STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
TRENTON, NEW JERSEY 08625

METRIC SPECIFICATIONS FOR RADAR DETECTORS (SPEED STATION)

N.J. Specification No. EBM-SPEED Effective Date: July 1, 2001

New Jersey Department of Transportation Specifications for a non-intrusive speed sensor station. This sensor is capable of measuring real-time vehicular speed utilizing low powered RF signals. Via communication modems, these speed measurements can be transferred to a central monitor station for processing. The sensor must not require any in-pavement construction.

The purpose of these specifications is to describe minimum acceptable design and operating requirements for the speed sensor.

GENERAL - I

1-1 Components

The system shall consist of a control unit assembly, from one to eight independent RF speed sensors, and other miscellaneous equipment and cables.

1-2 FCC Certification

The operation of the device shall not require any special frequency assignment or FCC licensing to operate as described in this specification.

1-3 Environment

All components of the speed station shall operate in the ambient temperature range of -34 °C to +70 °C and over a relative humidity of 0 to 100 percent non-condensing. The manufacturer must supply certification by an independent technical laboratory confirming that the equipment complies with these environmental specifications.

1-4 Testing

The units are subject to testing as described in Section VI of this specification.

1-5 Mounting

The speed sensor station shall be mountable on new or existing poles or overhead structures as indicated in the contract documents. For units to be installed, the supplier shall provide all incidental components, conduits, mounting brackets, and cabling required to achieve a fully functional assembly as described in the contract documents and in conformance with NJDOT standards. A secondary tethered mounting system

must be provided which shall insure that RF speed assemblies mounted over the travel lanes shall not accidentally fall onto the roadway surface while being maintained or during normal operation.

1-6 Options

Two different types of RF sensors must be supported. The Narrow Beam sensor measures speed and volume counts for a single travel lane and is mounted immediately above the lane. The field of view of the narrow beam sensor must be constrained to the individual lane being monitored and must not spill over to adjacent lanes. In this regard, each lane of a multi-lane highway can be monitored independently. The Wide Beam sensor is intended for mounting from a side-fire position and must be able to produce average speed data for at least five travel lanes.

The control unit may be equipped with an RS232 data modem. Such modem may operate on direct connect (i.e., Fiber optic or Leased Phone Service) or dial-up (On demand) medium. The type of modem to be supplied with each control unit is identified in the contract documents and shall not be compensated as part of the Sensor Station bid items.

CONTROL UNIT ASSEMBLY - II

The Speed Station Control Unit Assembly contains the necessary electronics to power and communicate with any combination of from one to eight Narrow or Wide Beam RF speed sensor units.

2-1 NEMA Enclosure

All of the components of the Control Unit Assembly shall be housed in a NEMA 3R Small Single Door Enclosure or equivalent. The outside dimension of the cabinet shall not exceed 568 by 391 by 178 millimeters. The cabinet shall be supplied with a 15-amp AC circuit breaker and a minimum of a 3 segment standard 115 volts AC convenience panel. The cabinet shall be supplied with a lock. The lock shall be CCL 2-NJIVHS type, or equal. One key shall be supplied with each lock. The keys shall be removable in the locked position only. The cabinet must be suitable for pole mounting and must be supplied with all required mounting hardware. A neoprene gasket shall be utilized to secure the handhole cutout to the pole.

2-2 Power Supply

An AC to DC power supply shall be supplied with sufficient capacity to power up to 8 RF Speed Sensor units. A minimum of 50% reserve capacity must be provided. The DC voltage to the Sensors shall not exceed 24 volts DC.

2-3 Data Multiplexer

A data multiplexer shall be supplied which will combine the speed counts obtained from up to eight individual sensors into a master RS232 port suitable to connection to a

standard modem. The multiplexer shall service each speed sensor at least two times a second. After polling all of the sensors connected to the multiplexer, the unit shall pass a status block of fixed message length over the transmit line of the control RS232 port.

This message block shall contain the last measured speed for each channel. In addition to the speed, an identifier character shall be passed which indicates if the reading was new or not. In this regard, the number of measurements (volume count for narrow beam units) can be determined by counting the number of new readings. The identifier character shall also indicate the existence of a detected failure of any speed sensor connected to the multiplexer. The entire fixed message block must be terminated with an 8-Bit checksum. As long as the Carrier Detect signal is obtained on the master port, the multiplexer shall continue to transmit the status block, even if there is no activity from any connected sensor during the scan period. The multiplexer's control port shall operate at a minimum baud rate of 2 400. The exact protocol shall be fully documented as part of the submission process.

A. Communication Wrap-Around Mode of Operation

In addition to its normal function, the multiplexer shall be capable of operating in a communication wrap-around mode. Upon receiving a character from the master RS232 port, the multiplexer shall re-transmit that character and suspend normal sensor processing for approximately five seconds.

B. Dual-Ported Control Port Termination

The control RS232 port shall be terminated with a male DB-25 connector configured for DTE operation. This control cable shall be a minimum of 1.8 meters in length and shall be suitable for connection to an RS232 modem.

In addition, a second male DB-9 connector shall be securely mounted to a flange and wired in parallel with the primary port. Diodes and resistors shall be utilized to insure that either port can transmit and receive concurrently. This secondary port shall be suitable for connection to a PC Notebook computer which can be utilized to monitor the transmission to the central over the primary port from the field.

C. Multiplexer Mounting And Connectors

The multiplexer must be firmly bolted to the inside of the NEMA enclosure in a fashion that all sensor connections are visual.

All connectors and AC power must be of the locking type so as to be resistant to possible vibrations.

2-4 Dial-Up Data Buffer Extension to Data Multiplexer

For those assemblies designated for use with a dial-up modem, additional logic shall be required. The data multiplexer shall continue to scan all speed sensors under its control. A smoothed speed measurement shall be maintained for each channel. This smoothing shall be accomplished via the following algorithm:

New Smooth = Current Smooth + (New Speed - Current Smooth)/XX

Where: XX is 10, 50, or 100 (Switch Selectable)

Upon the transition of the Carrier Detect signal from off to on, the multiplexer shall wait five seconds and transmit a fixed block with the current smooth speeds. The identifier code in the fixed block shall indicate that smooth data is being transmitted. Subsequently, each additional data block will contain current information as described under Subsection 2-3, as long as the Carrier Detect signal is being received. Upon loss of carrier detect, the unit will re-cycle and continue to maintain current smoothed speed measurements for each channel until the next off-to-on transition is obtained.

The Dial-Up extension to the multiplexer is only required for those units designated for dial-up operation. The function shall be supplied by an external processor. The supplier shall supply the source code and all necessary development tools which are necessary to modify the program and create new EPROMs. The development tools shall include all necessary cross-compilers, assemblers, and CPU board documentation, which are needed to modify the program on a PC. In addition, a suitable linker shall be supplied which can produce downloadable records to a standard EPROM burner. As part of the development package, an EPROM burner designed for internal operation on a PC, shall be supplied which is compatible with the development system. A development system shall be supplied with every twenty or fraction of dial-up multiplexer extensions delivered.

2-5 Fiber Optic Patch Panel

The control assembly shall contain a six position fiber optic patch panel assembly. This assembly shall consist of a flange with six holes drilled out. Standard ST mechanical couplers (Dual-Sided) shall be mounted in these holes. For assemblies designated for use in a fiber optic network, two (2) standard ST patch cords of at least 1.8 meters in length, shall be supplied which will allow connection to a fiber optic RS232 modem. The Engineer shall specify the use of Single Mode or Multi-mode patch cords.

2-6 Modular Telephone Plug

The cabinet shall be supplied with a standard 4-wire modular phone jack which is suitable for termination of outside plant phone service.

WIDE-BEAM RF SPEED SENSOR - III

The Wide-Beam RF Speed Sensor must operate from a pole-mounted side-fire position and be capable of measuring travel speeds for up to five 3.6 meter travel lanes. The unit must be mountable as far as 15 meters from the first travel lane to be monitored. The unit shall supply average speed measurements for the entire multi-lane roadway. In addition, the unit must be able to filter out and eliminate any readings obtained from vehicles moving in the opposite direction in the opposing travel lanes.

3-1 Mechanical and Environmental

The speed sensor must be housed in a corrosion resistant weather-tight enclosure. The outside dimensions of the unit shall not exceed 254 by 254 by 305 millimeters. The sensor shall not weigh more than 5.4 kilograms. The main assembly must be securely fastened to an integral mounting bracket. All miscellaneous hardware required to install the unit to a pole must be provided. In addition, a secondary tethering cable shall be supplied to prevent the unit from accidentally dropping to the ground.

The speed sensor shall connect to the Control assembly via a weather-tight cable. This cable shall be at least 30 meters in length and shall be terminated in the Control assembly. The cable shall be utilized to supply DC voltage to the speed sensor and to pass data signals back to the multiplexer. The cable shall enter the speed sensor assembly via a water-tight cable clamp.

The RF signal generated shall meet all FCC and OSHA requirements for power, frequency, stability, and emissions. The sensor shall require no special licensing to operate and shall not interfere with any licensed RF transmission in the State of New Jersey.

All electronic circuitry shall be protected from moisture and fungus growth. The sensor shall have no moving parts and shall require no routine maintenance.

3-2 Functional Requirements

The sensor shall be capable of operating from 3.6 meters to 12 meters above the roadway surface from a side-fire position. Installation of the sensor shall not require the installation of any component in the actual roadway surface to be monitored. The sensor shall have a range of up to 30 meters. The operation of the unit shall not be affected by weather conditions.

Vehicles shall be detected moving in the range of 8 to 129 kilometers per hour. Measured speeds shall be within a 8 kilometers per hour tolerance. The sensor shall require no special aiming or adjusting to establish the detection area. Periodic adjustments of the detection zone shall not be required. The unit shall continue to operate within tolerances for winds of at least 129 kilometers per hour on standard NJDOT structures. The detector shall be directional and user selectable.

NARROW-BEAM RF SPEED SENSOR - IV

The Narrow-Beam RF Speed Sensor must operate from an overhead structure and be capable of measuring travel speeds for a single 2.7 meter to 3.6 meter travel lane. The unit shall supply accurate speed and count measurements for the target lane. In addition, the unit must be able to filter out and eliminate any readings obtained from vehicles moving in adjacent or opposing travel lanes.

4-1 Mechanical and Environmental

The speed sensor must be housed in a corrosion resistant weather-tight enclosure. The outside dimensions of the unit shall not exceed 254 by 254 by 305 millimeters. The sensor shall not weigh more than 5.4 kilograms. The main assembly must be securely fastened to an integral mounting bracket. All miscellaneous hardware required to install the unit to a pole must be provided. In addition, a secondary tethering cable shall be supplied to prevent the unit from accidentally dropping to the ground.

The speed sensor shall connect to the Control assembly via a weather-tight cable. This cable shall be at least 30 meters in length and shall be terminated in the Control assembly. The cable shall be utilized to supply DC voltage to the speed sensor and to pass data signals back to the multiplexer. The cable shall enter the speed sensor assembly via a water-tight cable clamp.

The RF signal generated shall meet all FCC and OSHA requirements for power, frequency, stability, and emissions. The sensor shall require no special licensing to operate and shall not interfere with any licensed RF transmission in the State of New Jersey.

All electronic circuitry shall be protected from moisture and fungus growth. The sensor shall have no moving parts and shall require no routine maintenance.

4-2 Functional Requirements

The sensor shall be capable of operating from up to 9.6 meters above the roadway surface from an over-head position. Installation of the sensor shall not require the installation of any component in the actual roadway surface to be monitored. The detection zone shall not exceed 2.4 meters in diameter. The operation of the unit shall not be affected by weather conditions.

Vehicles shall be detected moving in the range of 8 to 129 kilometers per hour. Measured speeds shall be within a 3 kilometers per hour tolerance. The sensor shall require no special aiming or adjusting to establish the detection area. A given vehicle shall be detected only once. Periodic adjustments of the detection zone shall not be required. The unit shall continue to operate within tolerances for winds of at least 129 kilometers per hour on standard NJDOT structures.

MSDOS PC BASED DIAGNOSTIC SOFTWARE - V

With the delivery of the first sensor assembly and every ten subsequent assemblies from a given manufacturer, a diagnostic software program on 90 millimeter floppy disk and null-modem connection cable shall be supplied to NJDOT. The purpose of this program is to allow a speed sensor assembly to be tested.

5-1 Hardware Platform

The diagnostic program shall be designed to operate on a typical PC notebook computer operating under MSDOS 5.0 or above. The software shall operate in standard 80X25 text mode and shall be designed for operation on a monochrome

display. The program shall contain settings which will allow selection of COM1, COM2, COM3, or COM4. The program shall operate concurrently with MSDOS 5.0 or above within a standard 640 kilobyte memory. In addition, the program and all required data files shall be operational from a single 720 kilobyte, 90 millimeter floppy disk. State-of-the-art operator interface programming techniques shall be utilized.

A "null-modem" cable of at least 15 meters in length shall be supplied which will allow the standard DB-9 port of a notebook computer to be connected to the DB-9 monitor port of the Control Assembly. In addition, the program shall be operational through a standard Hayes-compatible modem connected to the notebook. The program shall contain a data base which will allow the telephone number of the remote sensor station to be specified and automatically dialed when commanded from the operator.

5-2 Functionality

Once initiated, the program shall enter a report which shall display each new speed measurement for any of the 8 sensors which can be supported by a given control unit. In addition, the program shall allow the operator to specify a reporting interval. At the end of the reporting interval, the program shall display the number of speed measurements reported and average speed for each sensor channel for the preceding interval. This information will remain on-screen while current sensor information is also displayed. The operator shall be able to direct this summary report information to a disk file or printer. For the case of a dial-up, the diagnostic program shall obtain the "smooth" speed data obtained from the controller on initiation of the connection cycle, as described in Subsection 2-4. This smooth information shall be clearly identified and retained on all reports.

The program shall continue to display information until terminated by the operator or communication is lost with the Speed Sensor Controller.

TESTING - VI

All radar detector assemblies shall be subject to factory and prototype testing as subsequently described. The factory test shall demonstrate or provide confirmation that all of the equipment operates over the specified environmental range for each component. In addition, the operation of the control assembly, PC software, and sensors shall be demonstrated in a laboratory environment. Confirmation shall be provided that the units are certified for unlicensed use by the FCC (Federal Communication Commission).

The prototype test shall be held at a roadway in New Jersey which is operated by NJDOT. The test will involve one control assembly and at least two radar sensors. One sensor shall be a Speed/Count narrow beam unit while the other sensor shall be a Speed-only wide beam unit. The equipment shall be mounted by the Supplier with assistance from NJDOT on a suitable structure. The test shall utilize a portable PC which is connected to the monitor port of the controller.

A portable radar speed gun, or other reliable speed measurement device, shall be made available for the test by the Supplier. In addition, at least one test vehicle shall be available which shall pass through the detection zones several times.

Prior to the test, the field crews will estimate the speed of the roadway. With the PC diagnostic connected, the observers will verify that a count is received each time a vehicle passes through the detection zone. In addition, for large vehicles, such as a tractor trailer, the observers will verify that multiple counts are not being obtained. For speed units, counts shall be obtainable whenever one or more vehicles pass through the detection zone at the same time. With the use of the portable radar gun, the field observers will correlate the speed measured by the radar detector with that obtained from the gun, for at least fifty vehicles. The readings shall not differ by more than 10%. To confirm the estimate, the test vehicle shall pass through the zone at a known speedometer reading. The readings from the radar detector shall be within the accuracy required by the specifications. Tests at excessively low speeds (Stop and Go) and high speeds shall also confirm the dynamic range of the radar sensors. The tests shall also verify the operation of the dial-up extension processor. Connection shall be simulated by toggling the Carrier Detect input into the front end processor.

The test will also establish the sensitivity of the unit to mounting. From the ideal position, each type of unit shall be rotated until unreliable readings are obtained. Based on this information, the sensitivity of sensor placement and alignment shall be established. Unreasonable sensitivity, defined as being unmaintainable over a full year on proposed mountings, shall be cause for rejecting the system.

The supplier shall be responsible for submitting a test plan which has been designed to exercise and monitor the equipment for the purpose of determining compliance with the specifications.

TRAINING - VII

Prior to the acceptance of the first unit of each type, training shall be provided for the Department's engineering, maintenance and operations staff, at a facility provided by the Department. The training shall include all material and manuals required for each participant. The training shall be as follows:

7-1 Maintenance Training

The training shall be provided for a minimum of 40 hours for at least five (5) personnel with an electronics background. The training shall include operation instructions, theory of operation, circuit description, field adjustments, preventive maintenance procedures, troubleshooting, operation of diagnostic software, and repair of all components.

7-2 Engineering Training

The training shall be provided for a minimum of 16 hours for at least twenty (20) engineering and operations personnel. The training shall include a complete demonstration of the operation and capabilities of the equipment. This session should include a complete review of any field adjustments or calibration of the transmission equipment which may be necessary for optimum performance and should stress day-to-day operation and isolation of problems down to the unit level. For example, procedures should be discussed for identifying a faulty module in the field, as opposed

to board level repairs covered in Section VII-1. Particular attention shall be given to the operation of the PC based diagnostic program.

INSTRUCTIONS AND GUARANTEES - VIII

8-1 One set of complete schematics and maintenance manual of the equipment shall be supplied with each five assemblies furnished. Maintenance manual shall include complete sub-component parts listing.

8-2 No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this specification shall be addressed to the Manager, Office of ITS Engineering, New Jersey Department of Transportation, P.O. Box 613, 1035 Parkway Avenue, Trenton, New Jersey 08625.

8-3 The complete control and auxiliary equipment shall carry a two-year guarantee from the date of acceptance against any imperfections in workmanship or materials.

8-4 The Supplier agrees upon the request of the Manager, Office of ITS Engineering to deliver to the Office, a sample of the complete Speed sensor assembly to be supplied in compliance with these specifications for inspection and test before acceptance. After completion of the test, the sample shall be returned.

8-5 The Supplier shall furnish any and all equipment which they deem necessary for safe and reliable field operation of the control equipment.

8-6 All sensors furnished under this specification must be current production equipment and of recent manufacturer, identical models of which are in field operation in not less than 100 locations in the United States or Canada. Untried or prototype units shall not be considered for acceptance.

8-7 All major components shall be identified with a metal plate containing the serial number with a bar code identification.

8-8 Any repairs made by a manufacturer or representative shall be documented and returned with units when warranty repaired. This documentation shall include an explanation of the exact repairs made and identification of parts replaced by part number and circuit number. All warranty repairs must be made within thirty days upon receiving equipment.