NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF RELEASE PREVENTION
TOXIC CATASTROPHE PREVENTION ACT (TCPA) PROGRAM

Guidance on Process Hazard Analysis with Risk Assessment (PHA/RA)

Issued: January 11, 2012

Revised: July 29, 2020

TABLE OF CONTENTS

Attachments

I. Introduction

The purpose of this guidance document is to assist the owners/operators of TCPA facilities to conduct and report TCPA process hazard analysis with risk assessments (PHA/RAs) in accordance with 40 CFR 68.67 incorporated with changes at N.J.A.C. 7:31-4.1(c)5 through 7, N.J.A.C. 7:1-4.2, and N.J.A.C. 7:1-4.6(c). The purpose of the PHA/RA is to identify potential EHS release scenarios, determine the cause(s) of each release scenario (e.g. equipment malfunction – tank failure/leak due to corrosion, failure to follow procedure – operator opens incorrect valve, or external events – piping failure due to vehicle collision), quantify the consequence and likelihood of each release scenario, and determine appropriate risk reduction measures.

This guidance document does not establish any regulatory requirements beyond what is required pursuant to N.J.A.C. 7:31-1 et.seq.

II. Process Hazard Analysis (PHA)

A. Initial PHA and Management of Change PHA

40 CFR 68.67(a) as incorporated with changes at N.J.A.C. 7:31-4.1(c)5 through 7 requires the Owner or Operator (O/O) to perform an initial process hazard analysis with risk assessment on the covered processes, and provides a list of the PHA methods that must be used. Detailed explanations of these methods are contained in References [1] and [2]. Depending on the complexity of the process, the O/O may use one or more of the methods to study the potential EHS releases at the covered process.

Any changes made to the covered process or procedure may impact the findings of the initial PHA. Therefore, you should update or revalidate your PHA whenever there is a change to your process such as introducing new equipment or substances, eliminating equipment, altering process chemistry, changing safe operating limits, or any other alteration that may introduce a new hazard. In addition, the PHA and the consequence and likelihood analyses required at N.J.A.C. 7:31-4.2 must be updated for changes that have associated release scenarios resulting in an offsite impact as specified at N.J.A.C. 7:31-4.6(b) and (c).

The PHA must be performed by a team with expertise in engineering and process operation, including at least one employee who has experience and knowledge in the process being evaluated and one team member who is knowledgeable in the specific PHA method that is being used. The team must use all the process safety information documents and all other Risk Management Program documents (i.e., operating and maintenance procedures, management system, training, management of change, contractors, etc…).

The team must review the incident reports, facility siting, and human factors. References [2], [3], [4], and [5] contain information on facility siting and human factors. Specifically, Appendices F and G of Reference [5] contain checklists for facility siting and human factors respectively and Reference [4] contains valuable information concerning facility siting and human factors as provided by OSHA.

Finally, the team must identify the potential EHS releases that could result in an offsite impact (endpoint criterion extending beyond the site boundary), including the release quantity, rate, and duration.

B. PHA Revalidation

40 CFR 68.67(f) as incorporated with changes at N.J.A.C. 7:31-4.1(c)5 through 7 requires the O/O to update and revalidate the initial process hazard analysis with risk assessment on the covered processes every 5 years. The O/O may use the OSHA Standard Interpretations (01/22/1998): Steps for updating and revalidating a Process Hazard Analysis (PHA) and information in Reference [5] to perform the PHA revalidation along with risk assessment and prepare the report in accordance with N.J.A.C. 7:31-4.2(e). Essentially, the revalidation involves defining the scope of the study; confirming that scenarios, safeguards, and risk reduction from the previous PHA still exist; evaluating controlled and uncontrolled changes and their cumulative effect on the the process; addressing gaps and deficiencies from the prior PHA; considering new knowledge; and reviewing incident investigations that occurred since the previous PHA. The team requirements are the same as that of the initial PHA.

Also, N.J.A.C. 7:31-4.12 requires the O/Oto revalidate and update an initial Inherently Safer Technology (IST) review on the same schedule as the process hazard analysis with risk assessment. **It is recommended that the PHA/RA and IST reviews be combined such that the selection of any risk reduction measure that would be applied is done through an IST approach.**

III. Risk Assessment (RA)

A. Quantification of the EHS Release

The TCPA risk assessment (RA) follows the PHA and is peformed to quantify the EHS release scenarios, any offsite consequences, and risk reduction. The TCPA rule specifies that estimates of the quantity or rate and duration of an EHS release be based on actual release mechanisms and reflect the operating procedures, safeguards, and mitigation equipment in place. The following example explains how to quantify the EHS release:

Example 1
EHS release scenario: What if a 2-inch outlet pipe from an aqueous ammonia storage tank leaks.
Cause: Corrosion/erosion.
Consequence: Potential release of ammonia to the atmosphere.

Safeguards/Mitigation: Non-destructive testing (NDT) of pipe every 5 years, manual valve at the bottom of the storage tank and Emergency Response (ER) team is trained to shut the manual valve within 30 min.

Therefore, the release duration is 30 minutes based on the ER team response time.

Estimate release rate and quantity based on safeguard/mitigation:
Assume the following in order to estimate the release rate: the aqueous ammonia is stored at atmospheric pressure, the height of liquid above the hole is 5ft, and the hole size is 2 inches (that is a guillotine failure which is 100% of the pipe diameter). From Reference [6], equation 15 of Appendix F, the liquid release rate is estimated as follows:

$QR_L = 153 * A_h * h^{.5}$ where:

QR_L = rate of spillage of ammonia solution onto the ground (lbs/min)

A_h = hole area (in^2)

h = static head (ft)

Therefore, $QR_L = 153 * (3.14*1^2) * (5^{.5})$ = 1075 lbs/min and in 30 minutes, the total amount spilled (QS) is 32,250 pounds (1075*30=32250).

From Appendix F of the EPA OCA (Equation 16), the evaporation rate (QR) is estimated as follows:

QR = .025*QS

=.025*32250 = 806 lbs/min

Example 2

EHS release scenario: What if a 2-inch outlet pipe from an aqueous ammonia storage tank leaks.
Cause: Corrosion/erosion.
Consequence: Potential release of ammonia to the atmosphere.

Safeguards/Mitigation: Dike, ammonia detector and alarm, NDT of piping system every 5 years, remote shutoff valve at the bottom of the storage tank interlocked with the ammonia detectors, and emergency response team applies water fog nozzle.

The release duration is 1 minute based on the action of the remote shutoff valve at the bottom of the storage tank, interlock system, and the ammonia detectors.

Estimate release rate and quantity based on safeguard/mitigation:
Assuming the following in order to estimate the release rate: the aqueous ammonia is stored at atmospheric pressure, the height of liquid above the hole is 5 ft, the hole size is 2 inches (that is, the hole is 100% of the pipe diameter) and dike area is 200 ft^2. From Reference [5], equation 15 of Appendix F, the liquid release rate is estimated as follows:

$QR_L = 153 * A_h * h^{.5}$ where:

QR_L = rate of spillage of ammonia solution onto the ground (lbs/min)

A_h = hole area (in^2)

h = static head (ft)

Therefore, $QR_L = 153 * (3.14*1^2) * (5^{.5})$ = 1075 lbs/min and in 1 minute, the total amount spilled (QS) is 1075 pounds (1075*1=1075).

Also, from Appendix F (Equation 17), the evaporation rate (QR) is estimated as follows:

$QR = 0.046 * A_p$

where:

QR = rate of evaporation from pool (lbs/min)

A_p = pool area (ft^2)

=.046*200 = 9.2 lbs/min

The above analysis is done using 100% of the pipe diameter (guillotine failure) as the size of the hole. Recommendations on how to determine the size of the hole are provided in Chapter 2 of Reference [7].

Hypothetical releases which are not realistic scenarios and do not apply to the covered process should not be used. One such example is to assume that the entire contents of a pressurized vessel is released in a minute. This may not be a realistic scenario unless an actual cause of such an occurrence is identified. In this case, assume that a possible cause of a release is a vehicular collision due to the location of the vessel. A realistic hole size should be selected, and depending on the location of the hole and the EHS properties, it may be a single phase or a two-phase release that results in a vapor flash fraction and an evaporating pool. Another scenario that may not be realistic is limiting the release duration with the assumption that it can be mitigated quickly by the site emergency response team. This assumption must be verified during an emergency response exercise required by N.J.A.C. 7:31-5 and documented with an emergency response exercise written assessment.

The O/O may use release calculation methods provided by the Environmental Protection Agency in the “Risk Management Program Guidance for Offsite Consequence Analysis,” March 2009, (OCA Guidance), Reference [6], which can be obtained from the EPA website(www.epa.gov/rmp/rmp-guidance-offsite-consequence-analysis). If using the EPA OCA Guidance, the equations and methods to estimate the release quantity or rate and duration resulting from the identified scenario may be obtained from Chapters 3 and 7. For pool evaporation rate, you may use equation 3-7 or 3-8 or modify the wind speed factor for pool evaporation rate in equations 7-8, 7-9, 7-10, 7-11 and 7-12 from 2.4 to 1.4 to reflect the TCPA value of wind speed of 1.5 meters per second, as the 2.4 factor was derived using the EPA value of 3 meters per second.

If a method other than the EPA guidance is used to quantify the EHS releases, the documentation must be provided explaining this method in detail, including any formulas, assumptions, basis for the assumptions, and calculations.

B. Consequence Analysis

N.J.A.C. 7:31-4.2(b)3 requires the O/O to identify all EHS release scenarios of toxic, flammable, and reactive hazards that have potential offsite impact for the criteria endpoints using a consequence analysis consisting of dispersion analysis, thermal analysis, and overpressure analysis as applicable. The EPA OCA Guidance provides several consequence analysis methods that may be used for the TCPA RA. Alternatively, the O/O may use any publicly or commercially available model that meets the modeling conditions specified at N.J.A.C.7: 31-4.2 (b)3 to estimate the distance to the endpoint. However, the model must be appropriate to the selected release scenario.

The Department has clarified the consequence analysis for EHSs by specifying that the toxicity, flammability, explosion, and reactivity hazards applicable to the EHS must be considered; however, consideration of toxicity is only required for EHSs that appear in N.J.A.C. 7:31-6.3(a), Table I, Parts A and/or B as a toxic substance. It is recommended that thermal analysis and overpressure analysis is to be limited to toxic EHSs that meet the definition of “flammable” at 29 CFR 1910.1200(c).

Ethylene oxide is an example of a toxic substance that is regulated as a toxic substance in Part A or B and also is a flammable hazard. It has an NFPA flammability of 4. Other examples include vinyl acetate, which has an NFPA flammability rating of 3, and acrylonitrile, which has a NFPA flammability of 3. These substances also contain Reactive Hazard Substance (RHS) mixture functional groups listed at N.J.A.C. 7:31-6.3, Table I, Part D, Group II. These substances have toxicity, flammability, and reactivity properties; therefore, the consequence analysis must be based on dispersion analysis, thermal analysis, and overpressure analysis using the respective endpoint criteria.

B1. Dispersion Analysis for Toxic EHS

The dispersion analysis requires modeling an EHS release using toxic endpoint criteria and dispersion parameters specified at N.J.A.C.7: 31-4.2(b)3 to estimate the distance to the endpoint. For toxic EHS, the toxic endpoint that must be used is the Acute Toxicity Concentration (ATC) or the endpoint criterion of five times the toxicity endpoint designated at N.J.A.C. 7:31-2.1(c)2, which refers to Appendix A of 40 CFR Part 68 for EPA regulated toxic substances. The ATC is defined at N.J.A.C. 7:31-1.5. The ATC values in Reference [9] are the original values developed in 1987 and may have changed since then; therefore, you may use the rule definition of ATC and current toxicity data to determine an ATC.

Alternatively, another acceptable toxic endpoint that may be used is the Acute Exposure Guideline Limit (AEGL) 2 final or interim value for the listed exposure time corresponding to the release duration. Detailed information on AEGLs including AEGL values is available at: http://www.epa.gov/oppt/aegl/

Example 3

Using the ALOHA dispersion model, the release rates from Examples 1 and 2 are modeled using TCPA dispersion parameters of 1.5 m/s at 10 m, F-stability, surface roughness for urban conditions, and a toxic endpoint of one ATC (423 ppm for ammonia) to determine the endpoint distances. The toxic endpoint distances for the release rates of 806 lbs/min from Example 1 and 9.2 lbs/min from Example 2 are 1.7 miles and 642 ft., respectively.

You may use the methodology for the estimation of worst-case distance to toxic endpoint as outlined in Chapter 4 of the OCA Guidance to estimate the distance to TCPA toxic endpoint. The examples in the OCA Guidance (with minor modifications to pool evaporation equations as stated above) are acceptable to comply with the requirements of the TCPA dispersion analysis.

B2. Thermal Analysis for Flammable EHS

Unlike the release of a toxic substance without flammability or reactivity properties, which results in a single outcome, a release of a flammable substance, an RHS, or an RHS mixture may result in many outcomes such as boiling liquid expanding vapor explosion (BLEVE), unconfined vapor cloud explosion, flash fire, jet fire, or pool fire. The identification of the outcome of the release is necessary to select the proper consequence analysis model and subsequent risk reduction strategy. As part of the hazard analysis for these substances, the O/O should construct an event tree to obtain the possible outcomes.

To estimate the distance to the lower flammability limit (LFL) endpoint, you may use the methodology outlined in Chapter 10 of the OCA Guidance; however, from Reference Tables 1 through 8 in Chapter 5, the table corresponding to the release density and surface conditions should be used to estimate the plume endpoint to comply with the TCPA RA meteorological parameters of 1.5 meters per second and F stability.

Methodology in Chapter 10 of the OCA Guidance may be used to model the radiant heat endpoint of 5 kw/m^2 for 40 seconds, for BLEVE, flash fire, jet fire, and pool fire scenarios.

B3. Overpressure Analysis for Flammable EHS

The owner/operator may estimate the overpressure endpoint distance for a vapor cloud explosion scenario following Section 10.4 of the OCA Guidance. However, for the TCPA RA, the endpoint distances obtained from the tables in the OCA Guidance are more stringent (longer distances) than the TCPA overpressure endpoint distances. This is because the TCPA overpressure endpoint distance is based on a 2.3 psi overpressure and the endpoint distance in the OCA Guidance tables is based on a 1.0 psi overpressure.

You may use the TNT-equivalency method as outlined in Appendix C of the OCA Guidance. To calculate the distance to 2.3 psi overpressure, replace the 0.0081 factor, which correlates to a 1.0 psi overpressure, in equation C-2 with a factor of 0.0047, which correlates to a 2.3 psi overpressure. See Appendix A for the derivation of this factor.

Alternatively, you may use other overpressure modeling methods such as the Baker-Strehlow and Multienergy methods instead of the OCA Guidance, which are based on the TNT equivalency method, to estimate the overpressure endpoint distance. If the Baker-Strehlow method is used, the input parameters such as reactive hazard substance reactivity, degree of confinement, and obstacle density must be properly justified and documented. If the Multienergy method is used, the input parameters such as initial blast strength number which ranges from 1 (very low strength) to 10 (detonative strength) must be properly justified and documented.

B4. Overpressure Analysis for RHS or RHS Mixture

To estimate the overpressure endpoint distance for an RHS or RHS mixture, you may use the same methodology described for the alternate release scenario in Reference [6]. However, to calculate the distance to 2.3 psi overpressure instead of 1 psi, which is the overpressure value estimated for the hazard assessment alternate release scenario, replace the 0.0081 factor, which correlates to a 1.0 psi overpressure, in Equation 2 with a factor of 0.0047, which correlates to a 2.3 psi overpressure. The derivation of this factor is shown in Appendix A.

Heat of reaction (ΔH_R) is needed to perform the overpressure analysis of RHS mixtures. The ΔH_R determined in accordance with N.J.A.C.7:31-6.3(b) may be used or modified to reflect the safeguards in place, such as dilution. As per Section B.4 of Reference [11], if more than one product is made in a particular vessel on a campaign basis and functional groups are present in those different products, determine the ΔH_R for each distinct RHS mixture in that vessel and identify the corresponding threshold quantities. In this situation, the product with the highest ΔH_R may be used to perform the overpressure analysis.

C. Likelihood of EHS Release Occurrence

N.J.A.C. 7:31-4.2(c)1 requires the owner/operator to determine the likelihood of release occurrence of any EHS release that results in an offsite impact. The likelihood of each EHS release scenario can be determined using site specific data that take into account the equipment reliability, human factors, and external forces and events, and generic failure rate, and release frequency data from References [2], [7], [13], [14], [15], [16], and [17]. The release frequency could result from a single event such as pipe failure, atmospheric tank failure, or unloading hose failure or from multiple events, all of which must occur to cause the undesired event. The TCPA risk assessment requirements closely follow the semi-quantitative risk assessment methodology of layer of protection analysis (LOPA). The Department highly recommends that O/O refers to "Layer of Protection Analysis (LOPA): Simplified Process Risk Assessment," Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, October 2001, Reference [16]. A simplified example of a release due to multiple event failures is release from a storage tank due to overfilling in which the tank is manually filled from the unloading truck, and the tank has a high-level interlock with the unloading pump. In this case, the spill and release can occur if the unloading operator fails to shut down the unloading pump and the high-level interlock fails to activate and shut down the pump. In the case of multiple events, event tree analysis should be used to estimate the likelihood of the event. If the EHS is flammable, estimate the likelihood of the EHS release scenario by multiplying the release likelihood (the initiating event likelihood) by the ignition probability. The probability of ignition may be determined by assigning probabilities to all the branches of the event tree as outlined in Chapter 3 of Reference [7] and then multiplying the probabilities of the path leading to the outcome. The likelihood of the release occurrence for the EHS releases that result in potential offsite impact must be reported preferably in a tabular format.

D. Risk Reduction Plan

Compare the likelihood of each EHS release occurrence that has offsite impact to the release frequency of $1*10^{-6}$ per year. If the likelihood of the EHS release occurrence is greater than or equal to $1*10^{-6}$ per year, the O/O must perform an evaluation of risk reduction measures which reduce the likelihood or consequences of an EHS release. Identification of risk reduction measures to be evaluated is left to the facility. There is no requirement to evaluate all available or a specific number of risk reduction measures. Upon identifying one or more risk reduction measures, the facility would then determine which ones are feasible. If the facility determines that a risk reduction measure that they have selected to evaluate is feasible, the facility would be required to implement that measure on a schedule of their choosing. An IST evaluation type of approach is recommended to identify risk reduction measures.

The O/O must develop and implement a risk reduction plan for feasible risk reduction measures that were identified. If an O/O identifies any risk reduction measure as not feasible, the infeasibility determination must be justified. Both likelihood and consequence may be reduced at the same time by implementing a risk reduction measure. If reduction in release frequency is the means by which risk reduction is achieved instead of reduction in consequences, the registrant should demonstrate that there actually is a reduction in frequency (i.e. by reporting an estimate of the frequency before and after the change, or by citing other pertinent studies). If the likelihood of the EHS release occurrence is less than $1*10^{-6}$ per year, no further assessment is required. The rule does not require that the likelihood be reduced down to less than $1*10^{-6}$ per year. It only requires the evaluation of any measures that can be applied to reduce the consequence and/or the likelihood, and if any feasible measures are identified by the O/O to implement those measures to minimize risks. At the next five-year PHA/RA revalidation, the O/O would look into any scenarios with offsite impact of the endpoints that have a likelihood of occurrence equal to or greater than $1*10^{-6}$ per year for any measures that may have become available, or became feasible since the last review to reduce the consequence and/or the likelihood.

It has been asked whether the O/O can assume that the likelihood is greater than $1*10^{-6}$ per year and implement risk reduction directly instead of performing the likelihood analysis required at N.J.A.C. 7:31-4.2(c)1. The facility would not have to perform the likelihood analysis only if the O/O implements risk reduction measure(s) that eliminate any offsite impact.

Example 4

For Example 1, assume that the distance from the release point to the property line is 1000 ft. The release rate of 806 lbs/min extends to 1.7 miles which is greater than the property line. Estimate the likelihood of the EHS release occurrence using pipe failure rate data. From Reference [14], the pipe failure rate is $1*10^{-5}$ per year. Since the likelihood of the EHS release occurrence is greater than $1*10^{-6}$ per year, the O/O must perform an evaluation of risk reduction measures which will reduce the likelihood and/or consequences of the EHS release.

Example 5

In Example 2, the release duration was estimated as 1 minute based on the action of safeguards including the remote shutoff valve at the bottom of the storage tank, the interlock system, and the ammonia detectors. It is recommended that the O/O evaluate whether these safeguards can fail, and if so, what would be the resulting scenario.

In this scenario, assume that the distance from the release point to the property line is 1000 ft. If the reliability of all the safeguards is 100% (i.e., assume that all safeguards function as expected), then the release rate is 9.2 lbs./min., and the toxic endpoint will extend to 642 ft., which is less than the property line. However, the PHA should include a scenario assuming that all of the safeguards failed. For the scenario including the failure of all safeguards, the resulting evaporation rate is 806 lb./min., which will result from an uncontained pool as in Example 4 above, and the toxic endpoint will extend to 1.7 miles. Use the failure rate of the safeguards to estimate the likelihood of the EHS release occurrence as follows:
Pipe failure rate = $1*10^{-5}$ per year (Reference [14])
Probability of dike failure = $1*10^{-2}$ (Reference [16])
Probability of failure of the basic control system for the ROV = $1*10^{-1}$; (Reference [16])
Using the LOPA methodology, the likelihood of the EHS release is estimated as follows:
Likelihood = $1*10^{-5}$/yr. * $1*10^{-2}$ * $1*10^{-1}$ = $1*10^{-8}$/yr.
Since the likelihood of the EHS release occurrence is less than $1*10^{-6}$ per year, the O/O need not perform an evaluation of risk reduction measures.

E. Results of Process Hazard Analysis with Risk Assessment

E1. Suggested Format for Process Hazard Analysis Results

The results of the process hazard analysis must be documented; see N.J.A.C. 7:31-4.2(d) for required information. Details to support the summarized findings of the process hazard analysis are required. If quantitative release scenario parameters (such as quantity, release rate and duration, etc.) are calculated from equations obtained in the literature, all references and computations should be provided. If quantitative release scenario parameters are obtained from a computer model, the model must be identified and printouts of all inputs/outputs must be provided for each release scenario. See Attachment 1 for the suggested format on how to present process hazard analysis results.

E2. Suggested Format for Consequence Analysis Results

Attachment 1 presents a suggested format for the results of the consequence analysis. The supporting documentation for the process hazard analysis with risk assessment must be maintained as specified at N.J.A.C. 7:31-4.2(d).

E3. Suggested Format for Process Hazard Analysis with Risk Assessment Report

Attachment 2 presents a suggested format for the results of the PHA/RA report required pursuant to N.J.A.C. 7:31-4.2(e). Essentially, the report should identify the process that is subject to the risk assessment, names and affiliations of those who performed the process hazard analysis with risk assessment, date of completion, methodology used, description of each scenario and a risk reduction plan. This report prepared in accordance with N.J.A.C. 7:31-4.2(e) must be submitted to the Department as part of the facility's next annual report pursuant to N.J.A.C. 7:31-4.9(b)3.

REFERENCES

[1] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Hazard Evaluation Procedures, Third Edition, April 2008.

[2] Frank P. Lees, Loss Prevention in the Chemical Process Industries: Hazard identification, Assessment and Control, Second edition.

[3] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Facility Siting and Layout, 2003.

[4] CPL 02-02-045-COL 2-2.45A CH-1-Process Safety Management of Highly Hazardous Chemicals-Compliance Guideline and Enforcement Procedures, pp23 and 69 of 83

[5] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Revalidating Process Hazard Analysis, 2001.

[6] EPA, Chemical Emergency Preparedness and Prevention Office, Risk Management Program Guidance for Offsite Consequence Analysis, EPA 550-B-99-009, March 2009.

[7] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Chemical Process Quantitative Risk Analysis, Second Edition, October 1999.

[8] National Fire Protection Association, Fire Protection Guide to Hazardous Materials, 13TH edition, 2002.

[9] Basis and Background Document for Proposed New Rule N.J.A.C. 7:31 Toxic Catastrophe Prevention Act Program, Bureau of Release Prevention, September 1987

[10] New Jersey Department of Environmental Protection, Bureau of Release prevention, Toxic Catastrophe Prevention Act (TCPA) Program, Guidance Document on Determining the Offsite Consequence Analysis Toxic Endpoint for New Jersey Extraordinarily Hazardous Substances (EHSs) Pursuant to N.J.A.C. 7:31-2.1(c)2, May 2015.

[11] New Jersey Department of Environmental Protection, Bureau of Release prevention, Toxic Catastrophe Prevention Act (TCPA) Program, Guidance on Hazard Assessment for Reactive Hazard Substances (RHS) and RHS Mixtures, March 2017.

[12] New Jersey Department of Environmental Protection, Bureau of Release prevention, Toxic Catastrophe Prevention Act (TCPA) Program, Guidance for Determining the Applicability of the TCPA Program Rules, June 2017.

[13] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Safe Automation of Chemical Processes (chapter 7), October 1993.

[14] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Process Equipment Reliability Data, 1989.

[15] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Improving Plant Reliability Data Collection and Analysis, June 1988.

[16] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Layer of Protection Analysis (LOPA): Simplified Process Risk Assessment, October 2001.

[17] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, Guidelines for Chemical Transportation Safety, Security, and Risk Management, September 2008.

Attachment 1

Suggested Format for TCPA Process Hazard Analysis (PHA) Documentation

Name of the covered process:
Name(s) of the persons who performed the PHA with positions, affiliations, and contact information:
Date of completion of the PHA:
Methodology used to perform the PHA:

Summary Table pursuant to N.J.A.C. 7:31-4.2(d)1

Scenario ID#	Scenario description	Causes	Consequences	Safeguards/IST options	Release quantity, rate and duration	Recommended action

Suggested Format for TCPA Consequence Analysis (CA) Documentation

Name of the covered process:
Name(s) of the persons who performed the CA with positions, affiliations, and contact information:
Date of completion of the CA:
Model used to perform the CA:

Summary Table pursuant to N.J.A.C. 7:31-4.2(d)2

Scenario ID#	Release quantity, rate and duration	Endpoint Criterion used	Endpoint distance(ft)	Property line distance(ft)	Offsite impact (Y/N)	Likelihood of Release

Attachment 2

Suggested Format for TCPA PHA/RA Report

Name of the covered process:
Name(s) of the persons who performed the PHA/RA with positions, affiliations, and contact information:
Date of completion of the PHA/RA:
Methodology used to perform the PHA/RA:

Risk Reduction Plan developed for scenarios with offsite impact, pursuant to N.J.A.C. 7:31-4.2(c)2

Scenario ID #	Brief description of the scenario	Risk reduction measure	Due date	Date completed
1				
2				

Risk Reduction Plan developed for scenarios without offsite impact, pursuant to N.J.A.C. 7:31-4.2(d)1

Scenario ID #	Brief description of the scenario	Risk reduction measure	Due date	Date completed
1				
2				

Appendix A: Derivation of Factor Correlating to 2.3 psi Overpressure

In the EPA's TNT-equivalency method equations found in EPA's "Risk Management Program Guidance for Offsite Consequence Analysis", March 2009, Appendix C, Flammable Substances, C-1 and C-2, EPA used a scaled distance factor (Z) of 17 to estimate distance to 1 psi overpressure for vapor cloud explosions [1]. Equation C-1 is as follows:

$$D = 17 \times [0.1 \times W \times (HC_f/HC_{TNT})]^{1/3} \qquad \text{Equation C-1}$$

where: D = distance of 1 psi overpressure, meters
17 = damage factor associated with 1.0 psi overpressure ($m/kg^{1/3}$)
0.1 = explosion efficiency factor
W = weight of the flammable substance, kg
HC_f = heat of combustion of the flammable substance, kJ/kg
HC_{TNT} = heat of explosion of trinitrotoluene (TNT), (4680 kJ/kg)

In Equation C-2, the quantity is in pounds and the endpoint distance is in miles:

$$D = 0.0081 \times [0.1 \times W \times (HC_f/HC_{TNT})]^{1/3} \qquad \text{Equation C-2}$$

where: D = distance of 1 psi overpressure (miles)
W = weight of the flammable substance (pounds)

The endpoint distance is converted from meters in equation C-1 to miles in equation C-2 using a factor of 0.0081 which is derived as follows:

$$\text{Damage factor} = (17\ m/kg^{1/3}) \times (kg/2.2lbs)^{1/3} \times (0.00062\ mile/m) = 0.0081\ mile/lbs^{1/3}$$

For TCPA, the damage factor (scaled distance factor) for 2.3 psi overpressure is 24.77 $ft/lb^{1/3}$, (9.82 $m/kg^{1/3}$) obtained from Figure 1. Figure 1 shows the scaled distance as function of overpressure for hemispherical TNT explosion on the surface at sea level, which is a plot of data extracted from the U. S. Army, Structure to Resist the Effects of Accidental Explosions, TM5-1300, 1990.

The endpoint distance is converted to miles using a factor of 0.0047 which is derived as follows:

$$\text{Damage factor} = (9.82\ m/kg^{1/3}) \times (kg/2.2lbs)^{1/3} \times (0.00062\ mile/m) = 0.0047\ mile/lbs^{1/3}$$

Figure 1: Scaled Distance as a Function of Overpressure