SYSTEM DESCRIPTION

STEAM TURBINE-GENERATOR

STARTUP SYSTEM T10

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1.0 FUNCTION

The function of the steam turbine-generator is to receive superheated, high-pressure steam from the steam generator superheater, transform the thermal energy of the steam into kinetic energy in the steam turbine, and convert the kinetic energy into electric energy in the electric generator.

The turbine, in addition to expanding the steam to produce shaft work, also provides controlled extraction steam for use at the thermal host, and uncontrolled extraction steam for use in the regenerative feedwater heaters.

2.0 SYSTEM DESCRIPTION

2.1 General

The following cycle parameters at the rated conditions are incorporated into the steam turbine-generator design:

Generator Output	48,500 kW (Summer) 49,600 kW (Winter)
Throttle Steam Pressure	1,500 psia
Throttle Steam Temperature	950°F
Backpressure	2.5" HgA (Summer) 2.15" HgA (Winter)
Process Steam to Host (After Desuperheater)	16,500* lbs/hr (Summer) 7,500* lbs/hr (Winter)

* Includes 500 lbs/hr to the steam-air ejector.

The unit is capable of providing a maximum of 20,500 lbs/hr (including 500 lbs/hr to the steam-air ejector) of saturated steam to the process at 215 psia at the summer power output, and 11,500 lbs/hr load (including 500 lbs/hr to the steam-air ejector) at the winter power output.

The unit is also capable of producing 51,550 kW and 51,900 kW gross output at the summer and winter conditions, respectively, with throttle flow of 410,000 lbs/hr and zero process steam to host.

The turbine is designed with five (5) percent steam flow margin above the guaranteed inlet flow-passing capability.

The unit is capable of providing maximum process steam flow (20,500 lbs/hr) at any electric load between 100 and 25 percent.

The unit is capable of ramp load changes during normal operation of 5.0 MW/minute up and down.

The unit is capable of starting and attaining 100 percent load in the following times from steam admission:

Cold Start (Shutdown over 36 hours)	3 hours
Warm Start (Shutdown 16-36 hours)	1.5 hours
Hot Start (shutdown under 16 hours)	1 hour

The unit is designed for a life expectancy of 25 years with a maximum of 40 startups and shutdowns per year.

2.1.2 Description

The turbine is a nonreheat, single-cylinder, axial-exhaust, condensing unit with two controlled extractions for process steam and four uncontrolled extractions for feedwater heating.

The turbine consists of fifteen stages. Stages 1 through 12 are impulse-type, while stages 13 through 15 are reaction-type stages. The blading material is 12% Chrome throughout the turbine.

The generator is a standard, totally-enclosed, revolving field, two-pole, smooth rotor, synchronous type. The generator is rated at 57,870 kVA when supplied with 86°F cooling water at any power factor from 0.90 lagging to 0.95 leading at 13,800 Volts, three-phase, 60 Hertz.

The steam turbine-generator also includes a main steam stop valve, main steam governing valves with actuators, power-assisted nonreturn valves for the extraction lines, turning gear, lubrication and control oil system, and all associated instrumentation and controls.

High-pressure superheated main steam is delivered from the steam generator to the turbine. As the steam passes through the turbine, the steam expands and produces useful shaft work and is exhausted to the steam surface condenser.

The cycle requires a condensing turbine-generator that supplies four uncontrolled extractions for regenerative feedwater heating, and two externally controlled extractions for process steam supply to the thermal host.

Steam from the steam turbine's gland seal system is delivered to the gland steam condenser where a majority of the steam is condensed. The latent heat of the condensing steam is recovered to the steam cycle by heating of the feedwater. High pressure leakoffs from the gland seal system are routed to the HP heater #4, and deaerator extractions.

Steam exhausted from the turbine is ducted to the steam surface condenser. Steam jet air ejectors are included for the removal of noncondensible gases from the condenser. The condenser backpressure is optimized at 2.5 inches HgA. This value is a result of selecting a design wet bulb temperature of 78°F (representative of a less than 5 percent occurrence value for the summer months), a cooling tower approach temperature of 18°F, and a condenser terminal temperature difference of 5°F. The steam condensate is collected in the condenser hotwell.

2.2 System Operation

The operation of a large steam turbine-generator requires a general knowledge of the major turbine components and their functions, and a broad understanding of the various support systems. The Mitsubishi O&M manual should be the reference for operation of the steam turbine.

3.0 COMPONENT DESCRIPTION

3.1 Mechanical Components

3.1.1 Turbine

General

Name of Turbine Manufacturer	Mitsubishi Heavy Ind.
Name of Generator Manufacturer	GEC Alsthom
Name of Excitation System Manufacturer	GEC Alsthom
Name of Governor Manufacturer & Model	Woodward 501
Type of Coupling Between Turbine & Generator	Rigid
Name of Thrust Bearing Manufacturer	Daido Metal
Overall Unit Length (above floor)	Approx. 48 ft
Overall Unit Width (above floor)	Approx. 15 ft
Overall Unit Height (above floor)	Approx. 17 ft

Assembled Weight of Turbine Complete without External Accessories, lbs	Approx. 255,000
Assembled Weight of Generator Complete without External Accessories, lbs	219,800
Stator Weight, lbs	121,300
Weight of Turbine Rotor, lbs	Approx. 30,000
Weight of Generator Rotor, lbs	Approx. 41,400
Heaviest Piece and Weight to be Handled During Erection, lbs	Turbine (Assembled) Approx. 255,000
Expected Vibration	
Maximum on Shaft, mils	2.5
Turbine Rated Speed, RPM	3,600
Generator Rated Speed, RPM	3,600
Minimum Distance Required from Foundation Top to CL Crane Hook to Lift Largest Piece	
After Erection	Approx. 23 ft (Turbine)
Specify which Piece	Turbine Upper Casing
Weight	Approx. 62,000 lbs
Pulling dimensions required for removing the generator field?	
Straight Pull (Axial from Center Generator)	31 ft
Approximate Box Dimensions of Components	
Lube Oil Unit (Excluding Oil Coolers), in	Approx. 105W x 220L 110H

Turbine

Type of Turbine	
Impulse	1st to 12th Stage
Reaction	13th to 15th Stage
First Stage Design	One-Row
Valves Wide Open, Throttle Flow, lb/hr	415,695
Percent of Rated Pressure for which Turbine is Designed when Operating Continuously	106 (1,590 psia)
Total Number of Stages	15
Variation	
Trip Stop Valve	
Number	1
Size	10-inch

Operation	Remote
Test while Operating	Yes
How many positions indicators Included	3 (Open,Close,Test)
Circuit Breaker Contacts	1 set

Inlet Control Valves (Governing Valves)

Type	Bar Lift Type
Number of Inlet Valves	4
Number of Separate Steam Ports	4
Feeding the First Stage	4
Upper Valves Only (Yes or No)	Yes
Type Valve Seats	Diffuser
Method of Fastening Valve Seats to Chest	Seal Welding

Materials

Stems	A1CrMo Steel or SS
Valves	CrMo Forged Steel or equivalent
Seats	CrMo Forged Steel or equivalent

Turbine Rotor

Material	CrMo Forged Steel
Build-up Wheels, Solid, or Combination	Solid
Blade Dovetail	Inside the Wheel
Blading Material	12% Cr Stainless Steel

Stationary Steam Path

Blade Rings or Diaphragms	Diaphragms
Nozzle Material	12% Cr Stainless Steel
Supported at the Center Line	Yes
Interstage Packing	Labyrinth
Interstage Packing	Single Rugged Type

Shaft Sealing System

Type of Packing	Labyrinth
Packing Material	Copper Alloy and SS

Sealing Fluid and Quantity Required, lb/hr	For Startup Steam/2,000
Items Supplied	
Evacuator (Gland Steam, Condenser Fan)	Centrifugal Type X2 Sets
Make	Hamada Blower or Equivalent
Horsepower	3.0 HP
Casing	
Casing Support	Supported at Centerline
Material	HP: CrMo Cast Steel LP: Carbon Steel Plate
Number of Vertical Joints in the Turbine Casing	1
Horizontal and Vertical Joint Surfaces	Machine-Lapped Means
Method of Stud Tensioning	By Means of Heating
Methods Employed in Construction to Reduce Thermal Stresses	Separate Nozzle Box for Inlet Steam
Bearings	
Number of Bearings	
Turbine	Journal:2/Thrust: 1
Generator	Journal:2/Thrust: N/A
Type of Bearings	Journal:Sleeve/ Thrust Kingsbury
Dummy Piston	Yes
Provision to move Rotor Axially under Load	No
Sight Flows	Yes (at Brg Box Outlet)
Bearing Inspection without Removal of Turbine Upper Half	Yes
Thrust Wear and Trip Alarm	Yes/By Rotor Axial Position Monitor)
Thrust Bearing Rating (lb)	44,800
Thrust Bearing Calculated Load (lb)	Approx. 22,000

Accessories

Oil System

Capacity of Oil Tank (gallons)	1,057 (nominal capacity)
Type of Main Pump	Centrifugal
Number, Type, and Motor HP of Pumps on Oil Tank	3 (including Main Oil Pump) Centrifugal 74, 74, 7.4 HP
Are Pressurized Oil Feed Lines Guarded Around High-Temperature Turbine Parts (Yes or No)?	No
Pump Running Switches Included	No
Automatic Pump Start Included	Yes
Low Oil Pressure Switch Included	Yes
Oil Pressure Transmitter Included	Yes
How Many Oil Thermometers Included	7
How Many Sight Flow Indicators Included	4
Vapor Extractor Motor HP	2
Duplex Oil Filter	Yes (for each L.O & C.O)
Filtration Level (Microns Absolute)	L.O: 125 C.O: 25
Filter Change with Unit in Service	Yes, Possible

Oil Coolers

Number	2
Total Cooling Capacity (Btu/hr)	Approx. 1.06×10^6
Tubing Diameter and Thickness	5/8" OD x 18 BWG
Tubing Material	Aluminum Brass
Required Cooling Water Flow Rate 86°F Inlet Temperature (gpm)	Approx. 400
Outlet Temperature (°F)	91.3
Cooling Water Pressure Drop @ Design Flow	Approx. 5 psi
Design Pressure	125 psig (for water side)

Turning Gear

Motor Horsepower	7.4
Bearing Pressure Interlock Included	Yes

Governing System

Type of System	Electronic / Digital
Can Emergency Governor be Tested (Yes or No)	No
With an Instantaneous Charge from Full Load with Maximum Setion Flows to No Load, the Maximum Speed of the Unit will be	Below Tripping Speed
The Overspeed Trip rpm will be	3,960 ± 36 RPM

Hydraulic Power Unit

Fluid Type		1S0-VG32 (Common with Lube Oil)
Instrument Panel		No
Low Pressure	Alarm	Yes
	Trip	No
Pumps-Duplex (Common with Lube Oil)		Yes (Main & Aux.)
	Auto Start	Yes
	Inlet Strainers	Yes
	Outlet Strainers	No
	Relief Valves	No
Hydraulic Fluid Pressure Transmitter		Yes
Pump Motor HP		74 (common w/lube oil)

Generator

kVA Rating	57,870
Voltage	13.8kV
Hertz	60
Phase	3
Speed	3,600 rpm
Power Factor	0.9
Short Circuit Ratio	0.65
Field Current @ Rated Excitation	579A

Temperature

Stator	$\leq$ 110°C
Field	$\leq$ 125°C
Cold Air	38°C

Hot Air	72°C
Armature Conductor Material	Electrolytic Copper
Armature Insulating Material	Glass, Samica & Epoxy Resin
Method of Fastening and Turns of Armature Bars	By Bracing on Rings Made of Statified Materials
Method of Balancing Generator Rotor	Dynamic High-Speed Balancing in Special Balancing Casement
Armature Slot Wedge Material	Glass Epoxy
Rotor Wedge Material	Special Brass
Number Stator Winding RTDs	6
Stator Insulating Material	Glass, Samica & Epoxy Resin
Guaranteed Temperature Rise-Stator, °C	72
Rotor, °C	87 (Above Cold air of 38°C
Generator Casing Liquid Detector	Yes
Generator Reactances (per unit)	
Zero Sequence at Rated Current	0.07
Negative Sequence at Rated Voltage	0.13
Subtransient at Rated Voltage	0.13
Transient at Rated Current	0.19
Synchronous at Rated Current	1.53
SCR at Rated kVA	0.65
Amount of Third Harmonic Component, %	Less than 3
Total Generator Loss Excluding Bearings and Including Exciter at Rated (.90) Power Factor and Rated kVA	79.8
Generator Efficiency at Rated kVA and 0.9 Power Factor Copper @ 95°C	98.37
Generator Regulation at Rated kVA and Unity Power Factor, %; 90% Power Factor	31.1 / 37.1
Excitation System	
Type of Excitation System	Brushless
Generator Field Current Required at Rated Conditions	579A

Diodes

Conditions of Whole Diode Can be Checked with Unit in Service	Yes, Fault Detection Device is Provided
Full Wave Bridge Assemblies	Polygonal 5-Phase Exciter
Required	1
Supplied	1

Generator Coolers

Type and Number	Finned Tubes/2
Location	On Top of Generator
GPM and Outlet Temperature with 86°F Inlet Water	760
Generator Capacity, kVA, with One Cooler Out of Service	57,870 (100%)
Cooling Water Pressure Drop at Rated Flow	5 meters of water
Cooling Water Design Pressure, psig	60

4.0 PREOPERATIONAL CHECKS AND SYSTEM STARTUP

4.1 General

For preoperational checks and system startup, refer to the detailed procedure in the Mitsubishi operation and maintenance manual, Tab 2.

4.2 Steam and Oil System Set Points

Service	Set Point
Lube Oil Pressure Low to Start Standby Pump	20 psig
Lube Oil Pressure Low - Alarm	20 psig
Lube Oil Pressure Low-Low - Turbine Trip	16 psig
Lube Oil Pressure Low to Start EOP	20 psig
Turbine Exhaust Pressure High - Alarm	21.4 inches HgG
Turbine Exhaust Pressure High-High - Turbine Trip	19.9 inches HgG
Lube Oil Temperature High - Alarm	125°F
Control Oil Pressure Low - Alarm	164.2 psig