The Application of the Generator Quality System

MFGGLO-GEZ-0030
Rev: 002

Introduction

GEZ-4982C, Section 1, describes key elements of the Quality System as it applies to certain major components and parts manufactured by STGGSC. Each section is designed to provide information relative to essential product design and quality assurance considerations necessary to meet engineering requirements.

GEZ-4982C, Section 2, describes a standard “Customer Participation Offering”, addressing typical areas in which the customer may desire to participate during the manufacture of the product. It also provides standard customer observation points and a description of the quality activities that usually occur at those points.

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Section 1: The Quality System Product Application

1.1 Generator Stator Frame

Stator Frame Product Design

1. **Function**

   A. Support the stator core, stator windings, and rotor.

   B. Provide cooling passages.

   C. Contain hydrogen gas without leakage (for hydrogen cooled designs).

2. **Operating Requirements**

   A. The stator frame operates through a wide range of operating temperatures resulting from both indoor and outdoor installations.

   B. The hydrogen cooled stator frames are designed for maximum operating hydrogen pressures ranging from 30 to 75 psig.

   C. The frame must operate with a substantial steady load imposed by the weight of the components within and must also operate in an environment of moderate vibration, both mechanical from the revolving rotor and electromagnetic field from the stator core.

   D. The stator frames are designed to withstand torques due to three phase faults.

3. **Materials**

   Stator frame materials are basically low carbon steel selected for the operating stresses and temperatures which the frame will be subjected to in service.

4. **Design Approach**

   Engineers and design draftsmen, working together, develop a 3D Model of each new frame design. They first assure that the structure will support the static weight of the core, winding and field as well as the peak torsional stresses under unusual short-circuit conditions. They then calculate the stiffness of the structure and make the adjustments necessary to assure that no resonance exists which is too close to the running speed. The gas flow passages are then selected to assure proper machine cooling, and the vibration isolating characteristics of the

core support are calculated. Finally, the overall length, width, and height dimensions are checked against permissible shipping clearances on the route to the customer's station, and it is verified that the design can be successfully transported to the site.

Quality Assurance

1. **Material Acceptance**

   Stator frame fabrications are procured from external vendors and are accepted for further processing based on a review of the manufacturer’s certifications and records and an inspection upon arrival.

2. **In-Process Quality Control**

   All critical operations are recorded by the operators on process control forms. The operator certifies completion and accuracy. These are then verified by inspectors and signed off. This is important in assuring proper fit for mating parts, such as end shields, hydrogen coolers and support feet.

3. **Final Release**

   A. Overpressurization Test - the integrity of the outer frame of hydrogen cooled units is demonstrated by pressurizing the frame with air to a level 50% above it's rated value and holding this value for a minimum of 10 minutes.

   B. Air Test - the ability of the outer frame of hydrogen cooled units to contain hydrogen under operating conditions is confirmed by an air leakage test performed at the rated hydrogen pressure. If the generator is a 'packaged' design (i.e. contains and integral oil seal and gas control system) it is tested with the field installed and the seal system operating, otherwise it is performed with the field not installed and test plates used to seal the end shields. The tests consists of pressurizing the unit and monitoring the internal pressure and temperature over time and calculating the leakage. Allowable leakage limits exist for each of the generator types manufactured.

4. **Quality Review**

   Before the frame is released for core stacking, a thorough inspection is made for cleanliness and to verify that all manufacturing operations have been performed properly.

5. **Record Retention**

Records of test results and QA Documentation are kept for five years after start-up of the turbine-generator.

Stator Core

Product Design

1. **Function**

   A. Provide a low reluctance path for the magnetic flux which is generated in the rotor and which links the stator windings.

   B. Provide support for the stator coils in appropriately designed slots.

   C. Provides overall mechanical stiffness against magnetic forces.

2. **Operating Requirements**

   The stator core operates over a moderate range of temperatures influenced by eddy current and hysteresis losses and is subject to electromagnetic vibration caused by the rotating flux from the field.

3. **Materials**

   Stator core material consists of segmented laminations of electrical grade high permeability, low-loss silicon steel. Each lamination is coated on both sides with an insulating enamel.

4. **Design Approach**

   The stator core designer first determines the cross-sectional area required to carry the design flux, taking into account the excitation requirements and the level of core losses. The required cooling gas flow is then calculated, based on generator losses. Core ventilation passages are then selected to assure acceptable core operating temperatures and to accommodate required rotor gas flows. Finally, the mechanical stiffness and resonance characteristics are determined. And an appropriate spring mounting. if required, is designed to assure satisfactory isolation of the electromagnetically - induced core vibration.

Punchings

Quality Assurance

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1. **Material Acceptance**

   A. Silicon Steel for Stator Laminations - Quality Control accepts or rejects each batch of silicon steel on the basis of a report of tests performed by the vendor.

   B. Core Plate Enamel for Stator Laminations - The enamel is purchased according to General Electric specifications and released to manufacturing based on a review of the suppliers Certificate of Test. The enamel is not released to Manufacturing without an approval from Quality Control.

2. **In-Process Quality Control**

   Many individual in-process checks are performed continually on stator laminations.

   A. New Die Check - All new dies used in making punchings are examined for clearance, chips, misalignment, or any physical damage. Also, the first two laminations punched are examined for conformance to drawing.

   B. Burr Height Check - The burr height on the punchings is measured continuously by the operator after each step in the processing. A Quality Control Sampling Plan has been statistically established to inspect burr heights and assure a high quality punching.

   C. Enamel Thickness Check - The enamel thickness on the punchings is measured each shift with an electronic tester when the enameling process is in operation,.

   D. Dielectric And Cure Check - The following tests are performed on sample punchings from each production line every operating shift:

      1) Franklin Test - The electrical resistance of the enamel coating is measured with a Franklin Tester. The tester uses a controlled voltage, pressure and temperature to measure the amount of current passing through the insulation.

      2) Burn-Off Test - This test is performed to determine the dielectric properties of the silica in the enamel. The enamel is burned away leaving the silica residue, and this area is subjected to a Franklin Test. This is done to assure proper insulation even in the event of a hot spot.

      3) Solvent Resistance Test - The sample punchings are solvent tested to assure that the enamel is properly cured.

4) Flexibility Test - the finger of a sample punching is bent around a mandrel. This tests the flexibility of the enamel to detect overcure.

Core Assembly

Quality Assurance

1. **In-Process Quality Control**

   A. Key Bar Alignment - Before core assembly is started, the key bar dovetail positions on which the punchings are stacked are verified to be correct.

   B. Core Alignment - Correct alignment of punchings during stacking onto the key bar dovetails is maintained by use of slot liners in the finger dovetails and is periodically verified using a slot gage.

   C. Core Build-up - Thickness measurements are made of each package as it is assembled and, during each intermediate pressing operation, the total core length build-up is checked to assure that the required final core length and tightness will be obtained and that the core is straight.

   D. In-Process Checks - Checks are made of each core being stacked, on a periodic basis, to assure proper assembly of core end punchings, ventilation ducts, core baffles and punching layers progression, and to carefully inspect for any type of core damage during assembly. Each section of the frame is also checked for cleanliness before proceeding to the next section.

   E. Final Core Tightness - Both before and after the final flanging and baking operations, measurements are made and recorded of the overall core length and tilt. The correct sealing of the core and baffle are checked after complete core assembly.

2. Record Retention

   Files are maintained of process control forms, material releases and records of special tests. Records are kept for five years after start-up of the turbine-generator.

Stator Winding

Product Design

1. **Function**

   The stator winding is formed by the stator bars which, when connected together, serve as the current-carrying conductors in which voltage is induced by the action of the rotating field.

2. **Operating Requirements**

   There are five distinct operating requirements to which the stator winding is exposed; they are:

   A. High voltage which results in exposure to corona and dielectric stress.

   B. Electromagnetic vibratory forces due to normal load current.

   C. Short circuit forces under abnormal conditions.

   D. Very high loss intensity, requiring an extremely effective cooling system.

   E. Thermal expansion forces.

3. **Materials**

   A. Stator bar materials include individually insulated copper strands, a high-voltage dielectric barrier specifically developed for the application, and voltage grading systems. The dielectric barrier named Micapal is a thermosetting mica mat tape system, backed with glass cloth and bonded with a special blend of epoxy resins.

   B. The stator bar support materials include tapered wedges, conforming material on the bar edges, glass-epoxy side pressure springs for the slot portion, and a resin impregnated system of conformable blocking and cotton phenolic and glass-polyester supports for the end winding portion.

4. **Design Approach**

   The designer selects the number of strands and cross-sectional area of an armature bar needed to balance the mechanical, thermal, and current-carrying requirements. The required layers of insulation are selected depending upon the voltage of the particular machine being designed. Data used for that purpose are

the results of extensive laboratory and field service experience under a wide range of both electrical and mechanical conditions. A special surface treatment is used on the outside of the bars to eliminate the effects of slot discharge and corona.

Armature Bars

Quality Assurance

1. **Material Acceptance**

   The two basic materials used in the manufacture of stator bars are copper and Micapal insulation. These materials, ordered to Engineering specifications, must be accompanied by a Certificate of Test, giving the results of tests performed by the vendor in accordance with the specifications. Release of these materials to Production is the responsibility of Quality Assurance based upon satisfactory certificates of test where applicable.

2. **In-Process Quality Control**

   A. Individual Bar Identification - Each bar is individually identified by a numbering system which is maintained with tags through all stages of production. This individual identification facilitates record retention of all operations performed which, in turn, helps control the quality during all operations for each bar.

   B. Bare Bar Strand Test - All bars are tested, after molding, for shorts between strands using an A.C. high-potential tester, programmed to automatically sequence this test for each strand and verify its insulation from all other strands. All strand shorts must be corrected prior to subsequent operations.

   C. Bar Cleaning Station Prior to Brazing on Strand Headers (water cooled bars only) - Bar strand headers and bar ends are cleaned chemically and mechanically. Each individual strand is air-flow tested to assure that the cooling passage is open.

   D. Braze Station - All brazers are qualified by STG. After brazing, each strand is inspected using a cystoscope to again verify that the water cooling passages are all open.

   E. Dummy Form Layout - For new generator designs, correct bar shape is verified on a full-scale model of a stator before full production of the bars is

started. This assures that the winding will fit correctly into the stator core at final assembly.

F. Armoring Station - Dimensional checks are made on every finished bar to assure proper fit in the stator slots for control of bar vibration and slot discharge.

3. **Testing of Water Cooled Bars**

A. Vacuum Decay Testing - After brazing, each bar is given a vacuum decay test before application of the Micapal insulation.

B. Impact Test - A flow continuity test is performed on each strand of a completed bar. One end of the bar is pressurized and the air flow through each strand is checked at the opposite end.

C. Pressure Test - Each bar is pressurized with nitrogen and all areas around the clips and adapters at both ends are checked with a leak-detecting solution.

4. **Testing of all Bars**

A. High-Potential Testing - Each bar is given a preassembly high-potential test to proof test the bar insulation before the bars are assembled into the stator core.

B. Process Control Bar - One bar selected (extra bar) from each water cooled generator order is evaluated by nondestructive and destructive testing in a testing laboratory to monitor the following insulation characteristics: dimensional checks, insulation builds, condition of mica, resin content, volatiles content, dielectric strength, tangent delta measurements and voltage endurance life testing.

C. Conventionally cooled bar production is monitored by performing the above testing on a bar selected from a production run every other week.

Insulation and Support Materials

Quality Assurance

1. **Material Acceptance**

The stator insulating and support materials include high temperature resistant polyester resins, epoxy resins, phenolic resins, cloth-reinforced high-pressure

laminates, various glass-reinforced laminates and carbon black, all of which are ordered to General Electric specifications. Release of these materials to Production is the responsibility of Quality Assurance and is based on satisfactory Certificates of Test where applicable.

Stator Assembly

Quality Assurance

1. **In-Process Quality Control**

Many in-process checks and audits are conducted on the above completed products during assembly into the stator winding. All critical operations are recorded by operators on process control forms and verified by Quality Control personnel to ensure conformance to standards. Some of the more important in-process checks are outlined below:

A. Before bar assembly, a thorough inspection is made of the frame for foreign material and core damage.

B. Electrical Ground Clearance Check - After assembly, a check is made to see that all series loop ends, connection rings, etc. are adequately spaced from grounded surfaces in accordance with the drawings. (Applies to large water cooled generators whose rated voltage exceeds 20KV).

C. Bar Movement Check - After hose molding, a check is made on all bars to ensure they are bottomed in the slot. (Applies to large water cooled generators).

D. Wedge Tightness Check - All wedges are checked for proper alignment and tightness in the core slots.

E. Core and Bar Damage Check - an inspection is made of the core and end winding for foreign material and damage before being released for shipment.

2. **Testing**

A. Bottom Bar High Potential Test - All bottom bars are given a high-potential test after being assembled in the stator but before the top bars are installed.

B. Pressure Test (applies to water cooled generators) - Each bar is pressurized with nitrogen after assembly in the stator and all areas around the strand header and adapters at both ends are checked with a leak-detecting solution.

C. Vacuum Decay Test (applies to water cooled generators) - The completed liquid-cooled winding is given a vacuum decay test for further assurance that there are no leaks in any brazed joints.

D. Final Assembly High-Potential Test - The completed stator winding is given a high-potential test before preparation to ship.

3. **Record Retention**

Records of test results and QA Documentation are kept for five years after start-up of the turbine-generator.

1.2 Prepare to Ship - Stator

Quality Assurance

1. **In-Process Quality Control - Large Water Cooled Generators**

After completion of all assembly operations, the stator undergoes a final testing, inspection, and preparation before shipment to the customer. A summary of the final tests, inspections, and preparations include the following:

A. The end shields are erected, aligned, and doweled in place on the stator to assure a uniform air gap around the generator rotor.

B. The stator core, end winding, and piping assemblies are vacuum cleaned and painted with a special epoxy paint. All exposed machined surfaces are given a Tectyl protective coating and all exterior surfaces are painted to prevent rusting.

C. Liquid Circuit Flush - The entire liquid-cooled system is flushed with water to clean the flow passages.

D. Flow Continuity Check - After flushing the liquid-cooled system, a Flow Continuity Test is reformed to detect any blocked flow paths. The RTD's and liquid header thermocouples are also checked during this test by monitoring the temperature drop at different intervals while the temperature of the liquid in the system is cycled.

E. Vacuum Decay Test - A final test is made of the completed liquid-cooled system to assure that all stator bars, headers, and pipe connections are free of leaks and that the winding is dry for shipment.

F. Shipping High Potential Test - The completed stator winding is given a final High Potential Test according to ANSI-C50 Standards before shipment.

2. **In-Process Quality Control - Conventionally Cooled Generators**

Industrial and small utility generators are small enough to be fully assembled for shipment. The assembly process is monitored of conformance to drawing and quality requirements. The inspection plan includes:

- Internal cleanliness and painting
- Proper assembly of hardware and parts
- Check and record internal running clearances
- Final inspection of unit for completeness and suitability for shipment.

3. **Final Release**

Authority to release the stator for shipment is assigned exclusively to the Manager-Quality Control or his delegate. Approval of the stator for shipment is based on evidence that all Engineering Specifications, Alteration Notices, and dispositions on Quality Control Reports have been met and all work has been satisfactorily completed.

1.3 Generator Field

Product Design

1. **Function**

The function of the generator rotor forging is to transmit the torque load provided by the turbine, to support the field coils, to provide a low reluctance path for magnetic flux and to provide ventilation ducts for removing heat from the rotor windings.

2. **Operating Requirements**

Generator rotors are designed to operate in air or hydrogen atmospheres at rated speed. Rated speed usually is either 1500, 1800, 3000, or 3600 rpm.

3. **Materials**

The generator rotor is a high-strength, high-magnetic permeability, alloy-steel forging furnished to GE specifications. It is a single piece, except for some of the very largest units.

4. **Design Approach**

The rotor forging is designed by first determining the overall diameter, length, field conductor area and cooling area required to meet the kva rating, then by calculating all pertinent stresses under both normal and abnormal operating conditions, and finally by selecting the required material specification. These variables are each optimized to assure that an overall balanced design is selected.

Quality Assurance

1. **Material Acceptance**

Power System Sourcing Quality Control will accept or reject each of the rotor forgings for use as generator rotors based on the following:

A. A Certificate of Test containing the following information indicating conformance to the specifications:

1) Chemical analysis

2) Mechanical Properties

3) Heat treatment

4) Impact transition temperature

5) Ingot size and weight

6) General Electric order number, specification number, drawing number, vendor serial number, GE serial number, and vendor's heat number.

B. A photomicrograph showing the microstructure at mid-body location.

C. Ultrasonic test measurements to assure that no unacceptable indications are present.

D. Center core and surface radial properties as determined by tests on samples removed from specified locations as required.

When the test results conform to the specifications required by the purchase order, the forging will be released for assignment.

2. **In-Process Quality Control**

All critical operations are recorded by the operators on process control forms. During machining, the major dimensions are recorded by the operators. The critical dimensions are checked and recorded by QA inspectors. Some of the more important in-process checks include the following:

A. Journal Diameters - The journals are carefully inspected for concentricity, three-point lobe, runout, and finished diameter.

B. Wedge Dovetail - The wedge dovetails machined in the field are carefully measured to assure close clearance wedge fits in all slots. In addition, after slot machining, dimensions are measured to ensure they are within tolerance.

C. Shrink Fit Dimensions - All shrink fit dimensions are inspected at the time of machining to ensure proper shrink interference.

D. Coupling Bolt Holes - The coupling holes are inspected for precision location to ensure proper alignment when assembled with the turbine.

E. Precision Lathe Runouts - Runout checks are performed on couplings, collectors, fans, and retaining rings to ensure that the field's rotating parts meet specifications.

F. Before the forging is released for coil assembly, a thorough inspection is made for cleanliness and to see that all manufacturing operations have been performed to specifications.

3. **Testing**

A. Magnetic Particle Test - The bore (where applicable) and the periphery of the spindle ends of the rotor are magnetic particle tested during the machining process.

4. **Record Retention**

   A. Forging Certificates of Tests and all nondestructive test records are retained for the rotor's life.

   B. In-process records of machining dimensions and "releases" are maintained for five years after start-up of the turbine-generator.

   C. Drawings and specifications are maintained for the rotor's life.

Field Winding

Product Design

1. **Function**

   The field winding, which is formed by connecting several multiturn field coils in series, carries the excitation current that produces a component of the main magnetic field.

2. **Operating Requirement**

   The field winding components must be designed to meet the following requirements:

   A. Mechanical and thermal balance.

   B. Withstand the crushing loads due to centrifugal forces.

   C. Withstand cyclic mechanical and thermal stresses.

   D. Be effectively cooled to remove the I2R losses.

   E. The conductors must remain electrically isolated from ground and each other.

3. **Materials**

   Field winding materials include: high conductivity silver bearing copper conductors for stress creep resistance, glass-composite turn insulation and layer separators, glass-epoxy creepage blocks to insulate the coils from the rotor wedges, and slot armors to insulate the coils from the rotor body.

4. **Design Approach**

   The designer determines the number of turns needed in the field winding to provide the desired air-gap flux. He also determines the proper balance between coolant flow passages and copper conductor area for optimum current-carrying ability and crushing strength.

Field Coils

Quality Assurance

1. **Material Acceptance**

   Release of copper raw material or copper assemblies to production are the responsibility of Quality Assurance. Requirements of the applicable area quality plan, release procedures and satisfactory certificate of test ensure the proper release of material to Manufacturing.

2. **In-Process Quality Control**

   A. Machining Station- Randomly selected slot bars and end straps from each machining station are audited for conformance to dimensions. This is in addition to operator's dimensional check sheets which are maintained continuously.

   B. Brazing Station - All brazers are qualified by the STG Department. All brazed joints are visually inspected for proper assembly and adequate alloy filling.

   C. Cleaning Station - All field coil cleaning operations are inspected to assure the elimination of all foreign materials and burrs which could cause dielectric failures after assembly.

Insulation and Blocking

Quality Assurance

1. **Material Acceptance**

   The two basic materials used in the field insulating and blocking components are glass reinforced epoxy and polyester resin laminates. These materials, ordered

to Engineering specifications, are accompanied by Certificates of Tests, which give the results of tests performed by the vendor in accordance with the specifications.

Field Assembly

Quality Assurance

1. **Material Acceptance**

   The basic field winding components are silver bearing copper coils, glass composite turn insulation and layer separators, glass epoxy creepage blocks, and glass reinforced epoxy slot armors, the raw materials of which are ordered to General Electric Specifications by STGGSC, which provides complete control from raw material purchase to final product assembly.

2. **In-Process Quality Control**

   Many individual in-process checks and audits are performed on the various items involved in the winding of a field, such as inspection of the assembly for damaged components, verification of mechanical fits and dimensions, and tests on completed processes, where applicable. The following in-process checks are conducted on the major processes during the field winding:

   A. A 100 percent recheck is performed on all shrink fit dimensions when received prior to assembly.

   B. Wedge Clearance Check - The wedges are checked for proper alignment and side clearance between the slots.

   C. Flow Clearance Check - The field ventilation passages are checked for blockage and clearance in the field.

3. **Testing**

   A. Coil Assembly Electrical Test - The ground insulation of each assembled coil is electrically tested after being assembled in the field.

   B. Shorted Turn Test - The field winding is checked for shorted field turns before assembling the retaining rings over the end windings.

C. Preretaining Ring High Potential Test - The field is high potential tested after permanent blocking and tested again before assembly of the retaining rings.

D. Winding Resistance Check - A field winding resistance check is made after assembly of the retaining rings.

E. Wind Shop Final High Potential Test - The completed field winding is high potential tested before being released for balancing.

4. **Record Retention**

Records of test results and QA Documentation are kept for five years after start-up of the turbine-generator.

Retaining Rings

Product Design

1. **Function**

The retaining rings restrain the end turns of the rotor winding against centrifugal force.

2. **Operating Requirements**

In addition to carrying the centrifugal force developed by the end turns of the rotor winding, the retaining rings must hold these end turns and their associated blocking in position to prevent changes in the condition of balance of the rotor.

3. **Materials**

A high strength nonmagnetic alloy steel, cold expanded to the required yield strength, is employed.

4. **Design Approach**

The inside diameter and length of a retaining ring are determined by the configuration of the coil end turns which it is to restrain. The outside diameter is then determined by the amount of ring cross-sectional area needed to carry the centrifugal force of the windings and the ring itself and by the ring stiffness needed to prevent excessive distortion. The ring is then designed to be mounted with a shrink fit on one end of the ring with sufficient interference to hold the ring and the end turns in position under operating conditions. A locking device is

included to withstand the axial thrust imparted to the ring by the windings as they elongate upon reaching their operating temperature.

Quality Assurance

1. **Material Acceptance**

   Quality Control will accept or reject retaining rings for use on generator rotors based on the following:

   A. A Certificate of Test containing the following information indicating conformance to the specifications:

      - Chemical composition
      - Tensile properties
      - Heat treatment

   B. A photomicrograph taken at 100X showing the microstructure of the test coupon (First piece qualification only).

   C. Ultrasonic test measurements are performed on the forging to assure that no unacceptable indications are present.

   D. The retaining ring forging is released for manufacturing after a Quality Assurance review and approval of the Certificate of Test. The suppliers Certificate of Test provides detail on the forging actual mechanical, chemical and/or electrical properties against the requirements of the material specification.

      Selected forgings are overchecked to verify ultrasonic reports, or forging test coupons may be sent to an approves testing laboratory for duplicate tensile and microstructure examination. When the results of the ultrasonic or laboratory tests are approved, Quality Control will release the ring for processing.

2. **In-Process Quality Control**

   All retaining ring forgings and the finish machined rings undergo a thorough program of inspection and testing to assure reliable performance. Great care is taken in handling the rings to prevent the surfaces form being damaged during manufacture testing and assembly. All critical operations are recorded by operators on process control forms and the critical dimensions checked by QA inspectors. Some of the major in-process checks include the following:

A. Shrink Fit Dimensions - All shrink fit dimensions are inspected at the time of machining to ensure proper shrink interference with the field.

B. Locking Grooves - The locking grooves machined in the retaining ring are carefully checked for size and location to ensure proper retention of the ring when assembled on the field body.

C. Four-Point Check for Concentricity - The inside diameter and wall thickness of the ring measured and recorded at four locations to ensure complete circular symmetry.

3. **In-Process Testing**

A. Liquid Penetrant - After finish machining, all rings are liquid penetrant tested for added assurance that the rings are free of surface imperfections.

4. **Record Retention**

A. Forging Certificates of Tests and all nondestructive test records are retained for a minimum of 7 years.

B. In-process records of machining dimensions are maintained for five years.

Field Balance

Product Design

1. **Function**
   All fields, when completely machined and with all parts assembled except fan blades, are multiplane balanced to run smoothly through their normal operating range.
2. **Design Approach**

   The balance program consists of installing weight distributions by means of the measured effect method. The vibration of the field is measured and analyzed at various speeds and locations. This data is used to determine optimum balance weight placement in the field for each vibration mode.

Quality Assurance

1. **In-Process Quality Control**

A. All fields, when completely machined and with all parts assembled except fan blades, are multiplane balanced.

B. Vibration detection devices are located at each journal and at the collector ring and turbine end coupling. Balance weights are installed to ensure that all 1/rev. amplitudes of vibration are within acceptable levels throughout the entire speed range.

C. During the balance process, fields are operated for three minutes at 120% of rated speed to confirm the ability of the field assembly to withstand higher than expected operating forces.

D. During the balancing process, and while at rated speed for the unit, a shorted turn test is performed utilizing facility-supplied field excitation and a probe to measure the distribution of the electromagnetic field.

E. A thermal sensitivity test is an integral part of the balance program for large generator fields. Excitation is supplied to the field and the effect of heating on field vibration is carefully analyzed.

2. Record Retention

Records of test results are kept for five years after start-up of the turbine-generator.

1.4 Prepare to Ship - Generator Field

1. **In-Process Quality Control**

After competition of all assembly operations and precision balance, the field undergoes a final testing, inspection, and special preparation before shipment to the customer. A summary of the tests, inspections, and special preparations include the following:

A. Bore Air Test (Hydrogen Cooled Units) - The collector terminal seals, seal plugs and main terminal seals are checked for leakage.

B. Megger Test - A test is made to ensure the integrity of the insulation system by measuring the resistance of field copper to ground.

C. Winding Resistance Check - A final resistance check is made of the field winding before release for shipment.

D. Shipping High Potential Test - The field is given a shipping High Potential Test according to the ANSI-C50 Standards before shipment.

E. The coil wedges, locking wedges and balance plugs are locked before final release for shipment

F. The journals and collector rings are inspected for surface finish and covered with Tectyl protective coatings and wrapped in wax paper to guard against moisture and mechanical damage.

G. The field body is spray painted and the body is covered with a plastic film before being fitted with body covers. Megger leads are attached so that periodic testing of the field insulation resistance can be made while the field is in storage.

H. For protection during transportation, the field is packaged in a desiccant-equipped shrink-wrap plastic. The sling areas are covered so that cables used in off-loading will not damage the wrapping.

I. If the field is to be assembled in the generator stator for shipment as an assembled unit, the field is not individually packaged as described above.

2. **Final Release**

Authority to release the field for shipment is assigned exclusively to the Manager-Quality Control or his delegate. Approval of the field for shipment is based on evidence that all Engineering Specifications, Alteration Notices, and dispositions on Quality Control Reports have been met and all work has been satisfactorily completed.

Section 2 : Customer Participation Offering

2.1 Introduction

STGGSC recognizes the need for customers to have access to manufacturing facilities and personnel for the purposes of obtaining information on production progress, determining status, observing tests or inspections and conducting audits. While every effort will be made to satisfy the needs of the customer, this activity is necessarily controlled in order to insure that the customers needs are, in fact, effectively satisfied with minimal impact on manufacturing activities and personnel and to insure the safety of all personnel involved. In this procedure, the word “customer” is meant to apply to the customer or his representative.

This procedure details a “Standard Offering” which is available to customers at no extra cost. Potential requests which fall beyond the “Standard Offering” are discussed *in italics* at the end of the appropriate section. The scope for customer access should be reviewed in the negotiations and incorporated into the terms of the contract with price and schedule impact where applicable.

Access Guidelines

Access to STGGSC facilities will be reasonable and governed by the terms of the contract. In order to assure that all the customer’s needs are satisfied in a timely and effective manner, the customer, in conjunction with General Electric, should identify their intentions and needs as detailed as possible in the contract. The Requisition Manager will assure that all contractual observation points, etc., are identified in a formal Manufacturing Instruction (MI) and incorporated into the Bill of Materials. Manufacturing will provide a list of responsible shop contacts.

"Reasonable access" will give consideration to the scope of work being performed by STGGSC, current shop load, available resources and the contract itself. It is assumed that customer visits and observations will be conducted by the customer's staff although third party contractors hired by the customer to perform such activities will be allowed with proper notification to STGGSC. The customer’s representatives shall operate within the guidelines of this document.

Customers will not be allowed unrestricted access to office or factory areas without escort by GE personnel. In addition, the customer’s direct involvement with factory hourly personnel will be restricted due to the possibility that delays to operations and production may result.

All customers will be provided with an identification/visitor badge which must be worn at all times. Access Privileges will be revoked if escort requirements / visitor badge

requirements are violated. All usual access will be conducted Monday through Friday, between the hours of 8:00AM and 5:00PM and must be scheduled with the responsible Project Manager prior to entry to the manufacturing areas. The Project Manager will establish appropriate access days and times with the Customer. Access to off-shift operations for scheduled witness points require advance approval and arrangements.

Due to the many proprietary manufacturing processes and operations, the use of cameras must necessarily be controlled. Any specific requests for photographs must be arranged through the Project Management Group with the approval of the area's manufacturing management.

Resident in-plant inspectors have a direct and major impact on STGGSC resources and thus are not considered part of the Standard Offering. This applies to third party representatives as well. Resident in-plant inspectors and their office arrangements will be negotiated at the time of Proposal.

Customer Review of STGGSC Documentation

A customer may review the appropriate quality control plans, procedures, drawings or records are necessary for operations/ tests/ inspections performed on his parts. (Under certain conditions when his parts may not be available, 'typical' documentation etc., may be reviewed to demonstrate examples.) Due to the fact that such documentation usually contains information considered proprietary to GE, copies are not normally provided.

All documentation reviews, etc., will be conducted with an authorized GE representative, such as the area Quality and Process Engineer. This is necessary as such documentation is usually of a "working" nature and will need interpretation by a knowledgeable individual. Under no circumstances will customers be allowed unrestricted access to documentation or data.

Since the review of documentation and data will usually involve in-process product and activities, certain types of documentation may not be made available for customer review until after full resolution and/or implementation of related issues.

Advance submittals of specifications, procedures, manufacturing quality plans, etc. are not part of the Standard Offering. Due to the proprietary nature of such documents, copies of documentation will not be provided unless specifically identified in the contract and allowed under internal procedures with the appropriate approvals.

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Customer Quality System Audits

STGGSC is certified to ISO 9001, an International Quality System, by Lloyd's Register Quality Assurance. Thus, STGGSC does not consider audits of its quality system as part of its Standard Offering.

Since quality system audits can require extensive involvement of STGGSC personnel and resources, they are considered extra cost and must be detailed in the terms of the contract. In addition, the performance of contractual quality systems audits must be limited to two auditors acting as a team and coordinated well in advance. Circumstances may exist which would limit the scope and duration of an audit.

Customer Observation Points

STGGSC has developed a "Standard Offering" of observation points available to customers at no extra cost. In order to ensure the satisfaction of the customer's needs and desires, the selection of observation points must be identified in the terms of the contract in order to incorporate such specifics into the planning and scheduling routines of the Department.

STGGSC will provide advance notification (usually 5 days) of observation points with confirmation of 24 - 48 hours. This would allow the customer sufficient time to plan a visit to STGGSC facilities at the designated time.

Generator parts are manufactured under an MRP production and inventory control system. Many parts are produced for "inventory" and are not assigned to a specific customer until time of shipment. Thus, except for certain large components and major serialized parts (generator fields stator frames, etc.), it may not be possible to provide an observation point on the actual parts a customer will receive. In such cases, STGGSC recommends that a customer observe the test or inspection on similar parts to assure that the procedures and processes are being followed that will assure a quality part.

The following inspections and tests are routinely performed in STGGSC facilities and, as such, are available as advance notice observation points. This list should not be taken to mean that any one such test will be performed on a particular part. Discussion should take place with Sales or Requisition Engineers to confirm which tests are applicable to a customer's specific part or component. These points have been developed by STGGSC based upon considerable past experience of what would be important to our customers in order to provide the quality assurance objectives they are seeking.

Observation of parts manufactured by STGGSC suppliers at their plants must be coordinated through the Power Systems Sourcing Operation.

2.2 **Generator Stator** - High Potential Test - Shipping
2.3 **Generator Field** - Overspeed, Balance
2.4. **Generator Field** - High Potential Test - Shipping

"Hold points", defined as a test or inspection point for which production stops until the customer arrives, have an obvious and significant impact on production. Many such points occur at critical times in the manufacturing cycle and at critical and tightly scheduled facilities. For that reason, STGGSC does not offer "hold points" but rather recommends "observation points" with advance notification. Any contractual requirement for hold points will give additional consideration to cost impact and the impact on schedules and delivery

Manufacturing operations are not subject to customer observation requiring prior notice or hold points. A customer may review whatever operations are in process on his parts while in-plant or view similar parts as long as such review does not interfere with production or violate security requirements, restricted areas or processes.

Advance notification requirements in excess of those specified above must be negotiated and incorporated into the terms of the contract.

Records

As steam turbines and generators are not fully assembled and tested, STGGSC does not provide a Standard Offering record package or report. Customer requests for manufacturing records will be considered extra cost and must be included in the terms of the contract.

2.2 Generator Stator: High Potential Test

Objective

To verify the insulation integrity of the assembled generator stator.

Description

The typically 2 to 4 hour inspection includes the following:

- General visual inspection of the fully assembled stator.
- Measurement of cold armature resistance by phase.
- Insulation resistance and polarization index measurements with 500 volt D.C. megger and readings at (1) minute, (3) minutes and (10) minutes for each phase.

- High potential test per GE standard but meeting or exceeding IEEE 115, ANSI C50.10 and IEC 34 for each phase.
- Insulation resistance recheck with 500 volt D.C. megger for (1) minute.
- Continuity and resistance check of RTDs.

Recommended Customer Witness Point.

2.3 Generator Field: Overspeed, Balance

Objective

To assure that the Engineering high speed operation requirements of generator fields are met.

Description

The primary objective of precision balancing is to reduce the residual unbalance of the field to the lowest possible level. The approach use in balancing fields is called modal balancing. Each mode of vibration, or critical speed, is balanced in turn, starting with the lowest speed, or first made. The process proceeds to each critical in turn from the first to the highest critical within the operating speed range. During the balance process, all fields are subjected to a three minute run at 120% of synchronous speed. Final balance vibration criteria for each field design is established by Engineering.

The second objective of the field balance process is to check each field winding for shorted turns via a flux probe test. This test is performed while the field is at rated speed, thus simulating operating conditions.

Discussion

The balance facility is operated on a tightly scheduled basis and is run, at times, 24 hours and day, 7 days a week, including holidays. Overspeed and balance witnessing is accomplished primarily through observation of the control room instrumentation. Customer representatives are usually placed on a phone call-up basis to avoid unnecessary waiting time in the spin cell during intermediate balancing runs.

***Note**: This activity is 5 day notification, 24 hour confirmation.*
Recommended Customer Witness Point.

2.4 Generator Field: High Potential Test

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Objective

To verify the insulation integrity of the assembled generator field.

Description

Electrical testing of the generator field is performed following the field overspeed and balance test.

The series of final electrical test include:

- Insulation resistance and polarization index measurements with 500 volt D.C. megger and readings over a 10 minute period.
- High potential testing per GE standard but meeting or exceeding IEEE 115, ANSI 50.120 and IEC 34..
- Measurement of cold field resistance.

Recommended Customer Witness Point.

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