# US-APWR

# GAS TURBINE GENERATOR

# Class 1E Qualification Plan

# NRC-MHI meeting on Sep.29th, 2009

September 28, 2009

Mitsubishi Heavy Industries, Ltd.

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# 1. Qualification Plan

## Objective

### MHI/ESI to build prototype 4.5 MWe Gas Turbine Generator (GTG) for qualification to IEEE 387

Prototype will be used for qualification testing in accordance with IEEE387-1995 as clarified by NRC Reg Guide 1.9 Rev 4

Qualification Activities include:

- Factory Testing
- Type Testing
- Seismic Qualification

Prototype GTG will not be installed in safety-related nuclear application. Design of unit will be fixed for qualification purposes. Unit will not be *Dedicated* for safety-related application. *(Dedication to be discussed later)*

# 1. Qualification Plan

- **Equipment Included in Prototype Build:**
  - GTG Assembly
    - Twin Gas Turbines
    - Speed Reducing Gearbox
    - Synchronous Generator
    - Lube Oil Cooling System
    - Frame & Acoustic Enclosure
  - Starting Air Valve Panel
  - Starting Air Receivers (see clarifications next slide)
  - Fuel Oil Day Tank (see clarifications next slide)
  - Exhaust Silencer
  - Engine Control Panel
- **Equipment Not Included in Prototype Build:**
  - Fuel Oil Transfer Pumps & Controls
  - Air Compressor
  - Generator Switchgear including Generator Protective Relays and Circuit Breaker
  - Generator Neutral Grounding Resistor

# 1. Qualification Plan

## Equipment Clarifications

### Air Receiver Skid

Air receivers for installation at Nuclear Power Plant will be designed and built in accordance with ASME Section III, Div 1, Class 3. Each GTG installation will have four (4) identical receivers to provide total of three (3) start capacity.

The GTG prototype will be tested with two (2) receivers. The receivers will be designed in accordance with ASME III to the same specifications as the installation. The receivers will not be ASME Section III Code stamped.

### Fuel Oil Day Tank

The fuel oil day tank for installation at Nuclear Power Plant will be designed and built in accordance with ASME Section III, Div 1, Class 3. Each GTG installation will have one fuel oil day tank.

The GTG prototype will be tested with one day tank. The tank will be designed in accordance with ASME III to the same specifications as the installation. The day tank will not be ASME Section III Code stamped.

# 2. Dedication Plan

**Following successful qualification of GTG, MHI/ESI will provide units qualified for 1E service for Nuclear Power Plant (Comanche Peak)**

- ESI maintains an approved 10CFR50 Appendix B, ASME NQA-1 and ANSI N45.2 Quality Assurance Program.
- ESI packages Emergency Diesel Generators for nuclear applications and presently supports over 250 in safety-related applications worldwide
- ESI will perform Commercial Grade Dedication on GTG in accordance with 10CFR-21 and EPRI NP-5652 guidelines

# 2. Dedication Plan

## NRC Limited Scope Inspection of ESI Facilities

- ✓ Report No 99901362/2006-21,
- ✓ Inspection Date: November 13-16, 2006
- ✓ Inspection Scope
  - Compliance with 10CFR21
  - Compliance with 10CFR50 Appendix B
    - Corrective Actions
    - Commercial Grade Dedication
- ✓ Satisfactory Results

# 2. Dedication Plan

## Dedication Process

- Customer PO / Specification Review
- Develop Component / Assembly Dedication Report
- Procurement
- Commercial Grade Survey
- Quality Inspection & Test
- Engineering Dedication Verification
- Documentation

# 2. Dedication Plan

## Purchase Order / Specification Review

- **Identify**
  - ✓ Component Application
  - ✓ Environmental Requirements (temp, humidity)
  - ✓ Seismic Requirements (earthquake)
  - ✓ Special Documentation Requirements

- **Requisition Material**
  - ✓ Add Technical Requirements
  - ✓ Requirements for lot qualification
    - Determine if extra part is required
    - Determine if supplier survey is required

# 2. Dedication Plan

## Develop Dedication Report

- **Identify Form, Fit, and Function**
- **Failure Mode Analysis**
  - ✓ Effect of part failure on System
  - ✓ Credible Failure Modes of Part
- **Design Information**
  - ✓ Catalog Information
  - ✓ Manufacturer's Drawings, etc.
  - ✓ Coordination with CES, EMD, Woodward, Kawasaki
- **Critical Characteristics**
  - ✓ Dimensions
  - ✓ Operability
  - ✓ Material

# 2. Dedication Plan

## Develop Dedication Report (continued)

- **Environmental Qualification**
  - ✓ Manufacturer's specs
  - ✓ Environmental chamber
- **Seismic Qualification**
  - ✓ Perform an analysis
  - ✓ Write seismic test procedure
- **Shelf Life**
  - ✓ Identify materials
  - ✓ Utilize published standards
- **Maintenance / Surveillance / Replacement Interval**
  - ✓ Activity required by customer to maintain qualification
- **Verify operability**
  - ✓ Write functional test procedure

# 2. Dedication Plan

## Procurement

- **ESI specifies technical and quality requirements for the commercial grade item:**
  - ✓ Gas Turbine buildup data sheets
  - ✓ Material test reports for major items
  - ✓ Non-destructive examination test records
  - ✓ Calibration records
  - ✓ Witness points as agreed upon
  - ✓ In-process production inspection and test records
  - ✓ Gas Turbine test report
  - ✓ Non-conformance reports

- **ESI Quality Assurance conducts commercial grade survey**

# Dedication Verification

- **Verify**
  - ✓ Measured Dimensions Meet DR Values
  - ✓ Functional Test Results Meet Acceptance Criteria
  - ✓ Material Test Results Meet Manufacturers Specs
  - ✓ Environmental Specs Meet Site Requirements
  - ✓ Seismic Qualification Meets Site Requirements

# 2. Dedication Plan

## Documentation

- Dedication Report
- Certificate of Conformance
- Inspections results
- Functional test results
- Material test results
- Seismic qualification report

# 2. Dedication Plan

## 10CFR21 - Reporting of Defects and Noncompliance

- **The organization that performs the dedication process is responsible for:**
  - ✓ Identifying and evaluating defects, deviations, and failures which could create a substantial safety hazard
  - ✓ Notifying the NRC and utility of dedicated (and supplied) items containing defects
  - ✓ Maintaining auditable records of the dedication process.

# 2. Dedication Plan

## ESI QA performed survey of GT manufacturer (Kawasaki Heavy Industries - Akashi Works Facility)

✓ Survey performed in May, 2008

✓ Focus on supply of M1T33 Gas Turbine Engine for nuclear applications

✓ Satisfactory design control, material control, purchase control, inspection and test control and process control elements of a commercial grade quality system

✓Ability to produce documentation necessary to properly dedicate the purchased equipment.

✓Ability to support the product with technical support and parts and service.

# 3. Test Plan

## Scope of Equipment

IEEE 387 defines the boundaries of emergency diesel generator systems shown in Figure 1. MHI plans to qualify the gas turbine generator (GTG) system of US-APWR as Class 1E system. The Figure 2 shows the boundaries of sub-systems and equipment included in the scope of our qualification.

# 3. Test Plan

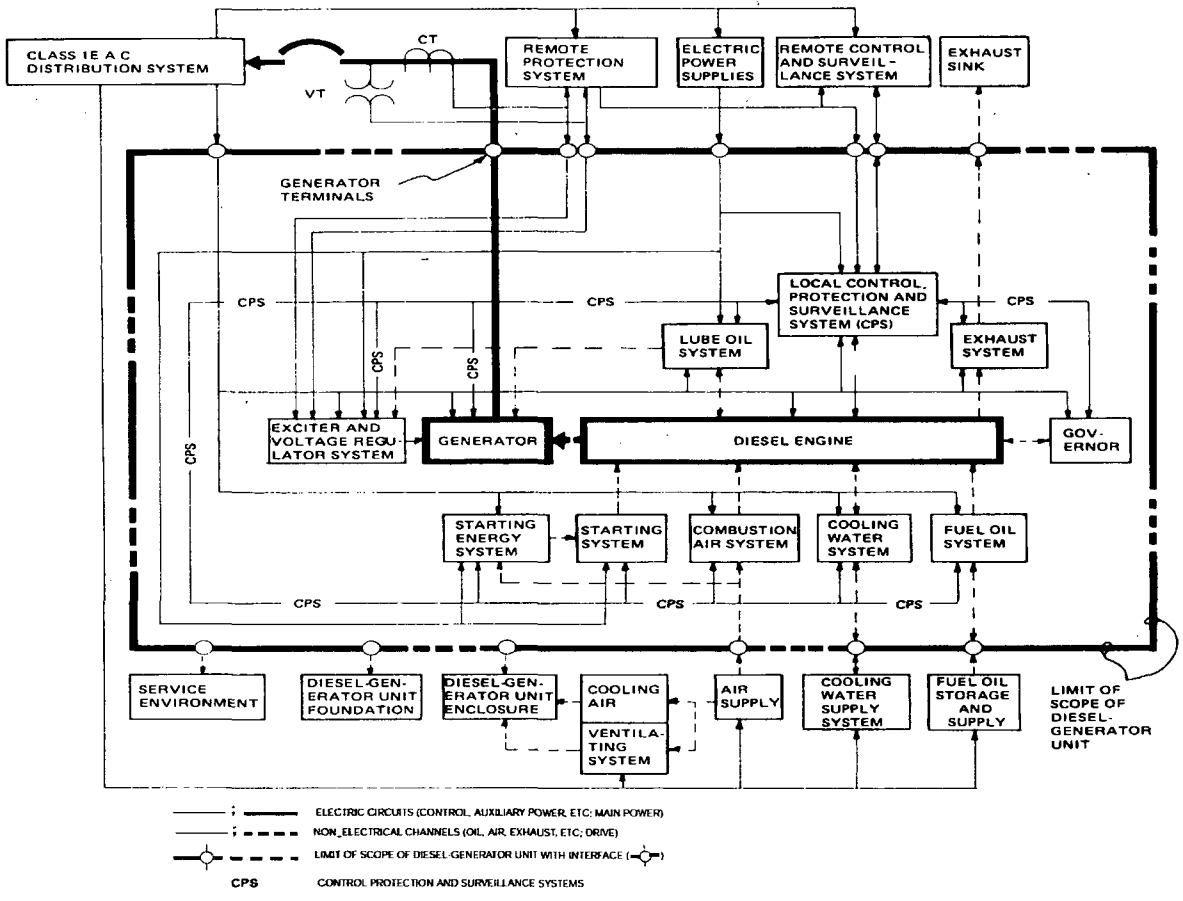


**Figure 1: Boundary of Class 1E qualification required in IEEE 387**

# 3. Test Plan

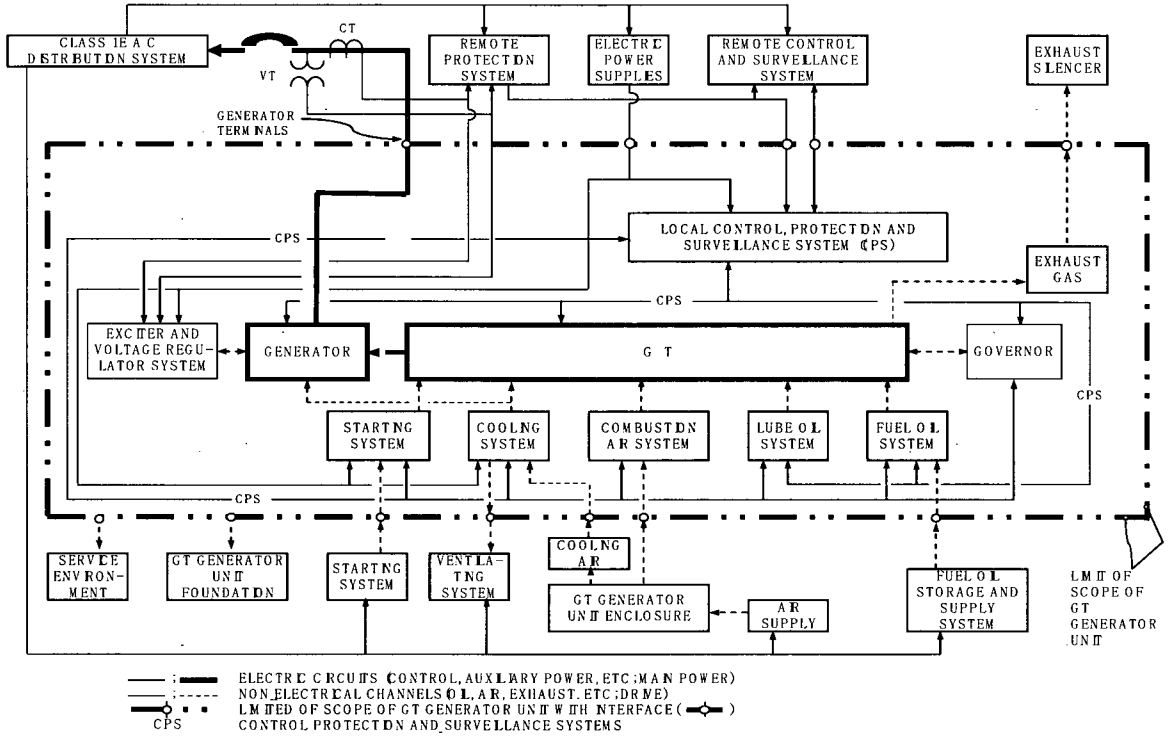


**Figure 2: Boundary of MHI's GTG Class 1E qualification**

# 3. Test Plan

## Main Objective, Near Term (12-16 months)

- Complete Type Testing on Prototype Unit
  Section 6.2 of IEEE 387-1995

- Complete Seismic Qualification of Prototype Unit
  IEEE 344 qualification of GTG Assembly

# 3. Test Plan

## Scope of tests

## Factory Production Tests (5.2)

1) Engine Tests

Break-in and inspection (5.2.1.a)

Performance Tests (5.2.1.b)

50% Load for 1 hour

75% Load for 1 hour

100% Load for 2 hours

110% Load for 2 hours

# 3. Test Plan

2) Generator Tests in accordance with NEMA MG-1 performed by the Generator Manufacturer at their facility (5.2.2). Typical tests include:
   (1) Air Gap Measurement
   (2) RTD Device Test
   (3) Winding Resistance Test
   (4) Space Heater Test
   (5) Insulation Resistance Test
   (6) Bearing Insulation Resistance Test
   (7) Stator High Potential Test
   (8) Rotor Dynamic Balance Test

# 3. Test Plan

(9) Phase Sequence Test
(10) Open Circuit Saturation Test
(11) Short Circuit Saturation Test
(12) Phase Balance Test
(13) Current Balance Test
(14) Permanent Magnet Generator Test
(15) Temperature Rise Test per IEEE 115
(16) Over speed and Vibration Test

(d) Excitation, Control, Accessories/Auxiliaries (5.2.3)

# 3. Test Plan

## Type Tests

Initial Type Tests (6.2)

1) Load Capability Tests (6.2.1)

(1) Continuous rating sufficient to reach temperature equilibrium

(2) Short-time rating for 2 hours

(3) Full load rating for 22 hours

(4) Short-time load rejection

(5) Light or no-load capability

# 3. Test Plan

## 2) Start and Load Acceptance Tests (6.2.2)

150 starts test for GTG

Note: NRC's requirement has shown in last meeting that reliability of Class 1E EPS is required over 0.95 with 95% confidence based on R.G 1.155. MHI has a plan to set a reliability target as 0.975 with 95% confidence. MHI will verify this reliability through this 150 starts test (with no failure).

- ✓ Start and accelerate to rated speed and voltage
- ✓ Add single step load of ≥50% of unit load rating
- ✓ 135 of the tests (90%) begin with unit in warm standby conditions
- ✓ 15 of the tests (10%) begin with unit at normal operating temperatures

- ✓ No failures are allowed

# 3. Test Plan

3) Margin Tests (6.2.3)

Evaluate emergency load profile for GTG and determine most severe load step.

(1) Single step load at least 10% greater than the magnitude of the most severe load step in the site load profile

(2) Verify generator and excitation systems stable and capable of recovery

(3) Verify sufficient engine torque is available to prevent stall and allow recovery to rated frequency.

Two Margin tests shall be performed

# 3. Test Plan

## Additional Qualification

### Aging (6.3)

- Evaluate significant aging mechanisms
  - Aging test or analysis if required

### Seismic Qualification (6.4)

- Qualification in accordance with IEEE344
- Combination of analytical and dynamic test methods

### Surveillance (6.5)

- Determine preventive maintenance inspections & tests

# 3. Test Plan

## Site tests

**Table 1 taken from Reg Guide 1.9, & IEEE-387**

Site tests are performed after equipment is installed at nuclear power plant.

Site Acceptance and Pre-operational tests must be performed during commissioning activities at the final installation.

Tests are repeated periodically during surveillance tests by utility.

Table 1

| Reference: IEEE 387 Clause: | Tests | Site acceptance tests (7.2)* | Pre-operational tests (7.3)* | Availability tests (7.4.2.1)* (Surveillance) | | System operation tests: shutdown/ refueling (7.4.2.2)* | Independence tests 10 years (7.4.2.3)* |
|---|---|---|---|---|---|---|---|
| | | | | Monthly | 6 Month | | |
| 7.2.1.1 | Starting | X | | X | | | |
| 7.2.1.2 | Load acceptance | X | | X | | | |
| 7.2.1.3 | Rated Load | X | | X | | | |
| 7.2.1.4 | Load Rejection | X | | | | | |
| 7.2.1.5 | Electrical | X | | | | | |
| 7.2.1.6 | Subsystem | X | | | | | |
| 7.3.3 | Reliability | | X | | | | |
| 7.5.1 | Start | | X | X | | | |
| 7.5.2 | Load Run | | X | X | | | |
| 7.5.3 | Fast Start | | X | | X | X | |
| 7.5.4 | LOOP | | X | | | X | |
| 7.5.5 | SIAS | | X | | | | |
| 7.5.6 | Combined SIAS and LOOP | | X | | | X | |
| 7.5.7 | Largest load rejection | | X | | | X | |
| 7.5.8 | Design load rejection | | X | | | X | |
| 7.5.9 | Endurance and load margin | | X[a] | | | X | |
| 7.5.10 | Hot restart | | X | | | X | |
| 7.5.11 | Synchronizing | | X | | | X | |
| 7.5.12 | Protective trip bypass | | X | | | X | |
| 7.5.13 | Test mode override | | X | | | X | |
| 7.5.14 | Independence | | X | | | | X |

[a] Use 2 h and 22 h

* IEEE Std 387-1995