITIES AND SURPLUS TO POLICYHOLDERS*	
Cash and Short Term Investments	$ (78,340)	Outstanding Losses and Loss Expenses	$ 10,545,326
United States Government, State and Municipal Bonds	7,063,387	Unearned Premiums	2,087,124
Other Bonds	5,366,068	Ceded Reinsurance Premiums Payable	739,431
Stocks	134,041	Provision for Reinsurance	57,140
Other Invested Assets	1,006,599	Other Liabilities	1,044,341
TOTAL INVESTMENTS	13,491,755	TOTAL LIABILITIES	14,473,362
Investments in Affiliates:			
Chubb Investment Holdings, Inc.	3,890,677	Capital Stock	20,980
Great Northern Insurance Company	557,388	Paid-In Surplus	3,209,193
Vigilant Insurance Company	327,316	Unassigned Funds	4,066,505
Chubb Indemnity Insurance Company	171,786		
Chubb National Insurance Company	171,493		
Chubb European Investment Holdings, SLP.	119,836	SURPLUS TO POLICYHOLDERS	7,296,678
Other Affiliates	76,806		
Premiums Receivable	1,594,780		
Other Assets	1,368,203		
TOTAL ADMITTED ASSETS	$ 21,770,040	TOTAL LIABILITIES AND SURPLUS	$ 21,770,040

Investments are valued in accordance with requirements of the National Association of Insurance Commissioners. At December 31, 2017, investments with a carrying value of $558,430,596 were deposited with government authorities as required by law.

State, County & City of New York, — ss:

Dawn M. Chloros, Assistant Secretary of the Federal Insurance Company being duly sworn, deposes and says that the foregoing Statement of Assets, Liabilities and Surplus to Policyholders of said Federal Insurance Company on December 31, 2017 is true and correct and is a true abstract of the Annual Statement of said Company as filed with the Secretary of the Treasury of the United States for the 12 months ending December 31, 2017.

Subscribed and sworn to before me
this March 1, 2018.

Jeanette Shipsey
Notary Public

JEANETTE SHIPSEY
Notary Public, State of New York
No. 02SH5074142
Qualified in Nassau County
Commission Expires March 10, 2019

Dawn M. Chloros
Assistant Secretary

Form 15-10-0313A (Rev. 3/18)

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SURETY DISCLOSURE STATEMENT AND CERTIFICATION

Federal Insurance Company, the

Surety(ies) on the attached bond, hereby certifies(y) the following:

(1) The surety meets the applicable capital and surplus requirements of R.S. 17:17-6 or R.S. 17:17-7 as of the surety's most current annual filing with the New Jersey Department of Insurance.

(2) The capital (where applicable) and surplus, as determined in accordance with the applicable laws of this State, of the surety(ies) participating in the issuance of the attached bond is (are) in the following amount(s) as of the calendar year ended December 31, 2017 (most recent calendar year for which capital and surplus amounts are available), which amounts have been certified as indicated by certified public accountants (indicating separately for each surety that surety's capital and surplus amounts, together with the name and address of the firm of certified public accounts that shall have certified in those amounts):

Federal Insurance Company
Capital: $20,980,000 Surplus: $7,296,678,000

certified as indicated by the certified public accountants, Ernst & Young LLP, 787 Seventh Avenue, New York, NY 10019

(3) (a) With respect to each surety participating in the issuance of the attached bond that has received from the United States Secretary of the Treasury a certificate of authority pursuant to 31 U.S.C. §9305, the underwriting limitation established therein and the date as of which that limitation was effective is as follows (indicating for each surety that surety's underwriting limitation and the effective date thereof):

Federal Insurance Company

Limitation per Bond: $1,000,918,000 Effective: July 1, 2017

(b) With respect to each surety participating in the issuance of the attached bond that has not received such a certificate of authority form the United States Secretary of the Treasury, the underwriting limitation of that surety as established pursuant to R.S. 17:18-9 as of (date on which such limitation was so established) is as follows (indicating for each such surety that surety's underwriting limitation and the date on which that limitation was established):

Not Applicable

(4) The amount of the bond to which this statement and certification is attached is:

$ 10% of Amount Bid NTE $20,000.00

P-00302A-1

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SURETY DISCLOSURE STATEMENT AND CERTIFICATION (continued)

(5) If, by virtue of one or more contracts of reinsurance, the amount of the bond indicated under item (4) above exceeds the total underwriting limitation of all sureties on the bond as set forth in items (3)(a) or (3)(b) above, or both, then for each such contract of reinsurance:

(a) The name and address of each such reinsurer under that contract and the amount of that reinsurer's participation in the contract is as follows:

Not Applicable

; and

(b) Each surety that is party to any such contract of reinsurance certifies that each reinsurer listed under item (5)(a) satisfies the credit for reinsurance requirement established under P.L. 1993, c.243 (C. 17:51B-1 et seq.) and any applicable regulations in effect as of the date on which the bond to which this statement and certification is attached shall have been filed with the appropriate public agency.

CERTIFICATE

(to be completed by an authorized certifying agent for each surety on the bond)

I Jessica Iannotta (Name of Agent), as Attorney-in-Fact (Title of Agent) for Federal Insurance Company (Name of Surety), a corporation/mutual insurance company/other (circle one) domiciled in Indiana (state of domicile), DO HEREBY CERTIFY that, to the best of my knowledge, the foregoing statements made by me are true, and ACKNOWLEDGE that, if any of those statements are false, this bond is VOIDABLE.

(Signature of Certifying Agent)

Jessica Iannotta

(Printed Name of Certifying Agent)

Attorney-in-Fact

(Title of Certifying Agent)

P-00302A-2

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SECTION P-00303

PROPOSER'S AFFIDAVIT

State of Florida)
ss:
County of Orange)

Andrew Gonzalez being duly sworn, deposes and says that he resides at 4400 Alafaya Trail, Orlando, FL 32826 that he is the Vice President North American Sales (Title) of Siemens Energy, Inc. (Name of Propser)

who signed the above Proposal, that he was duly authorized to sign, and that the Proposal is a true offer of the Proposer, and the seal attached is the seal of the Proposer and that all the declarations and statements contained in the Proposal are true to the best of his knowledge and belief.

(Affiant)

Sworn to and subscribed before me

this 14 day of Sept. 2018

Notary Public in and for

Orange County, Florida

DIANNE LOPEZ
MY COMMISSION # GG 086754
EXPIRES: July 23, 2021
Bonded Thru Notary Public Underwriters

My Commission Expires

7.23, 2021

5063-99634

P-00303-1

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SECTION P-00304

NON-COLLUSION AFFIDAVIT

STATE OF NEW JERSEY, COUNTY OF Essex ss.:

I, Andrew Goggin, of the City of Orlando in the County of Orange and the State of Florida of full age, being duly sworn according to law on my oath depose and say that:

I am Andrew Goggin of the firm of Siemens Energy, Inc the proposer making the Proposal for the above-named contract, and that I executed the said Proposal with full authority so to do; that said Proposer has not, directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free, competitive contracting in connection with the within Contract; and that all statements contained in said Proposal and in this Affidavit are true and correct, and made with full knowledge that the **Passaic Valley Sewerage Commission** relies upon the truth of the statements contained in said Proposal and in the statements contained in this Affidavit in awarding the Contract.

I further warrant that no person or selling agency has been employed or retained to solicit or secure such Contract upon an agreement or understanding for a commission, percentage, brokerage or contingent fee, except bona fide employees or bona fide established commercial or selling agencies maintained by the Proposer for the purpose of securing business.

For breach or violation of this warranty the Owner shall have the right to annul the Contract without liability or in its discretion to deduct from the Contract price or consideration the full amount of such commission, percentage, brokerage or contingent fee.

(Affiant)

Sworn to and subscribed before me

this 14 day of Sept, 2018

Notary Public in and for

Orange County, Florida

DIANNE LOPEZ
MY COMMISSION # GG 086754
EXPIRES: July 23, 2021
Bonded Thru Notary Public Underwriters

My Commission Expires

7.23, 2021

5063-99634

P-00304-1

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SECTION P-00305

STATEMENT OF OWNERSHIP

(OWNERSHIP DISCLOSURE CERTIFICATION)

N.J.S.A. 52:25-24.2 (P.L. 1977, c.33, as amended by P.L. 2016, c.43)

This Statement Shall Be Included with All Bid and Proposal Submissions

Name of Business: Siemens Energy Inc.

Address of Business: 4400 Alafaya Trail, Orlando, FL 32826

Name of person completing this form: Andy Goggin

N.J.S.A. 52:25-24.2:

"No corporation, partnership, or limited liability company shall be awarded any contract nor shall any agreement be entered into for the performance of any work or the furnishing of any materials or supplies, unless prior to the receipt of the bid or proposal, or accompanying the bid or proposal of said corporation, said partnership, or said limited liability company there is submitted a statement setting forth the names and addresses of all stockholders in the corporation who own 10 percent or more of its stock, of any class, or of all individual partners in the partnership who own a 10 percent or greater interest therein, or of all members in the limited liability company who own a 10 percent or greater interest therein, as the case may be.

If one or more such stockholder or partner or member is itself a corporation or partnership or limited liability company, the stockholders holding 10 percent or more of that corporation's stock, or the individual partners owning 10 percent or greater interest in that partnership, or the members owning 10 percent or greater interest in that limited liability company, as the case may be, shall also be listed. The disclosure shall be continued until names and addresses of every noncorporate stockholder, and individual partner, and member, exceeding the 10 percent ownership criteria established in this act, has been listed.

To comply with this section, a bidder or proposer with any direct or indirect parent entity which is publicly traded may submit the name and address of each publicly traded entity and the name and address of each person that holds a 10 percent or greater beneficial interest in the publicly traded entity as of the last annual filing with the federal Securities and Exchange Commission or the foreign equivalent, and, if there is any person that holds a 10 percent or greater beneficial interest, also shall submit links to the websites containing the last annual filings with the federal Securities and Exchange Commission or the foreign equivalent and the relevant page numbers of the filings that contain the information on each person that holds a 10 percent or greater beneficial interest."

The Attorney General has advised that the provisions of N.J.S.A. 52:25-24.2, which refer to corporations and partnerships apply to limited partnerships, limited liability partnerships, and Subchapter S corporations.

This Ownership Disclosure Certification form shall be completed, signed and notarized.

P-00305-1

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Failure of the bidder/proposer to submit the required information is cause for automatic rejection of the bid or proposal

Part I

Check the box that represents the type of business organization:

☐ Sole Proprietorship (skip Parts II and III, sign and notarize at the end)

☐ Non-Profit Corporation (skip Parts II and III, sign and notarize at the end)

☐ Partnership ☐ Limited Partnership ☐ Limited Liability Partnership

☐ Limited Liability Company

☒ For-profit Corporation (including Subchapters C and S or Professional Corporation)

☐ Other (be specific): _____

Part II

☒ I certify that the list below contains the names and addresses of all stockholders in the corporation who own 10 percent or more of its stock, of any class, or of all individual partners in the partnership who own a 10 percent or greater interest therein, or of all members in the limited liability company who own a 10 percent or greater interest therein, as the case may be.

OR

☐ I certify that no one stockholder in the corporation owns 10 percent or more of its stock, of any class, or no individual partner in the partnership owns a 10 percent or greater interest therein, or that no member in the limited liability company owns a 10 percent or greater interest therein, as the case may be.

Sign and notarize the form below, and, if necessary, complete the list below. (Please attach additional sheets if more space is needed):

Name: **Siemens Corp. 100%** Name: _____

Address: 300 New Jersey Ave.Ste 1000 Address: _____

Washington, DC, 20001 _____

Name: _____ Name: _____

P-00305-2

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Address: _____ Address: _____

_____ _____

Name: _____ Name: _____

Address: _____ Address: _____

_____ _____

Name: _____ Name: _____

Address: _____ Address: _____

_____ _____

Name: _____ Name: _____

Address: _____ Address: _____

_____ _____

Name: _____ Name: _____

Address: _____ Address: _____

_____ _____

Name: _____ Name: _____

Address: _____ Address: _____

_____ _____

P-00305-3

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Part III - Any Direct or Indirect Parent Entity Which is Publicly Traded:

"To comply with this section, a bidder or proposer with any direct or indirect parent entity which is publicly traded may submit the name and address of each publicly traded entity and the name and address of each person that holds a 10 percent or greater beneficial interest in the publicly traded entity as of the last annual filing with the federal Securities and Exchange Commission or the foreign equivalent, and, if there is any person that holds a 10 percent or greater beneficial interest, also shall submit links to the websites containing the last annual filings with the federal Securities and Exchange Commission or the foreign equivalent and the relevant page numbers of the filings that contain the information on each person that holds a 10 percent or greater beneficial interest."

☐ Pages attached with name and address of each publicly traded entity as well as the name and address of each person that holds a 10 percent or greater beneficial interest.

OR

☒ Submit here the links to the Websites (URLs) containing the last annual filings with the federal Securities and Exchange Commission or the foreign equivalent.

_https://www.siemens.com/investor/en/_____

AND

☐ Submit here the relevant page numbers of the filings containing the information on each person holding a 10 percent or greater beneficial interest.

____N/A_____

Subscribed and sworn before me this 14 day of Sept, 2018.

(Notary Public) Dianne E. Lopez

My Commission expires: 7.23.2021

DIANNE LOPEZ
MY COMMISSION # GG 086754
EXPIRES: July 23, 2021
Bonded Thru Notary Public Underwriters

(Affiant)

Andrew Goggin Vice President North American Sales

(Print name of affiant and title if applicable)

(Corporate Seal if a Corporation)

P-00305-4

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SECTION P-00306

AFFIRMATIVE ACTION AFFIDAVIT

(to be completed by firms with more than 50 employees)

Kathl een Will _____ of the firm of Siemens Corporation
(name)

being sworn according to law on his oath deposes and says that:

1. I am authorized to make this affidavit on behalf of:

   Siemens Energy, Inc.
   (name of firm)

2. In addition an agreement to comply with an Affirmative Action Program for equal employment opportunity heretofore submitted as part of any pre-qualification statement, or under other conditions of this contract for a similar program, I/we do hereby further affirm that I/we will comply with the rules and regulations which will be promulgated by the State Treasurer as of the effective date therefor pursuant to the Affirmative Action Law (P.L. 1975, c. 127), as amended.

Kathleen A. Will, IRLL HR Professional
Name and Title

K. Will
Signature of Authorized Representative

Subscribed and sworn to
before me this 6th
day of September 2018

Treven Phipps
Seal Notary Public of Florida

TREVEN PHIPPS
Notary Public - State of Florida
Commission # GG 148549
My Comm. Expires Oct 4, 2021
Bonded through National Notary Assn.

AFFIRMATIVE ACTION
AFFIDAVIT P-00306-1

5063-99634

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SECTION P-00307

ACKNOWLEDGEMENT OF RECEIPT OF CHANGES TO REQUEST FOR PROPOSAL DOCUMENTS FORM

PASSAIC VALLEY SEWERAGE COMMISSION

POWER GENERATION SYSTEM PROCUREMENT	B129
(Name of Project)	(Contract No.)

The undersigned proposer hereby acknowledges receipt of the following notices, revisions, or addenda to the request for proposal. By indicating date of receipt, proposer acknowledges the submitted proposal takes into account the provisions of the notices, revision or addendum. Note that the PVSC's record of notice to proposers shall take precedence and that failure to include provisions of changes in a proposal may be grounds for rejection of the proposal.

Addendum No.	How Received (mail, fax, Pick-up, etc)	Date Received
1	Download from PVSC website	August 3, 2018
2	Download from PVSC website	August 10, 2018
3	Download from PVSC website	August 22, 2018
4	Download from PVSC website	August 30, 2018
5	Download from PVSC website	September 6, 2018

Acknowledgement by proposer:

Name of Proposer: Siemens Energy, Inc.

By Authorized Representative: Andrew Goggin

Signature:

Printed Name and Title: Andrew Goggin Vice President North American Sales

Date: 9/14/18

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Section P-00406

DISCLOSURE OF INVESTMENT ACTIVITIES IN IRAN

Project Name: Passaic Valley Sewerage Commission

Bidder Name: Siemens Energy, Inc

PART 1: CERTIFICATION
BIDDERS MUST COMPLETE PART 1 BY CHECKING EITHER BOX

FAILURE TO CHECK ONE OF THE BOXES WILL RENDER THE PROPOSAL NON-RESPONSIVE

Pursuant to Public Law 2012, c.25, any person or entity that submits a bid or proposal or otherwise proposes to enter into or renew a contract must complete the certification below to attest, under penalty of perjury, that NEITHER the person or entity, nor any of its parents, subsidiaries, or affiliates, is identified on the Department of Treasury Chapter 25 list as a person or entity engaging in investment activities in Iran. The Chapter 25 list is found on the Division's website at http://www.state.nj.us/treasury/purchase/pdf/Chapter25List.pdf. Bidders must review this list prior to completing the below certification. **Failure to complete the certification will render a bidder's proposal non-responsive.** If the New Jersey Director of the Division of Purchase and Property finds a person or entity to be in violation of law, he/she shall take action as may be appropriate and provided by law, rule or contract, including but not limited to, imposing sanctions, seeking compliance, recovering damages, declaring the party in default and seeking suspension of the party.

PLEASE CHECK THE APPROPRIATE BOX:

☒ **I certify, pursuant to Public Law 2012, c.25, that neither the bidder listed above nor any of the bidder's parents, subsidiaries, or affiliates listed** on the N.J. Department of the Treasury's list of entities determined to be engaged in prohibited activities in Iran pursuant to P.L. 2012, c.25 ("Chapter 25 List"). I further certify that I am the person listed above, or I am an officer or representative of the entity listed above and am authorized to make this certification on its behalf. **I will skip Part 2 and sign and complete the Certification below: OR**

☐ **I am unable to certify as above because the bidder and/or one of its parents, subsidiaries, or affiliates is listed on the Department's Chapter 25 List. I will provide a detailed, accurate and precise description of the activities in Part 2 below and sign and complete the Certification below.** Failure to provide such will result in the proposal being rendered as non-responsive and appropriate penalties, fines and/or sanctions will be assessed as provided by law.

PART 2: PLEASE PROVIDE FURTHER INFORMATION RELATED TO INVESTMENT ACTIVITIES IN IRAN.
You must provide a detailed, accurate and precise description of the activities of the bidding person/entity, or one of its parents, subsidiaries or affiliates, engaging in the investment activities in Iran outlined above by completing the boxes below.

PLEASE PROVIDE THOROUGH ANSWERS TO EACH QUESTION. IF YOU NEED ADDITIONAL ROOM, ADD ADDITIONAL PAGES.

Name_____ Relationship to Bidder/Owner_____

Description of Activities_____

Duration of Engagement_____ Anticipated Cessation Date_____

Bidder/Offeror Contact Name_____

Certification: I, being duly sworn upon my oath, hereby represent and state that the foregoing information and any attachments thereto to the best of my knowledge are true and complete. I attest that I am authorized to execute this certification on behalf of the above-referenced person or entity. I acknowledge that the State of New Jersey and the Owner of the project are relying on the information contained herein and thereby acknowledge that I am under a continuing obligation from the date of this certification through the completion of any contracts with the State of New Jersey and the Owner to notify the State of New Jersey and the Owner in writing of any changes to the answers of information contained herein. I acknowledge that I am aware of that it is a criminal offense to make a false statement or misrepresentation in this certification, and if I do so, I recognize that I am subject to criminal prosecution under the law and that it will also constitute a material breach of my agreement(s) with the State of New Jersey and/or the Owner and that the State and/or the Owner at its option may declare any contract(s) resulting from this certification void and unenforceable.

Full Name (Print): Richard Mowad **Signature:** [signature]

Title: VP **Date:** Sept 12, 2018