The Application of the Steam Turbine Quality System

MFGGLO-GEZ-0020
Rev: 001

Introduction

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

GEZ-4982B, Section 2 describes a standard “Customer Participation Offering”, addressing typical areas in which the customer desires to participate in 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 Turbine Buckets

Product Design

1. **Function** - Turbine buckets are designed considering:

   A. Centrifugal forces of rotation

   B. Steam forces

   C. Vibratory forces

   D. Thermal stresses, steady state and transient

   E. Erosion from wet steam.

2. **Design Procedures**

   A. General types of buckets are developed in the Laboratory to arrive at the best compromise in design between aerodynamic and mechanical requirements.

   B. Every turbine design has type of bucket and parameters established based on output requirements.

   C. Each turbine stage is analyzed for stresses and frequencies in regard to the specific operating condition, using procedures established from fundamentals backed up by experience in service.

   D. Details of fits, clearances, and arrangement are established by enlarged layouts.

   E. Drawings are made outlining full dimensional and material requirements.

3. **Metallurgy**

   A. In general, turbine buckets are made of 12 percent nominal chromium alloy with variations of constituents to suit particular operating conditions.

   B. These alloys are chosen on the basis of strength at operating conditions, erosion and corrosion resistance, damping properties, and producibility.

C. Allowable stresses are established from results of extensive laboratory testing on creep, rupture, fatigue, erosion, corrosion resistance and experience.

Quality Assurance

1. **Materials Acceptance**

A. General - Turbine buckets are either machined from bar stock or from forgings; except for additional dimensional requirements in the latter case, the acceptance procedures are essentially the same.

B. Vendor Approval - The steel mills supplying the bars or billets to the forging vendors are recommended by Engineering and these forging vendors, in turn, are approved by Engineering and GSO Quality Control.

C. Release of Material - is the responsibility of Quality Control and is based on a Certificate of Test showing compliance to specification for:

- Chemical composition
- Mechanical properties, including:
  - ♦ Tensile tests
  - ♦ Impact (Charpy)
  - ♦ Hardness
  - ♦ Stress rupture (where specified)
- Laboratory tests on samples from audited lots, including:
  - ♦ Tensile tests
  - ♦ Charpy impact
  - ♦ Microstructure examination
- Any out-of-specification characteristic must be documented on a VRMD (Vendor Request for Material Deviation) or Quality Control Report and reviewed and approved by Engineering.

D. Forging Die Approval - is based on a metal or plaster cast impression submitted by the forging vendor. The impression is checked dimensionally by

Quality Control and Manufacturing Engineering to ensure parts meet applicable forging and specified machining tolerances. In addition, a minimum of two forgings are selected at random from each new shipment and are checked dimensionally before the lot is accepted for manufacture.

2. In-Process Controls

   A. General - In-process Quality Assurance procedures vary somewhat depending on such factors as: size (form of input forging or bar stock), alloy content, machining methods (Hydrotel or Excello), etc.

   B. Dimensional Checks - are made in process as characteristics on the buckets are generated, (i.e., the vane or dovetail), and are operator certified, first piece inspected or sampled.

   C. Spectrotest - When special alloy content is called for, a Spectrotest is © performed 100% before shipping to verify the correct chemistry for that material.

   D. Moment Weighing - Buckets are to be dead weighed or moment weighed as specified by Engineering and assembled on wheels in a prescribed sequence to ensure optimum balance of the wheel.

   E. Magnetic Particle Test - All finish machined buckets are magnetic particle tested.

   F. X-Ray and Liquid Penetrant Tests - All last stage bucket erosion shields are x-rayed and liquid penetrant tested for defects.

   G. Final Release - Before final release of buckets for assembly in wheels or rotors, each test and inspection requirement must be completed and signed off on the Final Inspection Planning Record Cards by Quality Control certifying compliance to specification.

3. **Records**

   A. Record Retention - The Final Release Record Cards are held in file for five years after start-up of the turbine-generator.

1.2 Turbine Rotors and Wheels

Product Design

1. **Function** - Turbine rotors and wheels are designed to:

   A. Carry the buckets and withstand the centrifugal loadings from them, carry residual operational thrust, transmit the accumulated torque and meet other design characteristics.

   B. Withstand the pressure and temperature conditions imposed, with very high resistance to creep and rupture.

   C. Resist erosion.

   D. In the case of rotors, be thermally stable, resist bowing and have good journal characteristics for the bearings.

   E. Resist damage due to rubbing of sealing rings.

2. **Design Procedures**

   A. Rotors and wheels are sized principally on the basis of torque, plus centrifugal and bending stresses.

   B. They are carefully analyzed for critical speeds, both transverse and torsional, and other operating characteristics.

   C. When major parameters are established, they are analyzed in detail for fillets, grooves, balancing provisions and contours.

3. **Metallurgy**

   Rotor and wheel materials are selected on the basis of laboratory tests and service experience that take account of:

   A. Chemistry

   B. Physical properties: yield, tensile, creep and rupture strengths, transition temperatures, hardness and impact strength.

   C. Resistance to erosion and corrosion due to normal steam chemistry.

   D. Homogeneity and stability.

Quality Assurance

1. **Materials Acceptance**

A. Vendor Approval - As long as the rotor or wheel size is within the range of forging size with which we have had previous experience, the order is placed with an approved vendor. If the forging is larger or differs in any way from previous practice, the requirements are reviewed with the vendor and an agreement reached on such things as trial heats, special in-process tests, etc. to assure that the necessary properties will be attained in the forging delivered for use.

B. Release of Material - Release of the material is the responsibility of Engineering and GSO Quality Control and is based on the following documents from the supplier:

1) Certificate of Test showing compliance to specification for:

- Chemistry
- Mechanical properties
- Heat treatment
- Impact transition temperature
- Microstructure.

2) Ultrasonic tests.

3) In the case of high temperature rotors, heat indication tests.

4) Tests on radial and center core specimens as required.

5) Periphery ultrasonic test before gashing

6) Heat test results on all high temperature rotors when required by specification.

2. **In-Process Controls - Rotors**

A. Release to Manufacturing - The results of the mill acceptance requirements are reviewed by GSO Quality Control and, if approved, the forging is released to Manufacturing.

B. In-Process Documentation:

1) Machined Rotors:

   a) Dimensional

   b) Magnetic Particle

   c) Ultrasonic Inspection of bores as required by engineering

2) Assembled Rotors:

   a) Magnetic Particle test of selected machined surfaces.

   b) Final runout checks

   c) Rotor balance

   d) Final magnetic particle test of buckets and covers after overspeed as required by specification.

   e) Final ultrasonic test of bore after overspeed as required by engineering.

C. Release to Ship

   If all previous tests and documentation is satisfactory, the rotor is released by Quality for direct shipment or for assembly.

3. **In-Process Controls - Wheels**

   Release to Manufacturing - The results of the mill acceptance requirements are reviewed by GSO Quality Control and, if approved, the forging is released to Manufacturing. The machined forging is released for bucket assembly after complete magnetic particle inspection. Once assembled, the wheel is considered part of a rotor and must pass the final release procedures for a rotor.

4. **Resonance**

   After bucketing, selected rotor stages as dictated by Engineering are given standing vibration modes to be sure that the ranges are within Engineering requirements. The modes tested are: bucket group tangentials, wheel axials and group axials. New designs are given more extensive tests and, if necessary, modifications are made in contour or grouping to avoid resonant frequencies.

5. **Storage and Shipment**

Specific instructions are issued describing processes to be used in preparation of rotors for shipping and storage at the job-site. These instructions may vary, depending on whether the rotor is for overseas or domestic shipment, whether for a nuclear or fossil-fuel station, on location of the job-site, and the estimated length of the storage period.

6. **Records**

A. Final Release - Check lists are maintained at each release point to be sure that all documents are complete before releasing the rotor for subsequent operations. Frequent audits are made to assure compliance with established quality standards and to check the accuracy of the documented data. A typical document will list the important drawing dimensions and will require that the operator enter the actual dimension and his pay number. All critical dimensions will require verification by an inspector, as well as the entries by the operator.

B. Record Retention

1) Forging certificates of tests and all nondestructive test records are retained for the life of the rotor or wheel.

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

3) Drawings and specifications are maintained for the life of the rotor or wheel.

1.3 Nozzle Diaphragms

Product Design

1. **Function** - Nozzle diaphragms are designed to provide the following characteristics:

A. Direct the steam flow into the rotating buckets at the design velocities and flow angles.

B. Perform over a wide range of temperature and pressure steam conditions.

C. Withstand steady-state thermal and pressure loadings, differential expansion stresses, and cyclic thermal stresses.

2. **Design Procedures**

A. General nozzle partition shapes are developed in the Laboratory to optimize the aerodynamic and mechanical requirements.

B. Different turbine sections have different basic partition types.

C. Each turbine diaphragm is analyzed for stresses after meeting number of partitions requirements dictated by bucket frequency design. Material selection is based on strength requirements and prior successful field experience in that application.

D. Details of fits, clearances and arrangement of diaphragms are established by full-size layouts.

E. Fabrication and machining drawings are made outlining full dimensional, material and weld assembly requirements.

3. **Metallurgy**

A. In general, nozzle partitions are made of 12 percent nominal chromium alloy.

B. The outer ring and inner web of the diaphragm use various materials from low carbon to high alloy steels.

C. Weld ability - The materials must be fully weldable to allow sound structural and repair welds.

D. The material creep and rupture strength after long exposure to high temperature must be adequate to meet the duty requirements.

E. The material must have erosion and corrosion resistance to normal steam chemistry, particularly for turbines supplied with steam from nuclear reactors. The materials are selected on the basis of both the test results obtained in our testing laboratories and on our service experience, as well as strength requirements.

F. Allowable stresses are established from results of extensive laboratory testing on creep, rupture, fatigue, and erosion, corrosion resistance, and experience.

Quality Assurance

1. Material Acceptance

A. Vendor Approval - All critical parts used in the construction of diaphragms are purchased from vendors approved and recommended by Engineering, GSO, and/or Quality Control.

B. Release of Material - Partitions, are machined from bar stock, forgings, or cold-rolled shapes or are hallow welded desion. Material release by Quality Control is based on Certificates of Test showing compliance to specification for:

- Chemical composition
- Mechanical properties, including:
  - ♦ Tensile tests
  - ♦ Impact (Charpy)
  - ♦ Hardness

Check tests are performed by a testing laboratory on all new vendors to confirm the results shown in the Certificates of Test. Additional tests may be required at the discretion of Engineering or Quality Control. The rings and webs forming the main structure of fabricated diaphragms are made from carbon or alloy steel forgings or plate, and Certificates of Test are required to show conformance to specifications for chemical composition and mechanical properties.

C. In-Process Controls

1) Fabricated diaphragms are welded using procedures specified by Engineering. Welders and welding operators are qualified in accordance with General Electric process instructions. All fabricated diaphragms are stress-relieved after main weld.

2) Dimensional Checks - In-process dimensional checks are made and recorded throughout the manufacturing process. These include measurements necessary to insure accurate alignment and running clearances in the assembled turbine. In addition, many measurements are made of the steam path itself to insure adequate flow capacity and maximum operating efficiency and to eliminate the possibility of undesirable excitation of the rotor wheels and buckets.

3) Nondestructive Tests - Ring and Webs of all diaphragms are non-destructive tested after machining and, in addition, the partitions are liquid penetrant tested.

D. Records - The summary of each diaphragm steam path area calculation is kept for the life of the turbine. Other records which include critical dimensional checks, non-destructive tests, and detailed area calculations are held for five years after start-up of the turbine-generator.

1.4 High Pressure Shells (Casings)

Product Design

1. **Function** - The HP turbine casings are designed to:

   A. Contain the high pressure steam and limit internal and external leakages.

   B. Position the stationary nozzles concentric with the turbine buckets for maximum efficiency and stability, maintaining close clearances under all conditions.

   C. Prevent large distortions and allow for free expansion during both steady-state and transient conditions.

   D. Provide for easy disassembly for inspection and maintenance purposes.

   E. Resist erosion, corrosion due to normal steam chemistry and creep.

   F. Provide external connections for extraction steam connections either controlled or uncontrolled.

2. **Metallurgy** - Turbine shells are almost exclusively castings and the materials are selected on the basis of:

   A. Weld ability - the material must be fully weldable to allow sound structural and repair welds of adequate strength.

   B. Castability - the material must produce sound castings with minimum of shrink, gas holes, segregation, and other flaws.

   C. The creep and rupture strength after long exposure to high temperature must be adequate to meet the duty requirements.

D. Resistance to erosion and corrosion due to normal steam chemistry, particularly for turbines supplied with steam from nuclear reactors. The materials are selected on the basis of both the test results obtained in testing laboratories and on our service experience.

3. **Design Procedure** - A general design philosophy is established that:

A. Uses a basic system of supporting and anchoring such that expansion and contraction are free while maintaining concentricity of all parts about the turbine centerline.

B. Provides a multishell construction as necessary for high pressures to limit bolting size and wall thicknesses, thus helping to reduce thermal stresses and aiding flexibility.

C. Provides flexibility in the admission parts for the governing stage. This is accomplished by separate nozzle boxes, by separate nozzle chests, or other arrangements.

D. Provide additional steam chests for control of extraction steam.

E. Divides the internal space into compartments to limit both temperature and pressure gradients.

F. Provides for inlet and exhaust pipe connections with a minimum of stress concentrations.

G. Uses a very successful bolt and flange arrangement which makes continuously tight flanges with bolts that are easily disassembled even after long-time exposure to high temperature. All high-temperature threading is of tapered design.

H. Starts with a pressure stress analysis and then is refined for thermal stresses with account for stress concentrations.

Quality Assurance

1. **Material Acceptance**

A. Castings - fully upgraded castings are procured to General Electric Specifications under the control of the Power Systems Sourcing Operation. Material Acceptance is based on a complete review of mechanical and chemical test results as well as a review of all upgrade and nondestructive test records and film.

B. Vendor Approval - All suppliers are thoroughly investigated by an Engineering, GSO Quality Control and Purchasing team to assure that all critical specification requirements are understood and can be met.

C. Release of Material - Responsibility for release of all castings in this category rests with Materials Engineering and GSO Quality Control and is based on a satisfactory Certificate of Test, including the following information:

1) Heat Number

2) Casting Serial and Drawing Number

3) Chemical Composition

4) Mechanical Properties

5) Heat Treatment

2. **In-Process Quality Control**

A. Dimensional Checks - During finish machining, dimensions are measured and recorded by operators and audited by inspectors. Threaded holes are checked for conformance to drawing. All deviations from specified dimensions are reviewed by Engineering personnel and corrective action is specified by them.

B. Dye Penetrant Inspection - All finish-machined internal surfaces are dye penetrant inspected for Schenectady type units. Fitchburg design units do not require Not After finish machining.

C. Hydrostatic Tests - Shells whose operating pressure is more than 15 psig and whose failure would cause a leak to the atmosphere are hydrostatic pressure tested at a minimum of 1 1/2 times operating pressures.

D. "Toll-Gate" Release - Check points are established throughout the manufacturing cycle and all tests and inspections are reviewed and cleared before the shell can proceed to the next operation.

E. Release from Machining Area - Before release for shipment is granted, it is determined that all specification requirements have been met, including corrective action on Quality Control Reports, and that all machining has been performed to the latest drawing revision.

3. **Erection and Assembly**

When required, shells are processed through the assembly area for alignment checks and subsequent assembly.

4. **Storage and Shipment**

   All as-cast surfaces of shells are painted or protected via a protective coating and all machined surfaces are given a protective coating.

5. **Record Retention**

   A. Shell master books containing records and documentation of nondestructive tests and repair welding are kept for the life of the turbine, as are Certificates of Test, drawings, and material specifications. X-rays are kept for the life of the turbine for nuclear-powered turbines and for 10 years after start-up of the turbine for fossil-powered turbines.

   B. Dimensional records, discrepant material reports, and test data are kept for five years after start-up of the turbine-generator.

1.5 Low Pressure Fabrications

Product Design

1. **Function**

   LP fabrications (casings) are generally composed of an integral barrel section for single flow casings and separate inner casing in a separate exhaust hood for double flow sections. Fabricated inner shells are employed in some inner casings.

   Turbine exhaust hoods are designed:

   A. To have inner barrels or inner casings (and inner shells) to support and locate the diaphragm so that nozzles are concentric with buckets under all transient and steady state conditions.

   B. To contain and guide the exhaust steam to the condenser without inward leakage of air and with low pressure drop.

   C. To have inner barrels or inner casings (and inner shells) which provide flexibility to accommodate temperature swings.

   D. To withstand full vacuum with minimum deflections to internal parts and bearing supports.

E. To act as anchor points to the foundation, withstanding exhaust hood and shell expansion forces.

F. In sections that can be shipped by rail or truck.

G. To have inner chambers that provide for extraction pockets from which steam is diverted from the steam path for feedwater heating, boiler feed pump drives, air preheating, etc.

H. To have an inner casing which contains an inlet bowl into which LP inlet steam is admitted directly from the crossover, crossarounds or high pressure section.

2. **Design Procedures**

A. There are various LP section designs - at least one for each last stage bucket group.

B. Prototype LP section components are designed to meet maximum application duty criteria within material allowables. Experience is factored in the final design.

C. Integral barrels, inner casings and fabricated inner shells are designed to carry a wide range of pressure and thermal loadings which may be experienced in service. Axisymmetric methods as well as local analyses (horizontal joints, extraction pockets, etc.) are employed.

D. Radial and axial motions of internal diaphragms are analyzed to assure reliable operation.

E. Field and factory testing is used to check and improve design systems.

F. Design systems, both structural and thermodynamic, are supplemented by scale model tests.

3. **Metallurgy**

Generally, all parts of exhaust hoods are for service below 750°F and are made of carbon steel. There are some exceptions for shims, dowels, bolts and expansion joints where alloy high-strength and stainless steels are used. If temperatures are higher, or if wet steam is used, modifications are made: for example, copper bearing carbon steel is used to some degree for nuclear turbines.

Quality Assurance

1. **Materials Acceptance**

   A. Raw Material - Plate and bar stock used in the manufacture are purchased to General Electric specification and require a Certificate of Test from the mill, or supplier, covering chemical composition.

   B. Vendor Approval - All large fabrications are purchased from outside vendors. Sourcing Quality Control and Engineering must approve the vendor's facilities and quality assurance capabilities before placing him on the approval list.

      Audits are made at the vendor's plant during manufacture, and prior to release for shipment, by General Electric Sourcing Quality Control personnel. In addition, a Certificate of Conformance is required of each vendor covering:

      1) Welder and welding process qualifications

      2) Final dimensional inspection

      3) Leak tests where required

      4) Nondestructive testing of welds where required.

      5) Heat treatment records

2. **Fabrication**

LP parts are fabricated from detailed assembly drawings using specified weld joint preparations and qualified welding processes by qualified welders. These are in accordance with drawing requirements and specifications. Heat treatment of fabricated assemblies, in-process repairs, and fabrication appearance standards are also prescribed by specifications. These include visual inspections, dimensional checks, magnetic particle tests, and leakage tests.

3. **In-Process Quality Control**

   A. In-Process Quality Control - Visual and dimensional inspections.

   B. Dimensional Inspections - During fabrication, layout and machining.

4. **Erection / Assembly**

A. Final erection of large hood sections is required prior to release for shipping to establish fits, concentricity and proper alignment.

B. Final assembly of medium hoods is required to check internal fits and clearances. In certain cases, they are shipped fully assembled when shipping limitations permit.

5. **Storage and Shipment**

A. Protective Coatings - Large fabrications are painted to prevent rusting. Machined surfaces are given a moisture-protective coating.

B. Shipment - Large fabrications require special procedures for shipping to prevent damage in transit. Special cars are required in some cases to provide the necessary bridge and tunnel clearances.

6. **Record Retention**

Dimensional records, discrepant material reports, and Certificates of Test, when required, are kept for five years after start-up of the turbine-generator.

1.6 Valves

Product Design

1. **Function**

Turbine valves in the main steam path perform the following functions and have the following characteristics:

A. Emergency steam shut-off in case of load loss (approximately 2/10 second closing).

B. Regulate steam flow to control speed and load.

C. Resist steam cutting and erosion.

D. Are stable and do not vibrate at high steam velocities.

E. Are testable under operation to verify operating conditions.

2. **Design Procedure**

A. Sizes and valve parts to give low pressure drop.

B. Lays out passage in accordance with results of extensive air testing to give low pressure drop and stable flow.

C. Calculates wall thickness of pressure vessel on basis of axisymmetric body.

D. Provides inlet and outlet connections with stresses calculated at intersections.

E. Designs head and bolting for pressure and differential temperature conditions.

F. Analyzes design for stress concentration points and modifies design to account for both steady-state and transient conditions.

G. Designs the operating mechanism to perform the opening and closing functions in the required time while limiting impact stresses.

H. Provides a testing system that allows testing in operation to assess operating condition.

I. Establishes allowable rates of heating and cooling to limit thermal stresses.

3. **Metallurgy**

Body materials are similar to those used for turbine shells and are selected on the same basis.

A. Creep and rupture at high temperature

B. Weld ability

C. Stability

D. Resistance to erosion and corrosion due to normal steam chemistry.

Quality Assurance

1. **Materials Acceptance**

A. Castings - fully upgraded castings are procured to General Electric specifications under the control of the Power Systems Sourcing Operation. Material acceptance by General Electric is based on a complete review of mechanical and chemical test results as well as a review of all upgrade and nondestructive test records and film.

B. Vendor Approval - All suppliers are thoroughly investigated by an Engineering, GSO Quality Control and Purchasing team to assure that all critical specification requirements are understood and can be met.

C. Release to Ship - A Laboratory Test Certificate is required for each casting from which the castings are poured. This Certificate will list the following data:

1) Heat number

2) Casting serial and drawing number

3) Chemical composition

4) Mechanical properties

5) Heat treatment

6) All other required Upgrading Documentation

Each Certificate is reviewed by GSO Quality Control prior to release for manufacturing.

2. **In-Process Control**

A. Dimensional Checks - During and after finish machining, critical dimensions are measured and recorded by the operators and audited by inspection. These dimensions include:

1) Wall thickness after finish machining when required by drawing.

2) Valve head stud holes - lean check.

3) Valve seat bore - for size.

4) Customer weld preparations.

B. Final Magnetic Particle Inspection - All machined surfaces are magnetic particle tested. All other parts of the valve are given close Material Acceptance and In-Process Quality Assurance inspections and tests appropriate to the function.

C. Assembly and Test - During and after assembly of the valve components, the following are some of the tests and inspections performed:

1) Hydrostatic test of valve body

2) Hydrostatic seat leakage test

3) Valve and seat contact

4) Stem clearance

5) Trip closing time on hydraulic cylinders

6) Valve lift

3. **Storage and Shipment**

The size of the main steam valves may necessitate that they be partially disassembled for shipment. All exposed machined surfaces are coated with preservative and all cast surfaces are painted. Openings are covered with plywood and sealed with moisture resistant tape. Hydraulic cylinders, studs, and other loose components are protective coated and crated prior to shipment.

4. **Record Retention**

A. Castings "master books" and Certificates of Test are kept in file for the life of the equipment. X-rays are kept for the life of the turbine for nuclear-powered turbines and for 10 years after start-up of the turbine for fossil-powered turbines.

B. All drawings and specifications are similarly kept for the life of the equipment to assure having adequate information for making replacement parts as necessary.

C. Dimensional records, discrepant materials reports, operating test records, etc., are retained for five years after start-up of the turbine-generator.

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.***

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.

Turbine and 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 (turbine rotors, generator fields large castings, 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 Turbine Rotors

2.2.1. Repair and Return - Incoming Inspection

2.2.2 Repair and Return - Incoming NDT
2.2.3. Incoming Bore Mag/Bore Sonic (if applicable)
2.2.4. Periphery Sonic
2.2.5. Final Magnetic Particle Before Assembly
2.2.6. Overspeed and Balance
2.2.7. NDT After Overspeed

2.3 Buckets
2.3.1 Final Mag Test
2.3.2 Final Inspection

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"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 test report. Customer requests for manufacturing records will be considered extra cost and must be included in the terms of the contract.

2.2.1 Turbine Rotors: Repair & Return - Incoming Inspection

Objective

To evaluate, document and report the as-received condition of a customer's rotor that has been returned to STMD for a defined scope of work.

Description

This inspection is primarily visual in nature unless otherwise specified by Manufacturing Instructions issued by Engineering. Due to the varying service conditions that rotors have been subjected to, the evaluation is based on the visual discrepancies as compared to new rotors. Characteristics noted include erosion, pitting, visual wear damage, damaged parts such as buckets and covers, scoring, etc. Besides establishing the condition of the rotor for record purposes, the inspection established a basis whereby Engineering may make recommendations to the customer for additional repairs beyond the original scope. Such recommendations, if accepted by the customer, may increase the negotiated price of the repair.

Discussion

The total evaluation of the rotor is closely tied to the results of any incoming non-destructive testing that is performed. There are procedures which document this inspection activity although each rotor is evaluated on an individual basis with close involvement by Engineering.

Customer participation, while permitted, is not recommended as he should already have inputs on the general condition of the rotor. In addition, due to the fact that such rotors are frequently processed on an urgent basis, prior notification cannot be committed to.

Customer participation, while permitted, is not recommended.

2.2.2 Turbine Rotors: Repair & Return - Incoming NDT

Objective

To access the material integrity of the rotor, buckets and other returned hardware for suitable repair work and continued service.

Description

The as-received rotor is first inspected as outlined in Section 3.1 and the report furnished to Engineering. The rotor is cleaned by suitable methods which may include glass bead or aluminum oxide blasting. After an acceptable surface is obtained, the NDT is performed in accordance with Engineering instructions. The results are evaluated by Engineering and further work scope determined.

Based on the work scope, initial inspection and / or Engineering evaluation, the NDT performed may include one or more of the following:

- Magnetic Particle Inspection
- Liquid Penetrant Inspection
- Ultrasonic Testing

Customer participation, while permitted, is not recommended.

2.2.3 Turbine Rotors: Bore Mag / Bore Sonic

Objective

To determine the base line sonic integrity of the rotor and disclose any material discrepancy before extensive machining takes place.

Description

The bore is first visually examined to determine if the surface is smooth and suitable for testing. Bore sonic is normally performed first using a proprietary computer controlled automatic data acquisition and storage system. This data is tabulated and

evaluated and then sent to Engineering for review and disposition. The bore magnetic particle test is then performed and the results also sent to Engineering.

On all rotors with bores, a bore eccentricity test is performed on the ends to insure the bore is concentric with peripheral surfaces. This is normally performed at the facility doing the machining of the rotor.

It is important to note that while all rotors are designed to accept a bore, most will be manufactured without a bore. Turbine Materials and Process Engineering should be contacted for such determination.

Magnetic particle testing will be performed on bored rotors in the early stages of manufacturing. In most cases, this work is also performed at the forging supplier's facility prior to shipment to General Electric.

Customer participation, while permitted, is not recommended.

2.2.4 Turbine Rotors: Periphery Sonic

Objective

To determine the base line sonic integrity of the rotor and disclose any material discrepancy before extensive machining takes place.

Description

All rotors are sonic tested in a lathe. The forging will be subject to both axial and radial ultrasonic testing. This data is tabulated, evaluated and then sent to Engineering for disposition.

All rotor receive a peripheral sonic test prior to being "gashed", that is, prior to the rough machining of the wheels while the body is intact. Peripheral sonic test would be performed at a supplier's plant (possibly foreign) is the rotor was to be rough machined by the supplier.

A sonic bore eccentricity test is performed on bored rotors to evaluate the eccentricity of the outside diameter relative to the bore. The results are evaluated by an NDE Engineer who may require the centers to be "drawn".

Customer participation, while permitted, is not recommended.

2.2.5 Turbine Rotors: Final Magnetic Particle Before Assembly

Objective

To confirm that the finished machined surfaces of the rotor / shaft are free of defects before assembly.

Description

The rotor is cleaned to remove any substance which would inhibit the magnetic particle inspection. Using the wet-continuous method and either a fluorescent or non-fluorescent suspension, the rotor is sprayed and inspected. After the inspection is complete, the rotor is demagnetized. This procedure will employ both the direct-circular and longitudinal magnetization methods. Any relevant indications are reported to Engineering for disposition.

Customer participation, while permitted, is not recommended.

2.2.6 Turbine Rotors: Overspeed and Balance

Objective

To ensure that every turbine rotor leaving the factory has the minimum amount of unbalance such that in the assembled turbine, corrective balance “shots” will generally not be necessary.

Description

The fully assembled rotor is transported to the balance facility where it is set up in factory bearings and pedestals. After all lube oil connections, instrumentation, electrical and drive connections are made, the bunker is sealed and balance and overspeed routines are initiated. The rotor is first low speed balance and then high speed balanced. After an acceptable preliminary balance is obtained, the overspeed run is made as a proof test of the assembled rotor. Overspeed is at 120% of rated speed although the turbine is set to trip off line at approximately 112% of rated speed. This final balance is performed after the overspeed test. Final weight resolution and rotor critical speeds are documented.

Discussion

The balance facility is operated on a tightly schedule basis and is run, at times, 24 hours a day, 7 days a week, including holidays. Overspeed and balance witnessing is accomplished primarily through observations 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.

2.2.7 Turbine Rotors: NDT After Overspeed

Objective

To evaluate the material integrity of selected assembled parts after rotor overspeed and balance.

Description

This activity is selective in that the entire rotor is not non-destructively tested. NDT is performed as follows:

- Magnetic particle testing of exposed vane surfaces on: all 23" LSB; all L and L-1 buckets on rotors which have a 26" or greater LSB.
- Magnetic particle testing of the exposed surface of peened tenons and bucket covers on: all 23" LSB; L and L-1 stages on 3000 / 3600 RPM units with last stage buckets 26" or greater; L, L-1 and L-2 stages on 1500 / 1800 RPM units with last stage buckets 35" or greater.
- Magnetic particle testing is performed on the tenons and covers of all bucket rows with gas turbine dovetail designs as well as on all 1st stage high pressure rows with integral covers;
- Visual inspection is performed on the exposed surfaces of all peened tenons and covers on all remaining rows.

***Customer participation, while permitted, is not recommended*.**

2.3.1 Buckets: Final Mag Test

Objective

To assess the material integrity of finished turbine buckets.

Description

All turbine buckets are required to be magnetic particle tested, which is accomplished during the final inspection process. (Buckets which are not ferromagnetic require liquid penetrant testing). Buckets manufactured from barstock are tested in the longitudinal direction only. Buckets made from forgings are tested in both directions as is the flame hardened area of buckets requiring that process. The test performed is a fluorescent wet medium suspension (wet bath) in which the current and solution concentration are strictly controlled.

Engineering establishes the acceptance standards for buckets. Many customers expect, and have at times included in the contract language, that buckets will be free of indications. It must be recognized that some indications are allowed in buckets within the parameters established by Engineering.

Customer participation, while permitted, is not recommended.

2.3.2 Buckets: Final Inspection

Objective

To assure all quality requirements have been satisfied on turbine buckets and to complete requirements that could not be established in-process prior to shipment.

Description

Bucket quality is assured through numerous in-process quality control techniques which may include first piece inspection, operator certification and documentation and inspection audits. The final inspection activity is not a reverification of dimensions previously established and verified but rather a sequence of inspections that include one or more of the following:

- Visual inspection *
- Vane dimensional checks *
- Curvature checks with special gages *
- Lineup checks of vane edge locations and tenon locations *
- Taper checks
- Cover fit on tenon *
- Mag test / liquid penetrant
- Spectrotest
- Vibration testing
- Weigh and chart
- Hardness
- Verification of quantity and type

Discussion

Customer participation, while permitted , is not recommended as the above activities involve several separate operations within the final inspection activity that are normally completed over a time frame of up to one week. A customer cannot have advance notification of the individual elements listed above. It can be arranged that he witness a sampling of the "bench inspection" items identified with an asterisk. A magnetic particle test is also available for witness with prior notification.

2.4.1 Steam Valves: Final NDT

Objective

To assure the material integrity of the finished machined surfaces of the valve.

Description

The valve body is received from the casting vendor in an upgraded condition. This means that the valve body has been x-ray cleared, sonic checked for wall thickness and magnetic particle tested prior to receipt by STMD. The casting has been cleared by Sourcing Quality Control prior to shipment from the vendor. A customer may review the records supplied to STMD by the vendor. A request by the customer to witness NDT processes at the casting Vendor's facilities should be submitted to the Power System Sourcing operation for review and approval.

Only finished machined surfaces are non-destructively tested in-house in accordance with the Engineering instructions.

Customer participation, while permitted, is not recommended.

2.4.2 Steam Valves: Hydro Body and Seat Test

Objective

To provide a factory proof test of the valve design, materials and workmanship in order to assure the capability of the part to withstand the stresses imposed during operation.

Description

Hydro testing is performed by pressurizing the casing with either water or oil. Specific pressures are determined by Engineering. Test pressures may vary depending on the specific area under test but will normally be 1-1/2 times operating pressure. This pressure is held for one hour. Parts used in the test are those that will be shipped to the customer.

The seat tightness test is done either as a pressure test or as a kerosene and whiting type leak test with no pressure. Any leakage is recorded and evaluated for acceptance. Test time is one hour. Test pressure is normally the operating pressure.

Discussion

1. Since hydro test is performed at high pressures, concern for safety is of primary importance. The customer must strictly comply with all direction given by shop personnel.

2. Set-up and testing occurs on all shifts and may required 24 hour coverage.

Recommended Customer Witness Point.

2.5.1 Shells: Final NDT

Objective

To assure the material integrity of turbine shell castings after finish machining.

Description

STGGSC shell castings are purchased fully upgraded from outside vendors. NDT performed in STGGSC facilities involves a liquid penetrant test of machined surfaces. Valve bore machined surfaces are magnetic particle tested. These two tests will most likely be performed during separate time periods which may require two trips by the customer if he wishes to observe both processes.

Any relevant indications outside specification limits are reviewed and dispositioned by Engineering.

A customer may review the records supplied to STGGSC by the casting vendor. A request by the customer to witness the NDT processes at the casting vendor's facilities should be submitted to the Power Systems Sourcing operation for review and approval.

Customer participation, while permitted, is not recommended.

2.5.2 Shells: Hydro Test - Outer Shells

Objective

To provide a factory proof test of the outer shell design, materials and workmanship in order to assure the capability of the part to withstand the stresses imposed during operation.

Description

Shells whose failure could cause a leak to the atmosphere are hydro tested at 1-1/2 times design pressure. Therefore, all turbine outer shells are hydro tested. Since shells are multichamber components, each chamber whose failure could cause a leak must be tested.

Shells are upgraded and non-destructively tested prior to the test. Test pressures will not exceed the maximums specified by Engineering.

The hydro test of a shell is acceptable once the requirements for minimum test pressures and duration have been satisfied with no leaks at the horizontal joint at 10% over design pressure and no leaks through the shell wall at 1 1/2 times design pressure. Any leaks observed in the joint hardware or the horizontal joint itself are evaluated by Engineering for disposition.

Discussion

1. Since this test is performed at high pressures, concern for safety is of primary importance. The customer must strictly comply with all directions given by shop personnel.

2. Set-up and testing occurs on all shifts and may require 3 shift coverage.

Recommended Customer Witness Point.

2.6.1 Nozzle Boxes: Final NDT

Objective

To assure the material integrity of the completed nozzle box after all fabrication and machining operations are complete.

Description

Final NDT consists of magnetic particle and liquid penetrant testing, which are accomplished in several distinct time periods.

Liquid penetrant testing is performed on the steampath immediately prior to final area check. This inspection is performed in several steps and also may consist of several distinct time frames in that a half steampath may be done at a time. Consequently, a double flow nozzle box, for example, considering upper and lower halves, may be checked in four distinct time frames. Consequently, this inspection, while available for customer witness, is really not recommended due to the obvious timing problems it may create.

Magnetic particle testing is performed on the entire nozzle box which include all outside surfaces exclusive of the steampath and internal bridge ring and pipe welds only.

Customer participation, while permitted, is not recommended.

2.6.2 Nozzle Boxes: Final Inspection

Objective

To assure the finished quality of the completed nozzle box prior to shipment.

Description

The final inspection activity includes:

- Dimensional checks of critical steam path characteristics (exclusive of steam path areas); joint checks; selected radii; inactive arc machining; hold down bolt machining and pocket depth; shell and gib clearances.
- Visual checks including blades, sidewalks, upper and lower half alignment; burrs; blends; spill strips; blade rotation; cleanliness; etc.
- Verification of in-process requirements such as X-rays, NDT, area check, etc.
- Stamping for identification, inlet identity, NDT and area inspection stamps.
- Paperwork review including clearance of all QCRs, ANs and MIs.

Discussion

Customer participation, while permitted, is not recommended as the final inspection activity described above is extensive and will take place over a time frame

of several days, requiring 24 hour coverage each day. A customer requesting this involvement, may wish to participate on a selective basis and review the records of inspections that were accomplished in his absence. The inspections cannot not be held up in his absence.

A complete record review by the customer is recommended in lieu of his in-depth participation in the final inspection process.

2.7.1 Diaphragms / Nozzle Plates: Final NDT

Objective

To assess the material integrity and fabrication quality of the web, ring, partitions and welds in diaphragms and nozzle plates.

Description

Both magnetic particle and liquid penetrant inspections are employed. These activities are performed at various points in the manufacturing process. Magnetic particle of the finish machined admission side web and ring surfaces is performed at or immediately after steam path upgrade. The discharged side is tested after finish machine operations.

Partitions are liquid penetrant tested complete at upgrade and may be LP tested piecemeal during the upgrade cycle. The discharge edge of only the adjusted partitions are tested after area adjust. The discharge side of the diaphragm setback faces are also tested at this time.

Discussion

The customer should plan on two visits if witness of MPI is desired. Customer witness of the MPI testing of the complete diaphragm is discouraged but is possible under special arrangement as this involves additional crane lifts. Due to the additional segmentation of the LP tests, plus the fact that these are performed as part of manufacturing operations, these tests are not available for routine customer witness and prior notification.

Customer participation, while permitted, is not recommended.

2.7.2 Diaphragms / Nozzle Plates: Final Inspection

Objective

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To assure all quality and engineering requirements have been satisfied prior to shipping, including the proper preservation level.

Description

As with most STMD / GMD products, the quality of many diaphragm characteristics are verified in-process, leaving the final inspection activity to include the following:

- Clearance of all QCRs, ANs, and MIs
- Review and acceptance of all in-process process control forms
- Check for burrs, handling damage, overall completeness and visual quality
- Check protective coatings for coverage and appearance

Discussion

Due to the nature of the final inspection activity on diaphragms and nozzle plates, this element is not recommended as a customer witness point but is available if deemed necessary. Such an involvement will be restricted to the items mentioned above. Dimensional checks cannot be repeated for the customer's inspector as such checks are taken in-process, frequently when set-up on machine tools.

Customer participation, while permitted, is not recommended. What is recommended, in lieu of the above, or in conjunction with, is a review of the associated quality records for the part.

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