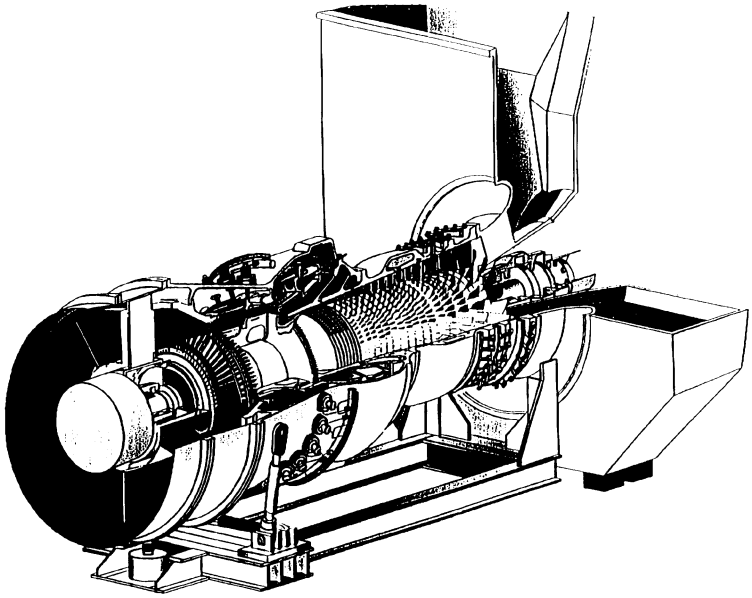
g *Quality Assurance System*



Gas Turbine Manufacturing Department

Greenville, South Carolina

"The Application of the Gas Turbine Quality System"

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Introduction

GEZ-8304-2, Section 1 - describes key elements of the Quality System as it applies to major components and parts manufactured by GEGT. Each section is designed to prov information relative to essential product design and quality assurance considerations n meet engineering requirements.

GEZ-8304-2, Section 2 - describes a standard “Customer Participation Offering”, addr typical areas in which the customer desires to participate in during the manufacture of product. It also provides standard customer observation points and a description of the activities that usually occur at those points.

Section 1: The Quality System Product Application

1.1 Stator Casings

Product Design

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

   A. Contain the compressed air in the compressor section, and the hot gas path the turbine, and limit both internal and external leakage.

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

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

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

   E. Resist erosion and corrosion due to normal air and hot gas path gas chemist

   F. Provide external connections on the compressor section for extraction air c and to provide connections on the turbine section for air cooling.

2. **Metallurgy** - Casings are almost exclusively castings and the materials are sele the basis of:

   A. Castability - the material must produce sound castings with minimum of sh holes, segregation, and other flaws.

   B. The creep and rupture strength after long exposure to high temperature mus adequate to meet the duty requirements.

   C. Resistance to erosion and corrosion due to normal air and hot gas path gase 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 c are free while maintaining concentricity of all parts about the turbine center

B. Provides a multi-shell construction as necessary to limit bolting size and wa thickness, thus helping to reduce thermal stresses and aiding flexibility.

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

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

E. Provides for pipe connections with a minimum of stress concentrations.

F. Uses a very successful bolt and flange arrangement which makes continuou flanges with bolts that are easily disassembled even after long-time exposur temperature.

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

Quality Assurance

1. **Material Acceptance**

A. Castings - Castings are procured to General Electric Specifications under th of the Power Systems Sourcing Operation. Material Acceptance is based o complete review of mechanical and chemical test results as well as a review nondestructive test requirements.

B. Vendor Approval - All suppliers are thoroughly investigated by an Enginee PSSO Quality Control and Purchasing team to assure that all critical specifi requirements are understood and can be met.

C. Release of Material - Responsibility for release of all castings in this catego with Materials Engineering and PSSO Quality Control and is based on a sat 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 a recorded by operators and audited by inspectors. All deviations from speci dimensions are reviewed by Engineering personnel and corrective action is by them.

   B. "Toll-Gate" Release - Check points are established throughout the manufac cycle and all tests and inspections are reviewed and cleared before the casir proceed to the next operation.

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

3. **Erection and Assembly**

   Casings are processed through the assembly area for alignment checks and subs assembly.

4. **Storage and Shipment**

   All as-cast surfaces of stator casings are painted or protected via a protective co all machined surfaces are given a protective coating.

5. **Record Retention**

   A. Records and documentation of nondestructive tests are kept by the supplier of the turbine, as are Certificates of Test, and material specifications.

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

1.2 Airfoils, Compressor Blades

Product Design

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

   A. Direct the air flow into the following compressor stages at the design veloc flow angles.

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

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

2. **Design Procedures**

   A. General airfoil shapes are developed in the Laboratory to optimize the aero and mechanical requirements.

   B. Different compressor sections have different basic airfoil designs.

   C. Each airfoil design is analyzed for stresses after meeting number of vane re dictated by airfoil pass frequency design. Material selection is based on str requirements and prior successful field experience in that application.

   D. Details of fits, clearances and arrangement of airfoils are established by des

   E. Fabrication and machining drawings are made defining full dimensional an requirements.

3. **Metallurgy**

   A. In general, compressor blades are made of a 400 series stainless steel alloy.

   B The material creep and rupture strength after long exposure to high tempera be adequate to meet the duty requirements.

   C. The material must have erosion and corrosion resistance to normal air chem materials are selected on the basis of both the test results obtained in our tes laboratories and on our service experience, as well as strength requirements

   D. Allowable stresses are established from results of extensive laboratory testi 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 compressor purchased from vendors approved by Engineering, PSSO, and Sourcing Qu

   B. Release of Material - Compressor airfoils are machined from bar stock, or a forgings. Material release is based on Certificates of Test showing compliа 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 con results shown in the Certificates of Test. Additional tests may be required a discretion of Engineering or Sourcing Quality.

   C. In-Process Controls

      1) Dimensional Checks - In-process dimensional checks are made and rec throughout the manufacturing process. These include measurements ne insure accurate alignment and running clearances in the assembled turb

      2) Nondestructive Tests - All airfoils are fluorescent penetrant tested after machining. Parts whose material is suitable for magnetic particle inspe also tested utilizing MPI.

   D. Records - Records are not retained for these parts upon completion, as they traceable to the non-serialized part.

1.3 Turbine Buckets

Product Design

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

   A. Centrifugal forces of rotation

   B. Gas forces

   C. Vibration forces

   D. Thermal stresses, steady state and transient

   E. Corrosion/erosion.

2. **Design Procedures**

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

   B. Each gas turbine design as a function of frame size/machine capacity, has a bucket design established.

   C. Each gas turbine bucket stage is analyzed for stresses and frequencies in reg specific operating conditions, using procedures established from fundamen up by experience in service.

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

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

3. **Metallurgy**

   A. In general, turbine buckets are made of GE patented high strength/high tem alloy with variations of constituents to suit particular operating conditions.

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

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

Quality Assurance

1. **Materials Acceptance**

   A. General - Gas turbine buckets are machined from precision castings, with tl acceptance procedures essentially the same for various stages.

   B. Vendor Approval - The casting vendors are approved by Engineering and S Quality.

   C. Release of Material - is the responsibility of the vendor, and is based on tes showing compliance to specification for:

   - Chemical composition
   - Mechanical properties, including:
     - Tensile Tests
     - Hardness
     - Stress Rupture (where specified)
   - Laboratory tests on samples from audited lots, including:
     - Tensile Tests
     - Microstructure Examination
   - Any out-of-specification characteristic must be documented on a VRMI Request for Material Deviation) or SDR (Supplier Deviation Request) a reviewed and approved by GE Gas Turbine Engineering prior to shippi material from the vendor.

   D. Casting Mold Approval - is based on a cast impression submitted by the cas vendor. The impression is checked dimensionally by Sourcing Quality and Product Introduction Engineering to ensure parts meet applicable casting ar machining tolerances.

2. **In-Process Controls**

   A. General - In-process Quality Assurance procedures vary somewhat dependi factors as: size, alloy content, machining methods, etc.

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

C. Moment Weighing - Buckets are to be moment weighed as specified by En and assembled on the turbine rotor in a prescribed sequence to ensure optin balance of the rotor.

D. Fluorescent Penetrant Test - All finish machined buckets are fluorescent pe tested.

E. Internal Cooling Passage Flow Tests - All buckets with internal cooling pas flow tested.

F. Final Release - Before final release of buckets for assembly in rotors, or as parts, each test and inspection requirement must be completed.

3. **Records**

Record Retention - Paper records are scanned, and stored electronically. Electr are maintained for a minimum of five years.

1.4 Gas Turbine Rotors, Wheels, and Shafts

Product Design

1. **Function -** Gas turbine wheels and shafts are designed to:

   A. Carry the airfoils and withstand the centrifugal loading from them, carry res operational thrust, transmit the accumulated torque and meet other design characteristics.

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

   C. Resist corrosion/erosion.

   D. In the case of rotors, be thermally stable, resist bowing and have good journ 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 centrifu bending stresses.

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

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

3. **Metallurgy**

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

   A. Chemistry

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

C. Resistance to erosion and corrosion.

D. Homogeneity and stability.

Quality Assurance

1. **Materials Acceptance**

A. General - Gas turbine rotor wheels and shafts are machined from forgings, v acceptance procedures essentially the same for various stages.

B. Vendor Approval - The forging vendors are approved by Engineering and S Quality.

C. Release of Material - is the responsibility of the vendor, and is based on tes showing compliance to specification for:

1) Certificate of Test showing compliance to specification for:

- Chemical composition
- Mechanical properties, including:
  - Tensile Tests
  - Hardness
  - Stress Rupture (where specified)
- Microstructure

2) Ultrasonic Tests.

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

4) Periphery ultrasonic test before broaching.

- Any out-of-specification characteristic must be documented on a VI (Vendor Request for Material Deviation) or SDR (Supplier Deviatic Request) and reviewed and approved by GE Gas Turbine Engineeri shipment of the material from the vendor.

2. **In-Process Controls - Wheels and Shafts**

   A. Release to Manufacturing - The results of the mill acceptance requirements reviewed by computer software and, if met, the forging is released to be shi the vendor to Manufacturing.

   B. In-Process Documentation

      1) Machined Rotor Wheels and Shafts:

         a) Dimensional checks
         b) Magnetic particle (when applicable)
         c) Fluorescent penetrant (when applicable)
         d) Ultrasonic inspection (when applicable)
         e) Spin testing (when applicable)

      2) Rotor Sub-Assemblies (Blade & Wheel):

         a) Dimensional checks
         b) Balance

      3) Rotor Assembly (Compressor Rotor/Turbine Rotor):

         a) Dimensional checks
         b) Component stack
         c) Bolt elongation/torque

      4) Assembled Compressor and Turbine Rotors:

         a) Dimensional checks
         b) Final run-out checks
         c) Rotor balance

      5) Assembled Unit Rotor:

         a) Dimensional checks
         b) Final run-out checks
         c) Rotor balance, (two bearing designs only)

   C. Pass for Load

      If all previous tests and documentation is satisfactory, the rotor is released f shipment to assembly, or to prep-to ship if a spare rotor.

1.5 Gas Turbine Assembly

Product Design

1. **Function** - Gas turbine assemblies are designed to provide the following chara

   A. Provide a compressor section capable of providing the required compressed provide machine component cooling air requirements, as well as providing compressor discharge air to meet the air requirements for combustion of fu power turbine.

   B. Provide a power turbine section capable of providing the required output p drive both the gas turbine compressor load, as well as the external load dev either a mechanical drive or power generation application.

   C. Perform over a wide range of both ambient site and types of fuel condition

   D. Provide service in terms of both availability and reliability, with considerat both initial cost and operating costs.

2. **Design Procedures**

   A. General Gas Turbine Design Practices have been developed over many yea experience to optimize the aerodynamic and mechanical requirements of th

   B. Different compressor/turbine sections have different basic airfoil designs.

   C. Each airfoil design is analyzed for stresses after meeting number of vane re dictated by airfoil pass frequency design. Material selection is based on str requirements and prior successful field experience in that application.

   D. Details of fits, clearances and arrangement of airfoils are established by des

   E. Fabrication and machining drawings are made defining full dimensional an requirements.

3. **Metallurgy**

   A. Metallurgy requirements have been defined in the above sections for the ma turbine components.

   B. The material creep and rupture strength after long exposure to high tempera be adequate to meet the duty requirements.

C. The material must have erosion and corrosion resistance to normal air/hot g gas chemistry. The materials are selected on the basis of both the test resul in our testing laboratories and on our service experience, as well as strengt requirements.

D. Allowable stresses are established for the major gas turbine components fro of extensive laboratory testing on creep, rupture, fatigue, and erosion, corro resistance, and experience.

Quality Assurance

1. **Materials Acceptance**

A. Vendor Approval - All critical parts used in the construction of the gas turb purchased from vendors approved by Engineering, and Sourcing Quality.

B. Release of Material - Major gas turbine components are made as forgings, c welded/machined fabrications, as previously defined. Material release by C Control is based on Certificates of Test showing compliance to specificatio appropriate.

- Chemical composition
- Mechanical properties as required, which may include:
  - Tensile Tests
  - Impact (Charpy)
  - Hardness
- Non-destructive testing is performed on some gas turbine components a previously defined, involving:
  - Radiographic Inspection
  - Ultrasonic Inspection
  - Dye Penetrant Tests
  - Fluorescent Penetrant Tests
  - Magnetic Particle Tests

Check tests are performed by a testing laboratory on all new vendors to con results shown in the Certificates of Test. Additional tests may be required a discretion of Engineering or Quality Control.

2. **In-Process Controls - Gas Turbine Assembly**

   A. Dimensional Checks - In-process dimensional checks are made and recorde throughout the manufacturing assembly process. These include measureme necessary to insure accurate alignment and running clearances in the assem turbine. In addition, many measurements are made of the gas/air path itself adequate flow capacity and maximum operating efficiency and to eliminate possibility of undesirable excitation of the rotor wheels and blades. Dimen checks taken during the assembly activities are normally recorded on Powe Turbine (PGT) forms, and cover:

      1) Stator Casing Alignment
      2) Bearing Alignment
      3) Rotor/Stator Clearances

   B. Lube oil system checks involve hot oil flushing utilizing filtration to assure lube oil system.

   C. Machines with gas fuel systems require hydrostatic testing.

3. **Records**

   A. Final Release - Check lists are maintained at each release point to be sure th documents are complete before releasing the machine assembly for subsequ operations. Frequent audits are made to assure compliance with establishec standards and to check the accuracy of the documented data. Typical docur data taken on PGT forms will list the important drawing dimensions and wi that the operator enter the actual dimension and his pay number.

   B. Final Machine Configuration Verifications - Check lists are maintained as p machine assembly activities which provide documentation of the major cor on the gas turbine, and document appropriate drawing number/serial numbe recording. This listing also is utilized to assure machine configuration cont specific Model List applied for the specific customer of that machine.

   C. Record Retention

      1) In-process records of machining dimensions and "releases" are maintair years after start-up of the turbine-generator.

      2) Drawings and specifications are maintained for the life of the gas turbin

1.6 Gas Turbine Testing/Certification for Shipment

1. **Function**

   A. The purpose of testing is to detect any major infant mortality failures of cor of the machine, as well as to assure that the machine is totally functional, a the performance criteria established for that specific design gas turbine. Te frequency may be on an audit basis as determined be GE.

   B. Testing involves:

      1) Installation of the machine to be tested in the appropriate test stand, inv hook-up of air inlet/turbine exhaust ducts, hook-up of instrumentation, fluid systems, such as cooling water, lube oil, and hydraulics, and the se these systems to the appropriate pressure/flow rate criteria.

      2) Cranking checks to validate instrumentation and support systems are fu and set correctly.

      3) Firing of the gas turbine, and then acquisition of performance data invo criteria as air flows/pressures/temperatures, bearing lube oil flows/pressures/temperatures, fuel flows, and vibration data.

      4) Detection and correction of any functional faults found on the gas turbi the final certification run of the machine.

      5) Acquisition of final certification run data.

      6) After successful completion of the testing of the gas turbine, it is remov the test stand, and is returned to the main factory for cleaning, final pair certification for shipment to the customer. All shipments are by rail, ba both physical weight and dimensional constraints.

      7) Final inspections are made for validation of preparation to ship, i.e. tem covers are provided and color coded, shock indicators are properly insta cosmetics are acceptable, lagging is correct for rail-car transportation, e

2. **Storage and Shipment**

   A. Protective Coatings - The gas turbine casings are painted to prevent rusting Machined surfaces are given a moisture-protective coating.

B. Shipment - Gas Turbines require special procedures for shipping to prevent transit. Special cars are required in some cases to provide the necessary bri tunnel clearances.

3. **Record Retention**

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

Section 2: Customer Participation Offering

2.1 Introduction

GEGT recognizes the need for customers to have access to manufacturing facilities an personnel for the purposes of obtaining information on production progress, determini observing tests or inspections and conducting audits. While every effort will be made the needs of the customer, this activity is necessarily controlled in order to insure that t customers needs are, in fact, effectively satisfied with minimal impact on manufacturi activities and personnel and to insure the safety of all personnel involved. In this proc 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 ext Potential requests which fall beyond the “Standard Offering” are discussed *in italics* a the appropriate section. The scope for customer access should be reviewed in the neg and incorporated into the terms of the contract with price and schedule impact where a

Access Guidelines

Customers and/or their representative (s) are expected to comply with all GE rules/regulations (safety/conduct) while on/within GE facilities.

Access to GEGT facilities will be reasonable and governed by the terms of the con order to assure that all the customer’s needs are satisfied in a timely and effective m customer, in conjunction with General Electric, should identify his intentions and r detailed as possible in the contract. Project Management will assure that all contra observation points, etc., are properly identified in appropriate GE documentation f activities.

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

Customers will not be allowed unrestricted access to office or factory areas withou GE personnel. In addition, the customer’s direct involvement with factory hourly p will be restricted due to the possibility that delays to operations and production ma

All customers will be provided with an identification/visitor badge which must be
times. All usual access will be conducted between the hours of 7:30AM and 4:30P
must be scheduled with manufacturing prior to entry. Access to off-shift operation
advance approval and arrangements.

Due to the many proprietary manufacturing processes and operations, the use of ca
must necessarily be controlled. Any specific requests for photographs must be arra
through the Quality and Customer Relations group.

*Resident in-plant inspectors have a direct and major impact on GEGT resources a
are not considered part of the Standard Offering. This applies to third party repre
as well. Customer representatives will be provided reasonable office arrangemen
in-plant.*

Customer Review of GEGT Documentation

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

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

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

*Advance submittals of specifications, procedures, manufacturing quality plans, et
part of the Standard Offering. Due to the impact on internal resources and giving
consideration to the proprietary nature of such documents, copies of such docume
will not be provided.*

Customer Quality System Audits

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

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

Customer Observation Points

GEGT has developed a “Standard Offering” of observation points available to cust no extra cost. In order to ensure the satisfaction of the customer’s needs and desire selection of observation points must be identified in the terms of the contract in orc incorporate such specifics into the planning and scheduling routines. GEGT will p advance notification (usually 10 working days) of observation points with confirma 24 - 48 hours. This would allow the customer sufficient time to plan a visit to GE(facilities at the designated time.

Turbine parts are manufactured under an MRP production and inventory control sy Many parts are produced for "inventory" and are not assigned to a specific custome time of shipment. Thus, except for certain large components and major serialized p (turbine rotors, turbine units, etc.), it may not be possible to provide an observation the actual parts a customer will receive. In such cases, GEGT recommends that a c observe the test or inspection on similar parts to assure that the procedures and pro being followed that will assure a quality part.

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

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

— 2.2 Rotor Balance
— 2.3 Turbine Factory Final Test
— 2.4 Unit Ready for Shipment

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

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

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

2.2 Rotor Balance

Objective

To have the Customer's representative directly observe the final balance of the Gas rotor(s) intended for his unit.

Description

The Customer's representative(s) is invited to observe the normal production opera final rotor balance on the rotor(s) designated for his unit. The completed rotor is se balance machine and stabilized. Unbalance readings are taken in two planes at low (300 to 500 rpm) and balance correction is applied to one or more planes by weigh Final balance readings and mathematical checks (closure calculation-when applicab performed to assure an acceptable rotor.

Advance notice of the rotor balance schedule is provided, but the operation will no delayed to accommodate customer schedules.

Final rotor balance is a single operation on the entire unit rotor for the MS5001, M MS6001FA, MS7001FA and MS9001FA gas turbine models. In the case of the tw models MS3002 and MS5002, the high pressure set is balanced in one operation an totally independent low pressure set (load turbine) is balanced in another operation MS7001EA and MS9001E models have separate final balance operations for the co section rotor and the turbine section rotor only, as no unit rotor balance is required (3) bearing machine designs. Manufacturing methods and priorities are such that th customer should plan on separate visits where multiple balancing operations are to observed.

Discussion

1. The probability that the observed rotor balance will remain customer assigned i there could be extenuating circumstances where this is not possible.

2. Required measurements during the balance operation will be performed by GE with GE instruments and gages. GE acceptance criteria will prevail.

3. The factory often works on a full 3-shift, 7-day basis. The complete balance op from set-up to final checks could be spread over more than one shift.

4. Balance operations may be performed at an authorized GE service shop facility

5. This service must be specifically listed in the contract documentation.

2.3 Turbine Factory Final Test

Objective

Factory no-load testing is the principal method of assuring that the gas turbine unit operable and that the aero-thermal performance is acceptable as compared to factor on similar models.

Factory testing of gas turbines will be performed on an audit basis as determined b When a customer's specific machine is scheduled for testing, the customer or his representative (s) are invited to directly observe operation of his gas turbine during final fire testing.

Description

When a part of the GE defined test audit, the gas turbine is tested in the factory unc speed no load conditions to assure that the unit is fully functional, and within the e vibration specifications.

The customer is provided access to GT Test to observe the turbine unit final test ru satisfactory automatic start-up sequence is demonstrated. Observation of temperat pressures, flows, and vibration is made at steady state full speed no load conditions normal stop sequence with cool-down cranking is executed.

The full unit test program is available for customer review including test data on de settings and any deficiencies cleared at test. The customer will be provided with ac notification if this event is specified in the contract as an inspection point, however program will not be delayed to accommodate customer schedules.

Running tests at 100% (uncorrected) speed enable evaluation of bearing temperatu wheel-space temperatures, steady state vibration levels, etc. Performance testing is conducted at 100% ISO corrected speed. At the operating point approximately 35 measurements and 55 temperature measurements are recorded. Also, compressor a extraction air flow, and fuel flow data is collected. The complete gas turbine cycle analyzed and a thermodynamic calculation is made for the performance test point. results are then compared to the database for similar machines.

The factory final fire test run provides assurance that the unit is fully functional wi devices set properly. Prior to this run, the unit has been involved for several days v running tests, cranking tests, and aero-thermal performance tests. The combustion dynamics systems have been inspected for proper operation and any defects discov have been cleared and rechecked.

Discussion

1. Test Stand Condition and Expectations:

   A. Both natural gas and distillate oil are available fuels to be used.

   B. The Gas Turbine is not complete in its final packaged form, i.e.:

      — *There is no connected load.*
      — *Unit lagging is not in place.*
      — *The contract fire protection system is not installed.*
      — *Some specific customer options including water wash and water or ste injection are not operated at unit test.*
      — *Regenerative and heat recovery equipment are not fitted.*
      — *Test inlet and exhaust systems are used.*
      — *Test water systems are used.*

   C. Factory Test Instrumentation and hardware is utilized for:

      — *Inlet and exhaust systems*
      — *Turbine control panel(s)*
      — *Lube Oil cooling system*
      — *Vibration probes (for acceptance criteria)*
      — *Alternate starting device (i.e., Motor instead of expansion turbine, or s devices)*

   D. Contract accessory bases are tested separately from the gas turbine.

2. Normally, GT test is worked on a 3-shift, 7-day basis.

3. All required measurements will be performed using GE personnel with GE inst and gages. GE acceptance criteria will prevail. The basis of judgment of performance acceptability is considered GE proprietary.

2.4 Unit Ready for Shipment

Objective

To satisfy the customer's representative that the unit is complete and adequately pa
and prepared for shipment.

Description

Consisting of up to three (3) distinct inspection points depending on the machine a
customer objectives, this option starts with a walk around inspection of the unit in
stages of preparation for shipment. This inspection is after final painting but befor
bolting of batten strips which secure the side panels on an on- base lagged unit, an
prevent internal access. During this inspection the customer may review overall
workmanship, completeness of assembly, adequacy of prime painting, application
blanking plates and other temporary covers, preservation techniques, and general s
practices.

Next, he may desire to see his unit on the rail car ready for shipment. The unit is fu
enclosed as a lagged unit. Un-lagged units are properly protected for shipment. U
secured to the rail-car with appropriate blocking/bolting, and are appropriately mar
this point, the customer formally acknowledges contractual conditions that may aff
of payment, transfer of ownership and insurance coverage, bonus or penalty, etc.

Finally, the customer may wish to review the contents of his summary sheet contai
summary sheet container is a portable stockroom containing hardware required for
installation as well as unit components that cannot be shipped assembled. It may c
to 3000 items. Packaging of the Summary Sheet container is normally spread over
weeks; check off sheets are used to assure completeness.

Discussion

1. The timing window for these inspections is critical - usually 4 to 8 hours. For t
   rail car the window may be only two hours due to pre-arranged railroad schedu
   events maybe separated by several weeks.

2. If source release of the unit is a contractual requirement or if the customer expe
   inside a lagged unit, then observation of the unit must occur in the prep-to-ship

3. Units which have separate Accessory Bases are shipped on separate rail cars. I
   of the Accessory Base may occur on a different schedule than that of the gas tu

4. At the first observation point ninety-five percent of the prep-to-ship activities w complete.

   — *Some external parts such as the oil tank liquid level gage and thermometer some piping will be removed.*
   — *All pipes will be covered and sealed.*
   — *External machined surfaces are preserved and wrapped.*

5. At the rail car observation point, the bill of lading may be at the railroad offices available for review at GEGT. The normal shipping period is between 7:00 AM 12:00 midnight.

6. Due to the diversity, number of parts and amount of packaging in the summary container, 100% verification is not feasible. The offering is to conduct audits o items from completed check-off sheets.

7. This service must be specified in contract documentation. GEGT acceptance c prevail.

Supporting Document

Certification of Gas Turbine Unit (PGT-4736)