

GTR 8000 P25 RF-Site Performance Verification (GTR-SPV)

Motorola Solutions® & ETA® International Competency Requirements



The intent of this **GTR 8000 P25 RF-Site Performance Verification (GTR-SPV)** certification is to ensure technicians have the appropriate knowledge and skills necessary verify and optimize an ASTRO® 25 GTR8000 P25 base radio site.

The certification program consists of a written exam including technical questions as well as verification and/or procedural scenario questions. Prior experience with an ASTRO® 25 GTR 8000 P25 base radio system and equipment is strongly recommended as a prerequisite to the certification. There is also a two-day verification and optimization course available, but not a necessary pre-requisite for the more experienced GTR 8000 technicians in the field.

The written exam is comprised of the following topics:

Site Optimization Process	25%
Test Equipment	24%
GTR 8000 P25 Hardware	22%
Regulatory	17%
Safety – RF, PPE, DC	12%

The following knowledge competency listing identifies the individual subject topics in which ASTRO® 25 GTR 8000 P25 Base Radio technicians are expected to learn in preparation for the Site Performance Verification optimization certification written examination:

1.0 Safety

- 1.1 Describe OSHA and general safety requirements to include:
 - 1.1.1 First Aid kit and training procedures are recommended
 - 1.1.2 an approved ladder is required following A14 regulations
 - 1.1.3 severe weather procedures while at an RF site
 - 1.1.4 unauthorized RF site intrusion by anything or anyone
- 1.2 Describe DC Power Systems safety precautions to include:
 - 1.2.1 an eye wash station is required
 - 1.2.2 a 48 V DC Power Source can provide sufficient current in a short circuit to be a fire hazard and/or an extreme safety hazard
 - 1.2.3 battery electrolyte is highly corrosive and dangerous
- 1.3 Describe RF Exposure and Hazards to also include:
 - 1.3.1 a transmitter can never be operated into an open circuit
 - 1.3.2 cable disconnection procedures from a transmitter (Tx) or the Tx distribution system

2.0 Regulatory

- 2.1 Describe RF Site Operating Authority (License) procedures to include:
 - 2.1.1 transmitter enabling and connection into a transmit antenna
 - 2.1.2 regulatory requirements are met
 - 2.1.3 station activity log procedures
- 2.2 Define Effective Radiated Power (ERP)
 - 2.2.1 Describe how to calculate ERP
 - 2.2.2 Describe who is responsible and accountable for ERP settings
- 2.3 Describe operating frequency to include:

- 2.3.1 tolerances
- 2.3.2 being specified in MHz
- 2.3.3 listed on the site license
- 2.3.4 error specification
- 2.4 Describe Emission Mask (EM) as a requirement ensuring modulation does not cause interference to include:
 - 2.4.1 EM measurement
 - 2.4.2 Substitute EM testing
- 2.5 Define APCO P25 / TIA-102 standards are not a regulatory requirement and are voluntary
 - 2.5.1 P25 compliant products must follow the standard
 - 2.5.2 P25 allows manufacturers to provide features not defined in the standard

3.0 Hardware

- 3.1 Explain the differences between an Expandable Site Subsystem (ESS) and a Stand-Alone (SA) base radio
 - 3.1.1 The ESS consists of the following:
 - 3.1.1.1 power supplies
 - 3.1.1.2 power distribution
 - 3.1.1.3 up to 6 base radios
 - 3.1.1.4 frequency
 - 3.1.1.5 network distribution
 - 3.1.1.6 transmit combining
 - 3.1.1.7 transmit filtering
 - 3.1.1.8 receive filtering
 - 3.1.1.9 multi-couplers
 - 3.1.2 An SA base radio comes from the factory with no power or RF distribution
 - 3.1.3 An SA base radio in CCSI staging is typically integrated with:
 - 3.1.3.1 power
 - 3.1.3.2 RF distribution equipment
- 3.2 Define VHF and UHF Expandable Site Subsystems (ESS)
 - 3.2.1 VHF and UHF ESS do not include:
 - 3.2.1.1 transmit combining
 - 3.2.1.2 transmit filtering
 - 3.2.1.3 receive filtering
 - 3.2.1.4 multi-couplers
 - 3.2.2 VHF and UHF ESS verification should use the Stand Alone (SA) Base Radio Procedure and Test Result Sheet
- 3.3 Define ESS Transmit (Tx) Radio Frequency Distribution Systems (RFDS)
 - 3.3.1 Describe ESS ceramic combiner tuning method
 - 3.3.2 Describe ESS ceramic combiner proper operation at full power
- 3.4 Define ESS Receive (Rx) Radio Frequency Distribution Systems (RFDS)
 - 3.4.1 Describe the Preselector Sample Port proper usage
 - 3.4.2 Describe Radio Management Client (RMC) dipswitches configuration and programming matching
 - 3.4.3 Describe the Site RMC and Cabinet RMC inclusion procedures per ESS racks
 - 3.4.4 Describe where the ESS receiver input is located
- 3.5 Describe how and when Tower Top Amplifiers (TTA) should be tested and inspected
 - 3.5.1 Describe how Control Multi-coupler Units (MCU) should be tested and inspected
- 3.6 Describe how gain of a TTA is measured
 - 3.6.5 Describe selectivity measurements
- 3.7 Describe Receive Overall Gain
 - 3.7.1 Explain how Receive Overall Gain attenuation is calculated

4.0 RF Site Verification Process

- 4.1 List the pre-requisites procedures before RF Site Performance Verification to include:
 - 4.1.1 Antenna Commissioning Procedure
 - 4.1.2 Antennas (transmit and receive) mounted with feedline connected to be completely installed to ESS equipment
- 4.2 Describe decibel math working knowledge to include:
 - 4.2.1 dBm
 - 4.2.2 dBW
 - 4.2.3 Adding or subtracting dB's is the same as multiplying or dividing Watts
 - 4.2.4 0 dBm is a power level of 1 mW
 - 4.2.5 30 dBm is a power level of 1 W
 - 4.2.6 30 dBm is equal to 0 dBW
- 4.3 Define Testing Pass/Fail and Test Uncertainty Ratio (TUR) to include:
 - 4.3.1 APCO P25 / TIA-102 complies with ANSI standards
 - 4.3.2 Effective testing equipment setup must be better than the tolerance
 - 4.3.3 The TUR describes the ability of the test equipment and setup to make an accurate pass/fail determination of the Site equipment being tested
 - 4.3.4 A TUR of 10:1 is ideal, 4:1 is workable and 1:1 is not workable (unacceptable)
 - 4.3.5 Describe what an unworkable TUR means
- 4.4 Describe RF Site Verification Procedure (SVP) required essential testing equipment & cables
 - 4.4.1 Using known loss cables and equipment in the SVP is the only way to ensure acceptable TUR and reproducibility of test results
 - 4.4.2 Reproducibility is a requirement that allows use of baseline measurements from the SVP when Preventative Site Maintenance is performed
- 4.5 Describe Basic Test setups to work across all product lines and modulation types are Base Radio testing, Tx RFDS and Rx RFDS (RF Distribution Systems) testing
 - 4.5.1 The order of testing cannot be changed as RFDS testing needs information from the Base Radio tests

5.0 Test Equipment

- 5.1 Describe why a suitably accurate or acceptable Frequency Standard (FS) is needed ensuring a workable TUR exists for the Motorola Frequency Error specification at a Simulcast Site
- 5.2 Describe why the highest accuracy Wattmeters are used for the Base Radio Tx Rated Power test
 - 5.2.1 Using Wattmeters not listed in the SPV result in an unworkable TUR accuracy, having a non-linear response to input power and may not accurately measure the power of a complex modulation format like Linear Simulcast Modulation (LSM)
- 5.3 Explain why a Communications Analyzer (CA) required model must have the performance and calibration features such as Modulation Fidelity and Symbol Deviation to correctly assess P25 systems
 - 5.3.1 The required CAs differ in performance of the RF signal generator accuracy at low levels
- 5.4 Describe P25 Test (bit) Patterns to include:
 - 5.4.1 the symbol rate pattern
 - 5.4.2 the 1011 test tone pattern
 - 5.4.3 the 511-bit pattern, which also has different labels as follows:
 - 5.4.3.1 V.52
 - 5.4.3.2 O.153
 - 5.4.3.3 PN9
 - 5.4.3.4 Std511
- 5.5 Describe what may cause Bit Error Rate (BER) patterns near 50%

- 5.6 List P25 Measurements to include:
 - 5.6.1 Modulation Fidelity
 - 5.6.2 Symbol Deviation for P25 Phase 1
 - 5.6.3 The peak FM deviation for the different test patterns
 - 5.6.4 The Constellation plot usefulness
 - 5.6.5 The Distribution plot is utilized very little
 - 5.6.6 The Eye Pattern usefulness

6.0 Test Procedures and Result Sheets

- 6.1 Explain why multiple P25 RF SPV procedures exist and are different
- 6.2 Describe different P25 RF SPV Result Sheet dependencies
 - 6.2.1 Explain that test cable loss entries are mandatory
 - 6.2.2 Explain that antenna gain data must be included
 - 6.2.3 Explain that feedline data must be accurate
 - 6.2.4 Define the formula for “Set CSS Power To” value
- 6.3 List that Result Sheets data entries must include:
 - 6.3.1 test equipment data to show measurement result traceability
 - 6.3.2 calibrated equipment use
 - 6.3.3 for internal Motorola use only
 - 6.3.4 converting to PDF for customer system documentation; no live information
 - 6.3.5 saving to hard drive
 - 6.3.6 uploading to compass site for future reference

7.0 Base Radio Testing

- 7.1 Describe Transmitter (Tx) test results and failures to include:
 - 7.1.1 the CSS Test and Measurement tab's test pattern
 - 7.1.2 Tx Rated Power fails on all channels
 - 7.1.3 modulation fidelity fails on one channel
 - 7.1.4 Tx BER result at 50%
- 7.2 Describe Receiver (Rx) test results and failures to include:
 - 7.2.1 a transceiver module problem may cause an Rx fail(s)
 - 7.2.2 Rx BER Floor test result at 50%
- 7.3 Describe RSSI Direct test fails on all radios for an ESS site causes

8.0 Transmitter (Tx) Radio Frequency Distribution Systems (RFDS)

- 8.1 Describe Combiners, especially ceramic, component factors to include:
 - 8.1.1 Output Return Loss measurements
 - 8.1.2 vector network analyzer use to tune a combiner
 - 8.1.3 more drift in tuning with temperature than air dielectric
 - 8.1.4 SA base radio combiner insertion loss determination and calculation
 - 8.1.5 before keying Tx at full power into a combiner procedure
- 8.2 Describe ERP and Base Radio Power factors to include:
 - 8.2.1 licensed ERP is not exceeded
 - 8.2.2 “Set CSS Power Out To” and “Actual Set CSS Power Out” values
 - 8.2.3 calculations are highly dependent on accurate input values
- 8.3 Describe Advanced Power Monitor (APM) calibrations for output power and insertion loss

9.0 Receiver (Rx) Radio Frequency Distribution Systems (RFDS)

- 9.1 Describe Tower Top Antenna Receive Overall Gain to include:
 - 9.1.1 a calculated decibel attenuation value on the Result Sheet
 - 9.1.2 the total amount of gain expected should be stated by the system project engineer

- 9.1.2.1 If there is no guidance from the engineer for the Receive Overall Gain, an RF Site reasonable range is between 8 and 12 dB
- 9.1.2.2 Default initial value for the Receive Overall Gain at an RF Site is 10 dB
- 9.2 Explain performance testing for tower top amplifiers (TTAs) to include:
 - 9.2.1 why there are no specifications or pass/fail for in the P25 RF SPV procedures
 - 9.2.2 primary metrics
 - 9.2.3 specifications are difficult to interpret in the field
 - 9.2.4 noise figure measurement is not part of P25 RF SPV procedures
- 9.3 Explain why tower top amplifiers (TTAs) testing must be done prior to install
- 9.4 Describe how Effective Receiver Sensitivity (ERS) is determined and is directly related to the Signal-to-Noise (S/N) ratio
- 9.5 Describe ERS calculation guidelines and for what ERS is used
- 9.6 Describe how to use Received Signal Strength Indicator (RSSI) for troubleshooting and to what RSSI can and cannot determine

End of GTR8000 RF-Site Performance Verification competencies

Suggested Additional Resource and Study Material:

Please see the https://www.motorolasolutions.com/en_us/services/managed-support-services/training.html webpage and the description information on the ETA webpage left of the competency link: <http://www.etai.org/motorola.html>

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