# NYCT Procurement of
# Twelve Heavy Rail 3-ton Crane Cars
## NYCT Contract R34253

# Radiated EMI Field Test Procedure

**Revision 1**
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## Arva Industries Inc.
**43 Gaylord Road • St. Thomas**
**Ontario Canada**

**prepared by**

T U R N E R
E N G I N E E R I N G
C O R P O R A T I O N

2006 Glyndon Avenue Venice, CA 90291 tele (310) 915-7601
Arva.turner-engineering.com

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# Table of Contents

# NYCT Procurement of Twelve Heavy Rail 3-Ton Crane Cars Radiated EMI Field Test Procedure

# 1 Introduction

Arva Industries Inc. (Arva) is supplying New York City Transit (NYCT) with twelve heavy rail 3-ton Crane Cars in NYCT Contract R34253. The Crane Car is designed to aid in the replacement of steel rails. The Crane Car is not self-propelled, so it will be hauled by NYCT diesel-electric switcher work train locomotives.

NYCT classifies the Crane Car as a Non-Third Rail Powered (NTRP) Work Cars. This indicates the Crane Car is used in maintenance of way, does not carry passengers, and does not draw electrical power from the third rail for propulsion or any other purpose.

Per the NYCT R34253 Technical Specifications (TS) requirements, Arva and its EMC consultant Turner Engineering Corporation (Tenco) are conducting a Crane Car electromagnetic compatibility (EMC) Program.

TS Section 2.8.1.2 requires the Crane Car to conform to the NYCT EMC Standard for Non-Third Rail Powered Work Cars (ESWC), which include emission limits and electromagnetic interference (EMI) tests.

This Radiated EMI Field Test Procedure (RETP) details the tests to be performed and describes equipment under test; test schedule; staff, logistics, coordination and support requirements; test site; test scenarios, instrumentation setup, and test steps; data collection forms; and test report format.

## 1.1 Overview of the Radiated EMI Field Test Procedure

This RETP provides a test method, test arrangement, and related technical information for performance of the Crane Car Radiated EMI field test. This RETP also describes the format of the test results documentation.

Generally, Arva and Tenco will perform a Radiated EMI Field Test (RET) to document that the Crane Car worst-case radiated emissions do not exceed the NYCT specified amplitude in the specified frequency range. To accomplish this, Arva and Tenco will perform and document a Radiated EMI Test compatible with Radiated Interference in Rapid Transit Signaling Systems Volume II: Suggested Test Procedures, UMTA-MA-06-0153-85-11, Method RT/IE01A, “Broadband Emissions of Rapid Transit Vehicles - 140 kHz to 400 MHz” (RSTP) using the radiated emission limits in Section 5.3.2 of the ESWC.

Arva and Tenco will perform the Crane Car EMI tests at low speeds on a suitable section of NYCT track, referred to as the EMI Conformance Test Track (ETT).

Tenco will supply a test instrument setup and will measure and record the amplitude of the radiated electric field at the specified distance from the track, during passage of the Crane Car.

The test team will perform the RET on a Crane Car, using appropriate operation modes such as Battery Mode or Hybrid Mode or Diesel Mode, and performing various crane activation functions.

## 1.2 Objectives of the Radiated EMI Field Test Procedure and the Radiated EMI Field Test

The objective of this RETP is to define the train level radiated emissions field test procedure and test results documentation for the Crane Car.

The objective of the Radiated EMI Field Test is to demonstrate that the worst-case Crane Car radiated emissions are compatible with the ESWC Section 5.3.2.

## 1.3 Scope

The scope of this RETP is EMI field testing of the Crane Car for radiated emissions on the ETT.

The RET excludes all other equipment, activities outside the Crane Car equipment.

## 1.4 Radiated EMI Field Test Requirements

Worst-case emissions due to operation of the Crane Car measured with a suitable antenna and spectrum analyzer must not exceed the greater of the NYCT ambient or the specified amplitude in the specified frequency ranges, either for a duration or with a repetition interval significant for nearby equipment.

The radiated emission limits per train in ESWC Section 5.3.2 are repeated in Section 7 of this RETP.

## 1.5 Participants and Responsibilities

The participants are Arva, Tenco, and NYCT.

Arva is responsible to provide:

- Crane Car, ready for test
- Test crew to operate the Crane Car for ETT testing
- Engineer to support the EMI tests

Tenco is responsible to provide:

- Test engineers
- Test equipment
- Data media and test consumables.
- Test operation, data collection, and recording

NYCT is responsible to provide:

- A suitable EMI Conformance Test Track (ETT)
- A locomotive and crew on the ETT to move the Crane Car
- Communications
- Safety protection and security
- Staff or consultants to witness EMI conformance tests
- Operations support

## 1.6 Reference Information

The following are reference documents for the Crane Car EMC Program.

**Table 1-1**
**Reference Documents for Arva Crane Car EMC Program**

| Publisher | Document Number / ID | Document Name |
|---|---|---|
| NYCT | R34253 | NYCT CONTRACT R-34253: TECHNICAL SPECIFICATION |
| NYCT | ESWC | EMC Standard for Non-Third Rail Powered Work Cars, Rev. 1.0, NYCT, November 22, 2002 |
| Arva | EMI Safety Analysis | Electromagnetic Interference Safety Analysis, Rev NIL, May 23, 2022. |
| DoD | MIL-HDBK-237 | Electromagnetic Compatibility/Interference Program Requirements |
| DoD | MIL-STD-461D | Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference |
| DoD | MIL-STD-462 | Measurement of Electromagnetic Interference Characteristics |
| CENELEC | EN 50155:2007 | Railway applications – Electronic equipment used on rolling stock, CENELEC European Standard |
| FTA | UMTA-MA-06-0153-85-11 | Radiated Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures (RSTP) |

## 1.7 Acronyms and Abbreviations

Table 1-2 shows the RETP acronyms and abbreviations:

**Table 1-2**
**Acronyms and Abbreviations**

| Acronym | Definition |
|---|---|
| A | Amperes |
| AC | Alternating Current |
| DC | Direct Current |
| DoD | Department of Defense |
| dB | Decibel |
| EMC | Electromagnetic Compatibility |
| EMCP | Electromagnetic Compatibility Plan |
| EMI | Electromagnetic Interference |
| ESWC | Electromagnetic Compatibility Standard for Non-Third Rail Powered Work Cars |
| ETT | EMI Conformance Test Track |
| f | Frequency |
| fps | Feet per second |
| FFT | Fast Fourier Transform |
| FTA | Federal Transportation Administration |
| Hz | Hertz |
| IET | Inductive EMI Field Test |
| IETP | Inductive EMI Field Test Procedure |
| kps | Kilometers per hour |
| LEM | Liaisons Electroniques Mecaniques |
| MIL | Military Standard |
| MP | Measurement Point |
| mph | miles per hour |
| MTA | Metropolitan Transportation Authority |
| NYCT | New York City Transit |
| RET | Radiated EMI Field Test |
| RETP | Radiated EMI Field Test Procedure |
| rms | root mean square |
| RSQT | Radio Susceptibility Qualification Test |
| RSQTP | Radio Susceptibility Qualification Test Procedure |
| RSTP | Radiated Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures, UMTA-MA-06-0153-85-11, Method RT/RE01A, “Broadband Emissions of Rapid Transit Vehicles - 140 kHz to 400 MHz”. Radiated Suggested Test Procedure |
| Tenco | Turner Engineering Corporation |
| TS | Technical Specifications |
| UMTA | Urban Mass Transit Administration (now Federal Transportation Administration or FTA) |
| V | Volts |

## 1.8 Contents of this Procedure

This RETP consists of the following sections.

**Section 2, Test Schedule:** The Test Schedule section shows the planned test days.

**Section 3, Crane Car Configuration Under Test:** The Crane Car Configuration Under Test section specifies the Crane Car equipment configuration relevant to EMI.

**Section 4, Test Track Requirement:** The Test Track Requirement section describes the requirements for the tracks planned for the tests.

**Section 5, Test Equipment:** The Test Equipment section describes the planned test equipment configuration, including the list of test equipment with model numbers, connection diagram, and the planned calibration method. Calibration includes both instrument and setup calibration.

**Section 6, Test Runs:** The Test Runs section describes the runs Tenco will use to identify the Crane Car worst-case conditions. For each run, the Test Run List provides an identifier and states the test variables, such as frequency band, operating mode, direction, and speed and, as required, any notes on the run purpose or condition.

**Section 7, Radiated EMI Test Method:** The Radiated EMI Test Method section lists the test steps Tenco will use to perform the tests, describes the test equipment set-up, and provides data evaluation guidelines.

**Section 8, Test Data Collection**: The Test Data Collection section describes the test data to be collected and gives examples of the data format to be used and how it is to be recorded, indexed, and organized.

**Section 9, Test Report Format:** The Test Report Format section outlines the Radiated EMI Test Report. The Test Report sections will be Introduction, Test Results and Conclusions, Crane Car Configuration Under Test, Test Track, Test Equipment Configuration, Test Procedure, Test Runs and Results, and Test Data.

**Appendix A, Data Collection Forms:** Appendix A provides data collection forms for the Radiated EMI Tests.

**Appendix B, List of Controls:** Appendix B provides a list of controls to operate the Crane Car.

# 2 Test Schedule

The Inductive, Radiated and Radio Susceptibility Qualification EMI Tests (RSQT) will be performed at low speeds on the ETT during non-revenue service hours. The Inductive Test and RSQT are described in separate documents.

The following calendar shows the planned EMI field tests.

| EMI Conformance Test Track Schedule | | | | | | |
|---|---|---|---|---|---|---|
| **Sun TBD** | **Mon TBD** | **Tue TBD** | **Wed TBD** | **Thu TBD** | **Fri TBD** | **Sat TBD** |
| Travel | Unpack, setup, calibrate, and checkout EMI test equipment<br><br>RSQT | Radiated Test | Inductive Test | Contingency Day | Contingency Day | Pack and ship equipment<br><br>Travel |

Preliminary ETT test dates are to be determined.

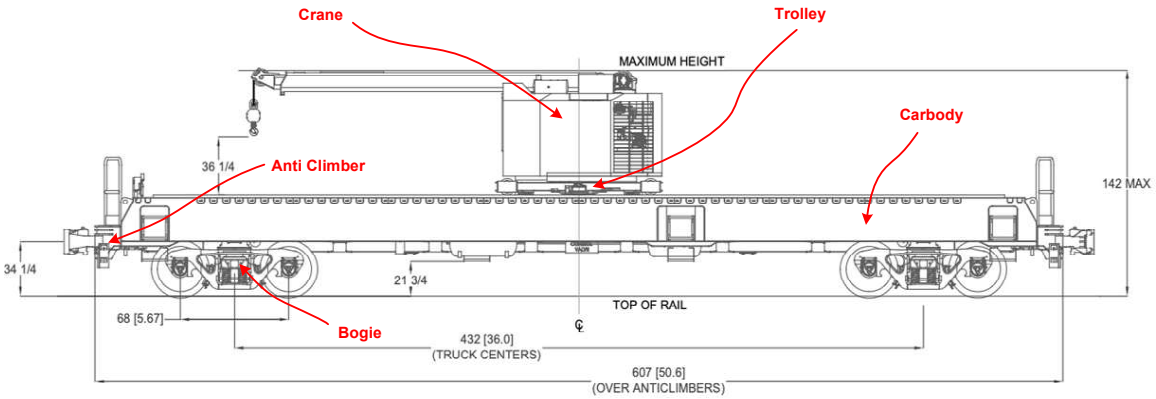
# 3 Crane Car Configuration Under Test

## 3.1 Crane Car Loading

The test team will perform Radiated EMI tests on a Crane Car, and run all higher power electrical equipment (e.g. electric motors, HVAC, etc.) to ensure maximum electric load and to confirm No equipment produces excess emissions.

The Crane Car includes a trolley which allows the boom to traverse the length of the work car, and is capable of a maximum lift of 3 tons. The crane and trolley are powered by a hybrid power unit, which provides mechanical power to the hydraulic pumps to drive the hydraulic equipment. Figure 3-1 shows the general assembly of the Crane Car.

**Figure 3-1 Crane Car General Assembly – Left View**




The test team will ensure that the Crane Car is in correct working condition.

The Crane Car is propelled by a diesel electric locomotive. The test team will arrange and perform tests to exclude locomotive electromagnetic emissions from the Crane Car emission measurements.

## 3.2 Configuration

At the time of the test, the Crane Car will have completed all manufacturing tests and inspections, all factory performance tests, and major portions of conformance and acceptance tests. The Crane Car will be adjusted with the same parameters expected to be in use.

The test team will record the software revision level and parameter configurations for the Crane Car as part of the test record, using the form in Appendix A.

# 4 Test Track Requirements

The test team will perform the RET on the ETT, which should be located on a suitable section of NYCT yard track at the Yard where the Crane Car is stored.

## 4.1 EMI Conformance Test Track

The test team will perform the RET using one Crane Car hauled by a diesel-electric work train locomotive on a suitable section of NYCT track. That track, referred to as the ETT, should have the following characteristics:

- The test track should be a straight, level section of track which permits operation of the Crane Car hauled by a locomotive for testing at NYCT. There is no need for third rail.

- The test team should have access to the track, Crane Car, crew, communications, safety protection, security as needed, and operations support, preferably during daylight hours. The test team needs at least eight test hours per day.

- NYCT must provide radio communications for the test staff, Central Control, and other NYCT staff, on a channel that will not interfere with NYCT train operations, if there are any.

- The RET measurements are made on the wayside. The test area should be distant from high tension lines, power generating stations, and other sources of broadband emissions other than the Crane Car under test.

- The RET measurement points (MP) should be:

    - 50 ft (15 m) from the centerline of the track under test.

    - There should be no fence or other significant metal structure above the rail level between the MP and the train, or immediately behind or to the sides of the MP.

    - The antenna mounting point should allow easy setup of the antenna 6.5 ft (2 m) above the rail head level.

    - The test shall identify the source of any narrow band emission whose amplitude significantly exceeds the emission limit. If any such emission is found, and if it is safe to measure under these conditions, the test should measure that portion of the train with the antenna preferably 72 in (1.8 m) from the track centerline, which is 44 in (1.1 m) from the near rail and about 20 in (0.5 m) from the side of the train. The antenna should measure at a height of 24 in (0.6 m) above the top of the running rails. The test may only be performed with the antenna set up in a place where the safety of the staff and equipment is assured. If the location is not safe for measurement, the test will measure at the nearest safe location.

Most trains do not emit significant narrowband emissions. There is no benefit to NYCT to measuring radiated emissions close to the Crane Car if no significant emissions are found at the normal 50 ft emission MP.

If the Crane Car emits a non-compliant radiated emission, it is useful and important to measure close to the train to determine the source.

Therefore, this RETP recommends measuring close to the Crane Car for emissions which exceed the limit at 50 ft.

- The test equipment needs 110 VAC power. Tenco will provide a generator to power the test equipment.

- The test location must safely accommodate the test crew. The area for the test crew and test equipment should preferably either have a place to bring in and park a test van or be inside a structure. As an alternative, there should be a place to set up a table sheltered from the wind and sun.

- The tests require exclusive use of the track to allow the Crane Car to make multiple runs in both directions.

The EMI Test Report will include a track diagram showing the test location and other relevant information.

The ETT location may be at the Linden Yard, where Arva expects the Crane Car to be stored. Linden Yard is located at 1500 Linden Blvd, Brooklyn, NY 11212.

Figure 4-1 shows a map of the Linden Yard facility and Figure 4-2 shows the potential RET test location. Figure 4-3 shows a picture of the Linden Yard Test Track.

The EMI Test Report will include a track diagram showing the test location and other relevant information.

**Figure 4-1**
## Linden Yard Facility Map

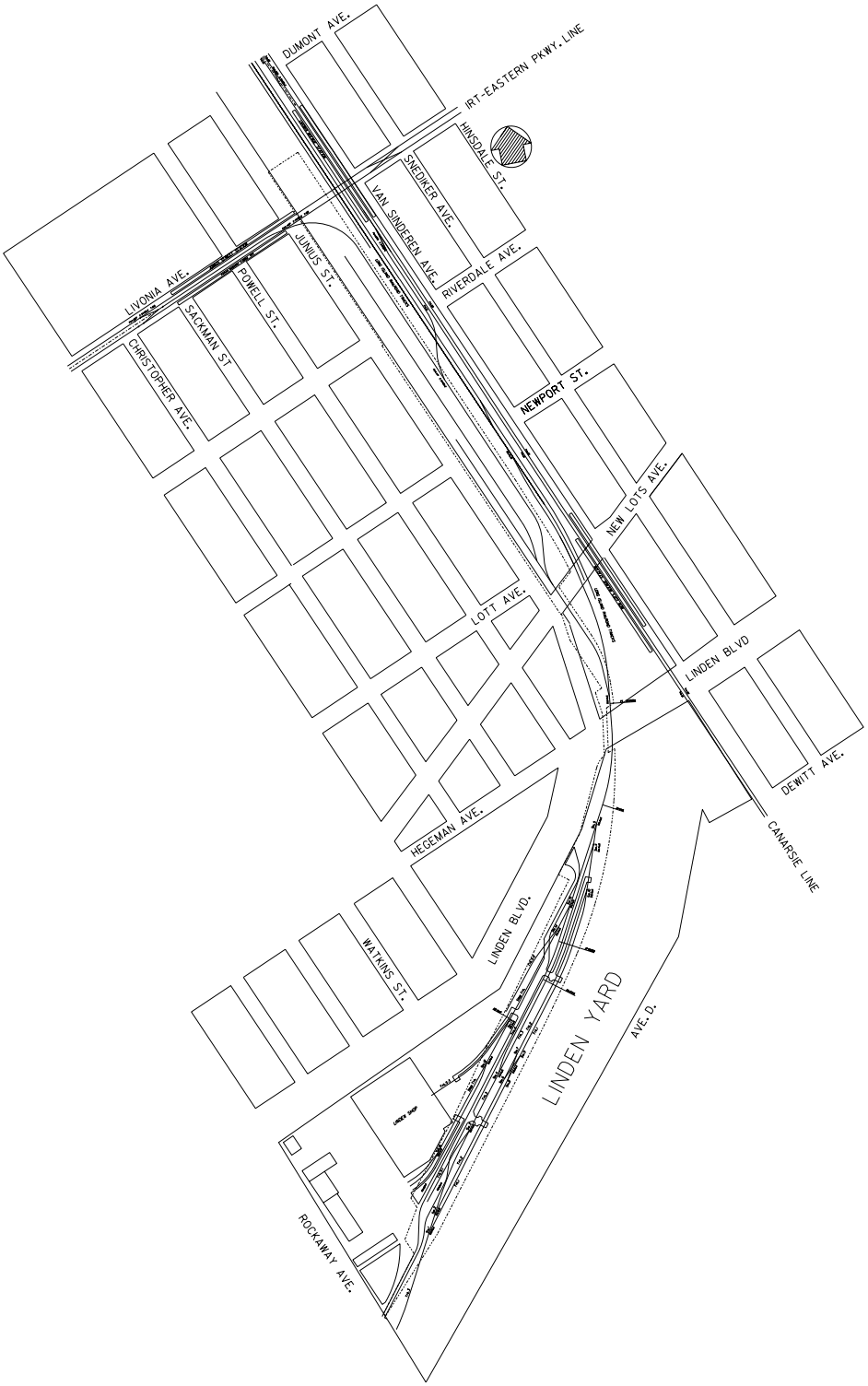


**Figure 4-2**
**Potential RET Location**

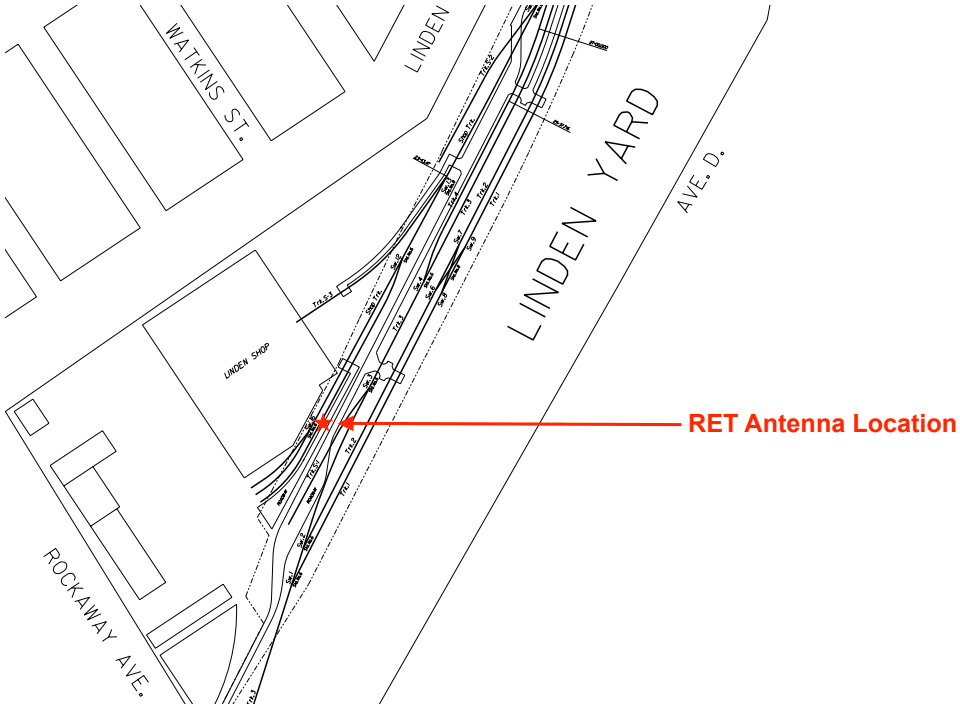



**Figure 4-3**
**Linden Yard Test Track**

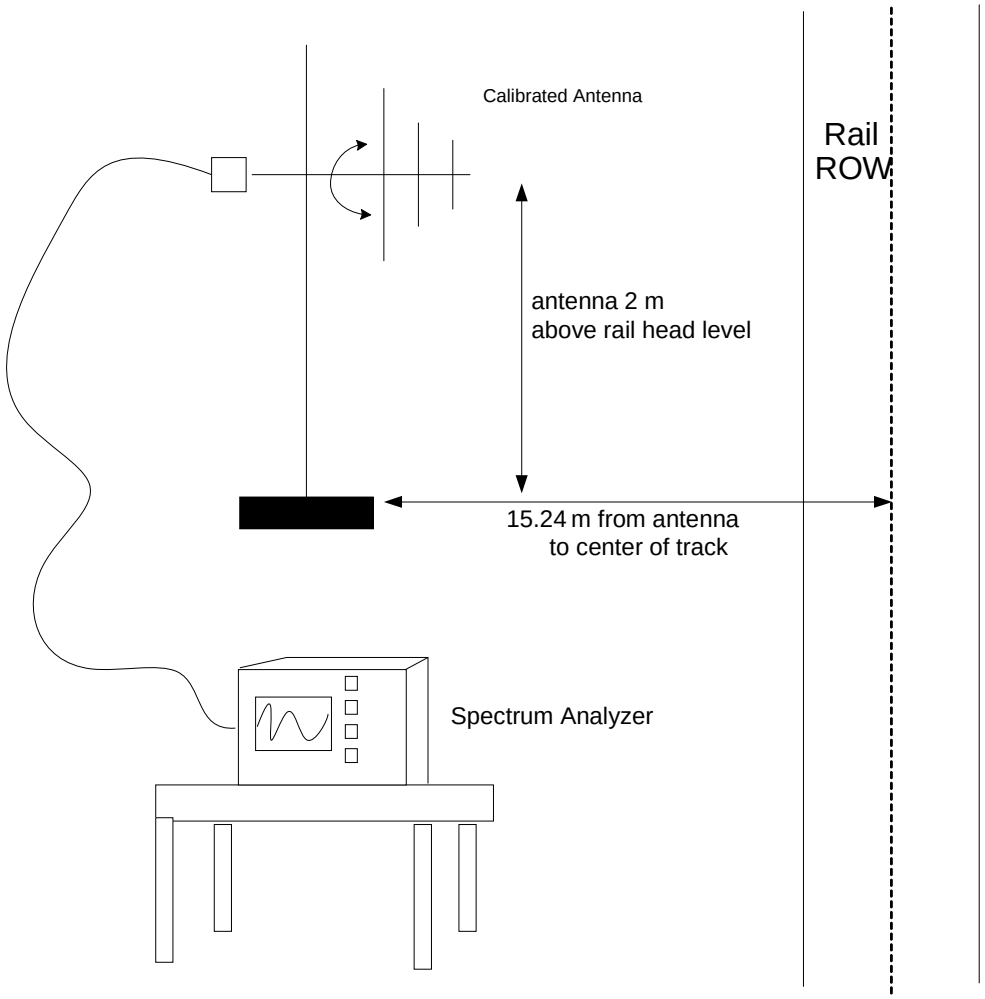
# 5 Test Equipment Configuration and Calibration

## 5.1 Radiated Emissions Test

Figure 5-1 shows the test equipment setup for the Radiated EMI Field Test for the radiated electric field emissions.

The test antenna will be placed 50 ft (15 m) from the centerline of the track under test and 6.5 ft (2 m) above the rail head, as specified in UMTA-MA-06-0153-85-11, method RT/RE01A.

**Figure 5-1**
**NYCT Radiated Emissions Test Configuration**




The test will identify the source of any narrow band emission whose amplitude significantly exceeds the emission limit. If any such emission is found, the test will remeasure that portion of the train with the antenna preferably 72 in (1.8 m) from the nearest rail of the track, and 24 in (0.6 m) above the top of the running rails, per section 5.3.1 of the ESWC. The test may only be performed with the antenna set up in a place where the safety of the staff and equipment is assured.

## 5.2 Test Equipment

Table 5-1 lists the RET equipment.

**Table 5-1**
**Radiated EMI Test Equipment List**

| # | Item | Supplied By | Comment |
|---|---|---|---|
| 1 | RF Spectrum Analyzer, Agilent 8562EC, 30 Hz to 13.2 GHz Spectrum Analyzer w/GPIB, or Keysight KT-N9010A-513/P13 10Hz-13.6GHz EXA Signal Analyzer, or equivalent. | Tenco | For measuring EMI field intensity between 30 Hz and 13.2 GHz. |
| 2 | PC Software, AT/E4444A Benchlink Software for 8562 Series or equivalent | Tenco | For transfer of data from Spectrum Analyzer to PC |
| 3 | HP 930 Deskjet Printer, or equivalent | Tenco | For plotting emission spectra. Compatible with spectrum analyzer. |
| 4 | A.H Systems SAS-550-1: Active Monopole Antenna or equivalent, 10 kHz to 60 MHz | Tenco | Calibrated antenna for Bands 0 – 4 |
| 5 | A.H. Systems SAS-521F-7: Bilogical Antenna or equivalent, 25 MHz to 7 GHz | Tenco | Calibrated antenna for Bands 5 – 7 |
| 6 | Adjustable Antenna Tripod | Tenco | To support antennas |
| 7 | Laptop computer | Tenco | For control of printer and storage of test data results |
| 8 | AC Power Source | Tenco | AC line, generator, or car battery inverter. |

The following subsections describe the major test equipment items.

### 5.2.1 RF Spectrum Analyzer

The Agilent Technologies Model 8562EC Spectrum Analyzer measures intensity of the RF field over a frequency range of 30 Hz to 13.2 GHz. The spectrum analyzer:

- Measures and documents the field intensity received from calibrated antennas.
- Converts received signals from calibrated antennas into standard dBμV/m units.
- Stores system configuration including antenna factors and cable losses.
- Has amplitude accuracy better than ±1.0 dB, adequate for the task
- Displays Limit Lines to indicate NYCT specification limits.

The spectrum analyzer will be connected to a laptop or PC by a data link for data acquisition, storage, and printing.

The test team will use standard techniques to assure calibration of the impulse bandwidth of the spectrum analyzers. For spectrum analyzers whose intermediate frequency (IF) stages have Gaussian passbands, such as the Agilent Technologies spectrum analyzer used here, the impulse bandwidth is 1.4 times the resolution bandwidth (-3 dB bandwidth), and is approximately equal to the -6 dB IF bandwidth.

### 5.2.2 Antennas

The test team will mount antennas on a tripod with the antenna base plate 2 m above rail level. The tests will orient the antennas as follows:

**Active Monopole Antenna:** The Active Monopole Antenna covers the frequency range of 10 kHz to 60 MHz. Measurements are taken with this antenna oriented vertically.

**Bilogical Antenna:** The Bilogical Antenna is a wide operating range antenna which covers the frequency range of 25 MHz to 7 GHz. The name "bilogical" indicates that the antenna combines the characteristics and response of a biconical and log periodic antenna. Measurements are taken with this antenna oriented vertically, with its axis perpendicular to the ground, and with the antenna oriented horizontally, with the antenna axis parallel to the Crane Car's path.

Calibrated antennas receive and convert RF field intensities into electrical signals with a known conversion antenna factor. These antenna factors are provided by the antenna supplier, and are entered into the spectrum analyzer so the spectrum analyzer can display received signals in units of the corresponding electrical field intensity.

## 5.3 Test Band

The test team will perform broadband emission measurements in the range 10 kHz to 6 GHz using active monopole and bilogical antennas for horizontal and vertical electric fields as appropriate.

The test team will divide the measurement band into nine smaller test bands, listed in Table 5-2.

The test team will use the active monopole antenna to cover the range from 10 kHz - 30 MHz, in five measurement subbands. Per the RSTP, The test team will measure with the active monopole oriented vertically.

The test team will use the bilogical antenna to cover the range from 25 MHz to 6 GHz, with both horizontal and vertical orientation.

For the Radiated EMI Test, the specified spectrum analyzer resolution bandwidths are:

- 200 Hz for measurements up to 150 kHz, although 1 kHz bandwidth may be used to reduce scan duration
- 10 kHz for measurements between 140 kHz and 30 MHz
- 100 kHz above 30 MHz.

**Table 5-2**
**Radiated Emissions Test Bands**

| ID | Frequency Range | Antenna | Ant Orientation | Resolution Bandwidth |
|---|---|---|---|---|
| B0 | 10 kHz – 160 kHz | Active Monopole | Vertical | 200 Hz (or 1kHz) |
| B1 | 150 kHz – 650 kHz | Active Monopole | Vertical | 10 kHz |
| B2 | 500 kHz – 3 MHz | Active Monopole | Vertical | 10 kHz |
| B3 | 2.5 MHz – 7.5 MHz | Active Monopole | Vertical | 10 kHz |
| B4 | 5 MHz – 30 MHz | Active Monopole | Vertical | 10 kHz |
| B5h | 25 MHz – 325 MHz | Bilogical | Horizontal | 100 kHz |
| B5v | 25 MHz – 325 MHz | Bilogical | Vertical | 100 kHz |
| B6h | 300 MHz – 1.3 GHz | Bilogical | Horizontal | 100 kHz |
| B6v | 300 MHz – 1.3 GHz | Bilogical | Vertical | 100 kHz |
| B7h | 1 GHz – 6 GHz | Bilogical | Horizontal | 100 kHz |
| B7v | 1 GHz – 6 GHz | Bilogical | Vertical | 100 kHz |

## 5.4 Spectrum Analyzer Calibration

The test team will do the following steps to verify proper operation of the RET equipment:

- Turn on spectrum analyzer and let it warm up for 5 minutes.
- After warm up, calibrate the spectrum analyzer as described in the user's manual. This calibration procedure should be followed after transport or after a long time period.
- Verify cable loss matches calibration record. The internal calibrator can be used to make this measurement.
- Verify antennas are operating properly.

# 6 Test Runs

The test team will perform tests to determine the modes and conditions under which the Crane Car makes its worst-case emissions, considering various crane activation functions, and auxiliaries.

The test team will perform the Radiated EMI Field Test on a Crane Car with auxiliary equipment with low and high loads; and will check the different operating modes, with different crane activation functions. The test team will select combinations of test conditions to identify the worst case emissions.

The test team will measure radiated electric field emissions following the UMTA RSTP. The test team will perform sufficient test runs to identify worst-case conditions for normal conditions, and in combinations of applicable operating modes and speeds.

For all test runs, the test team will maintain a test log per the requirements of Section 8 of this RETP, providing the test type, Crane Car configuration, run description, comments for each run, and other relevant information.

## 6.1 Test Variables

The test team will perform test runs for the Crane Car configurations and operating modes described below. The test team will evaluate results during the first series of test runs to determine the modes and conditions under which the Crane Car makes its worst-case emissions. Further tests will focus on worst-case modes and conditions.

**Crane Operation/Loading:** The test team will test emissions from the Crane in various crane operations, including hoisting, luffing, telescoping, etc with and without a physical load picked by the crane.

**Direction:** The test team will perform several test runs in forward and reverse directions, but does not expect any influence from direction of travel.

**Operating Modes:** The test team will consider various crane activation functions, and test operating modes, including appropriate combinations of:

- Battery Mode
- Hybrid Mode
- Diesel Mode

**Auxiliaries**: Generally, peak emissions from the auxiliaries occur when the auxiliary equipment runs near full power. The test team will perform test runs with vehicle auxiliaries on full power and also with all auxiliaries switched off.

As noted above, the test team will test the possible operating ranges, modes, and combinations to identify worst cases. From among those tests, the team will select, further test, and document conditions for crane operations worst-case emissions.

## 6.2 Planned Test Series and Runs

The test team will perform the following test types, measuring radiated emissions under different operating modes of the Crane Car as appropriate.

In the following test runs, the test team will operate the test Crane Car safely within the test track speed restrictions.

The test team will perform the RET with a Crane Car hauled by a diesel-electric work train locomotive. To exclude the locomotive emissions from the Crane Car emission measurements, the test team will start and stop the data collection to only collect data while the Crane Car is in front of the measurement antenna. Further, the test team will collect ambient radiated emission measurements. If needed to characterize and exclude locomotive emissions, the test team will make measurements with only the locomotive in front of the measurement antenna.

If any significant emissions are measured, the test team will make additional runs as needed to confirm that the locomotive is not the source of the emissions.

For most of the tests below, the trolley will be positioned at midpoint of the carbody, as shown in Figure 3-1. Since the trolley does not use much power, it will remain stationary for all tests, except for one confirmation test.

### R0: Calibration: Receiver Sensitivity and Spurious Response Levels

- Each time the test equipment is set up, perform this spectrum analyzer calibration to establish the noise baseline.

- Adjust the spectrum analyzer sensitivity following the manufacturer's adjustment procedure, using the built-in calibration signal of the spectrum analyzer.

- Place the spectrum analyzer and equipment at the test site. Attach a matched termination to the spectrum analyzer's antenna input terminal. Accelerate the test Crane Car past the test setup.

- Observe and record the spectrum analyzer measured levels across the entire frequency range. Label data "With Antenna Terminal Terminated." Note any spurious receiver response.

## R1: No Crane Car Present

With no Crane Car nearby, measure and record emission levels at all frequency subbands and antenna polarizations from 10 kHz to 6 GHz, per Table 5-2.

## R2a Battery Mode – Crane Operations, High Current Draw

- Position the trolley at midpoint of the carbody (25.3 ft away from the No. 1 or No. 2 anti climber). The trolley will stay in this position for all the tests, except for test R2c.
- Use the locomotive to move the entire Crane Car so the Crane Car midpoint between the No. 1 and No. 2 bogies is at the MP. Leave the trolley centered on the carbody.
- Rotate the crane, so the engine/motors are facing directly the antenna and test equipment.
    - Turn ignition ON, select Battery Mode,
    - Attach a load close to the maximum 3-ton load to the crane hook.
    - Hoist the load and activate the telescope in and out at a flat boom angle.
    - Start and stop movement multiple times to achieve high starting currents.
    - Run auxiliary systems (heaters, lights, AC) all on and all off, and have the air compressor forced on.
- Measure and record emission levels at all frequency subbands and antenna polarizations from 10 kHz to 6 GHz, per Table 5-2.
- Repeat the test with the electric motors at 2400 rpm

## R2b: Battery Mode – Crane Operations, Low Current Draw

- Remove the load from the crane hook.
- Perform luffing and telescoping operations without any crane load.
- Measure and record emission levels at all frequency subbands and antenna polarizations from 10 kHz to 6 GHz, per Table 5-2.

## R2c: Battery Mode – Trolley Operations

- Position the trolley at either end of the Crane Car. Using worst-case crane operation modes found in tests R2a-R2b, move the trolley to the other end of the Crane Car,
- Measure and record emission levels at all frequency subbands and antenna polarizations from 10 kHz to 6 GHz, per Table 5-2.
- Repeat the test with the trolley starting from the other end of the Crane Car.

## R2d Battery Mode – Craning Operations, Pass MP at 2 mph

- Position the trolley back at the midpoint of the carbody.
- Using the locomotive, move the Crane Car past the MP at 2 mph, using worst-case crane operation modes found in tests R2a-R2b. Back and forth operation is acceptable.

- Measure and record emission levels at all frequency subbands and antenna polarizations from 10 kHz to above 6 GHz, per Table 5-2. Begin the measurement when the lead car of the Crane Car reaches the MP, and stop the measurement when trail car passes the MP.

### R2e: Battery Mode – Crane Operations, Pass MP at 2 mph, Opposite Direction

- Repeat R2d, but flip direction of boom in case worst-case emissions are from other side of equipment on trolley.
- Determine whether there is any significant difference in signal levels due to direction.

### R3 Hybrid Mode – High Battery Charging, Pass MP at 2 mph, Max Current Draw

- Ensure the batteries have been drained to a low enough voltage prior this test to ensure maximum charging current.
- Select Hybrid Mode, and set battery charge to High
- Using the locomotive, move the Crane Car past the MP at 2 mph, using worst-case trolley orientation found in tests R2d-R2e.
- If significant emissions are measured, make multiple passes past the MP.

### R4a Diesel Mode – Switch from OFF to Diesel mode, Pass MP at 2 mph,

Repeat R2d, while switching from OFF to Diesel Mode.

### R4b Diesel Mode – Switch from Diesel to Hybrid mode, Pass MP at 2 mph,

Repeat R2d, while switching from Diesel Mode to Hybrid Mode.

## 6.3 Planned Test Series and Runs

Table 6-1 below lists the Crane Car and Test Configurations used for Calibration, Ambient, Crane Car Standing, and Crane Car Operating while passing the MP at 2 mph.

The test will identify the source of any narrow band emission whose amplitude significantly exceeds the emission limit. If any such emission is found, the test will remeasure that portion of the train with the antenna preferably 72 in (1.8 m) from the nearest rail of the track, and 24 in (0.6 m) above the top of the running rails, per section 5.3.1 of the ESWC. The test may only be performed with the antenna set up in a place where the safety of the staff and equipment is assured.

The test team will perform the tests on the following list in an order which makes efficient use of track and Crane Car time and staff availability.

**Table 6-1**
**Radiated EMI Test Run List**

| Band | Measurement Range | Resolution Bandwidth | Antenna | E-field | Test ID | Operating Mode | Description |
|---|---|---|---|---|---|---|---|
| B0 | 10 kHz to 160 kHz | 200 Hz (or 1 kHz) | Active Monopole | Vertical | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B1 | 150 kHz to 650 kHz | 10 kHz | Active Monopole | Vertical | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B2 | 500 MHz to 3 MHz | 10 kHz | Active Monopole | Vertical | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |

**Table 6-1**
## Radiated EMI Test Run List

| Band | Measurement Range | Resolution Bandwidth | Antenna | E-field | Test ID | Operating Mode | Description |
|---|---|---|---|---|---|---|---|
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B3 | 2.5 MHz to 7.5 MHz | 10 kHz | Active Monopole | Vertical | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B4 | 5 MHz to 30 MHz | 10 kHz | Active Monopole | Vertical | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B5h | 25 MHz to 325 MHz | 100 kHz | Bilogical | Horizontal | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |

**Table 6-1**
## Radiated EMI Test Run List

| Band | Measurement Range | Resolution Bandwidth | Antenna | E-field | Test ID | Operating Mode | Description |
|---|---|---|---|---|---|---|---|
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B5v | 25 MHz to 325 MHz | 100 kHz | Bilogical | Vertical | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B6h | 300 MHz to 1.3 GHz | 100 kHz | Bilogical | Horizontal | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B6v | 300 MHz to 1.3 GHz | 100 kHz | Bilogical | Horizontal | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |

**Table 6-1**
## Radiated EMI Test Run List

| Band | Measurement Range | Resolution Bandwidth | Antenna | E-field | Test ID | Operating Mode | Description |
|---|---|---|---|---|---|---|---|
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B7h | 1.0 MHz to 6.0 GHz | 100 kHz | Bilogical | Horizontal | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |
| B7v | 1.0 MHz to 6.0 GHz | 100 kHz | Bilogical | Horizontal | R1 | N/A | No Crane Car Present |
| | | | | | R2a | Battery Mode | Crane Operations, High Current Draw |
| | | | | | R2b | | Crane Operations, Low Current Draw |
| | | | | | R2c | | Trolley Operations |
| | | | | | R2d | | Crane Operations, Pass MP at 2 mph |
| | | | | | R2e | | Crane Operations, Pass MP at 2 mph, Opposite Direction |
| | | | | | R3 | Hybrid Mode | Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw |
| | | | | | R4a | Diesel Mode | Switch from OFF to Diesel Mode, Pass MP at 2 mph |
| | | | | | R4b | | Switch from Diesel to Hybrid Mode, Pass MP at 2 mph |

## 6.4 Test Run Notes

The test team will follow all Arva and NYCT Operating Rules, including the maximum safe operating speed on the ETT and requirements for rigging and hoisting. The test team expects early test runs will establish there is no influence solely from Crane Car direction on Radiated emissions. If there is no influence from direction, direction for subsequent test runs will be selected to maximize emissions at the MP.

Appendix B provides a list of controls to operate the Crane Car. The test team will use the appropriate ones per the test run requirements.

# 7 Radiated EMI Test Method

## 7.1 Radiated EMI Pass / Fail Criterion

The objective of the RET is to demonstrate that the worst-case emissions of a Crane Car must not exceed the greater of the NYCT ambient or the specified amplitude in the specified frequency ranges, either for a duration or with a repetition interval significant for nearby equipment. Figure 7-1 shows the limits specified in Section 5.3.2 of the ESWC.

**Figure 7-1**

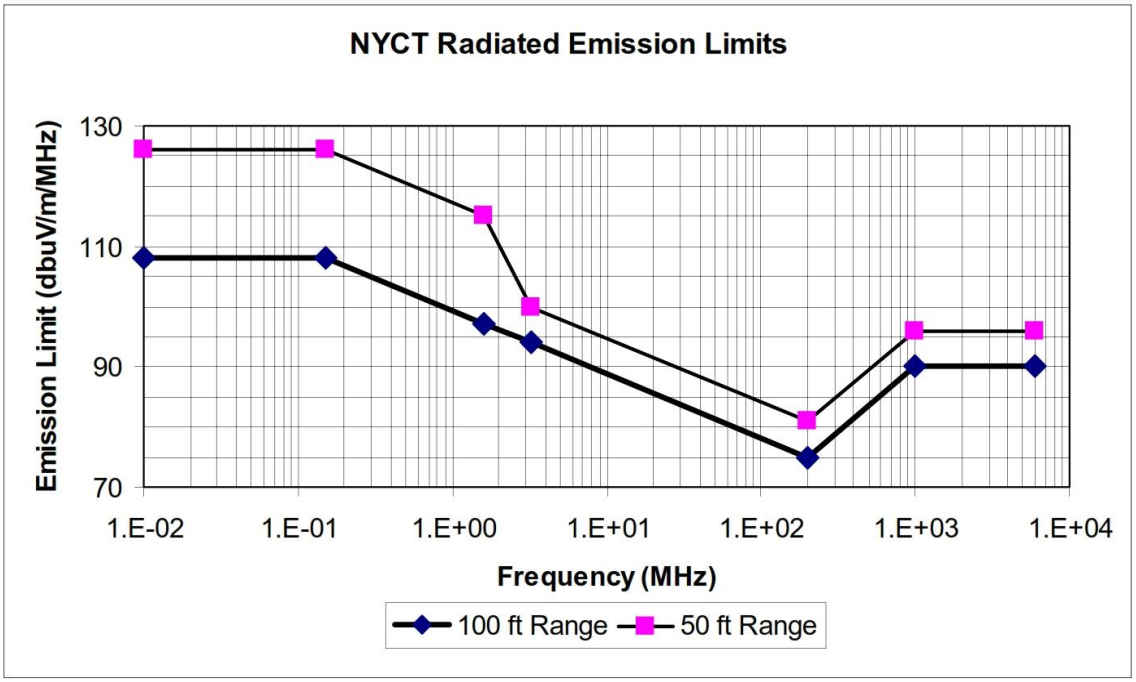



Table 7-1 provides the radiated emission limits given in Section 5.3.2 of the ESWC.

**Table 7-1**
**NYCT AC Train Radiated Emission Limits**

| Frequency Range (Hz) | Limit at 50 ft (dBµV/m/MHz) | Limit at 100 ft (dBµV/m/MHz) |
|---|---|---|
| 10 kHz | 126 | 108 |
| 150 kHz | 126 | 108 |
| 1.6 MHz | 115 | 97 |
| 3.2 MHz | 100 | 94 |
| 200 MHz | 81 | 75 |
| 1.0 GHz | 96 | 90 |
| 6.0 GHz | 96 | 90 |

To identify broadband Crane Car emission levels observed at a particular frequency and polarization as distinct Crane Car emissions, the emission levels must exceed the corresponding observed ambient broadband level by 10 dB or more. The frequency in question must be at least twice the impulse bandwidth from any ambient narrowband signal producing receiver output greater than the observed broadband emission levels. If a questionable signal is found that would be excluded under these criteria, the test team will retest it later under similar conditions in an attempt to find a lower ambient condition and determine whether the signal is actually ambient or a Crane Car emission.

Some rail lines have test locations where the maximum useful distance between track centerline and antenna is only about 30 ft (10 m). It is possible to use a location with only 30 feet of space from the track centerline, if no better location is available. If the available test location requires the test team to measure at around 30 ft (10 m), and the measured levels exceed the specified limits or the compensated limits above, the test team will use additional correction factors similar to those in the RSTP to adjust field measurements for comparison with the specification levels.

## 7.2 Test Run Instructions

The test team will perform the following test instructions when measuring Radiated emissions with the Crane Car standing, and operating while passing the MP at 2 mph, with the objective of obtaining worst-case data:

1. With the Crane Car, run each test type for each band, as shown in Table 6-1.
2. Perform the tests for the three different modes: Battery Mode, Hybrid Mode, and Diesel Mode

The test set-up for data collection is in RETP section 5.

## 7.3 Test Repetitions

Make sufficient runs for the principal test features to ensure that results are consistent under similar test conditions. If data in some test indicates strongly that another later test will not produce greater levels of interference, the later test need not be performed, or can be modified. Record the justification for not performing the test on the appropriate form.

## 7.4 Field Reduction of Data

The test team will set up the spectrum analyzer to account for antenna factors, calibration factors, gain, and conversion units so that the emission amplitudes are recorded in dBµV/m/MHz. The test team will plot or print the spectrum analyzer data on completion of each frequency test run, annotating the test results as appropriate.

Data for Crane Car emissions and ambient levels will be regarded as invalid at frequencies at which the receiver accuracy is affected adversely by spurious response or lack of sufficient receiver sensitivity.

# 8 Test Data Collection

The test team will collect and maintain data from the RET, including for test equipment calibration, test set-up calibration, and each test run. Sample Radiated emissions field test forms are shown in Appendix A.

## 8.1 Equipment Calibration

The test team will record calibration data for each major test equipment item. Calibration data will include:

- Test Equipment Item
- Provided By (Tenco, or other)
- Manufacturer, Model, and Serial Number
- Calibration Date, Calibration Source and Reference Number
- Notes.

## 8.2 Test Set-Up

The test team will document correct operation for all instruments.

Measurement will be made using the peak hold averaging mode on the spectrum analyzer while the Crane Car is passing the MP or while ambient measurements are being made.

Min/Max Hold or Quasi-peak detector functions will be used to distinguish broadband and narrowband, continuous versus discontinuous emissions.

For each frequency sub-band, the test team will test the car for the following test operating conditions:

R0 Calibration
R1 Ambient with no Crane Car present
R2a Battery Mode – Crane Car standing and operating, high current draw
R2b Battery Mode – Crane Car standing and operating, low current draw
R2c Battery Mode – Crane Car passing MP at 2 mph and operating
R2d Battery Mode – Crane Car passing MP at 2 mph and operating, opposite direction
R3 Hybrid Mode – Crane Car passing MP at 2 mph, high battery charging, max current draw
R4a Diesel Mode – Crane Car passing MP at 2 mph, switching from OFF to Diesel Mode
R4b Diesel Mode – Crane Car passing MP at 2 mph, switching from Diesel to Hybrid Mode.

The test team will frequently repeat the power-on ambient measurement R1 to document variations in the radiated ambient.

## 8.3 Test Run Log

The test team will maintain a test run log, recording the following for each test run:

- Date and Time
- Performed By
- Location
- Crane Car Configuration, including loading
- Run #
- Identification # for plot
- Test Type, including operating mode
- Run Description, including from/to
- Test Configuration Data, such as gain settings
- Summary Results
- Notes.

See the Test Run Log and Directory of Test Run forms in Appendix A.

# 9 Test Report Format

The test team will document the test in a Radiated EMI Test Report compatible with this RETP. The Test Report will consist of sections including or equivalent to the following:

**Section 1, Introduction:** The Introduction section provides the purpose, scope, applicable requirements, participants, reference documents including car configuration documentation, test procedure overview, and organization for the rest of the report.

**Section 2, Test Results and Conclusions:** The Test Results and Conclusions section:

- Identifies the Crane Car operations and Auxiliary worst-case conditions
- Documents the Crane Car worst-case emissions for each condition
- States whether or not the worst-case emissions exceed the single-car emissions limits
- Summarizes the test schedule and scope
- Provides a top level index of all test runs
- Identifies, references, and describes the most important results
- Clearly states conclusions

**Section 3, Crane Car Configuration Under Test:** The Crane Car Configuration Under Test section states the as-tested configuration of the Crane Car relevant to EMI; and the values of any items or parameters which could affect EMI performance.

The Crane Car Configuration Under Test section may reference other NYCT documents such as a design document or a configuration control drawing to specify parameters.

**Section 4, Test Track:** The Test Track section describes the as-tested test track configurations on the ETT. This section notes any differences or modifications to the ETT configuration described in section 4 of this procedure.

**Section 5, Test Equipment Configuration:** The Test Equipment Configuration section describes the as-performed test equipment configuration, including a detailed connection diagram of the test equipment setup, the list of test equipment with model numbers, and instrument calibration dates and calibration certificates.

The Test Equipment Configuration section provides complete information on the scale or conversion factors which apply to all test data. It also provides initial setup calibration data including Signal Analyzer plots which demonstrate that the FFT Signal Analyzer and external instruments give correct, accurate, and repeatable results.

**Section 6, Test Procedure:** The Test Procedure section summarizes the test steps, and describes any differences between the "as-performed" test steps and this RETP.

**Section 7, Test Runs and Data:** The Test Runs and Data section describes significant test results, conclusions, or considerations. This section summarizes all data collected during the test. It includes a list, log, or index of all test runs, print outs, and spectral plots. It includes the Date, Performed by, Location, and Crane Car Configuration for all tests.

For each test it provides the Test Run Number, Test Type, Time, and plot; Test Run description; test configuration data such as gain settings; summary result; and notes. The Test Runs and Data section provides all appropriate test data, such as plots, logs, and other support information supporting the test results and conclusions.

# Appendix A

# Radiated Emissions Field Test Forms

The following Radiated emissions field test forms are attached:

- Test Equipment Calibration Record
- NYCT Crane Car Configuration Record
- NYCT Crane Car Radiated EMI Field Test Run Log
- NYCT Crane Car Radiated EMI Test Run Directory
- Test Site Plan

**Recorded by:** _____ **Date:** _____

| NYCT Crane Car Radiated EMI Test Equipment Calibration Record | | | | |
|---|---|---|---|---|
| **#** | **Item** | **Manufacturer** | **Model/Serial Number** | **Calibration / Date** |
| 1 | RF Spectrum Analyzer | Keysight | KT-N9010A-513/P13 10Hz-13.6GHz EXA Signal Analyzer | |
| 2 | Benchlink PC Software | Agilent Technologies | E4444A for E4404 Series, or equivalent | |
| 3 | Printer | Hewlett Packard | HP3747, or equivalent | |
| 4 | Active Monopole Antenna 10 kHz to 60 MHz | A.H Systems | SAS-550-1, or equivalent | |
| 5 | Bilogical Antenna 25 MHz to 7000 MHz | A.H. Systems | SAS-521F-7, or equivalent | |
| 6 | Laptop computer | Toshiba | 2805-S302, or equivalent | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |

**Recorded by:**_____ **Date:** _____

**Time:**_____

## NYCT Crane Car Configuration Record

| # | Item | Supplier | Configuration | Comment |
|---|---|---|---|---|
| 1 | Diesel Engine | Cummins | | |
| 2 | Diesel Engine Starter | Cummins | | |
| 3 | Diesel Engine Alternator | Cummins | | |
| 4 | Diesel Engine Grid Heater | Cummins | | |
| 5 | Hybrid Module | Transfluid | | |
| 6 | Electric Motors | Transfluid | | |
| 7 | 96 VDC Batteries | Transfluid | | |
| 8 | System Control | Transfluid | | |
| 9 | Battery Charger | Transfluid | | |
| 10 | HVAC | Kenway | | |
| 11 | HVAC Speed Sensor | Kenway | | |
| 12 | Emergency Hydraulic Pump | Sunsource | | |
| 13 | Wiper Motor | AM Equipment | | |
| 14 | Hydraulic Oil Cooler | Copper Core | | |
| 15 | Electric Fan for Motor Drives | Transfluid | | |

| NYCT Crane Car Configuration Record | | | | |
|---|---|---|---|---|
| # | Item | Supplier | Configuration | Comment |
| 16 | DC-DC Converter | Transfluid | | |
| 17 | Internal DC-DC Converter | Littlefuse | | |
| 18 | Solar Charger System | Pulse Tech | | |
| 19 | Fire Suppression Kit | Ansul | | |
| 20 | Camera System | Safe Fleet | | |
| 21 | Hybrid Air Pack | Transfluid | | |
| 22 | PVG Valve | Sunsource | | |
| 23 | Hawe Valve | Hydra-Fab | | |
| 24 | HVAC Flow Control Valve | Sunsource | | |
| 25 | Trolley Brake Release Valve | Sunsource | | |

# NYCT Crane Car Radiated EMI Field Test Run Log

**Date / Time:** _____ **Weather:** _____ **Performed By:**_____

**Crane Car Configuration:** _____ **Location:**_____

| Test Run ID | Time | Test Series / Test Type | Frequency Band | Crane Car Configuration, Faults, and Notes | From / To / Note | Results |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Date:** _____ **Time:** _____ **Performed By:** _____

**Crane Car Configuration:** _____ **Location:** _____

# NYCT Crane Car Radiated EMI Test Run Directory

| Run Type | | Frequency Band | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **B0: 10 to 160 kHz** Monopole Vertical 1 kHz res bw (or 200 Hz) | **B1: 150 to 650 kHz** Monopole Vertical 10 kHz res bw | **B2: 500 kHz to 3 MHz** Monopole Vertical 10 kHz res bw | **B3: 2.5 to 7.5 MHz** Monopole Vertical 10 kHz res bw | **B4: 5 to 30 MHz** Monopole Vertical 10 kHz res bw | **B5: 25 to 325 MHz (Note V or H polarity)** Bilogical, 100 kHz res bw | **B6: 0.3 to 1.3GHz (Note V or H polarity)** Bilogical, 100 kHz rbw | **B7: 1.0 to 6.0GHz (Note V or H polarity)** Bilogical, 100 kHz rbw |
| **R0** | Calibration | | | | | | | | |
| **R1** | No Crane Car | | | | | | | | |
| **R2a** | Battery Mode Crane Operations High Current Draw | | | | | | | | |
| **R2b** | Battery Mode Crane Operations Low Current Draw | | | | | | | | |
| **R2c** | Battery Mode Trolley Operations | | | | | | | | |
| **R2d** | Battery Mode Crane Operations Pass MP at 2 mph | | | | | | | | |

# NYCT Crane Car Radiated EMI Test Run Directory

| Run Type | | Frequency Band | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **B0: 10 to 160 kHz** Monopole Vertical 1 kHz res bw (or 200 Hz) | **B1: 150 to 650 kHz** Monopole Vertical 10 kHz res bw | **B2: 500 kHz to 3 MHz** Monopole Vertical 10 kHz res bw | **B3: 2.5 to 7.5 MHz** Monopole Vertical 10 kHz res bw | **B4: 5 to 30 MHz** Monopole Vertical 10 kHz res bw | **B5: 25 to 325 MHz (Note V or H polarity)** Bilogical, 100 kHz res bw | **B6: 0.3 to 1.3GHz (Note V or H polarity)** Bilogical, 100 kHz rbw | **B7: 1.0 to 6.0GHz (Note V or H polarity)** Bilogical, 100 kHz rbw |
| **R2e** | Battery Mode Crane Operations Pass MP at 2 mph Opposite Direction | | | | | | | | |
| **R3** | Hybrid Mode Crane Operations, High Battery Charging, Pass MP at 2 mph, Max Current Draw | | | | | | | | |
| **R4a** | Diesel Mode Switch from OFF to Diesel Mode, Pass MP at 2 mph | | | | | | | | |
| **R4b** | Diesel Mode Switch from Diesel to Hybrid Mode, Pass MP at 2 mph | | | | | | | | |
| | Worst Cases | | | | | | | | |

**Date:** _____**Time:** _____ **Performed By:** _____

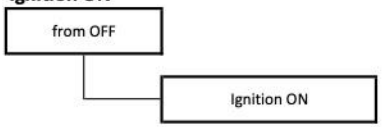
**Crane Car Configuration:** _____ **Location:**_____

# NYCT Crane Car Radiated EMI Site Plan

# Appendix B

# NYCT Crane Car – List of Controls

**Ignition ON**




| *Action* | *Conditions/Requirements* | *Output/Response* |
|---|---|---|
| Ignition ON - Hardwired Toggle (2 POS) | | Turn ON Run/Ignition Relay |
| | battery switch closed | Supply Power to: Display, HVAC, Windows, Wipers, Lights, LMI, TF |
| | E-stops circuit (including Fire Supp Pressure SWs) must be complete/ok. | |

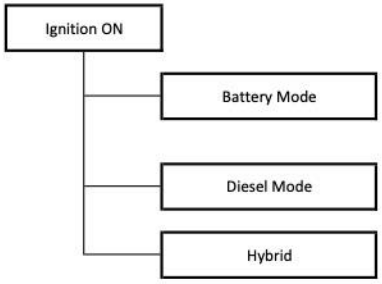
**Selecting a Power Mode**

Arva to control
(if Transfluid controlled this, there wouldn't be any interlocks when changing modes while craning, which we require)

Battery Only
Motors power the pumps
TF dc/dc converter supplies 24 V power
The dc-dc has an enable signal. Arva can manage this signal and turn it off when in diesel only
TF Clutch disengaged - TF to send CANbus signal to Arva confirming that the clutch is disengaged and 'safe to run in battery mode'

Diesel Only
Diesel engine power the pumps
Diesel engine (alternator) supplies 24 V power
The 96v to 24v diesel battery converter is OFF
The dc-dc has an enable signal. Arva can manage this signal and turn it off when in diesel only
TF Clutch engaged - TF to send CANbus signal to Arva confirming that the clutch is engaged and 'safe to run in diesel mode'

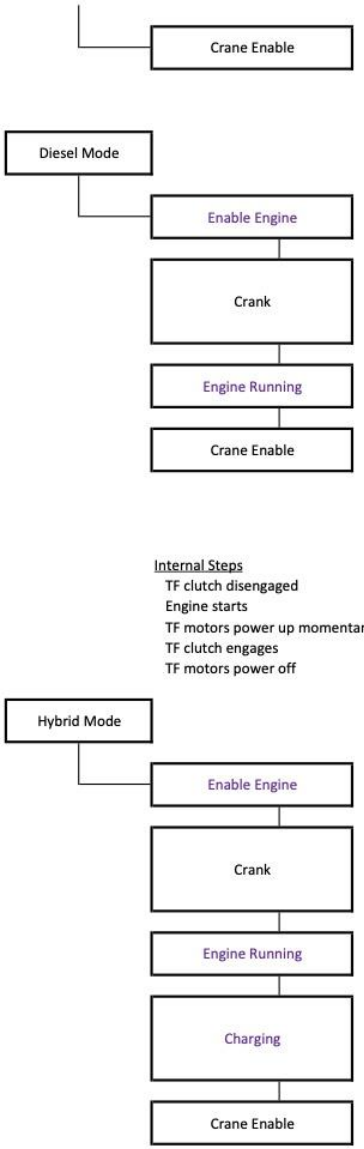
Hybrid (Regen)
Diesel engine powers the pumps
Diesel engine (alternator) supplies 24 V power
The 96v to 24v diesel battery converter is OFF
The dc-dc has an enable signal. Arva can manage this signal and turn it off when in diesel only
TF Clutch engaged - TF to send CANbus signal to Arva confirming that the clutch is engaged and 'safe to run in hybrid mode'
Diesel engine also powers the Motors to charge TF battery
Based on a CAN signal from Arva, TF will switch between 3 Charge settings.
Arva will monitor Craning commands and relay a CAN message to TF on which setting to use.
LOW, MEDIUM, OR HIGH charging signal from Arva




Transfluid to send battery percentage by CANbus to Arva all of the time

| | |
|---|---|
| Battery Mode - hold 0.25 Sec (CANbus button in CAB Bank) | Displayed on Arva Screen |
| Only when Crane Controls and other Arva or Transfluid interlocks NOT active | |
| Arva to send TF a CANbus signal of required electric motor RPM, Arva will limit this to 3 settings, 0 rpm, 1800 rpm, and 2400 rpm | |
| Diesel Mode - hold 0.25 Sec (CANbus button in CAB Bank) | Displayed on Arva Screen |
| Only when Crane Controls and other Arva or Transfluid interlocks NOT active | |
| Hybrid Mode - hold 0.25 Sec (CANbus button in CAB Bank) | Displayed on Arva Screen |
| Only when Crane Controls and other Arva or Transfluid interlocks NOT active | |

**Moving from Power Mode Select to Craning**




Crane Enable Switch - hold 0.25 Sec (CAB Bank)
Battery Mode Active
TF to send signal "safe to run" (D21)

Crane functions active
Deactivate other Mode Buttons
Displayed on Arva Screen

Diesel Mode active

Engine Start/ON signal enabled

Crank - hold (CAB Bank)
Arva will send the signal to crank the engine
Diesel Mode active
Engine has its own crank lockout

Engine speed above 400 rpm

Crane Enable Switch - hold 0.25 Sec (CAB Bank)
Diesel Mode Active & Engine Running
TF to send signal "safe to run" (D26)

Crane functions active
Deactivate other Mode Buttons
Displayed on Arva Screen

Internal Steps
TF clutch disengaged
Engine starts
TF motors power up momentarily (match engine speed)
TF clutch engages
TF motors power off

Hybrid Mode active

Engine Start/ON signal enabled

Crank - hold 0.25 Sec (CAB Bank)
Arva will send the signal to crank the engine
Hybrid Mode active
Engine has its own crank lockout

Engine speed above 400 rpm

Based on a CAN signal from Arva, TF will switch between 3 Charge settings.
Arva will monitor Craning commands and relay a CAN message to TF on which setting to use.
LOW, MEDIUM, OR HIGH charging signal from Arva

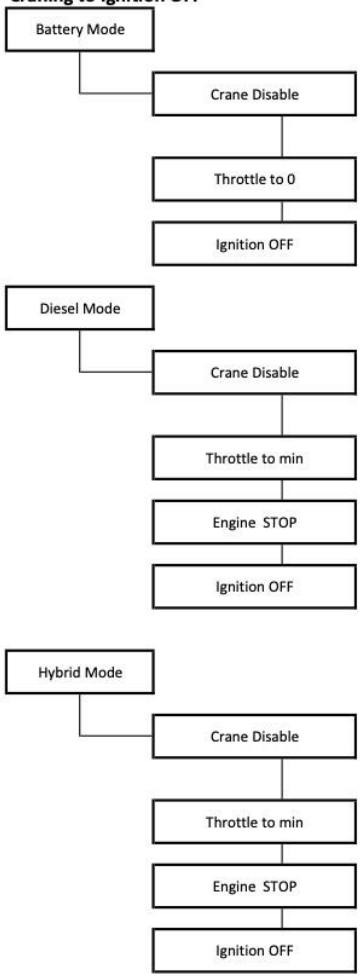
Crane Enable Switch - hold 0.25 Sec (CAB Bank)
Hybrid Mode Active & Engine Running
TF to send signal "safe to run" (D31)

Crane functions active
Deactivate other Mode Buttons
Displayed on Arva Screen

Internal Steps

TF clutch disengaged
Engine starts
TF motors power up momentarily (match engine speed)
TF clutch engages

**Craning to Ignition OFF**




Crane Enable - hold 0.25 Sec (CAB Bank)
Or:
Battery Mode Active

Crane functions active
Deactivate other Mode Buttons
Displayed on Arva Screen

Hold toggle for 0.25 Sec
Arva to send TF CANbus signal for 0 rpm on electric motors

Signal to TF to stop motors

Ignition OFF - Hardwired Toggle (2 POS)

Turn OFF Run/Ignition Relay
Cuts Power to: Display, HVAC, Windows, Wipers, Lights, LMI, Transfluid

Crane Enable - hold 0.25 Sec (CAB Bank)
Diesel Mode Active & Engine Running

Crane functions active
Deactivate other Mode Buttons
Displayed on Arva Screen

Toggle all Down

Engine OFF - hold 0.25 Sec (CAB Bank)

Engine Start/ON signal cut
Engine Stops

Ignition OFF - Hardwired Toggle (2 POS)

Turn OFF Run/Ignition Relay
Cuts Power to: Display, HVAC, Windows, Wipers, Lights, LMI, Transfluid

Crane Enable - hold 0.25 Sec (CAB Bank)
Hybrid Mode Active & Engine Running

Crane functions active
Deactivate other Mode Buttons
Displayed on Arva Screen

Toggle all Down

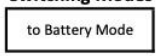
Engine OFF - hold 0.25 Sec (CAB Bank)

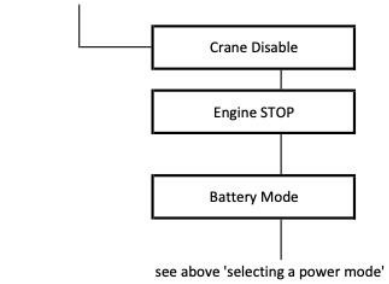
Engine Start/ON signal cut
Engine Stops

Ignition OFF - Hardwired Toggle (2 POS)

Turn OFF Run/Ignition Relay
Cuts Power to: Display, HVAC, Windows, Wipers, Lights, LMI, Transfluid

**Switching Modes**






Crane Enable - hold 0.25 Sec

Activate other Mode Buttons
Displayed on Arva Screen

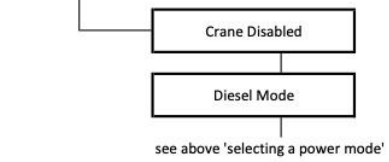
Engine OFF - hold 0.25 Sec (CAB Bank)

Engine Start/ON signal disabled

Battery Mode - hold 0.25 Sec
Only when Crane Controls NOT active
Engine must be off

Displayed on Arva Screen

to Diesel Mode



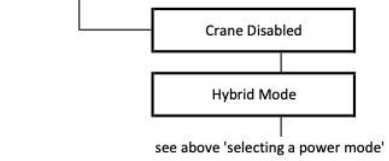

Crane Enable - hold 0.25 Sec

Activate other Mode Buttons
Displayed on Arva Screen

Diesel Mode - hold 0.25 Sec
Only when Crane Controls NOT active

Displayed on Arva Screen

to Hybrid Mode




Crane Enable - hold 0.25 Sec

Activate other Mode Buttons
Displayed on Arva Screen

Hybrid Mode - hold 0.25 Sec
Only when Crane Controls NOT active

Displayed on Arva Screen

When switching from Diesel to Hybrid (and vice versa):
The engine will remain ON
The engine will remain at the current speed

When switching Modes, we can keep the pumps operating at their current speed
The clutch CAN disengage at speed (we do NOT need to lower RPM to disengage)

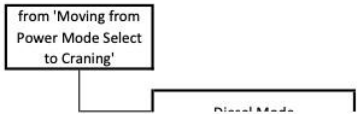
Arva requires that the Crane Controls are OFF is to ensure operator is not Craning (safe to change)

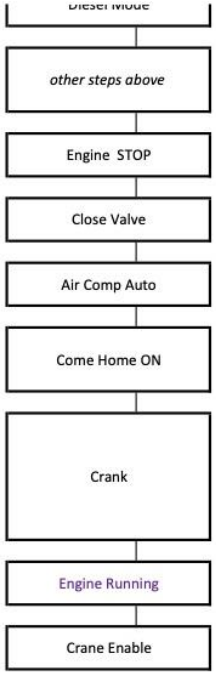
**Come Home**

**Procedure 1 (TF control system still active)**

Used if there is a fault with TF 96 V system (motors or batteries) & TF control system still active.

If we press a mode button and do not get 'safe to run' from transfluid, we will post an error message on the Arva screen






Engine OFF - hold 0.25 Sec (CAB Bank)
Only if running

Engine Start/ON signal cut
Engine Stops

Close ball valve on TF transmssion

AUTO MANUAL

Verify Air Compressor Switch set to Auto on TF air compressor

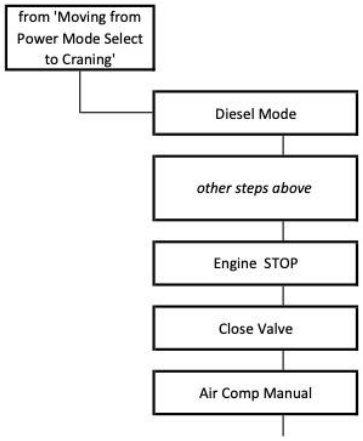
Come Home Button - hold 2 Sec (CAB Bank), Arva takes this input and send TF a CANbus signal to activate 'come home'
Diesel Mode active
Engine NOT running

Crank - hold 0.25 Sec (CAB Bank)
Arva will send the signal to crank the engine
Diesel Mode active
**Come Home ON**
**Arva to receive CAN message from TF safe to continue with Come Home Mode**
Engine has its own crank lockout

Engine speed above 400 rpm

Note: There are two Come Home inputs to TF. We might need to start engine with only 1 active, then activate second if engine cannot crank with clutch engaged

**Procedure 2 (TF control system NOT active)**
Used if there is a fault in the TF control system.



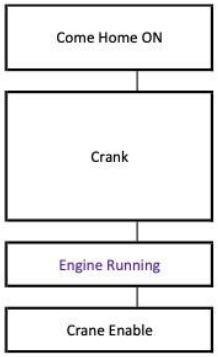

Engine OFF - hold 0.25 Sec (CAB Bank)
Only if running

Engine Start/ON signal cut
Engine Stops

Close ball valve on TF transmssion

Verify Air Compressor Switch set to Manual on TF air compressor

AUTO MANUAL



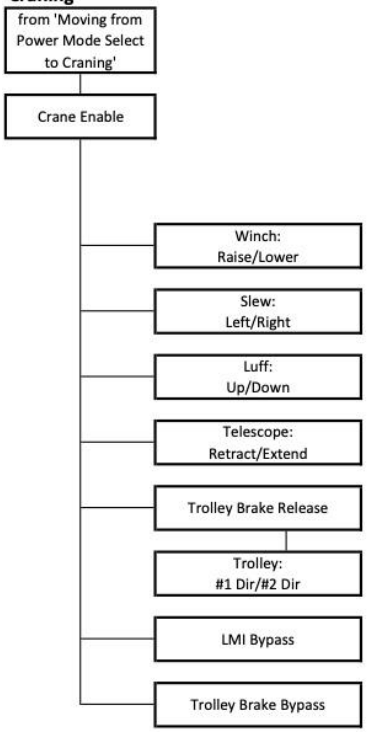

TF Come Home Button - hold 1 Sec (CAB Bank)
Diesel Mode active
Engine NOT running

Crank - hold 0.25 Sec (CAB Bank)
Arva will send the signal to crank the engine
Diesel Mode active
**Come Home ON**
**Operator input on screen (TF system NOT active)**
Engine has its own crank lockout

Engine speed above 400 rpm

Note: There are two Come Home inputs to TF. We might need to start engine with only 1 active, then activate second if engine cannot crank with clutch engaged

**Craning**




Crane Enable - hold 0.25 Sec (CAB Bank)

Joystick (LH Pull/Push)

Joystick (LH Left/Right)

Joystick (RH Pull/Push)

Joystick (RH Left/Right)

Trolley Brake - hold 0.25 Sec to change state (CAB Bank)

Pedal (FWD/REV)

LMI Bypass - hold 2 Sec (CAB Bank)

Trolley Bypass - on operator screen

**Accs**


Ignition ON
Work Lamp: Boom
Work Lamp: Turret Front
Work Lamp: Turret Rear
Window Heater: Front
Window Heater: Top
Window Heater: Side
Wiper
HVAC
CAN Button - hold 0.25 Sec to change state (CAB Bank)
CAN Button - hold 0.25 Sec to change state (CAB Bank)
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CAN Button - hold 0.25 Sec to change state (CAB Bank)
CAN Button - hold 0.25 Sec to change state (CAB Bank)
Hardwired
Hardwired
for heat or AC motors or Engine running