Technical Specification

Transport and Main Roads Specifications MRTS203 Provision of Weigh-in-Motion System

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Queensland Government

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1 Introduction

This Technical Specification defines the design, supply, installation, testing and commissioning, performance, documentation, training and maintenance requirements for a high-speed Weigh-in-Motion System (WiM System).

A high-speed WiM System is used for collecting traffic flow data and heavy vehicle mass and classification data.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

2 Definition of terms

The terms defined in MRTS201 *General Equipment Requirements* apply to this Technical Specification. Additional terminology relevant to this Technical Specification is defined in Table 2 below.

Table 2 – Definitions

Term	Definition
Accuracy	The closeness or degree of agreement (within a stated tolerance and probability of conformity) between a value measured or estimated by a WiM system and an accepted reference value.
ANPR	Automatic Number Plate Recognition.
ASCII	American Standard Code for Information Interchange.
Axle	The axis oriented transversely to the nominal direction of vehicle motion, and extending the full width of the vehicle, about which the wheel(s) at both ends rotate.
Axle Group Load	The sum of all tyre loads of the wheels on a group of adjacent axles, a portion of the gross vehicle weight. (An axle group can be defined in terms of the number of axles included in the group and their respective interspaces).
Axle Weight	The sum of all tyre loads of the wheels on an axle, a portion of the gross vehicle weight.
Calibration	Adjustment to a reference level of values from any measuring device.
Calibration Factor	Numerical factor by which the raw result of a measurement is multiplied to compensate for systematic error.
CAT	Customer Acceptance Test.
Coefficient of Variation	Ratio of the standard deviation to the mean.
Confidence Interval	Interval that contains the true value of a parameter represented by a random variable, with a given probability.
Confidence Level	Probability that an interval contains the true value of a parameter represented by a random variable.
CT	Commissioning Test.
Data Logger	A device designed to collect, process, store and transmit vehicle data.

Term	Definition
ELV	Extra Low Voltage.
Extra Low Voltage	Not exceeding 50 V a c, or 120 V, ripple free d c.
FAT	Factory Acceptance Test.
Gross Vehicle Weight	The total weight of the vehicle or the vehicle combination including all connected components, also, the sum of the tyre loads of all wheels on the vehicle.
IAT	Installation Acceptance Testing.
Piezo Sensor	A piezo sensor (also known as piezoelectric sensor) is a device that uses the piezoelectric effect, to measure changes in pressure, strain or force by converting them to an electrical signal.
POS	Point of electrical supply.
QTDF	Queensland Traffic Data Format.
Single Axle Load	The load transmitted to the road surface by the tyres of all wheels lying between two parallel transverse vertical planes 1 m apart, extending across the full width of the vehicle, a portion of the gross vehicle weight.
Tandem Axle Load	The total load sent to the road surface by the tyres on all wheels of two consecutive vehicle axles that are more than 1 m and not more than 2.1 m apart, a portion of the gross vehicle weight.
Tolerance	The defined limit of allowable departure of a value measured or estimated by a WiM System from an accepted reference value.
Triaxle Load	The total load sent to the road surface by the tyres on all wheels of three consecutive vehicle axles, a portion of the gross vehicle weight.
Weigh-in-Motion (WiM)	The process of estimating a moving vehicle's gross weight and the portion of that weight that is carried by each wheel, axle, or axle group, or combination thereof, by measurement and analysis of dynamic vehicle tyre forces.
Weight	The external force of gravity acting vertically downwards upon a body with a magnitude equal to the body's mass multiplied by the local acceleration of free fall. (The force of gravity, thus the acceleration of free fall, is different at various locations on or near the surface of Earth, therefore, weighing devices in commercial use or in official use by government agencies for enforcement of traffic and highway laws or collecting statistical information are usually used in one locality and are adjusted or calibrated to indicate mass at that locality. The indicated mass can be converted to weight (in units of force) by multiplying by the local value of the acceleration of free fall, if it is known. The conventional value adopted by ISO is 9.806 65 m / s^2. Weight is a special case of force, as weight is due only to the local force of gravity that is always directed vertically downwards).

Term	Definition
WiM System	The WiM System comprises equipment installed at the WiM site. The WiM System includes a set of sensors and supporting instruments that measure the presence of a moving vehicle and the related dynamic tyre forces at specified locations with respect to time, estimated tyre loads, calculated speed, axle spacing, vehicle class according to axle arrangement, and other parameters concerning the vehicle. The WiM System must process and store data locally, and allow transmission of this information to a locally connected laptop computer and/or remote PC.

3 Reference documents

The requirements of the referenced documents listed in Table 3 of MRTS201 *General Equipment Requirements* and Table 3 on page 3 applies to this Technical Specification. Where there are inconsistencies between this Technical Specification and the referenced MRTS (including those referenced in MRTS201 *General Equipment Requirements*), the requirements specified in this Technical Specification must take precedence.

Table 3 – Referenced documents

Reference	Title
Austroads 2009	*Guide to Traffic Management Part 3: Traffic Studies and Analysis*
MRTS01	*Introduction to Technical Specifications*
MRTS50	*Specific Quality System Requirements*
MRTS201	*General Equipment Requirements*
MRTS207	*Traffic Survey Data Management (TSDM) Foundation equipment*
MRTS226	*Telecommunications Field Cabinets*
Standard Drawing 1906	*TSDM WiM Piezo Sensor Installation Details*
Standard Drawing 1908	*TSDM WiM Sensor Configuration Piezo-Loop-Piezo*
Standard Drawing 1909	*TSDM WiM Sensor Configuration Piezo-Piezo-Loop-Piezo-Piezo*
Standard Drawing 1910	*TSDM WiM Sensor Configuration Piezo-Piezo*
Standard Drawing 1911	*TSDM WiM Sensor Configuration Strain Gauge Sensor*

4 Quality system requirements

The quality system requirements defined in MRTS201 *General Equipment Requirements* apply to this Technical Specification. Additional quality system requirements relevant to this Technical Specification are defined in Table 4 below.

There are no Milestones defined in the document.

Table 4 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
11.2	1. Contractor must provide adequate operating environment for the system's sensors and instruments. The final location must be confirmed by the Contractor to the Principal		
11.2.5		1. The WiM System pavement surface must be smooth before sensor installation. The deviation from a 3 m straightedge placed anywhere within a lane and the road roughness count measured at 20 m intervals must not exceed the limits as specified on Table 11.2.5	
12.1	2. The Contractor must supply a certificate showing that each supplied tyre-force sensor has met the FAT requirements of Clause 12.1		
12.2		2. The IAT must be conducted on site by the Contractor immediately after the WiM System has been installed and calibrated to the manufacturer's specification	

5 Functional requirements

The WiM System must detect, collect, process, store, and transmit traffic information related to the counting, classifying and speed monitoring of all vehicles and the weighing of heavy vehicles at highway speeds.

The WiM system must be capable of interfacing with a co-located ANPR system to identify the vehicles being weighed by the WiM system.

The WiM System must be able to accommodate vehicles and vehicle combinations with up to 25 axles and must automatically determine for each vehicle, by lane of travel: vehicle classification, vehicle speed, axle spacing and axle / axle group weight.

The WiM System must process data in real time in the field in a data logger and provide a connection for the purposes of configuration and data retrieval. It must also allow data to be viewed in real time, both locally and remotely.

6 Equipment

6.1 General

Equipment shall be manufactured by companies that are skilled and have regularly engaged in the manufacture of equipment of the type specified herein for a period of not less than five years. The supplier shall be a sales and service facility authorised by the manufacturer for the product offered. The equipment shall be established, reliable and have been used successfully in applications equivalent to those required by the Contract. Equipment of experimental or unproven design is prohibited.

6.2 Components

The WiM System shall include:

- road pavement which is suitable for instrumentation
- weight sensors, necessary cabling and mounting hardware for each lane to be instrumented
- sufficient axle sensors per lane to determine vehicle speed and axle spacings
- a vehicle detector per lane, such as an inductive loop detector, to separate vehicle events
- a data logger
- all necessary interconnecting cables and miscellaneous materials to make an operational system, and
- all other necessary supporting infrastructure including equipment enclosures, power supplies, communications hardware, POS connection, pits, conduits, poles, and footings.

The system must include all necessary electrical, electronic, electro-mechanical hardware and software required to calculate, store and transmit all data specified in this Technical Specification.

7 Operational requirements

The operational requirements defined in MRTS201 *General Equipment Requirements* apply to this Technical Specification. Additional operational requirements for equipment provided under this Technical Specification are described below.

7.1 General

Installed equipment must meet the accuracy tolerances requirements specified in Clause 7.3 for the different classes of equipment based on axle weights, gross vehicle weights, speeds and axle spacings.

The WiM System must provide for single threshold weighing, and operate over a speed range of 16 km/h to 130 km/h.

Single threshold weighing will be performed by weight sensors in each lane of measurement. The weight sensors must cover the entire lane width.

7.2 Environmental requirements

The Contractor must supply evidence that the offered WiM System has previously performed satisfactorily (within accuracy tolerances specified in Clause 7.3) throughout the specified ambient air temperature range expected at the site.

7.3 Accuracy

The WiM System must be capable of performing the indicated functions within the accuracy tolerances described in Table 7.3 with a minimum 95% Confidence Level.

Table 7.3 – Accuracy

Function	Accuracy Tolerance		
	Class A	**Class B**	**Class C**
Single Axles	± 15%	± 20%	± 30%
Axle Groups	± 10%	± 15%	± 20%
Gross-Vehicle Weight	± 6%	± 10%	± 15%
Speed	±2 km/h		
Axle-Spacing	±15 mm		

The classes mentioned in the above table refer to the required accuracy tolerances for each class. Different needs may lead to different accuracy requirements for the intended application. If the contract does not specify the accuracy requirement of the site, then Class B shall be delivered.

The WiM must provide calibration features such that the required accuracy can be met and maintained.

7.4 Recorded data

The data logger must store the following data:

- vehicle counts by vehicle class and by speed range summarised to a quarter hour interval, and
- individual vehicle records for all vehicles, with the option of selecting specific Austroads vehicle types to be recorded.

Individual vehicle records must be classified in accordance with Clause 7.5. Such classification parameters must be programmable by the Principal's operator. Each vehicle record must include, as a minimum, the following data:

- Date and Time (to a resolution of at least two decimal places of a second)
- Lane Number
- Vehicle Speed
- Vehicle Classification
- Axle Load
- Axle Group Load
- Gross Vehicle Weight, and
- Spacings in between each sequentially numbered axle.

The data logger of the WiM System must calculate and store all specified data with the capacity to store a minimum of three months of vehicle count data and individual vehicle records. The data logger should be capable of notifying the systems administrative team when its data capacity reaches 90%.

The data logger must continue to calculate and store data for all vehicles passing through the system during periods of access for purposes of programming, real-time view and transfer of data.

Data must be calculated, recorded and formatted such that it can be intuitively understood when viewed in an ASCII text editor.

7.5 Vehicle classification

Vehicle classification must be accomplished by the WiM System by the following data:

- number of axles
- axle spacing, and
- number of axle groups.

The Contractor must incorporate software within the WiM System for using the axle count and axle spacing information to classify the Austroads vehicle types as described briefly below. Refer to *Austroads Guide to Traffic Management Part 3: Traffic Studies and Analysis* for the complete description of vehicle types. The axle spacing values used for this process must be associated with each vehicle type as listed in Table 7.5. These values must be readily viewed and updated by the Principal's operator. The classified vehicle type must be indicated by the 2-digit code shown in Table 7.5.

Table 7.5 – Austroads vehicle types

2-digit code	Brief description
01	Short Vehicle
02	Short Vehicle Towing
03	Two-axle Truck or Bus
04	Three-axle Truck or Bus
05	Four-axle Truck
06	Three-axle Articulated Vehicle
07	Four-axle Articulated Vehicle
08	Five-axle Articulated Vehicle
09	Six-axle Articulated Vehicle
10	B Double
11	Double Road Train
12	Triple Road Train

8 Control system

The control system must be furnished as part of the WiM System and must facilitate communications between a locally connected laptop computer and the data logger; and, connection between a remote host and the data logger. The control system must be able to process data to generate the specific ASCII files. Although referred to herein as a single software program, communications functions and data processing functions may be provided as two separate programs as long as all functional requirements are met.

It shall be possible to perform all configurations and data transfer tasks locally from a laptop computer running Microsoft Windows® XP-Professional, Windows® 7 Professional or Windows® 10.

8.1 Communications

The communications portion of the control system must include the applications listed in Clause 8.1.1 to 8.1.3 of this Technical Specification.

8.1.1 Real time view

The real time view application must support on-line monitoring of traffic. The display must depict the axle configuration of each vehicle passing through the site. The user must have the options of displaying either all traffic or any selected Austroads vehicle types, the weight violation table, as well as the option of displaying a selected individual lane or all lanes.

8.1.2 System configuration parameters

The control system must support on-line modification to the data logger's configuration parameters such as speed and weight calibration factors, vehicle classification parameters, weight violation table parameters, and front axle weight threshold. The control system shall be capable of retaining all System Configuration parameters in the event of a power failure.

8.1.3 Data transfer

The control system must support the transfer of data files from the data logger to a local laptop or remote host. The system must provide for the transfer of the current day's data stored as of the time of transfer.

8.2 Data processing

The control system must provide for the generation of data files which are compliant with Transport and Main Roads QTDF data format. Details of this data format can be obtained from the Principal.

8.3 Data security

Industry-standard secure shell shall be used for remote communication via the logger's Ethernet port. It is also desirable that industry-standard secure FTP shall be used for data transfer.

9 Electrical requirements

The WiM system shall be powered by an ELV power supply.

10 Telecommunications requirements

The telecommunication requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification.

In addition, the WiM system shall be equipped with at least one EIA RS232 serial port and one Ethernet port.

The connection must cope with high latency network connections.

The Contractor shall arrange with the Principal the connection of the WiM system to the department’s telecommunications network.

11 Installation requirements

The installation requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification. Additional testing and commissioning requirements relevant to work provided under this Technical Specification are described below.

11.1 General

The Contractor must provide full-time on-site supervision during weigh-in-motion system installation and system start-up.

11.2 WiM site selection

In order for the WiM System to perform properly, the Contractor must provide and maintain an adequate operating environment for the system's sensors and instruments. Selection, construction and continuing maintenance of each WiM site, as well as continuing maintenance of the sensors, are extremely important considerations. The following site conditions, or better, must be provided by the Contractor to meet the performance criteria specified herein consistently. The final location and site conditions must be confirmed by the Contractor to the Principal. **Hold Point 1**

11.2.1 Horizontal alignment

The horizontal curvature of the roadway lane for 100 m in advance of and 50 m beyond the WiM System sensors must have a radius not less than 1700 m measured along the centreline of the lane.

11.2.2 Longitudinal alignment

The longitudinal gradient of the road surface for 100 m in advance of and 50 m beyond the WiM System sensors must not exceed ±2%.

11.2.3 Cross slope

For bi-directional single carriageways the cross-slope (lateral slope) of the road surface for 100 m in advance of and 100 m beyond the WiM System sensors must not exceed -3%.

For dual carriageways the cross-slope (lateral slope) of the road surface for 100 m in advance of and 50 m beyond the WiM System sensors must not exceed -3%

11.2.4 Lane width and Line markings

The width of the paved roadway for 100 m in advance of and 50 m beyond the WiM System sensors shall accommodate a sealed shoulder of minimum 1.0 m wide on each side of the road and 3.5 m per trafficable lane. The trafficable lane is the portion of the road devoted particularly to the use of vehicles moving in a forward direction as demarcated by appropriate line markings which shall be 100 mm to 150 mm wide.

11.2.5 Surface evenness

The surface of the paved roadway for 100 m in advance of and 50 m beyond the WiM System sensors must be smooth before sensor installation and maintained in a condition such that the deviation from a 3 m straightedge placed anywhere within a lane and the road roughness count measured at 20 m intervals must not exceed the limits as specified on Table 11.2.5. **Witness Point 1**

Table 11.2.5 – Surface evenness

	Surface evenness requirements		
	Class A	**Class B**	**Class C**
Rutting (3 m straightedge)	less than or equal to 4 mm	less than or equal to 7 mm	less than or equal to 10 mm
Roughness (NRM)	< 33 counts per km	< 70 counts per km	< 105 counts per km

11.3 Field cabinet

All electronics associated with the WiM System with the exception of sensors must be housed in a field cabinet that complies with MRTS201 *General Equipment Requirements*, MRTS226 *Telecommunications Field Cabinets*, MRTS207 *Traffic Survey Data Management (TSDM) Foundation equipment*, and relevant Standard Drawings.

11.4 Sensors installation

WiM sensor installation shall be in accordance with Standard Drawings 1906, 1908 to 1911 unless the Contractor is able to prove otherwise with better performance.

12 Testing and commissioning

The testing and commissioning requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification. Additional testing and commissioning requirements relevant under this Technical Specification are described below.

12.1 Factory Acceptance Test (FAT)

The Factory Acceptance Test must meet the following requirements

Prior to installation, the Contractor must provide a manufacturer supplied certificate showing that each supplied tyre-force sensor has been factory tested under a simulated tyre load and found to produce an output signal that was linear within 7% of the applied load up to 90% of the sensor's rated load capacity throughout the lateral extent of the sensor.

Additionally, the contractor must visually inspect the tyre-force sensor for visible damage and perform an electrical test to the Principal Representative's satisfaction measuring:

- resistance
- capacitance, and
- dissipation of the tyre-force sensor.

Hold Point 2

12.2 Calibration and Installation Acceptance Test (IAT)

The Contractor must demonstrate that the WiM System is available for use by successfully completing the IAT for each lane of data collection at each WiM site.

The IAT must verify accuracy of the recorded data as described in Clause 7.3 and pass all electrical measurement tests to the satisfaction of the Principal's Representative.

The IAT must be conducted on site by the Contractor after the WiM System has been installed and calibrated to the manufacturer's specification. The Contractor is required to perform electrical tests on

all sensors after a minimum 72 hours of the installation. The calibration of the WiM system must not be performed prior to the confirmation of the performance of all sensors. **Witness Point 2**

The following steps are required for calibration of each instrumented lane:

12.2.1 Calibration vehicles

The calibration requirements for the WiM systems differs for culvert-based strain gauge type sensors and embedded in-road type sensors. The calibration process requires a number of test vehicles that are loaded, pre-weighed (on a suitable static scale or weighbridge) and measured, that will make multiple runs over the WiM System sensors in each lane at differing speeds. The reference test vehicles used in the WiM sensor calibration procedures are:

- two-axle rigid truck (Austroads vehicle type 03)
- three-axle truck (Austroads vehicle type 04), and
- six-axle articulated vehicle (Austroads vehicle type 09).

The six-axle articulated vehicle must be equipped with air suspension.

For calibrating culvert-based strain gauge type sensors, the test vehicles required are two-axle rigid trucks and six-axle articulated vehicles. The two-axle rigid truck test vehicles must be loaded to approximately 4, 6 ,8 and 10 tonnes on the drive axles with a non-shifting, approximately symmetric (side-to-side) load. Additionally, the test vehicle carrying 10 tonnes must be certified as safely capable of carrying a 10 tonne load and be approved with an ‘Over Mass’ Permit. The six-axle articulated test vehicles shall be loaded with differing payloads. The first being a fully loaded payload and the second being half a payload.

For calibrating embedded in-road type sensors, the test vehicles required are two two-axle rigid trucks, a three-axle rigid truck and a six-axle articulated vehicles. Each of these vehicles are required to be fully loaded with a non-shifting, approximately symmetric (side-to-side) load. Additionally, one of the two-axle rigid truck test vehicles must be loaded to 10 tonnes on the drive axle. This test vehicle must also be certified as safely capable of carrying a 10 tonne load and be approved with an ‘Over Mass’ Permit.

The test vehicles must be in sound mechanical condition. Special care must be exercised to ensure that the tyres on the test vehicles are in sound condition, dynamically balanced and inflated to recommended pressures.

12.2.2 Calibration procedure

After the settings have been installed on the WiM System, each of the reference test vehicles must make a minimum of 10 runs over the sensors in each lane at the sign posted speed or at a speed deemed safe for the payload. With a calibrated radar speed meter, or by some other means (such as wheelbase / time) that is acceptable to both the Principal and the Contractor, the speed of each test vehicle every time it passes over the WiM System sensors must be measured. All data must be recorded, and the vehicle record number must be noted for every run of each test vehicle. The radar speed meter, if used, must be calibrated by the method recommended by its manufacturer within 30 days prior to use.

12.2.3 Installation Acceptance Test Criteria

All specified data collection features, data processing features, and options of the system described herein must be fully documented and demonstrated to function properly before the systems are released for the Customer Acceptance Test (CAT). If any part of the WiM System fails to function properly, or if more than 5% of the calculated differences for any applicable data item resulting from all passes of the two test vehicles exceed the tolerance specified herein, the WiM System will be deemed to have failed the IAT and / or CAT.

12.2.4 Commissioning test

The CT requirements defined in MRTS201 *General Equipment Requirements* apply to this Technical Specification. Additionally, the equipment shall be commissioned by integrating the operation, monitoring and control with other equipment and/or systems as appropriate. This shall include initialising performance parameters to suit the Site-specific function of operation. Commissioning shall prove the correct operation, monitoring and control as required to meet the requirements of the Contract. Additionally, the Contractor must demonstrate that the WiM system is connected to the Principals' communications network and can reconnect successfully upon restarting in the event of a power failure.

12.3 WiM system Customer Acceptance Test (CAT)

With the exception to the requirement of 'Streams' integration, the CAT requirements defined in MRTS201 *General Equipment Requirements* apply to this Technical Specification.

13 Documentation

The documentation requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification. Additional minimum documentation requirements relevant under this Technical Specification are described below.

13.1 Operations manual and maintenance manual

The WiM System sections in the operations manuals and the maintenance manuals must detail all WiM System assets including the data logger, sensor units, control system and software. The manuals must include, as a minimum, the following items:

- Specifications
- design characteristics
- operation theory
- function of all controls
- signal responses and acceptable thresholds
- list of component parts with stock numbers
- documentation for the control system
- documentation for all protocols used for communications with the data logger, and
- documentation for all data formats utilised by the data logger.

14 Training

The training requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification. In addition two full days of onsite training for a least three operations personnel nominated by the Principal must be provided.

15 Maintenance

The maintenance requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification. Additional maintenance requirements relevant under this Technical Specification are described below.

15.1 Pavement

The surface of the paved roadway at each WiM site must be maintained in a condition that meets or exceeds the surface evenness requirements specified in Clause 11.2.5. The Contractor must verify pavement smoothness following any significant pavement maintenance but no less frequently than annually. The Maintenance Plan must incorporate such tests.

15.2 Recalibration

The Contractor must recalibrate the WiM System following any significant maintenance. Recalibration must be performed no less frequently than annually. The Maintenance Plan must describe the required recalibration details.

15.3 Culvert-based strain gauge WiM systems

Additional to the Clauses 15.1 and 15.2, the Contractor must undertake annual inspections of the road condition around the sensors, the culvert and the WiM system equipment. Care should be taken to ensure the culvert is kept clean and free of flammable debris, to reduce the possibility of damage occurring to the strain-gauge sensors should a bushfire at the site occur. Additional to any recalibration required, the Contractor must also measure and record the electrical properties of each road sensor and strain-gauge of the WiM system. The maintenance plan for culvert-based strain gauge WiM Systems must include these details and inspection response times to significant weather events local to the site.

15.4 Embedded in-road WiM systems

Additional to the Clauses 15.1 and 15.2, the Contractor must undertake annual inspections and measurements of the road condition around the sensors and the WiM system. Additional to any recalibration required, the Contractor must also measure and record the electrical properties of each embedded in-road sensor of the WiM system. The maintenance plan for embedded in-road WiM systems must include these details and inspection response times to significant weather events local to the site.

16 Handover

The handover requirements defined in MRTS201 *General Equipment Requirements* apply to work provided under this Technical Specification.