**TAB I.4 - QUALITY ASSURANCE PLAN**

A. The Offeror is to provide an outline of the Quality System Manual and Project Quality Plan requirements stipulated in T 19.02 and T 19.03 of the Technical Provisions within Part B of its proposal. The outline should include details of approach, organization, sample procedures, sample documentation, and feedback mechanisms for all phases of the program (design, manufacture, final assembly, test/commissioning, warranty).

**PART I: QUALITY SYSTEM MANUAL OUTLINE**

This outline describes the organization and contents of Hyundai Rotem’s Quality System Manual (QSM). The complete QSM provides all process details, which are summarized in this outline. Hyundai Rotem’s Quality System conforms to ANSI/ISO/ASQ 9001-2008.

1. **Quality Policy**

   All employees of Hyundai Rotem shall maintain high quality awareness, with the goal of continuous improvement. All managers and supervisors have responsibility to continuously promote quality awareness for all employees.

2. **QSM Purpose**

   The QSM provides a time-tested framework for guiding management review, design and document control, production, equipment procurement, subcontractor management, customer satisfaction, corrective and preventive action, and process improvement on all projects. The QSM provides standard work processes to assure staff across all functional groups understand their responsibilities, and understand how to hand off information to other functional groups, while maintaining compliance with customer requirements, company standards, and statutory regulations. Hyundai Rotem’s QSM is to be applied on stages of all projects, including: design, material supply, production, First Article Inspection, delivery, testing/commissioning and warranty.

3. **QA/QC Organization**

   The Hyundai Rotem QA/QC organization and main responsibilities are described in Figure 1.
Figure 1 – QA/QC Team Organization and Responsibilities

**Quality Management Division**
(Mr. K.D. Kyung, QM General Director)

- Company-wide Quality Planning
- Management of Company Quality System
- Quality Audit (Subsupply)

**Quality Planning Team**
(Mr. H.S. Kim, General Manager)

- Advanced Quality Director
(Mr. M.S. Choi)

- General management of advanced quality control

- Advanced QC Team
(Mr. K.C. Youm, General Management)

- Feed-back & Improvement of Past Projects Quality Issues
- Quality Improvement at Initial Production Stage of Vehicle
- EQC : QC for Electronic/Electrical Equipment

- Advanced EQC Team
(Mr. D.S. You, General Management)

- CS Team
(Mr. Y.G. Son, General Management)

- Quality Assurance Team
(Mr. H.W. Kim, General Management)

- Drafting & control of QAP
- Quality Audit

- Quality Assurance Director
(Mr. K.S. Chae)

- Quality Management Representative the project

- Quality Assurance Team
(Mr. H.W. Kim, General Management)

- Quality Control Team
(Mr. S.J. Cho, General Management)

- Part QC

- Carbody & Bogie QC

- Outfitting QC

- CS Team
(Mr. Y.G. Son, General Management)

- Testing & Commissioning
(Chang-Won Factory)

- System Assurance during warranty period

- Testing, Commissioning & DLP
Team (DMRC Depots, Delhi)
(Mr. BK Kim)

- Functional tests of Vehicles
- Static & Dynamic test of train
- Pre-delivery inspection (Function Test part)
- Car History Book of Test & Commissioning

- After sales service(A/S) during warranty period
- Reception/feedback/action for Employer's quality feedback
- Analysis of field quality

- Functional tests of Vehicles
- Static & Dynamic test of train
- Commissioning test at Main-Line
4. Management Review

Management review of quality procedures & processes, implementation, and improvement occurs at several levels within Hyundai Rotem. The overall planning of the company quality processes, documentation, and direction is provided by the Quality Planning Team. The Advanced Quality Team looks at improvements of the Quality System based on feedback from all projects and production processes, including mechanical, electrical and software issues.

The Quality Assurance Director has overall management of the Quality Assurance Team, the Quality Control Team, and the Commissioning & Service Team. Each team manages a specific area of quality, and the feedback from all areas is continuously reviewed to improve the design, procurement, production, service, and training processes.

5. Design Control

5.1 Design Concept Development

The Design team defines the scope and targets for each design and development activity. For the vehicle design, a Vehicle Design Document (VDD) and Vehicle Interface Control Document (VICD) are created. The VDD describes the overall features and performance of the vehicle based on the performance requirements, customer specifications, industry standards and statutory/regulatory requirements related to the product. The VICD describes all the mechanical, electrical and software/control interfaces for the overall vehicle, married pair, train and all of the vehicle subsystems. From the VICD, an Interface Control Document (ICD) is created for each of the vehicle subsystems that define all of the interfaces for the specific subsystem.

Within the VDD, VICD and ICDs, the Design Team identifies relevant quality requirements to ensure the overall quality is achieved through the manufacturing and assembly processes. As the design progresses from conceptual design, preliminary design to final design, the VDD, VICD and ICDs are updated based on feedback from the customer, subcontractors, production, and Design Team to address all issues of the design, including performance, fit and functionality, ergonomics, safety, reliability, maintainability, and quality. Feedback is also received from testing and field service activities from the current project and also from previous projects where longer term data, especially relating to reliability and quality, is available.

All design documents, including the definition of relevant standards, contractual requirements, catalogue data, component specifications and all engineering calculations and analyses are maintained in the permanent project file through the Document Control system.

5.2 Design Reviews

At appropriate stages of design, documented internal design reviews are planned and conducted. Participants at each design review include representatives of all functions concerned with the design features being reviewed, as well as other specialist personnel, and subcontractor representatives as required. Records of all design reviews are maintained as design review meeting minutes and action items.

Formal design reviews will be conducted with the similar personnel as above and customer personnel. The formal design reviews will include:

1. Conceptual design review (CDR);
2. Preliminary design review (PDR);
3. Final design review (FDR).

Formal records of these meetings and the design decisions and action items will be distributed to all parties, and maintained in the permanent project file.

5.3 Design Verification

At appropriate stages of design, design verification is performed through analysis, test and measurement as appropriate. In addition to conducting design reviews, design verification may also include activities such as:

1) performing alternative calculations;
2) comparing the new design with a similar proven design, if available;
3) completing testing, mock-ups and prototype samples.

Final design validation is performed to ensure that the product conforms to defined user needs and/or requirements. The design of the vehicle/train is validated through the testing and commissioning on the revenue service line of the customer under actual service operation conditions.

5.4 Design Changes

All design changes and modifications are identified, documented, reviewed and approved by authorized personnel before their implementation.

If, during or after Pilot Train testing and commissioning, design changes, including software, are deemed necessary, Hyundai Rotem will submit such changes for customer approval and internal approval through an Engineering Change Notification (ECN). All supporting information will be provided, including reason for change, updated drawings and other documentation, modification plan and schedule, impacted production vehicles, detailed Field Modification Instructions (FMI) as appropriate, parts required, and any other data required to allow the Authority to fully evaluate any proposed design change.

6. Document Control

Documentation relating to the requirements of each contract and the quality system are subject to review and approval by authorized personnel prior to issue. Such documentation shall include, but not be limited to the Quality Management Plan (QMP), Inspection and Test Plan (ITP), Project Quality System Procedures, Work Instructions, Procedures, Specifications, Drawings, Inspection/Test Reports.

Access to this documentation is available for all work-site locations.

Obsolete documents are disposed of, or clearly identified as obsolete, or stored in a separate location identified for obsolete data.

Changes to the documentation will be reviewed and approved by the original functional authority as those personnel responsible for the original review and approval of the documentation. Changes will be identified on the concerned document.

All documentation must be identified by document number, revision, date, and have signatures that verify official release. Each Design Team manager and the Project Manager are responsible for review and approval of the outgoing documents and data.
6.1  **Internal Document Control**

Quality system documents issued by each team are reviewed and approved by authorized personnel in accordance with the Quality System Document Control Procedure (RMS-S201) and the Engineering Document Control Procedure (RMS-D207).

The latest approved quality system documents are maintained within the Groupware system of Hyundai Rotem. The documents can be accessed by all employees as required. A hardcopy can be used as information only.

6.2  **Control of Documents to be Submitted to the Customer**

Documents to be submitted to the customer include: drawings, design calculations, technical specifications, car schematics, wire lists, and software documents. Similar subcontractor documents will also be submitted.

7.  **Subcontractor Management**

The Purchasing team is responsible for purchasing items from the selected subcontractors. According to the purchasing requests from the relevant team, the team selects subcontractors.

To ensure, maintain and improve the quality of purchased products, the purchasing team shall control subcontractors by reviewing their delivery performance (faithfulness to schedule, quality).

7.1  **Purchase Order Technical Requirements**

All material and equipment that is purchased by Hyundai Rotem, is based on the technical description defined by the Design Team and any additional quality requirements defined by the Quality Assurance Team. The full requirements are described in the Purchase Order Requirements document, including where applicable, the following:

1)  Type, kind, grade or other details;

2)  Designation, specifications & drawings, production requirements, inspection instructions, technical data relating to evaluation and approval of alternate products, necessary production equipment and production staff qualifications;

3)  Designation, standard number, and issued year of quality system standard to be applied.

Specifies of PO requirements shall review the PO to determine if it is accurate and complete, and then approve the PO.

7.2  **Identification and Traceability of Product/Materials**

The Design team shall set up and document an arrangement for the identification of product/material which requires permanent identification and traceability, such as punching marks, cast batch no, name plate, etc. including product/material name, model name, work number, revision number and etc. to the extent required.

At incoming inspection (receiving inspection or source inspection), the quality control team shall confirm the identification of the purchased product/material such as by name, part number, order number, etc. as required by the procurement specification.
(1) For identification of the product/material being stocked in the warehouse, produced, tested/inspected and delivered, appropriate means (a traveler sheet, check sheet, relative drawing and etc.) shall be used to the extent necessary or required.

(2) If product traceability is required (e.g. to confirm parts are authentic), the inspector is required to confirm the requirement has been met as stated in the purchase order. Records concerned with traceability of material/product, if it is required contractually or needed to control, shall be maintained and controlled as quality record.

8. Production Process Control

Hyundai Rotem shall identify and plan the production, installation and servicing processes which directly affect quality, and shall ensure that these processes are carried out under controlled conditions.

8.1 Production Plan and Schedule Control

The production control team shall develop a production plan at the beginning of each month, and distribute it to relevant teams. The production plan shall take into account facility capacity, personnel capability, man loading, quality requirements, expected material deliveries, and the delivery plan.

The materials procurement team shall assure the materials demands of the production plan are met.

The quality control team shall prepare an inspection/test schedule based on the production plan.

8.2 Standard Work Procedures/Methods and Work Instructions

1) The Production Engineering team establishes the manufacturing program by issuing manufacturing documents as necessary such as work flowcharts or work flow block diagram, work process sheets and work instructions.

2) The QA/QC team issues the Inspection and Test Plan (ITP) in accordance with the design documents and manufacturing documents.

Work process sheets shall be revision-controlled documents. Production supervisors shall assure that production employees receive and use the latest manufacturing document revisions, including detailed work instructions and process instructions.

8.3 Control and Preservation of Production Facilities

Production equipment shall be periodically inspected and tested to ensure functionality and precision. The facility and equipment management team shall establish instruction sheets/check sheets to serve this need.

8.4 Control of Equipment, Personnel, and Work Environment

Production management shall assure all equipment and production personnel operate in an appropriate environment, including attention to temperature, humidity, air born contaminants.

8.5 Special Processes

The scope of special processes includes: welding, painting, heat treatment, non-destructive testing and cable harness crimping. The followings steps must be performed for all special processes:

(1) Approval of the process and monitoring;
8.6 Process Improvements

Where it is necessary to make any quality-affecting change in the product or component manufacturing process, changes shall be defined by the design team through revised drawings, and any changes in the manufacturing processes shall be defined by the production engineering team using revised Instruction sheets and other documents.

Any post-FDR process changes that affect materials or components need to be approved according to the ECN process.

Records related to process control such as facility checks, qualification of workers, approval of processes, monitoring, etc. are maintained and controlled as quality records.

9. Calibration of Tools, Inspection and Test Equipment

This chapter defines the control of inspection, measuring, and test equipment.

9.1 General

Measuring and test equipment shall be calibrated (and/or validated) in accordance with documented procedures to demonstrate equipment conformance. The extent and frequency of calibration (and/or validation) shall be established and the records shall be maintained as evidence of quality control.

Inspection, measuring and test equipment shall be used in a manner which ensures that the measurement uncertainty is known and is consistent with the required measurement capability.

If technical data pertaining to inspection, measuring, and test equipment is specified by customer requirements, such data shall be made available to equipment users and maintainers.

Test equipment calibration records are to be accessible at all times by staff and customer representatives.

9.2 Control Procedure

To comply with design requirements, production work instructions shall include essential measurements and other controls, which must be verified according QA check sheets. Each document developer shall specify appropriate inspection, measuring, and test equipment for assuring the required accuracy and precision are met.

Measurement equipment shall be calibrated (and/or validated) at prescribed intervals against a standard that is traceable to internationally or nationally recognized standards.

Where no such standard exist, the basis used for calibration and method shall be in accordance with the documented internal procedure/method.

Inspection, measuring and test equipment shall be identified with a suitable indicator or approved identification record to show the calibration status, and maintained within archived records.

10. Training
New employees are to be trained to understand the quality system and corporate ways of working.

Employees classified as laborers shall be evaluated for their capability to perform the expected work with the supplied equipment and documentation. Employees that lack necessary skills or knowledge are to be trained until they gain the required proficiencies.

11. Inspection and Testing

This section describes the procedures for inspection and test. Project-specific inspection and test documents shall be detailed in the Project Quality Plan.

11.1 Inspection and Test Plan (ITP)

The QC team and Test team, will jointly establish the project Inspection and Test Plan (hereinafter called ITP), which will be incorporated into the PQP. The ITP is to specify detailed inspections, testing, and commissioning requirements based on the customer specification, design documents, manufacturing flow, and systems information.

11.2 Incoming Receiving/Source Inspection and Test

1) The quality control team shall verify through inspection, testing, and evaluation of supplier’s documentation if incoming product complies with the Purchase Order requirements.

2) If the purchased material is source inspected, the verification will be performed by Hyundai Rotem or an authorized subcontractor according to Purchase Order requirements.

3) The quality control team must ensure that incoming product is not used or processed until it has been validated.

4) Quality control manager shall assure a qualified person has performed validation of the purchased item(s).

5) The PM is responsible for all outputs delivered for this project, and therefore is the final authority for assuring compliance with the design.

11.3 In-process Inspection and Test

1) Workers will first perform source inspection using documented procedures.

2) The QC team then will conduct the inspection and test in accordance with the ITP.

3) Product shall not be transferred to the next process or consigned until the required in-process inspections and tests have been completed unless agreed to by the customer and Hyundai Rotem.

11.4 Final Inspection and Test

1) The QC team shall carry out final inspection and testing per the ITP.

2) No cars shall be shipped until all the activities specified in the procedures have been satisfactorily completed and signed off, unless agreed to by the customer and Hyundai Rotem.

11.5 Site Test & Commissioning
Test & commissioning at site/depot shall be performed by Hyundai Rotem with customer participation per the requirements of the contract.

12. **Control of Non-Conforming Product**

Hyundai Rotem shall control non-conforming product to ensure that non-conforming products are prevented from unintended use or installation. This control process includes identification, documentation, evaluation, segregation (when practical), disposition of non-conforming product, and notifying applicable personnel.

12.1 **Identification, Documentation and Segregation**

Any team that detects a non-conforming product during manufacturing, inspection or test shall issue and transmit a Non-Conformity Report (NCR) to the Quality Control team. The non-conforming product shall be identified and segregated for disposition.

12.2 **Evaluation and Disposition**

For minor non-conformities, the evaluation and disposition of nonconformity can be decided at the site by the discussion between quality control team and relative teams.

For all but minor problems, non-conforming materials will be evaluated and dispositioned by a materials review board (MRB), consisting of the responsible staff members from design engineering, production engineering, materials group, and QC.

Disposition of non-conforming product is classified as follows:

1) Reclassified as conforming;
2) Concession;
3) Use as is;
4) Repair;
5) Rework;
6) Scrap;
7) Claim;
8) Conditional use;
9) Hold pending future decision.

According to the results of the meeting with relative team, the responsible team shall carry outs next activities.

In case of Concession, it shall be handled in accordance with the documented procedure for the issue, review and approval.

In case of repair, if necessary, the repair procedure shall be prepared by responsible team. The repaired and reworked nonconforming product shall be re-inspected to ensure that it conforms to the specifications.

13. **Quality Audits**
Internal audits for the quality management system will be conducted at least once per year. External audits for quality management system of subcontractors will be conducted by Hyundai Rotem on a yearly basis.

13.1 Quality Audit Procedures

The quality planning team, QA team, and Advanced QC/EQC team prepare an audit plan. The audit plan is notified to the organizations to be audited at least 1 week prior to the audit.

The audit plan structured considers the status and importance of the processes, and areas to be audited, as well as the results of previous audits.

The audit will cover all areas of operations during the year of audit.

The audit shall be carried out by personnel independent of those having direct responsibility for the activity being audited.

The results of the audits shall be recorded and brought to the attention of the personnel having responsibility in the area audited.

If a non-conformance is detected during the audit, audit non-conformity report shall be issued to the responsible organization.

The responsible organization shall take timely corrective action on the non-conformity and submit the evidence of action table evidence of action taken to be the auditor for verification and confirmation of satisfactory implementation.

For preventive actions training, periodical check & review will be conducted.

The auditor shall verify the implementation and effectiveness of the corrective action by performing a follow-up audit and/or review of the evidence submitted by the responsible party.

The audit result will be used as an input data for management review.

14. Failure Reporting and Corrective Action System (FRACAS)

Hyundai Rotem shall maintain procedures for implementing corrective action. Any corrective action shall be proposed in an engineering change request. The proposed change is then evaluated to determine the likelihood of success. Evaluation may include prototyping and demonstrating the change on a sample of the equipment. If the demonstration is successful, then the change could be approved, then the related documentation changed, and finally the change implemented in accordance with a change instruction.

15. Customer Satisfaction

Hyundai Rotem shall maintain documented procedures for follow-up of all quality related aspects of the product with the customer, to ensure that all quality control processes and procedures are being implemented, and all known quality issues are addressed.

Corrective actions shall be conducted based on customer complaints and reports of product non-conformity. All feedback and complaints from customer on previous project also need to be taken as base for preventive action.
PART 2: PROJECT QUALITY PLAN

This section outlines the Project Quality Plan (PQP). To provide an understandable framework, baseline text is provided in standard font, while instructions and notes to be followed during final PQP development are provided in italics.

1. Introduction

This Project Quality Plan (PQP) specifies project-specific quality requirements for the MBTA Red and Orange Line New Vehicle Procurement project. Hyundai Rotem and all suppliers & subcontractors shall comply with this project plan. This PQP applies to all aspects of the project, including engineering, software development, procurement, manufacturing, testing & commissioning, transport, and quality control.

Project quality requirements are derived from the following:

- MBTA Technical Specification VE-10-036
- Request for proposal document CAP 27-10
- RFP addendums 1 through 10.

Quality aspects not specifically addressed in the MBTA requirements are governed by Hyundai Rotem corporate standards.

2. Project Description

This project includes the supply of the following new equipment and services. All deliverables are covered by this PQP.

- Orange line married-pair metro rail cars
- Red line married-pair metro rail cars
- List all other categories of deliverables, including: Rail bed RFID tags & programming equipment; Spare parts; Special tools & protocol analyzers; Diagnostic test equipment (PTEs, BTEs, DTEs) and corresponding software; Automated announcement workstations; Chip programmers and corresponding firmware; Escrowed software source code, development tools, and corresponding operating system software; Wayside wireless LAN system (including routers, servers, software), Manuals, Training (including training documentation and aids); Renderings, mockups, and models; Drawings & documentation; Training simulator...

3. Project Team Quality Responsibilities

All project participants are responsible for quality, including Hyundai Rotem employees, subcontractors, suppliers & OEMs, and MBTA project representatives. Quality control applies to the following disciplines:

1. Design & specify
2. Analysis

3. Software development

4. Document & data transfer and archiving

5. Production

6. Inspection & test

Primary responsibility for checking work resides with the initiator (e.g. designer, software developer, buyer, production worker, etc.) However, each of these tasks is subject to one or more additional verification & validation (V&V) checks. A V&V checklist is to be followed during each review to assure all primary aspects are covered. V&V responsibilities and lists of appropriate check lists are provided in this section.
3.1 Document and Data V&V Responsibility

Refer to Table 1 for a matrix of documentation V&V responsibilities.

<table>
<thead>
<tr>
<th>DOCUMENTATION TYPE</th>
<th>SELF CHECK</th>
<th>PRIMARY CHECKER</th>
<th>APPROVER</th>
<th>OTHER APPROVALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTS (Procurement Technical Specifications)</td>
<td>Engineer</td>
<td>System Engineer</td>
<td>Project Engineer</td>
<td>Quality Engineer</td>
</tr>
<tr>
<td>Drawings – Parts</td>
<td>Designer</td>
<td>Engineer</td>
<td>Lead ME</td>
<td></td>
</tr>
</tbody>
</table>

OTHER DOCUMENT TYPES TO BE LISTED: Drawings – Assembly, Drawings – Installation, Schematics – Piping, Schematics – Electrical, Wire lists, SFDs, VDD, VICD, ICDs, Software documents, Weight & Balance Report, Fire Safety Data, RAMS documents, Test Plans, Test Procedures, Test Reports, Work Instructions, Process Instructions, Quality Documents, QA Checklists, Purchase Orders, Audit Forms, Certificates of Compliance, Traceability Records, Calibration Records, Weight Records...

3.2 Document & Data Checking Checklists

The following document and data checklists are to be created and used: self-check checklists; primary checker checklists; approver checklists; other approvals checklists.

3.3 Other checklists

The following additional checklists are to be developed and used: software development self-check checklist; document & data transfer checklist; production self-check checklist; production inspector checklist.

3.4 Testing responsibilities

Provide a matrix of test performance and recording responsibilities.

4. Project Design Control Procedures

Refer to Fig xxx for a chart of design control (extract the relevant information from Design Review Process (tab I.1.k) and System Integration Plan (tab I.1.l)).

5. Production and Manufacturing Procedures

5.1 In-shop Equipment and Material Protection & Precautions

Specify procedures to perform the following: Shelf life monitoring; Electrostatic discharge protection; Floor protection; Carbody protection during manufacturing...
5.2 Process standards

The process standards listed in this section are general instructions, which apply irrespective of the affected part numbers.

List the following process instructions in this section and add any others that apply: Qualified welding processes; Qualified air pipe brazing processes; Threaded pipe and tube fitting processes; Conduit fitting processes; Cleaning processes; Sound deadener application process; Painting & priming processes; Fastening & torqueing processes; Safety wire application process; Caulking and sealing process; Insulation installation process; Window installation process; Floor leveling compound application process; Flooring adhesion process; Wire and cable marking processes; Wire and cable cutting & stripping processes; Wire lug and connector contact crimping processes; Crimp qualifying processes; Connector assembly processes; Grounding wire and cable connections; Wire harness protection, supporting, dressing, and terminating processes; Decal application and edge sealing process.

5.3 In-process tests and inspections

In-process tests and inspections are to be performed on an as-needed basis.

List the following in-process tests and inspections in this section and add any others that apply: Spot weld pull testing; Die penetrant crack checking; Ultrasonic inspection; Truck frame magnetic particle inspection; Air piping leak checks; Paint thickness testing process; Paint adhesion testing process; Carbody water test; Car wiring continuity test; Car wiring hipot and insulation resistance tests.

5.4 Production Work instructions

Production work instructions are to be performed for every car.

List the following in-process tests and inspections in this section and add any others that apply: Carshell assembly instructions; System installation instructions; Wire harness and cable routing instructions; Truck assembly & tramming instructions; Door adjustment instructions; Truck attachment instructions; Car height adjustment and leveling procedure; Sensor signal trimming; Radio broadcast power adjustment.

5.5 Car movement and handling instructions

List the following car movement and handling instructions in this section and add any others that apply: Carbody lifting instructions; Setting and removing carbody from shop dollies; Preparing,
loading, and unloading carbody on/off trailer; Preparing, loading, and unloading carbody on/off ocean transport vessel; Preparing, loading, and unloading complete car on/off trailer...

6. **Tool validation and adjustments**  
   This section applies to precision adjustable tools, such as crimpers.

7. **Equipment calibration**  
   This section applies only to measurement equipment, such as tape measures, torque wrenches, air gauges, force gauges, temperature gauges, and electrical meters.

8. **Configuration Management**  
   This section applies vehicle configuration management, and includes car history book details.

8.1 **Hardware Configuration Management**  
   Physical item revision and serial number tracking

8.2 **Software Configuration Management**  
   Software version tracking

9. **Engineering Change Control**  
   Specify customization of HRC’s standard release and change process to assure responsiveness to site issues and customer concerns.

10. **Non-conforming Material Control Procedures**  
    Specify process for impounding non-conforming material, and dispositioning non-conforming materials.

11. **Procurement Quality Procedures**  
    Specify PO development instructions, which include procedures for incorporating acceptance requirements (including tests and inspections), certificates of compliance requirements, lot traceability requirements, shelf life requirements, and other quality requirements.

12. **Subcontractor Quality Control Procedures**  
    Specify the supplier qualification process, supplier manufacturing & test auditing process, standards required, inspection requirements, and testing requirements.

13. **Inspection Procedures**  
    Specify procedures and/or checklists for the following types of inspections.
13.1 First Article Inspections
13.2 Incoming Inspections
13.3 Hold Point Inspections

Inspection checklists are to be developed and used at every production station. Inspections minimally must cover the following hold points prior to being covered up (inspections may need to be broken into segments): carbody structure prior to covering hidden items; carbody structure at completion; carbody water-tightness test, interior equipment installations, underfloor equipment installations, carbody piping installation, carbody wiring installation, all items prior to installing interior walls, floor, and ceiling panels, truck installation, completed car.

13.4 Source Inspection (if required)
13.5 Pre-Shipment Inspection
13.6 Receiving Inspection
13.7 Field Modification Inspection
13.8 Pre-acceptance Inspection at car shop

14. Test Procedures

Specify procedures for each of the following test categories.

14.1 Life cycle and endurance testing
14.2 Material qualification testing
14.3 Routine testing
14.4 System testing
14.5 Software testing
14.6 Integration testing
14.7 Pilot car testing
14.8 Vehicle testing
14.9 Acceptance testing

15. Warranty Management Procedures

Specify procedures for filing warranty claims, and specify materials flow and time limits for replacing or repairing faulty items.
PART 3: SAMPLE DOCUMENTATION

Please refer to Attachment 1 for samples of Hyundai Rotem’s project quality documents.
B. The Offeror shall describe their approach to subcontractor quality compliance, first article inspections and quality control/quality assurance role at the final assembly site.

1. Subcontractor Quality Compliance

The following actions are taken to assure subcontractor quality compliance:

1. Whenever possible, use subcontractors with a record of positive past performance.
2. All customer requirements and referenced standards are to be enforced by the purchase order.
3. New subcontractors must undergo an initial quality audit by HRU’s quality engineer.
4. Existing subcontractors are subjected to on-going quality audits by HRU’s quality engineer if quality problems occur, or if other significant supplier changes occur.
5. Suppliers of items with regular quality problems will be subjected to source inspections, and may be required to develop and implement a production improvement plan.
6. Suppliers of fasteners and structural materials are required to provide mill traceability documentation to assure compliance with all composition, strength, and treatment requirements.
7. Items (or samples of incoming items) are to be inspected upon receipt of all shipments if not already source inspected.
8. A certificate of compliance must be provided for all non-COTS items.
9. All subsystem and major parts will undergo a first article inspection (FAI).
10. Suppliers of subsystems and major components must provide their routine inspection criteria and routine test documentation for approval.
11. Suppliers of subsystems and major components must perform independently-witnessed type testing to assure their design and workmanship is of sufficient quality.

2. First Article Inspection

Prior to conducting any FAIs with the suppliers and MBTA, Hyundai Rotem will conduct a pre-FAI at the supplier’s factory. If the pre-FAI is determined to be successful, an FAI will be planned, and MBTA will be invited. However, if the pre-FAI reveals problems, follow-up pre-FAIs will be held until the product is ready for an FAI.

FAI's will be prepared and performed in accordance with TS19.05 and C5.19. FAIs will be performed on all major components, subsystems, the car structure (at predetermined hold points), and completed pilot cars. Subsystems include:

1. Propulsion System
2. Trucks and Major Truck Components
3. Auxiliary Inverters and Low Voltage DC Power Supply
4. HVAC units
5. Carshell
6. Couplers / Draft Gear
7. Wheel Sets
9. Air Brake Equipment and Controls
10. ATP/ASR Equipment
11. Door Systems
12. Seats
13. Vehicle Monitoring System
14. Network Integration
15. Communications Equipment including LED and LCD Signage
16. Lighting
17. Event Recorder
18. Cab Windows

3. Quality Control/Quality Assurance at Final Assembly Site

During the initial project stage (i.e. design stage), HRU’s Springfield MA-based project quality engineer will lead the development of Rotem’s PQP, but will work with the quality engineer in Korea and all managers in Springfield, Boston, and Philadelphia to list and outline all checklists and other quality documentation as previously described. The Springfield quality engineer will simultaneously spend a percentage of his working hours evaluating and auditing potential US-based suppliers for quality compliance. As definition of the supplier base matures, the quality engineer will develop project-specific quality requirements to the purchase orders. As POs are placed, the Springfield quality engineer will continue to focus on evaluating and responding to US supplier quality documents and issues. Concurrently, HRC’s Korean-based staff will work with international-based suppliers to assure quality, and will be working on the development of car-related quality documentation. When base-line quality documentation from Korea is ready, it will be sent to Springfield for evaluation by the local quality engineer. When the Springfield quality engineer is familiarized with the quality documentation, he will do the following:

- Issue requisitions for purchasing equipment to be used by Springfield-based inspectors;
- Issue requisitions for purchasing equipment to be used by Springfield-based test technicians;

When any measurement equipment arrives, it will be sent for calibration. Upon return from the calibration lab, all such equipment will be logged, and assigned a re-calibration due date. Any test materials that need to be prepared for use on the cars, such as continuity test cables and hipot test cables, will be prepared by staff in Korea, so it is ready for use when the Springfield staff is hired.

Prior to receipt of the pilot carbodies, local lead inspectors and test technicians will be hired with assistance of the Hyundai Rotem training institute. These leaders will be trained by a combination of the Springfield quality engineer and quality staff temporarily brought over from Korea. After the first Springfield married pair is accepted, the Korean staff will return home, but will be available for recall if needed. The newly trained lead staff will then train new hires at Springfield.

Since supplier source-inspection specialists need to work independently, HRU’s experienced Philadelphia-based site inspectors are expected to perform all domestic source inspections.
It should be noted that Rotem’s line inspectors and lead test technicians will be authorized to interface directly with MBTA’s on-site inspectors.

Finally it should be noted that Rotem’s local test technicians will have troubleshooting responsibility.
Figure 1- Sample Carbody Major Dimensions Verification Record
RFP No. CAP 27-10
New Orange and Red Line Vehicles
Massachusetts Bay Transportation Authority

Figure 2 - Sample Truck Welding Inspection Record
Figure 3 - Sample Truck Magnetic Particle Inspection Record
## APPENDIX I: FRACAS DATA

### Table 1.4 - Sample FRACAS Data

<table>
<thead>
<tr>
<th>ITEM</th>
<th>STATUS</th>
<th>TITLE</th>
<th>FRAGAS NO.</th>
<th>CLOSED DATE</th>
<th>SYSTEM</th>
<th>SHADE SYSTEM</th>
<th>EQUIPMENT</th>
<th>CAN (NO.)</th>
<th>BUS/CRD (NO.)</th>
<th>SSRPG (NO.)</th>
<th>MILLAGE</th>
<th>INVESTIGATOR/ACTION PLAN</th>
<th>MONITOR</th>
<th>CLOSED</th>
<th>RESPONSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CASE CLOSED</td>
<td>RE-TEST OUTFITTED OUT</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Passenger Information</td>
<td>009</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Replaced the PPI at PPI</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
</tr>
<tr>
<td>2</td>
<td>CASE CLOSED</td>
<td>COMMUNICATION SYSTEM SHOULD NOT ACCEPT WAVE OFF</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Communication System</td>
<td>312</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
</tr>
<tr>
<td>3</td>
<td>CASE CLOSED</td>
<td>Reported an issue for door drop announcement</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Communication System</td>
<td>010</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
</tr>
<tr>
<td>4</td>
<td>CASE CLOSED</td>
<td>Over-idecar lights are all off</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Communication System</td>
<td>011</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
</tr>
<tr>
<td>5</td>
<td>CASE CLOSED</td>
<td>Over-idecar lights are all off</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Communication System</td>
<td>012</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
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<tr>
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<td>Over-idecar lights are all off</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Communication System</td>
<td>013</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
</tr>
<tr>
<td>7</td>
<td>CASE CLOSED</td>
<td>Over-idecar lights are all off</td>
<td>1105/08/11</td>
<td>Communication Equipment</td>
<td>System Failure Risk A</td>
<td>Communication System</td>
<td>014</td>
<td>05/08/11</td>
<td>No affect</td>
<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
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<td>WADDACO</td>
</tr>
<tr>
<td>8</td>
<td>CASE CLOSED</td>
<td>Over-idecar lights are all off</td>
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<td>Communication Equipment</td>
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<td>Communication System</td>
<td>015</td>
<td>05/08/11</td>
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<td>0501/16</td>
<td>No “KICK” LIGHTS ARE OUT</td>
<td>Installed the problem as per PPI and submitted the update</td>
<td>05/08/11</td>
<td>Y</td>
<td>WADDACO</td>
</tr>
</tbody>
</table>

---

**Figure 4 - Sample FRACAS Data**

---

TAB l.4

B.5.4.1_Quality Assurance Plan_Attachment 1_rev.0.doc

Page 4 of 10
4.2 Reliability Figure

In January, SEPTA utilized 120 cars in service and service trains accumulated 444,461 miles during one month span. The total failure count increased from December (67) to January (99) due to the increase in failure count from the door system and communication system. Rotem has started HVAC 1.12 installation and HVAC blowem motor wire modification. Due to the severe weather storms, failure links along with HVAC failure count have gone up. However, twist links failure count declined in January. Westcode have completed HVAC blower motor wiring mod on 107 cars. Moreover, the buzzer mod and intercar jumper modification have been implemented. Out of 99 changeable failures, communication system (24), and door system (23) exhibited high failure rate. On the contrary, car system failure count has decreased. ROTEM and Fairway continue to work on pending items in order to minimize the intermittent door issues that are pending. MELCO continues to investigate on the nuisance ground faults along with many other spurious contactor faults. Number of failure count and monthly MDFB are displayed in table 4.2.1 and table 4.2.2 accordingly.

<table>
<thead>
<tr>
<th>System/Subsystem Description</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
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<th>Jun</th>
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<tr>
<td>System/Subsystem Description</td>
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<td>Dec</td>
<td>Accumulated MDFB</td>
</tr>
</tbody>
</table>

Table 4.2.1: Number of Failure

Figure 5 - Reliability Demonstration Report Excerpt (part 1)
4.3 Target compliance

<table>
<thead>
<tr>
<th>System/Subsystem Description</th>
<th>Target MDEF (Car-Jan)</th>
<th>Current Month MDEF (Car-Feb)</th>
<th>Accumulated MDEF (Car-Feb)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete propulsion system</td>
<td>90,000</td>
<td>53,464</td>
<td>112,312</td>
<td>Achieved</td>
</tr>
<tr>
<td>Cab Signaling &amp; TC system</td>
<td>100,000</td>
<td>45,661</td>
<td>123,872</td>
<td>Achieved</td>
</tr>
<tr>
<td>Auxiliary power system (all-voltages)</td>
<td>150,000</td>
<td>84,044</td>
<td>177,714</td>
<td>Failed</td>
</tr>
<tr>
<td>Heating and air conditioning system</td>
<td>90,000</td>
<td>95,082</td>
<td>195,162</td>
<td>Failed</td>
</tr>
<tr>
<td>Door system and controls</td>
<td>90,000</td>
<td>10,504</td>
<td>123,540</td>
<td>Failed</td>
</tr>
<tr>
<td>Compresed air supply and friction brake system</td>
<td>80,000</td>
<td>63,044</td>
<td>46,402</td>
<td>Failed</td>
</tr>
<tr>
<td>Cab and Carbody heater fans</td>
<td>Not Specified</td>
<td>20,651</td>
<td>30,097</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Car System</td>
<td>Not Specified</td>
<td>111,115</td>
<td>99,090</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Cabin Steel and interior items</td>
<td>Not Specified</td>
<td>-</td>
<td>98,189</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Communication Equipment</td>
<td>Not Specified</td>
<td>10,919</td>
<td>27,430</td>
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</tr>
<tr>
<td>Couper and Draft Gear</td>
<td>Not Specified</td>
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<td>667,950</td>
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</tr>
<tr>
<td>Diagnostic Test Equipment</td>
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</tr>
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<td>Photosyn &amp; High Voltage Regulator</td>
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</tr>
<tr>
<td>Thrusts</td>
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<td>444,661</td>
<td>195,692</td>
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</tr>
<tr>
<td>Overall percent average</td>
<td>19,092</td>
<td>2,685</td>
<td>6,947</td>
<td>Failed</td>
</tr>
</tbody>
</table>

Table 4.3-1: Target Compliance

4.4 Failure review and Corrective Action

4.4.1 Complete propulsion system

Propulsion system failed 7 times, and trains serviced 62,464 miles without propulsion failure in January. Propulsion system has reached the reliability target in January. Meanwhile, RC STEM has completed ground brush ring movement test but the root cause is still unclear. Unfusible switch that causes invalid train line are completed and Faslekey have installed 15 new modified inverter controllers in January.

4.4.2 Cab Signal & ATC system

During January 2014, ATC system had 1 failure. Failure was the brake charging failure. Problem was isolated to the VPC power supply inside ATC FMI has been issued and waiting for the software C4. To be updated due to the failed run while conducting the dual carrier signal test. MDEF for the ATC system was 4,446 miles and failed the test.

4.4.3 Auxiliary power system (all-voltages)

APU failure figures is 15 and MDEF is 4,446 miles. Since the completion of the new APU software installation, APU system has stabilized. In January, AC ground faults were reported twice. TransTech has issued the software patch that will eliminate numerous APU, Inverter faults. Test version has been installed and been documented by 11 cars. Moreover, AC ground module settings are being adjusted to mitigate the AC ground fault issue.

4.4.4 Heating and air conditioning system

During January 2014, countable failure in HVAC is 6. Total failure count has decreased compared to the previous months. The reason is due to the decrease in low current nuisance fault and failed fuse issue. Fusable links failure investigation is in process. Westcode plans to resume the HVAC module modification. The software 1.12 has been approved and installed in 187 cars. Monthly MDEF at HVAC in January was 98,692 miles and passed the target.

4.4.5 Door system and controls

Door system reported 23 failures in January. Mounting bolts that hold the door failed and sliding threshold travelled even when the trap door is down due to the bent hook. Sliding threshold hook modification implemented in all cars and trap door stopper and threshold heater installation are in process. Most of door issues were due to the lack of threshold heater operation. Threshold heater installation is prioritized. Due to the inclement weather, doors are found frozen and inoperable. MDEF is 19,324 and did not pass the door system target.

4.4.6 Compressed air supply and friction brake system

During January 2014, brake system was requested to be investigated 7 times and majority of the failure was due to the component failure. Air Compressor controller failure did not happen since the completion of the air...
RFP No. CAP 27-10
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Massachusetts Bay Transportation Authority

Figure 7 - Quality Assurance Plan Excerpt (part 1)
8.2.6 Records control
Nonconformity Control records (NCR, UR and MRB) shall be maintained and controlled as quality records.

[Attachments of this Section]
#1: Nonconformity Report (NCR) Form
#2: Unusual/Factory (UR) Form
#3: Material Review Board (MRB) Report Form

**Figure 8- Quality Assurance Plan Excerpt (part 2)**
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<tr>
<td>2</td>
<td>AIR CONDITIONER installation</td>
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</tbody>
</table>

**Figure 9 - Sample Installation Work Instruction (part 1)**
3. Install the HVAC cover. (Refer to photo)

Figure 10- Sample Installation Work Instruction (part 2)