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 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 required
  - 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

3.6 Describe how gain of a TTA is measured

3.7 Describe reserve gain and how reserve 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
- 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
  - 4.3.5 Describe what an unworkable TUR means
- 4.4 Describe RF Site Verification Procedure required essential testing equipment and 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 details
- 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 Reserve Gain to include:
  - 9.1.1 a measurable decibel attenuation value on the Result Sheet
  - 9.1.2 the total amount of gain expected is stated by the system project engineer
    - 9.1.2.1 If there is no guidance from the engineer for the reserve gain, an ESS Site reasonable range is between 4 and 8 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 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

