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1. Introduction

1.1 General

The MS6001FA gas turbine is the mid-size model in GE's family of F-class gas turbines - the world's largest, most experienced fleet of advanced technology gas turbines.

Developments at GE Aircraft Engines and Corporate Research & Development have provided a basis for enhancements to "F" technology gas turbines in advanced cooling techniques, improved sealing methods, patented high-strength alloys, and superior high-temperature coatings. State-of-the-art technology is also utilized in the 18-stage axial flow compressor, the Dry Low NOx combustion system, the turbine nozzles and buckets, and the modular off-base accessory arrangement.

The MS6001FA is the industry leader in combined cycle performance for plants of its size. It is ideal for applications requiring high performance gas turbines for moderate electrical capacity additions and combined heat and power applications.

- Simple cycle, combined cycle, integrated gasification combined cycle
- Single-shaft or multi-shaft combined cycle configurations
- Base load power generation
- Cogeneration and district heating

The MS6001FA builds on a tradition of technological leadership that has made GE gas turbines the standard by which all others have been measured for over four decades. Today, GE’s gas turbine product line is the most efficient, most reliable, and most proven in the market.

1.2 Prepackaged for Rapid Installation

The MS6001FA is prepackaged in a modularized design to assure fast installation with minimum installation cost. Under this concept, the majority of accessory equipment is skid-mounted and the location of the accessory package is standardized. This maximizes factory piping and wiring, while minimizing piping and wiring work in the field. Component arrangements reduce site interconnection requirements and ensure trouble-free site installation.

The basic MS6001FA power plant arrangement includes the accessory module(s) - housing the lubrication and hydraulic systems and fuel system(s).

Like the turbine, the air-cooled generator is fully packaged to reduce installation costs.

1.3 Availability/Reliability

GE heavy-duty gas turbines lead the industry in reliability and availability statistics. In fact, reliability and availability of GE "F" class machines rate higher than any other gas turbine design producing more than 50 MW. One key factor in the unmatched reliability of GE's gas turbines is the redundancy built into GE's state-of-the-art gas turbine control system. Because this microprocessor-based turbine control system employs a distributed processor and a redundant architecture, its overall performance is unmatched in the industry. The control system uses independent digital controllers to achieve the reliability of triple redundancy for the turbine control and protective functions.

1.4 Reduced Maintenance Costs

A critical goal in designing GE "F" technology gas turbines is reduced maintenance costs. The result is that competitive units require two to four times as many inspections as the GE "F" class machines. This means a GE machine will save millions of dollars over its service life.

When assessing improvements to gas turbine equipment, GE maintains a strict adherence to key design parameters affecting maintenance. The advantage of analysis and feedback from the largest fleet of gas turbines enables GE to develop design improvements and better maintenance procedures.

To keep customers informed of such new technology, GE conducts Gas Turbine User and Maintenance Seminars and issues technical publications to GE customers. The operating data from the vast fleet of gas turbines in service, coupled with an evolutionary design philosophy, enable GE to keep customers abreast of the latest advances and know-how in servicing and supporting their units.

1.5 Service and Plant Support

GE provides full-time support of the largest localized service network in the world. GE service is full scope, extending from unit order through unit retirement. GE field engineers are available to assist with installation and start-up and also with planned and emergency maintenance, with capabilities to perform diagnostics, performance assessments, craft labor coordination, repairs, overhauls, and upgrades.

Backing up these field service engineers is a network of GE service centers located around the globe. Whether for routine maintenance or emergency repairs, spare parts are available from warehouses and manufacturing centers all over the world.

2. General Plant Description

2.1 Design Condition

Characteristic	Specification
Elevation	12 m
Design ambient temperature	15 °C
Minimum ambient temperature	-6 °C
Maximum ambient temperature	40 °C
Design relative humidity	60 %
Minimum relative humidity	45 %
Maximum relative humidity	98%
Wind applicable Code	CIRSOC-102 (edition 1984)
Wind: Beta coefficiente	32.5m/sec
Wind: Cp coefficient	2.13
Snow Code	CIRSOC-104 (edition 1997)
Snow load	150kg/m²
Seismic Code	CIRSOC-103 (edition 1991)
Seismic zone	Zone 0, Building type A, Soil type 1
Horizontal acceleration	0.2g
Salt classification	Marine Environnement
Other contaminants	N/A
Dust level	N/A

Note: Refer to the Design Criteria/Assumptions Tab for additional plant design information

2.2 Equipment Overview

2.2.1 Gas Turbine

Feature	Specification
Frame size	PG6111FA
Fuel system	Dual fuel (natural gas + Light diesel oil)
Air filtration	Static
Compressor/Turbine Cleaning	On and Off-line Compressor Water Wash
Exhaust System	Axial
Emissions Control	Gas – Dry low NOx Liquid – Water injection
Fire Protection	High pressure CO2

2.2.2 Generator

Feature	Specification
Model	6FAG
Frequency	50 Hz
Power factor (pf)	0.85 Lagging
Power factor (pf)	Capability to 0.95 Leading
Terminal Voltage	11.5 kV
Acoustical Treatment	Standard On-Base package

2.2.3 Control Systems

Feature	Specification
Generator	Control, excitation, regulation and protection panel
Operator interface	Local <HMI>
	Remote <HMI>

3. Performance Data

3.1 Guaranteed Performance

Operating Point	Fuel	Gross Output at Generator Terminals (kW)	Gross Heat Rate at Generator Terminals (LHV) (kJ/KWh)	Gas Turbine Model
Baseload (100% load)	Natural Gas	77 600	10 060	PG6111FA
Baseload (100% load)	Light Distillate n°2	82 840	10 700	PG6111FA

Heat Rate = Fuel Gas Consumption (LHV) / Output (kW)

3.1.1 Basis for Unit Performance

The performance guarantees listed above are given at the generator terminals and based on the scope of equipment supply as defined in the proposal and as stated for the following operating conditions and parameters:

Measurement	Value
Atmospheric pressure bar	1.0121
Ambient temperature °C	15
Relative humidity %	60
Inlet system pressure drop mm H2O	95
Outlet static pressure @ ISO condition mm H2O	35
Combustion system type	Dry Low NOx
Grid frequency Hz	50 Hz
Power factor	0.80

Customer Natural Gas Fuel Characteristics	Value
Gas Fuel heating value (LHV) kJ/kg	47 891
Gas Fuel Temperature °C	6.9
Diluent injection flow kg/h	None
Natural Gas Characteristics & Composition	As given in 9.1.1

Liquid Fuel Distillate n°2 Characteristics	Value
Gas Fuel heating value (LHV) kJ/kg	47 891
Gas Fuel Temperature °C	16
Diluent injection flow kg/h	Water
Water injection flow Kg/hr to meet 42ppm NOx	25 691
Distillate Fuel Characteristics & Composition	As given in 9.1.2

A. The natural gas fuel is in compliance with Seller's Gas Fuel Specification GEI-41040 last revision and with the design basis of this proposal.

B. The customer distillate fuel is in compliance with Seller's Distillate Fuel Specification GEI-41047 latest revision and with the design basis of this proposal.

C. Gas turbine is operating at steady state base load.

D. Tests to demonstrate guaranteed performance shall be conducted in accordance with the ASME Modified Performance Test Procedure as defined in Seller’s GEK-107551.

E. Performance is measured at the generator terminals and includes allowances for excitation power and the shaft-driven equipment normally operating equipment supplied herein by GE.

F. The equipment is in a new and clean condition (less than 200 fire hours of operation).

G. Performance curves such as ambient effects curves and generator loss curves will be provided after contract award. These curves along with correction factors such as fuel property corrections are to be used during the site performance test to correct performance readings back to the site conditions at which the performance guarantees were provided.

H. Compressor air extraction from gas turbine = 0.

3.2 Emissions Guarantees

3.2.1 Natural Gas

On customer natural gas fuel, the NOx exhaust gas emissions shall not exceed the following concentrations during steady-state operation from base (100%) load down to 50% load over the ambient temperature range from -6°C to 40°C.

On customer natural gas fuel, the CO exhaust gas emissions shall not exceed the following concentrations during steady-state operation from base (100%) load down to 60% load over the ambient temperature range from -6°C to 40°C.

Pollutant	Natural Gas
NOx, ppmvd @ 15% O2	15
CO, ppmvd	9

3.2.2 Distillate

NOx exhaust gas emissions shall not exceed the following concentrations during steady-state operation from baseload down to 50% load over the ambient temperature range from -6°C to 40°C.

CO exhaust gas emissions shall not exceed the following concentrations during steady-state operation from baseload down to 50% load over the ambient temperature range from -6°C to 40°C.

Water injection, in the representative amounts shown on the Liquid Fuel "Estimated Performance" page later in this chapter, is required to meet the below emissions guarantees. Exact amounts of this diluent injection shall be determined during the detailed design phase of the project.

Pollutant	On Distillate Nr 2 Fuel**
NOx, ppmvd @ 15% O2	42
CO, ppmvd	20

**The physical and chemical properties of Customer Distillate Fuel are shown in chapter 9 of this proposal

3.2.3 Basis For Emissions Guarantees

A. The customer gas fuel is in compliance with Seller's Gas Fuel Specification GEI-41040 and with the design basis of this proposal.
B. The customer liquid fuel is in compliance with Seller's Liquid Fuel Specification GEI-41047 last revision and with the design basis of this proposal.
C. Testing and system adjustments are conducted in accordance with Seller's GEK-28172, Standard Field Testing Procedure for Emissions Compliance.
D. Atmospheric pressure = 1.0121 bar
E. Emissions are per gas turbine on a one hour average basis.
F. Fuel bound nitrogen less than 0.015% weight.
G. Fuel ash content = 0%
H. Sulfur emissions are a function of the sulfur present in the incoming air and fuel flows. Since the gas turbine(s) have no influence on the sulfur emissions. Sulfur emission are not guaranteed.
I. GE reserves the right to determine the emission rates on a net basis wherein emissions at the gas turbine inlet are subtracted from the measured exhaust emission rate if required to demonstrate guarantee rate.
J. Gas turbine is operating with a steady state frequency.
K. Peak load and overfiring operation are excluded from these emissions guarantees.
L. Maintenance factors per GER-3620 are applicable on both natural gas and distillate fuel operation.

3.3 Noise Guarantees

3.3.1 Near Field Noise Guarantees

Fuel	Gas Turbine Load	SPL, dBA
Natural Gas	Base	85
Distillate Oil	Base	85

The average sound pressure levels (SPL) (re: 20 micropascals) from theoutdoor supplier equipment defined in this proposal, shown in the Drawing/Diagrams Section of this proposal, shall not exceed the value stated above, when measured 1 m (3 ft) in the horizontal plane and at an elevation of 1.5 m (5 ft) above the gas turbine operating level, , and generator operating level (if different) identified on the General Arrangement drawings with the equipment operating at base load in accordance with contract specifications. Walkways and/or platforms that are not easily accessible by stairs are excluded from the above guarantee.

Near field guarantees apply to areas along a Site specific Source Envelope(s), determined by a line established 1 meter (3 ft.) from the outermost surface of the equipment defined in the proposal scope of supply (including noise abatement equipment). Depending on the site arrangement and relationship of equipment locations, multiple source envelopes may be designated. (See sample figure 3.4 – 1 below)

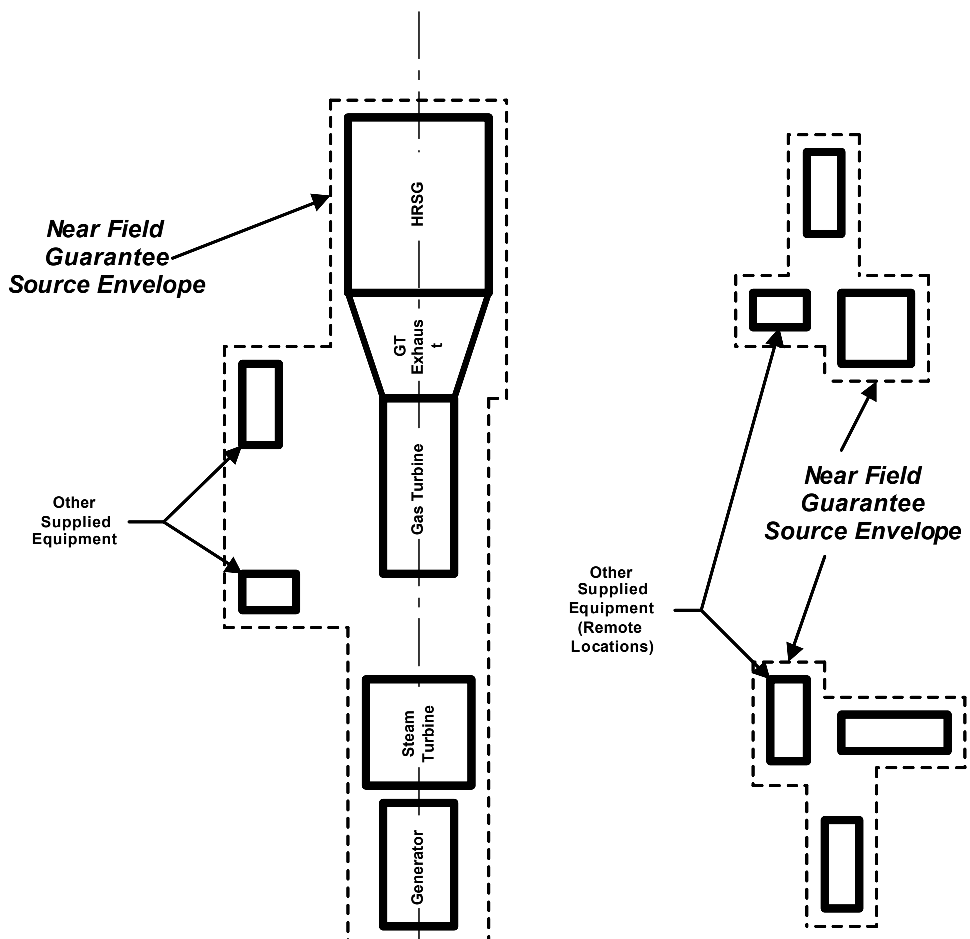

Figure 3.4 - 1 - Single Shaft STAG

(For reference only, envelope(s) should include all equipment defined in this proposals, and will be determined by Site conditions)

3.3.1.1 Basis for Near Field Noise Guarantee

A. The GE supplied equipment will be deemed compliant with the acoustic guarantee if the arithmetic average result from measurements taken at agreed upon locations along the source envelope(s), after background and other corrections for environmental influences and test factors have been applied do not exceed the noise limit(s) specified above. For cases where noise abatement equipment is included to meet the guaranteed sound pressure level, all measurements for compliance verification will be taken outside of the noise abatement equipment.

B. Testing will be conducted in accordance with a project specific test plan agreed to by both the Owner and GE. The test plan must adhere to the requirements listed in the GEK-110392 "Standard Noise Assessment Procedure" included in the Specifications / Documents Tab in this proposal. There is no single test standard that adequately addresses acoustic test requirements relating to power generation equipment; therefore the referenced GEK document is a compilation and adaptation of available ISO and ANSI test standards to address acoustic measurement of power facility equipment.

C. Equipment is operated in a new and clean condition when measurements are taken. All access compartments, doors, panels and other temporary openings are fully closed, all silencing hardware is fully installed and all systems designed to be airtight are sealed. Inspection of Installation Quality will be conducted prior to compliance testing. Identified defects must be corrected prior to Compliance Testing.

D. Corrections for background noise will be made to the measured SPL, as referenced in the GEK-110392 "Standard Noise Assessment Procedure" document. Background noise is defined, as the noise measured with all equipment identified in the proposal scope of supply not operating and all other plant equipment in operation. If the above guaranteed SPL is greater than 10 dBA above the measured background noise, no correction to the measured SPL is necessary.

E. Free field conditions must exist at measurement locations. Testing for, and corrections to, a free field are per the applicable standards, ISO 3744/46 and/or ANSI/ASME PTC 36 1985

F. Noises of an interim nature such as blow down valves, filter pulse noise, and startup / shutdown activities are not included in the above guarantee.

G. Measurements shall be taken 1 m (3 ft) away from the outermost exterior surfaces of equipment including piping, conduit, framework, barriers, noise abatement equipment, and personnel protection devices if provided.

H. Measurements shall not be taken in any location where there is an airflow velocity greater than 1.5 m/s (5 ft/s) including nearby air intakes or exhausts. Outdoor measurements shall not be taken when wind speeds exceed 1.5 m/s (3 mi/hr).

I. Responsibility for measurement and development of the project specific test plan will be stated in the contract. Testing shall be conducted in accordance with GEK 110392 "Standard Noise Assessment Procedure", included in the Reference Specifications / Documents Tab in this proposal. The test plan must be submitted a minimum of 30 days prior to the noise test for review and approval of all parties. If the Owner performs the compliance measurements, GE reserves the right to audit or parallel these measurements.

3.4 Gas Turbine Estimated Performances

3.4.1 Estimated performances On Natural Gas Operation

CENTRALES DE LA COSTA POWER PLANT– VILLA GESEL ESTIMATED PERFORMANCE PG6111 50 Hz

Load Condition		BASE	BASE	BASE
Inlet Loss	mm H2O	95.	95.	95.
Exhaust Pressure Loss	mm H2O	39.8	35.0	27.2
Ambient Temperature	deg C	-6.	15.	40.
Ambient Relative Humidity	%	60.0	60.0	60.0
Fuel Type		Cust Gas	Cust Gas	Cust Gas
Fuel LHV	kJ/kg	47 891	47 891	47 891
Fuel Temperature	deg C	7	7	7
Gross Output	kW	84 660.	77 600.	62 550.
Gross Heat Rate (LHV)	kJ/kWh	9 845.	10 060.	10 830.
Heat Cons. (LHV)	GJ/hr	833.5	780.7	677.4
Exhaust Flow	x10^3 kg/hr	816.3	759.	663.6
Exhaust Temperature	deg C	570.9	597.1	625.7
Exhaust MolWt	kg/kgmol	28.48	28.40	28.05
Exhaust Energy	GJ/hr	505.5	478.7	431.1

EMISSIONS

NOx	ppmvd @ 15% O2	15.	15.	15.
CO	ppmvd	9.	9.	9.

EXHAUST ANALYSIS % VOL.

Argon	0.91	0.87	0.87
Nitrogen	75.10	74.50	72.02
Oxygen	12.87	12.68	12.15
Carbon Dioxide	3.71	3.73	3.65
Water	7.42	8.22	11.32

SITE CONDITIONS

Elevation	meter	12.0
Site Pressure	bar	1.0121
Exhaust Loss	mm H2O	35.00 @ ISO Conditions
Relative Humidity	%	60
Application		Air-Cooled Generator
Power Factor (lag)		0.8
Combustion System		15/42 DLN Combustor

Emission information based on GE recommended measurement methods. NOx emissions are corrected to 15% O2 without heat rate correction and are not corrected to ISO reference condition per 40CFR 60.335(a)(1)(i). NOx levels shown will be controlled by algorithms within the SPEEDTRONIC control system.
Normal (N) is defined at 0 °C and 1.013 bars(a)
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3.4.2 Estimated performances On Liquid Fuel Operation

CENTRALES DE LA COSTA POWER PLANT– VILLA GESEL ESTIMATED PERFORMANCE PG6111 50 Hz

Load Condition		BASE	BASE	BASE
Inlet Loss	mm H2O	95.	95.	95.
Exhaust Pressure Loss	mm H2O	41.3	37.6	28.8
Ambient Temperature	deg C	-6.	15.	40.
Ambient Relative Humidity	%	60.0	60.0	60.0
Fuel Type		Liquid	Liquid	Liquid
Fuel LHV	kJ/kg	42 566	42 566	42 566
Fuel Temperature	deg C	16	16	16
Liquid Fuel H/C Ratio		1.78	1.78	1.78
Gross Output	kW	87 160.	82 840.	67 010.
Gross Heat Rate (LHV)	kJ/kWh	10 670.	10 700.	11 300.
Heat Cons. (LHV)	GJ/hr	930.0	886.4	757.2
Exhaust Flow	x10^3 kg/hr	831.4	789.5	684.6
Exhaust Temperature	deg C	568.3	586.5	620.7
Exhaust MolWt	kg/kgmol	28.41	28.34	28.12
Exhaust Energy	GJ/hr	520.7	495.8	444.7
Water Flow	kg/hr	27 683.	25 691.	17 722.
EMISSIONS				
NOx	ppmvd @ 15% O2	42.	42.	42.
CO	ppmvd	20.	20.	20.
EXHAUST ANALYSIS	% VOL.			
Argon		0.85	0.85	0.84
Nitrogen		71.93	71.46	69.88
Oxygen		11.44	11.31	11.06
Carbon Dioxide		5.45	5.45	5.33
Water		10.33	10.94	12.90

SITE CONDITIONS

Elevation	meter	12.0
Site Pressure	bar	1.0121
Exhaust Loss	mm H2O	35.00 @ ISO Conditions
Relative Humidity	%	60
Application		Air-Cooled Generator
Power Factor (lag)		0.8
Combustion System		15/42 DLN Combustor

Emission information based on GE recommended measurement methods. NOx emissions are corrected to 15% O2 without heat rate correction and are not corrected to ISO reference condition per 40CFR 60.335(a)(1)(i). NOx levels shown will be controlled by algorithms within the SPEEDTRONIC control system.
Liquid Fuel is assumed to have 0.015% Fuel-Bound Nitrogen, or less.
FBN amounts greater than 0.015% will add to the reported NOx value.
Normal (N) is defined at 0 °C and 1.013 bars(a)
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4. Performance Curves and Estimated Generator Data

4.1 Gas Turbine Performance Curves

Following correction curves are preliminary typical curves submitted in the proposal phase for information only.

Final curves applicable to the project which will apply for performance tests, will be submitted during the contract implementation phase.

4.1.1 50 Hz curves

Curves	Number	Date
Estimated Single Unit Performance, DLN, Base with Natural Gas	544HA935-1 Rev4	08/08/06
Compressor Inlet Temperature Corrections, DLN, Base with Natural Gas	544HA935-2 Rev4	08/08/06
Modulated Inlet Guide Vanes Effect, DLN, Base with Natural Gas	544HA935-3 Rev4	08/08/06
Estimated Single Unit Performance, DLN, Base with Distillate	544HA935-4 Rev4	08/08/06
Compressor Inlet Temperature Corrections, DLN, Base with Distillate	544HA935-5 Rev4	08/08/06
Modulated Inlet Guide Vanes Effect, DLN, Base with Distillate	544HA935-6 Rev4	08/08/06
Frequency effects curves, DLN, 50 Hz	6111-A-017 to 6111-A-021	10/03/03
Degradation Curves for Heavy Duty Product Line Gas Turbines	519HA772&744 RevA	09/02/95
Altitude Correction for Turbine	416HA662 RevB	06/30/99
Humidity Effects Curve	498HA697 RevB	10/10/89

4.2 TEWAC Generator Performance Curves

4.2.1 50 Hz Curves

Curve	Number
Estimated Saturation and Synchronous Impedance Curves	705244G-1a
Estimated Reactive Capability Curves, Base	705244G-2a
Estimated VEE Curves, Base	705244G-3a
Generator Output as a Function of Cold Gas Temp, Base	705244G-7a
Generator Output as a Function of Liquid Temp, Base	705244G-7b

4.2.2 Estimated Generator Data (See Attachment)

GENERAL ELECTRIC MODEL PG6111FA+e-50Hz- GAS TURBINE

Estimated Perfomance - Configuration : DLN with Bleed Heating

Compressor Inlet Conditions 59F (15°C), 60% Relative Humidity

Atmospheric Pressure 14.7 psia (1.013bar)

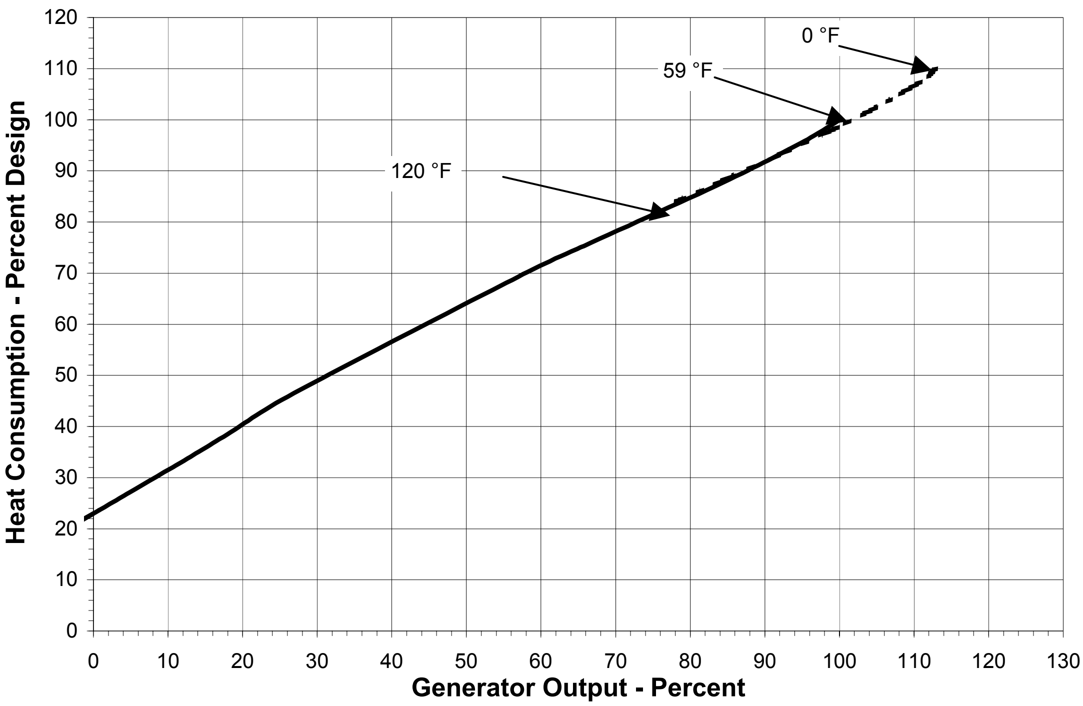
Fuel		**NATURAL GAS**
Design Output	kW	**77 060.**
Design Heat Rate (LVH)	kJ/kWh	**10 140.**
Design Heat Cons (LVH)*10^6	kJ/h	**781.4**
Design Exhaust Flow * 10^3	kg/h	**761.6**
Exhaust Temperature	°C	**598.3**
Mode		**BASE LOAD**

Cycle Deck: IPS- Version Code - 3.6.2/120A0/3.6.2/PG6111-01A-0506

Notes:

1. Altitude correction on curve 416HA662 Rev B
2. Ambient temperature correction on curve 544HA935-2 Rev 4
3. Effect on modulating IGV's on exhaust temperature and flow on curve 544HA935-3 Rev 4
4. Humidity effects on curve 498HA697 Rev B - all performance calculated with a constant specific humidity of .0064 or less so as not to exceed 100% relative humidity.
5. Plant Performances is measured at the generator terminals and includes allowances for the effects of excitation power, shaft driven auxiliaries, 2.5 inlet and 5.5 in H20 exhaust pressure drops
6. Additional inlet and exhaust pressure loss effects:

	% Efffect on		Effect on
	Output	Heat Rate	Exhaust Temp.
4 in Water (10.0 mbar) inlet	-1.50%	0.50%	2.6 °F (1.4 °C)
4 in Water (10.0 mbar) outlet	-0.50%	0.50%	2.6 °F (1.4 °C)

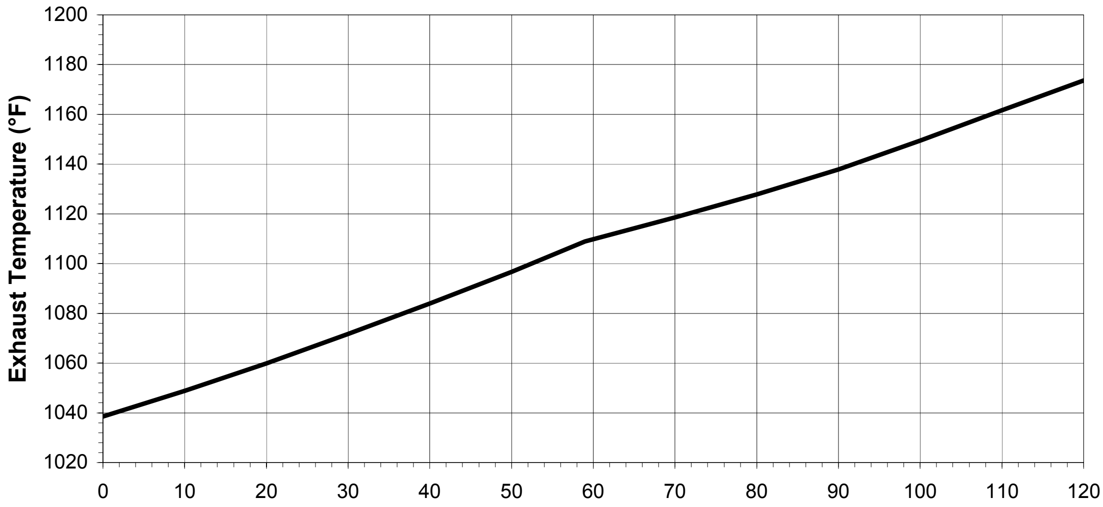


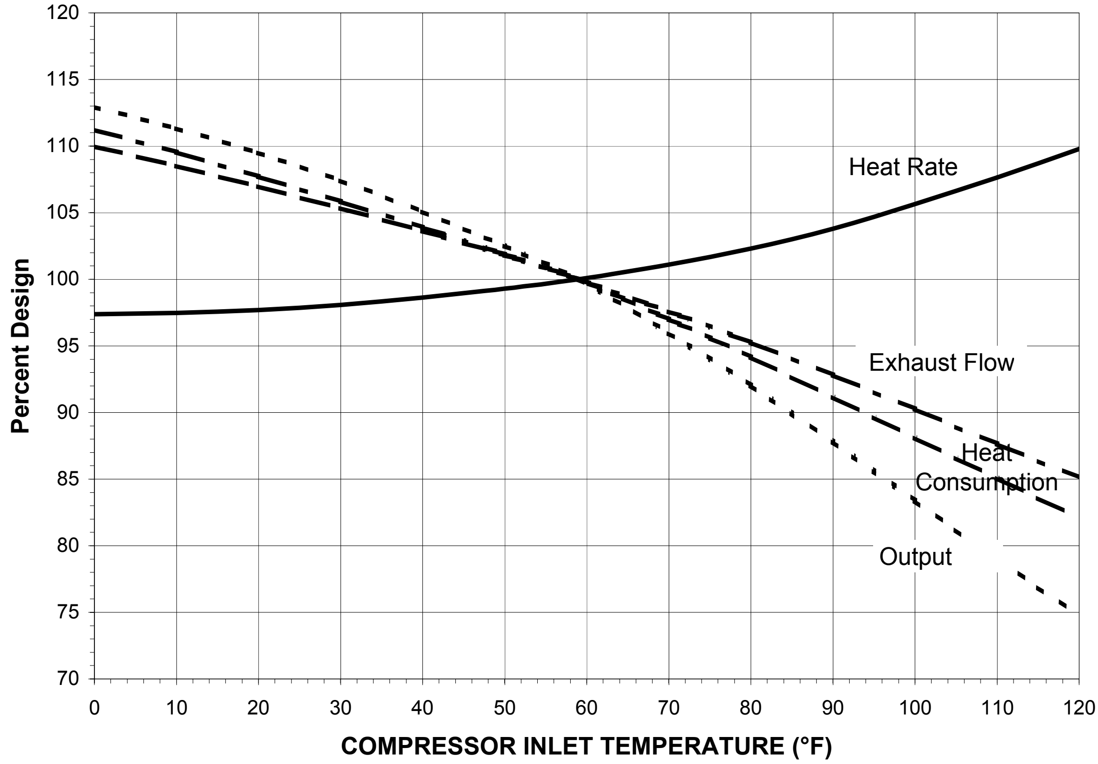
E.KANDEL **Number 544HA935-1**
08/08/2006 **Revision 4**

GENERAL ELECTRIC MODEL PG6111FA+e-50Hz- GAS TURBINE

Effect of compressor Inlet Temperature on
Output,Heat Rate, Heat Consumption, Exhaust Flow
And Exhaust Temperature at **BASE LOAD**

Fuel	**NATURAL GAS**	@ 80deg F
Combustor	**DLN with Bleed Heating**	



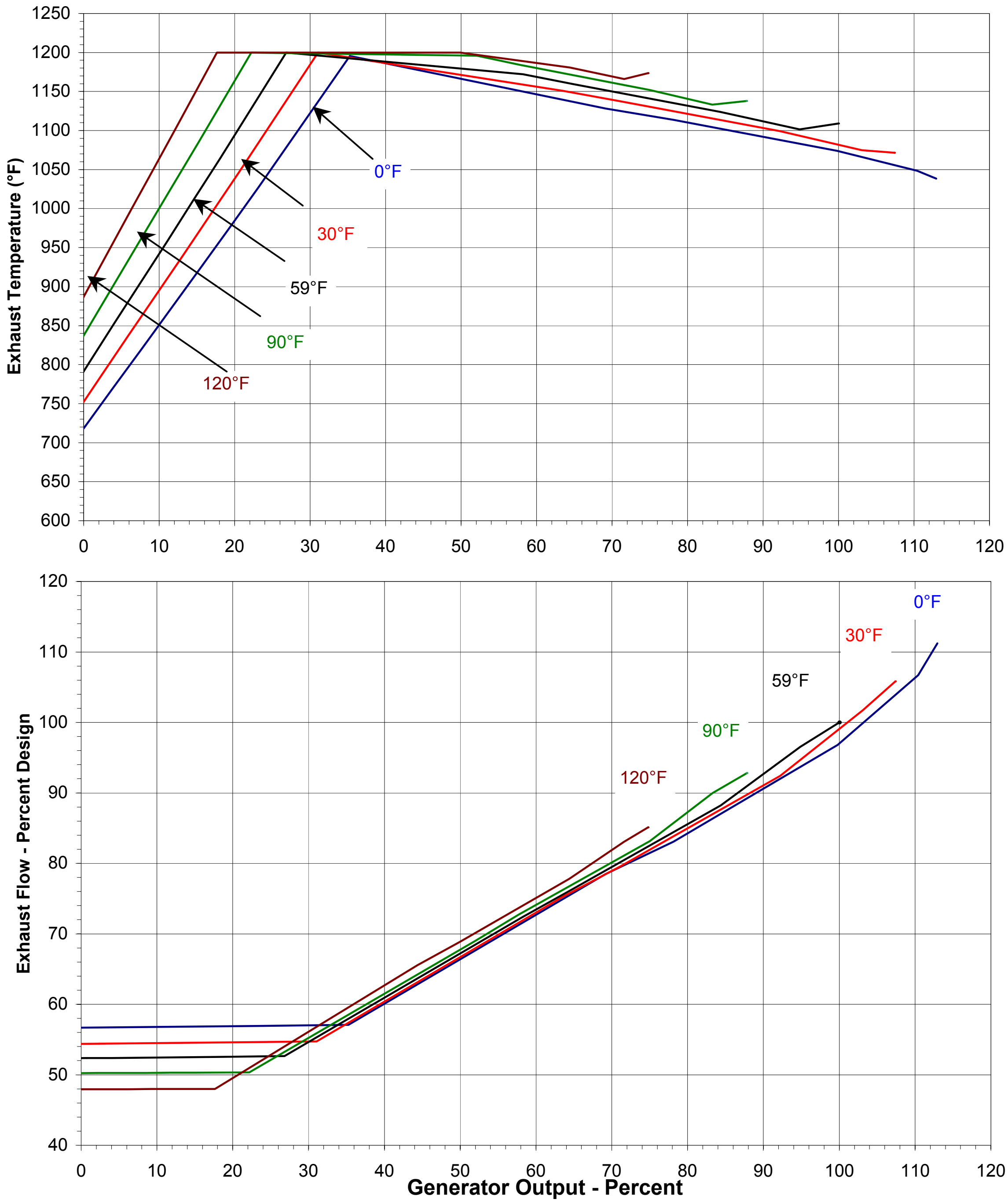


E.KANDEL	**Number 544HA935-2**
08/08/2006	**Revision 4**

GENERAL ELECTRIC MODEL PG6111FA+e-50Hz- GAS TURBINE

Effect of Inlet Guide Vane on Exhaust Flow and Temperature
As a function of Output and Compressor Inlet Temperature

Fuel	**NATURAL GAS**	@ 80deg F
Combustor	**DLN with Bleed Heating**	



E.KANDEL
08/08/2006

Number 544HA935-3
Revision 4

GENERAL ELECTRIC MODEL PG6111FA+e-50Hz- GAS TURBINE

Estimated Perfomance - Configuration : DLN with Bleed Heating

Compressor Inlet Conditions 59F (15°C), 60% Relative Humidity

Atmospheric Pressure 14.7 psia (1.013bar)

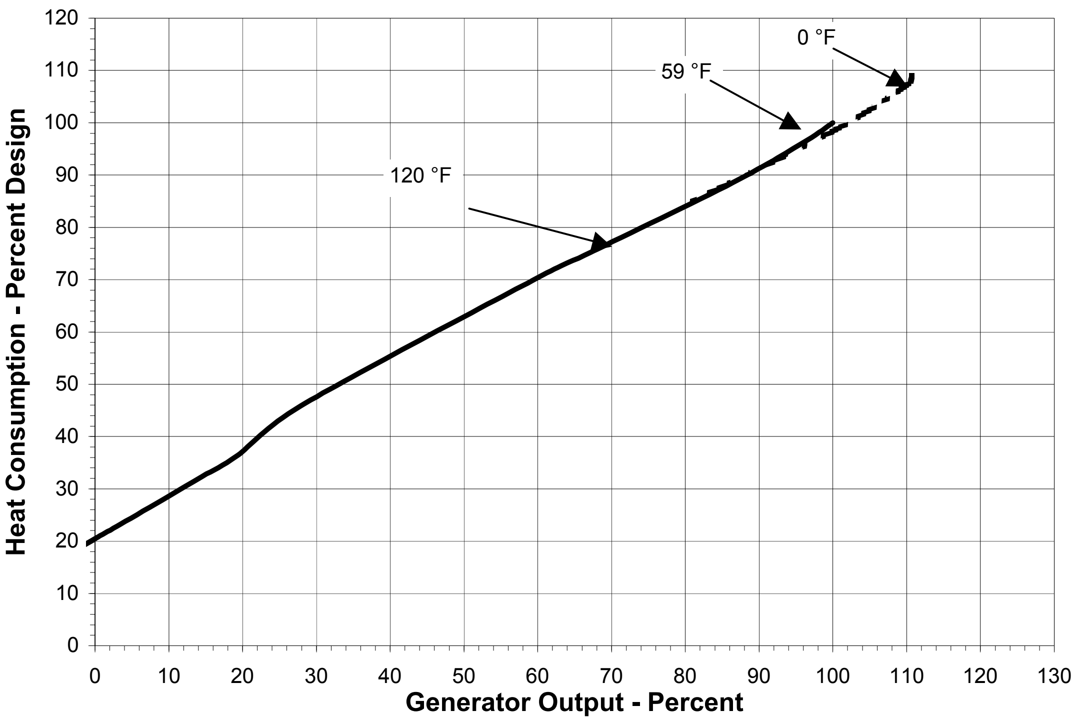
Fuel		**DISTILLATE**	
Design Output	kW	**82 330.**	
Design Heat Rate (LVH)	kJ/kWh	**10 770.**	
Design Heat Cons (LVH)*10^6	kJ/h	**886.7**	
Design Exhaust Flow * 10^3	kg/h	**792.9**	
Exhaust Temperature	°C	**587.2**	
Water Flow	kg/hr	**25 800.**	(for 42ppm@15%O2 Nox)
Mode		**BASE LOAD**	

Cycle Deck: IPS- Version Code - 3.6.2/120A0/3.6.2/PG6111-01A-0506

Notes:

1. Altitude correction on curve 416HA662 Rev B
2. Ambient temperature correction on curve 544HA935-5 Rev 4
3. Effect on modulating IGV's on exhaust temperature and flow on curve 544HA935-6 Rev 4
4. Humidity effects on curve 498HA697 Rev B - all performance calculated with a constant specific humidity of .0064 or less so as not to exceed 100% relative humidity.
5. Plant Performances is measured at the generator terminals and includes allowances for the effects of excitation power, shaft driven auxiliaries, 2.5 inlet and 5.5 in H20 exhaust pressure drops
6. Additional inlet and exhaust pressure loss effects:

	% Effect on Output	% Effect on Heat Rate	Effect on Exhaust Temp.
4 in Water (10.0 mbar) inlet	-1.4%	0.4%	2.2 °F (1.2 °C)
4 in Water (10.0 mbar) outlet	-0.5%	0.4%	2.1 °F (1.2 °C)



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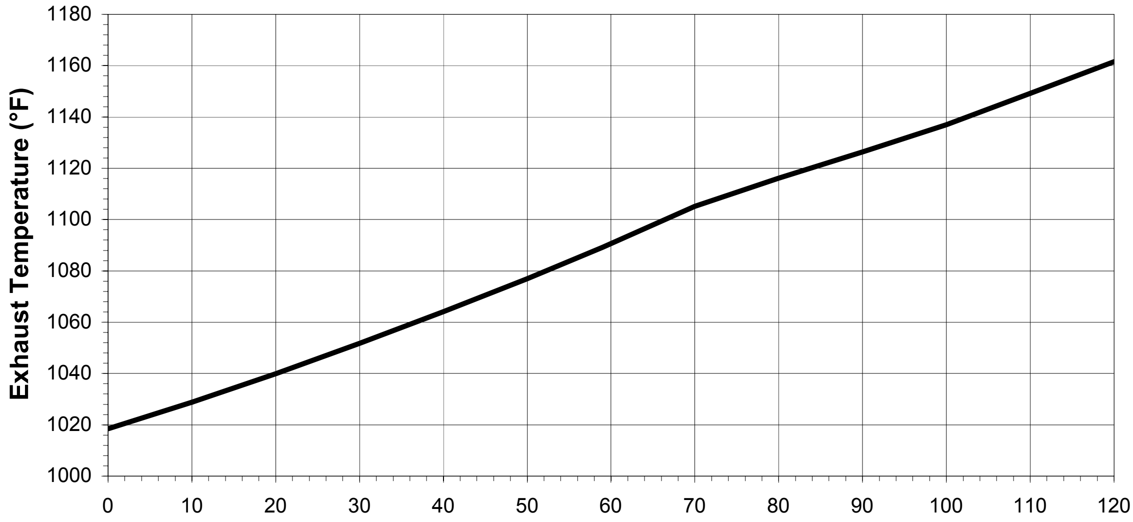
E.KANDEL **Number 4**

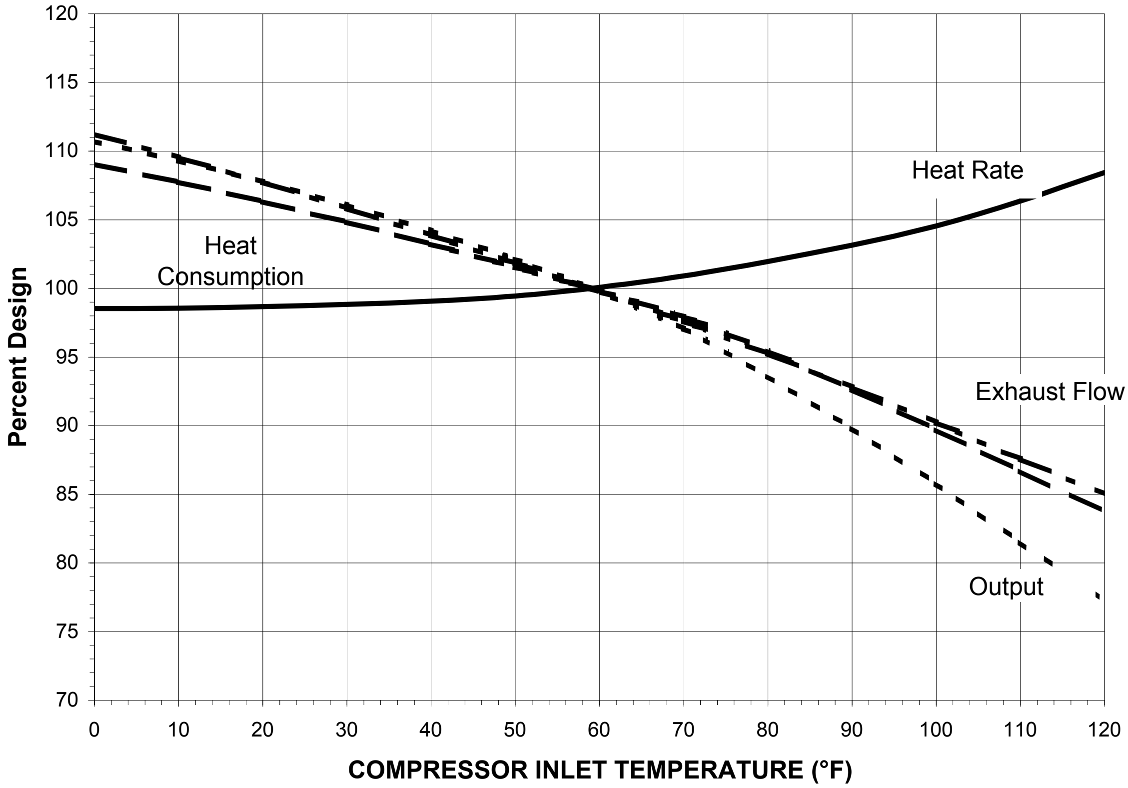
08/08/2006 **Revision**

GENERAL ELECTRIC MODEL PG6111FA+e-50Hz- GAS TURBINE

Effect of compressor Inlet Temperature on
Output, Heat Rate, Heat Consumption, Exhaust Flow
And Exhaust Temperature at **BASE LOAD**

Fuel **DISTILLATE** @ 80deg F
Combustor **DLN with Bleed Heating**





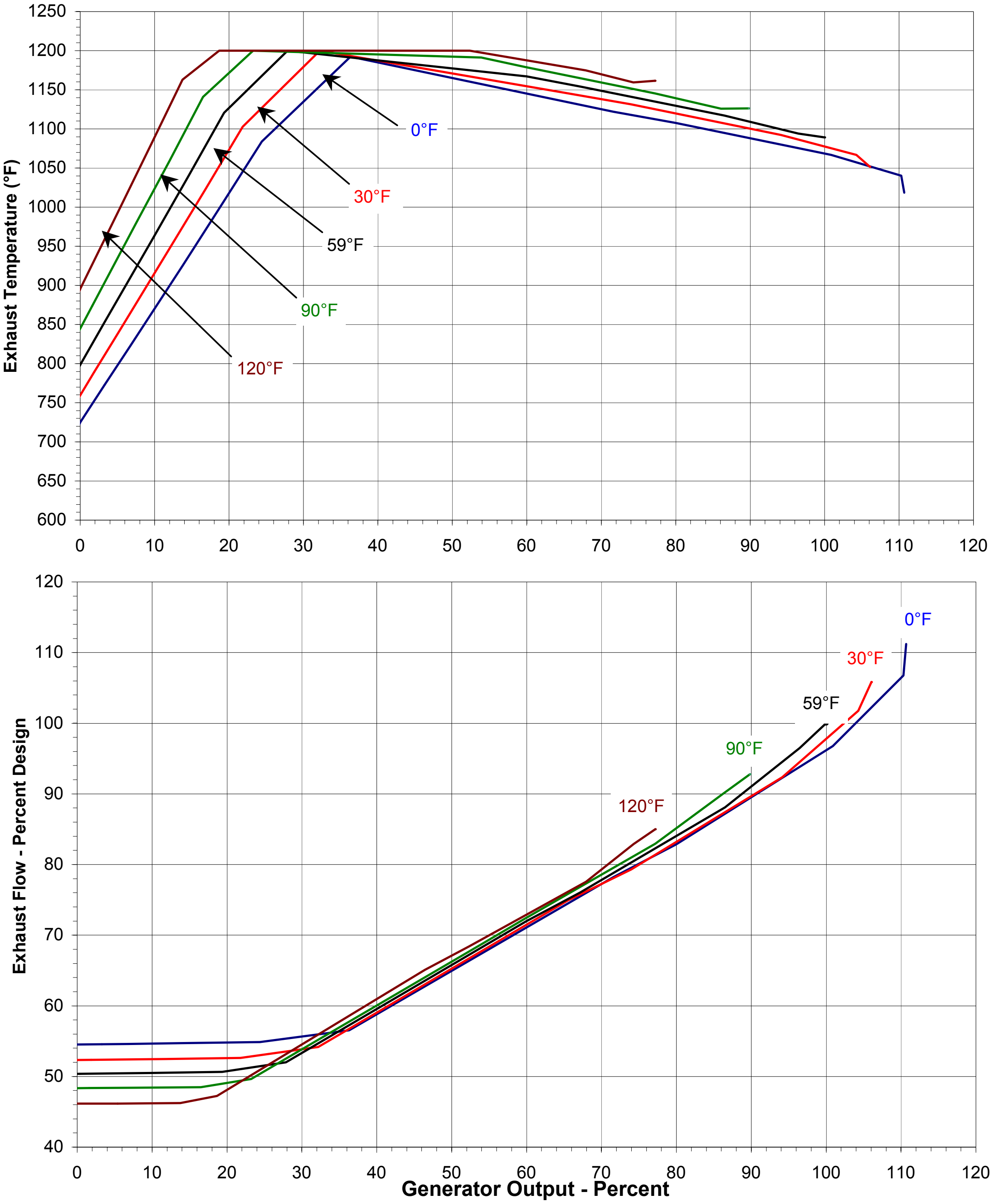
E.KANDEL
08/08/2006

Number 544HA935-5
Revision 4

GENERAL ELECTRIC MODEL PG6111FA+e-50Hz- GAS TURBINE

Effect of Inlet Guide Vane on Exhaust Flow and Temperature
As a function of Output and Compressor Inlet Temperature

Fuel **DISTILLATE** @ 80deg F
Combustor **DLN with Bleed Heating**



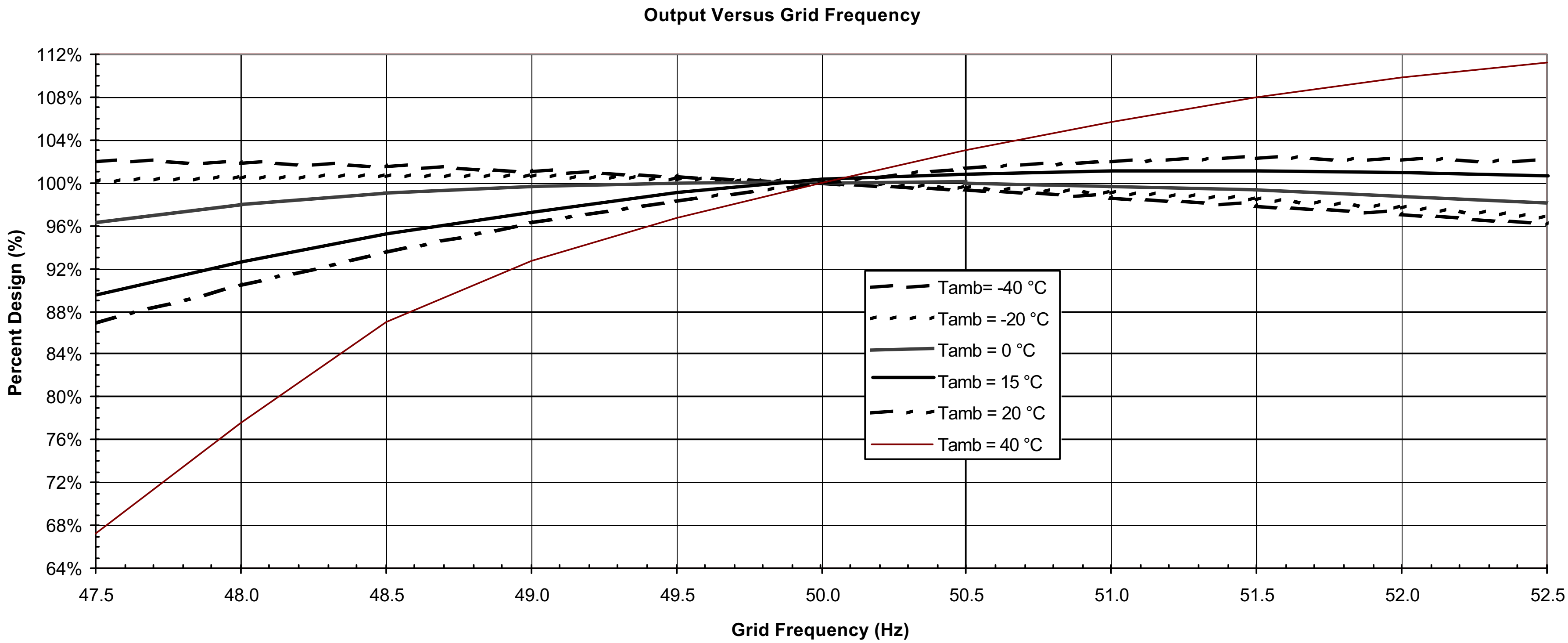
E.KANDEL
08/08/2006

Number **544HA935-6**
Revision **4**

Turbine Model : PG6111FA
Estimated Performance

This sheet to be used only with the related design sheet

Combustion Chamber : DLN
Natural Gas



Made by : F. MOINE
Checked by : V. SICARD
Approved by : V. SICARD

March 10 2003
6111 -A- 017

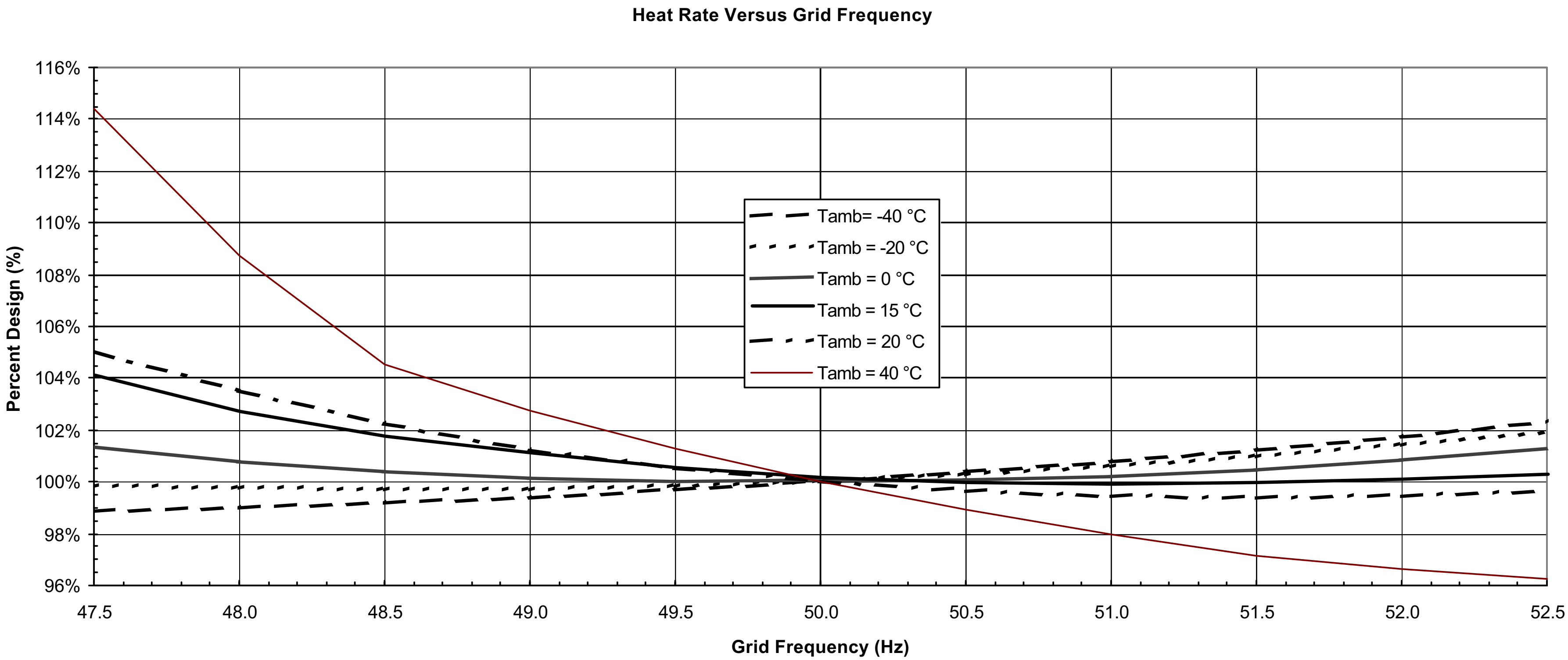
GE Energy Products –Europe

A GE Power Systems Business

Turbine Model : PG6111FA
Estimated Performance

This sheet to be used only with the related design sheet

Combustion Chamber : DLN
Natural Gas



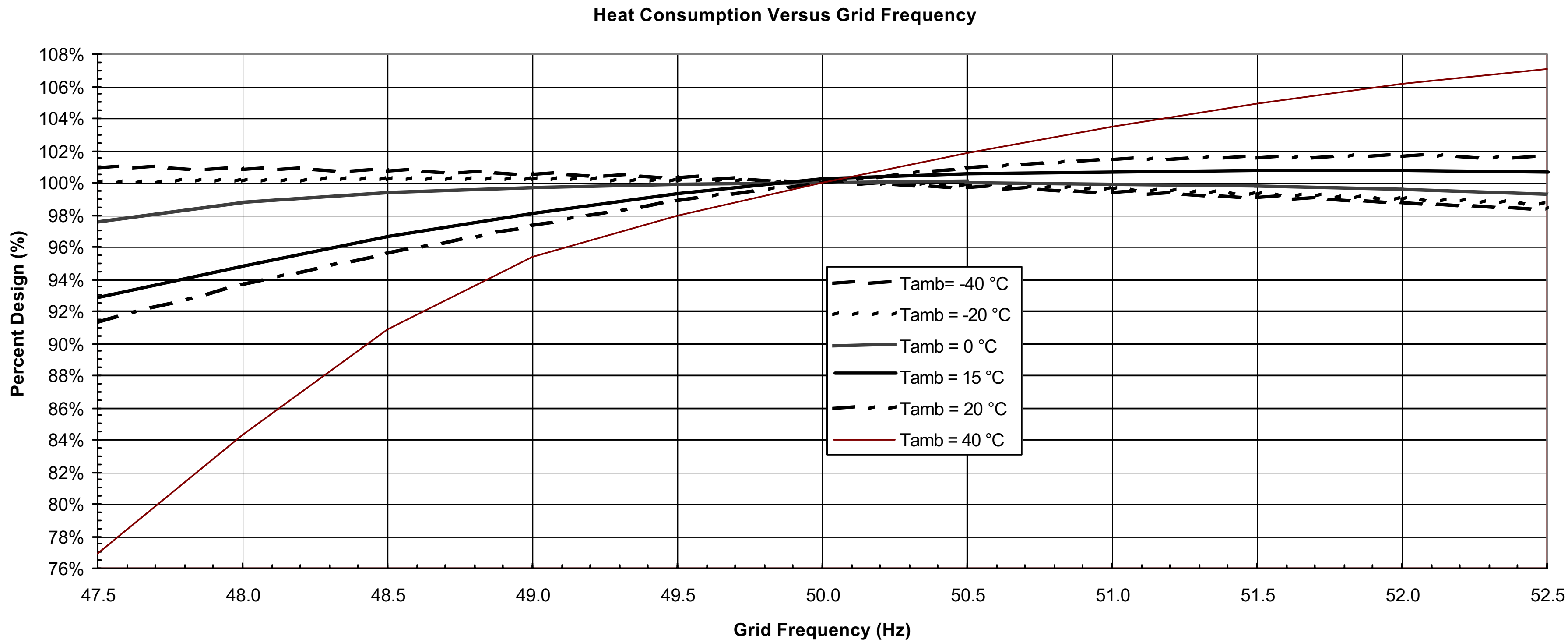
Made by : F. MOINE
Checked by : V. SICARD
Approved by : V. SICARD

March 10 2003
6111 -A- 018

Turbine Model : PG6111FA
Estimated Performance

This sheet to be used only with the related design sheet

Combustion Chamber : DLN
Natural Gas



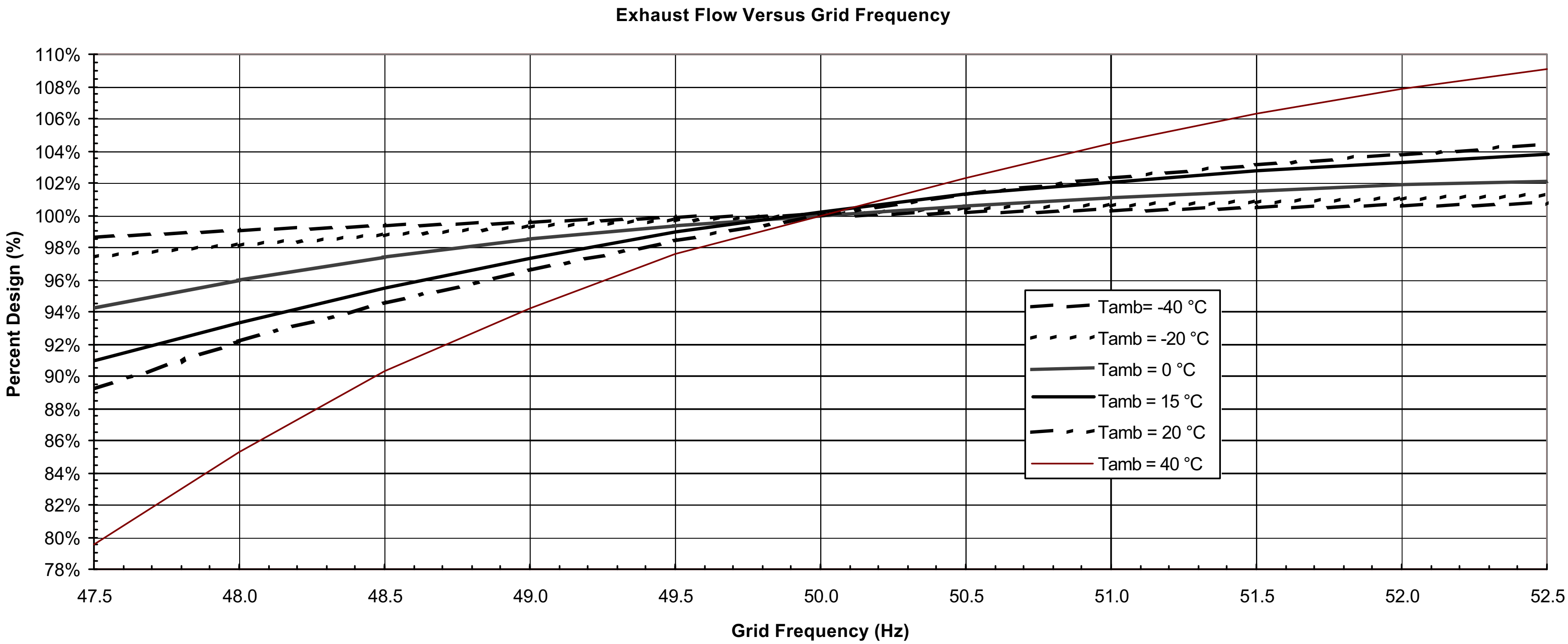
Made by : F. MOINE
Checked by : V. SICARD
Approved by : V. SICARD

March 10 2003
6111 -A- 019

Turbine Model : PG6111FA
Estimated Performance

This sheet to be used only with the related design sheet

Combustion Chamber : DLN
Natural Gas



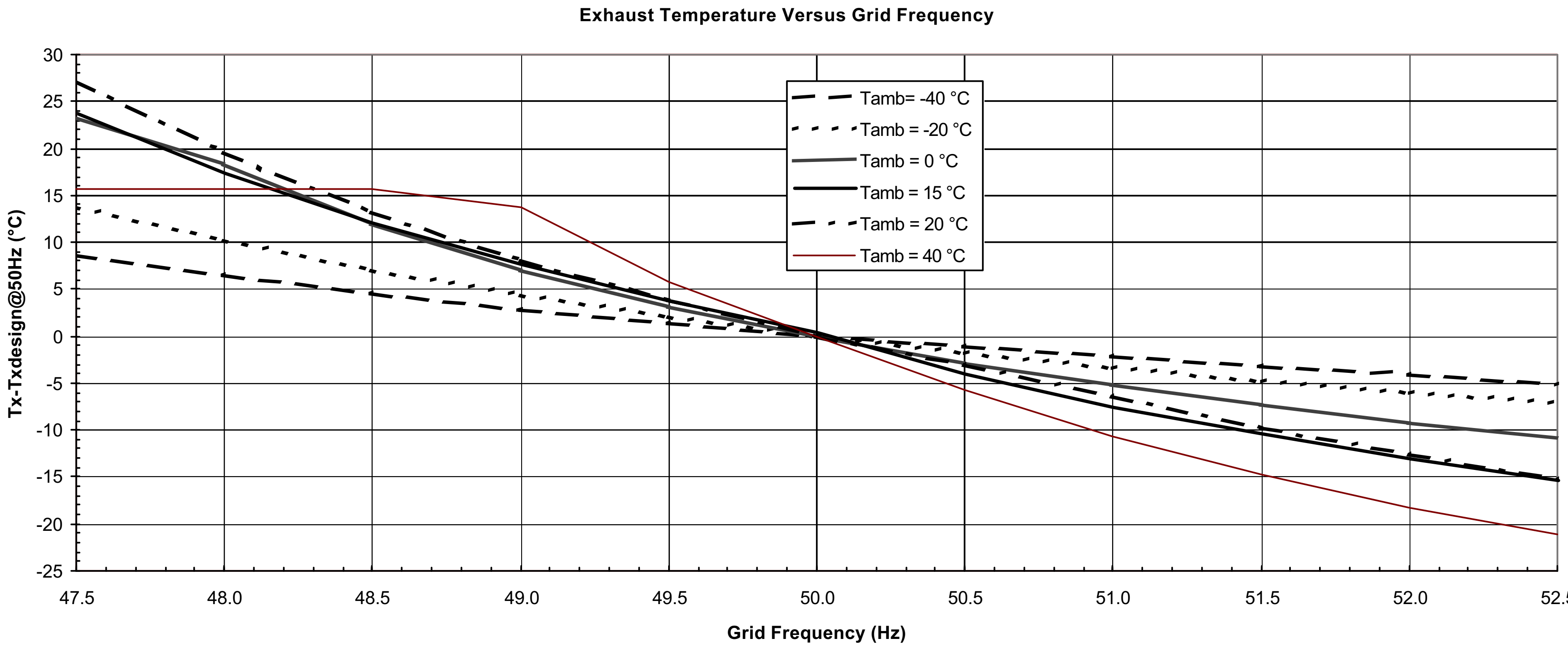
Made by : F. MOINE
Checked by : V. SICARD
Approved by : V. SICARD

March 10 2003
6111 -A - 020

Turbine Model : PG6111FA
Estimated Performance

This sheet to be used only with the related design sheet

Combustion Chamber : DLN
Natural Gas



Made by : F. MOINE
Checked by : V. SICARD
Approved by : V. SICARD

March 10 2003
6111 -A- 021

Degradation Curves for Heavy Duty Product Line Gas Turbines

Gas turbine performance loss during extended operational periods is largely due to compressor fouling. The rates of both compressor fouling and performance loss are a result of the variation in environmental conditions, fuel used, machine operating scenario and maintenance practices.

Performance loss during normal operation is minimized by periodic on-line and off-line compressor water washes. Performance loss during extended operation is expected to be greater for plants that are located in humid and/or contaminated industrial environments. Also, plants operated under non-ideal running scenarios, along with neglected or poorly performed maintenance practices can be expected to exhibit increased performance losses. Plants that are sited in relatively clean less humid environments, operated within equipment design recommendations and cleaned with regular on and off-line compressor washes will experience less performance degradation.

Performance recovery, beyond that which occurs with normal maintenance, including on and off-line washes, can be achieved following other off-line procedures. One procedure in particular involves removing both the compressor and turbine casing to accommodate hand scouring of the compressor rotor and stator airfoils. Compressor inlet air filter cleaning/replacement, along with other required maintenance, may also be performed during these inspections. Such an outage would most likely coincide with hot gas path or major inspection intervals, since significant machine disassembly is required.

A typical gas turbine operation profile, reflecting on- and off-line maintenance procedures, is presented in the attached figures. Plant performance degradation during normal operation is cyclic as impacted by on- and off-line compressor water washes. Drawing 519HA772 represents expected performance loss, in accordance with the stated basis for operation, maintenance and testing procedures. Note that this curve represents the locus of points following specific shut down maintenance activities, not actual continuous on-line operating capability. Drawing 519HA744 represents a comparable locus of data following the more extreme machine disassembly and hand scouring procedure.

EXPECTED GAS TURBINE PLANT PERFORMANCE LOSS FOLLOWING NORMAL MAINTENANCE AND OFF-LINE COMPRESSOR WATER WASH

THE AGED PERFORMANCE EFFECTS REPRESENTED BY THESE CURVES ARE BASED ON THE FOLLOWING:

* PERFORMANCE IS RELATIVE TO THE GUARANTEE LEVEL.

* ALL GAS TURBINE PLANT EQUIPMENT SHALL BE OPERATED AND MAINTAINED IN ACCORDANCE WITH GE'S RECOMMENDED PROCEDURES FOR OPERATION, PREVENTIVE MAINTENANCE, INSPECTION AND BOTH ON-LINE AND OFF-LINE CLEANING.

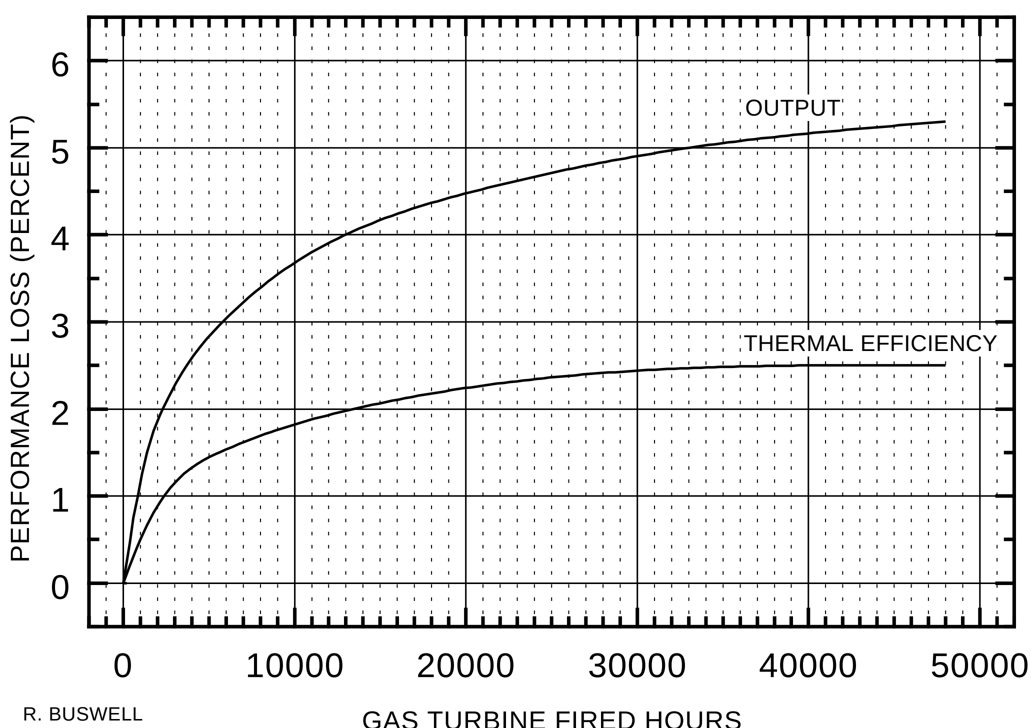
* ALL OPERATIONS SHALL BE WITHIN THE DESIGN CONDITIONS SPECIFIED IN THE RELEVANT TECHNICAL SPECIFICATIONS.

* A DETAILED OPERATIONAL LOG SHALL BE MAINTAINED FOR ALL RELEVANT OPERATIONAL DATA, TO BE AGREED TO AMONGST THE PARTIES PRIOR TO COMMENCEMENT OF CONTRACT.

* GE TECHNICAL PERSONNEL SHALL HAVE ACCESS TO PLANT OPERATIONAL DATA, LOGS, AND SITE VISITS PRIOR TO CONDUCTING A PERFORMANCE TEST. THE OWNER WILL CLEAN AND MAINTAIN THE EQUIPMENT. THE DEGREE OF CLEANING AND MAINTENANCE WILL BE DETERMINED BASED ON THE OPERATING HISTORY OF EACH UNIT, ATMOSPHERIC CONDITIONS EXPERIENCED DURING THE PERIOD OF OPERATION, THE PREVENTIVE AND SCHEDULED MAINTENANCE PROGRAMS EXECUTED, AND THE RESULTS OF THE GE INSPECTION.

* THE GAS TURBINE WILL BE SHUT DOWN FOR INSPECTION AND OFF-LINE COMPRESSOR WATER WASH, AS A MINIMUM, IMMEDIATELY PRIOR TO PERFORMANCE TESTING TO DETERMINE PERFORMANCE LOSS. THE GAS TURBINE PERFORMANCE TEST SHALL OCCUR WITHIN 100 FIRED HOURS OF THESE ACTIONS.

* DEMONSTRATION OF GAS TURBINE PLANT PERFORMANCE SHALL BE IN ACCORDANCE WITH TEST PROCEDURES WHICH ARE MUTUALLY AGREED UPON.



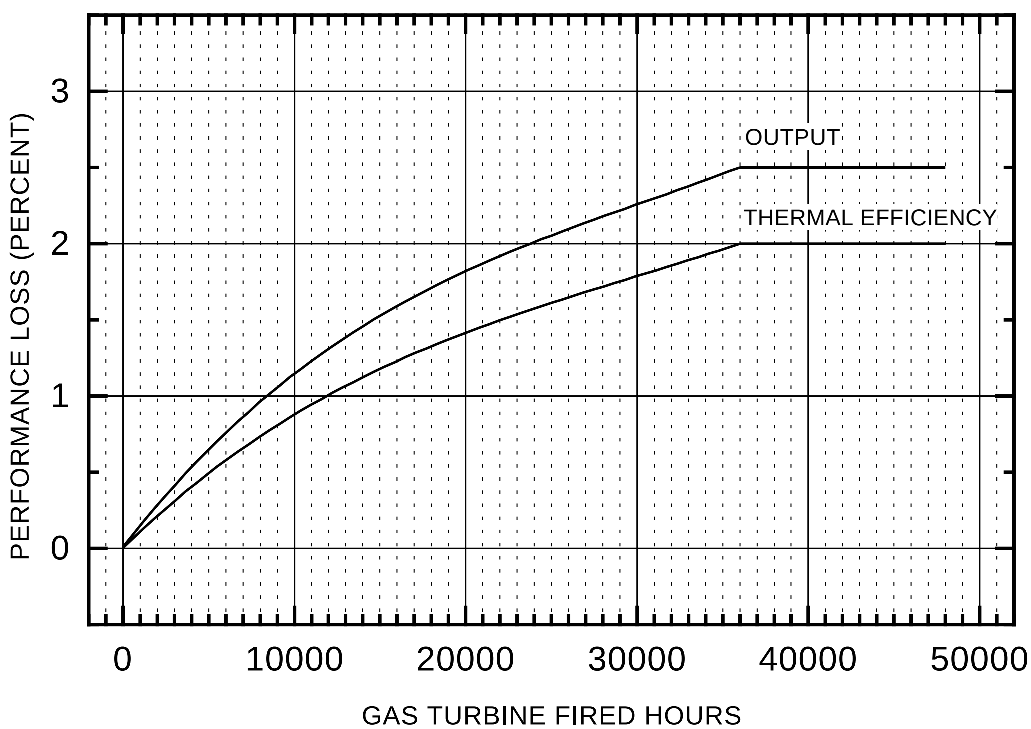
R. BUSWELL
REV A FEB. 9, 1995

519HA772

EXPECTED GAS TURBINE PLANT NON-RECOVERABLE PERFORMANCE LOSS DURING EXTENDED PERIOD OPERATION

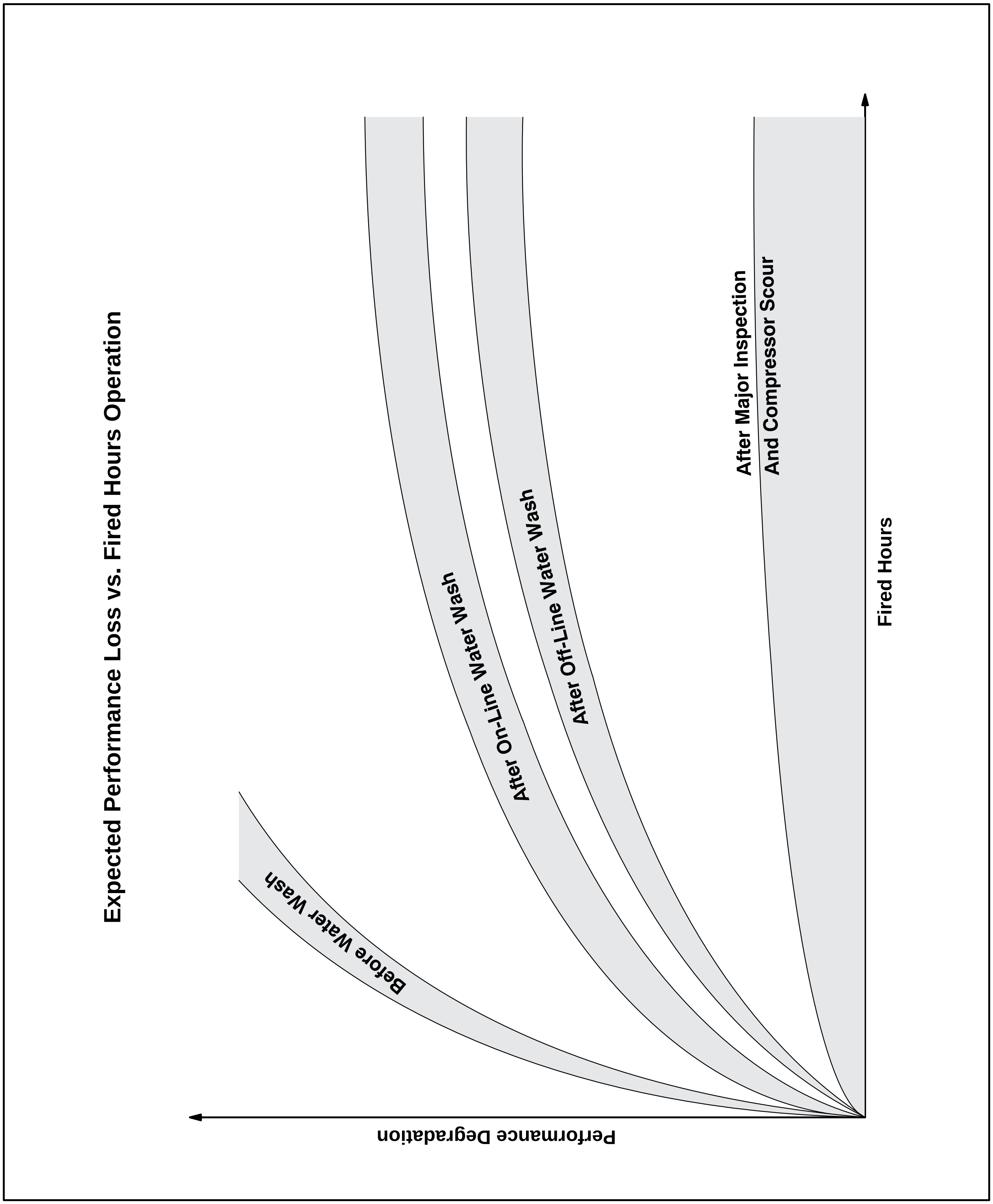
THE AGED PERFORMANCE EFFECTS REPRESENTED BY THESE CURVES ARE BASED ON THE FOLLOWING:

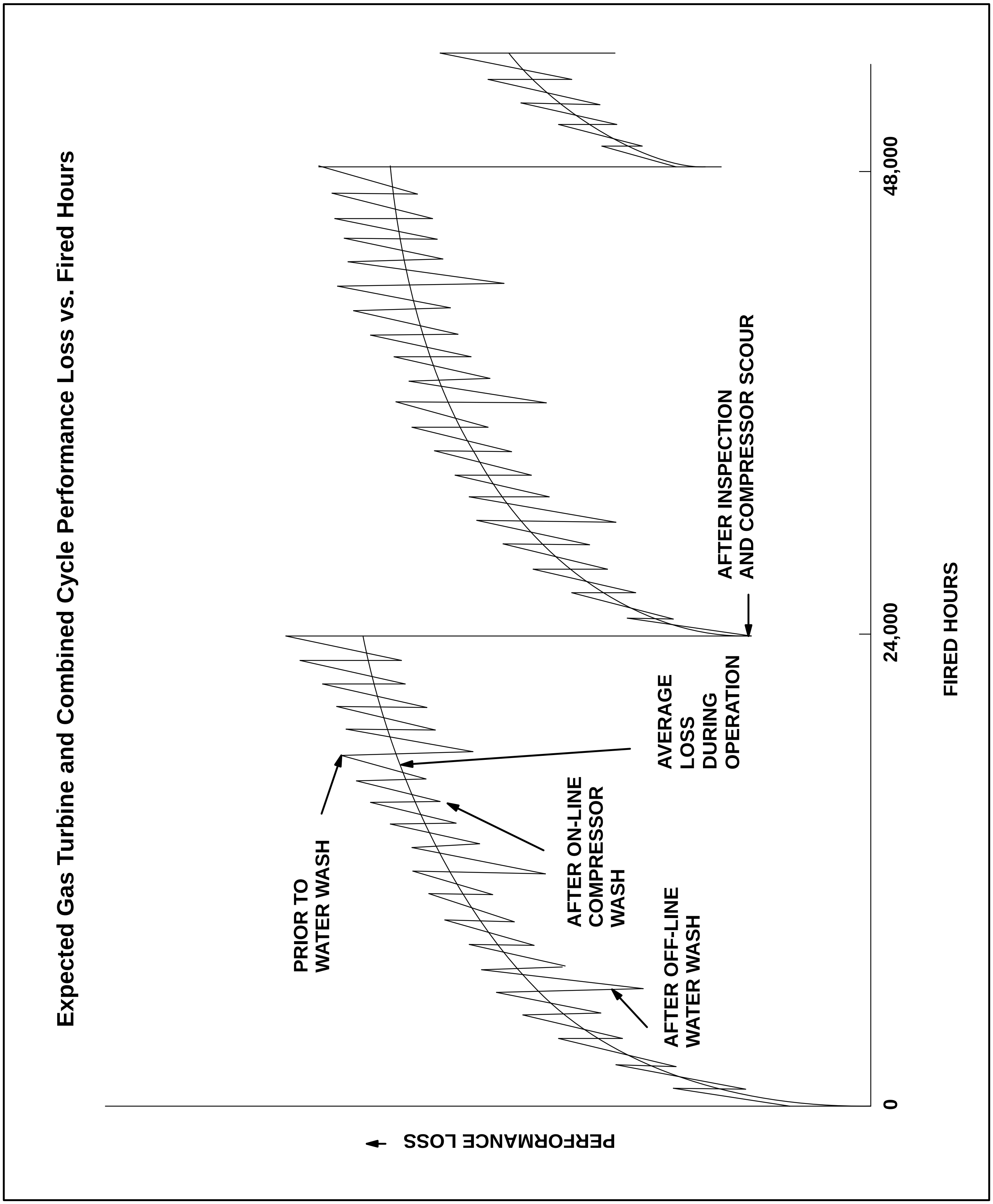
* PERFORMANCE IS RELATIVE TO THE GUARANTEE LEVEL.
* ALL GAS TURBINE PLANT EQUIPMENT SHALL BE OPERATED AND MAINTAINED IN ACCORDANCE WITH GE'S RECOMMENDED PROCEDURES FOR OPERATION, PREVENTIVE MAINTENANCE, INSPECTION AND BOTH ON-LINE AND OFF-LINE CLEANING.
* ALL OPERATIONS SHALL BE WITHIN THE DESIGN CONDITIONS SPECIFIED IN THE RELEVANT TECHNICAL SPECIFICATIONS.
* A DETAILED OPERATIONAL LOG SHALL BE MAINTAINED FOR ALL RELEVANT OPERATIONAL DATA, TO BE AGREED TO AMONGST THE PARTIES PRIOR TO COMMENCEMENT OF CONTRACT.
* GE TECHNICAL PERSONNEL SHALL HAVE ACCESS TO PLANT OPERATIONAL DATA, LOGS, AND SITE VISITS PRIOR TO CONDUCTING A PERFORMANCE TEST. THE OWNER WILL CLEAN AND MAINTAIN THE EQUIPMENT. THE DEGREE OF CLEANING AND MAINTENANCE WILL BE DETERMINED BASED ON THE OPERATING HISTORY OF EACH UNIT, ATMOSPHERIC CONDITIONS EXPERIENCED DURING THE PERIOD OF OPERATION, THE PREVENTIVE AND SCHEDULED MAINTENANCE PROGRAMS EXECUTED, AND THE RESULTS OF THE GE INSPECTION.
* THE GAS TURBINE WILL BE SHUT DOWN FOR INSPECTION AND MAINTENANCE WITH COMPRESSOR ROTOR AND STATOR SCOURING, AS A MINIMUM, IMMEDIATELY PRIOR TO PERFORMANCE TESTING TO DETERMINE PERFORMANCE LOSS. THE GAS TURBINE PERFORMANCE TEST SHALL OCCUR WITHIN 100 FIRED HOURS OF THESE ACTIONS.
* DEMONSTRATION OF GAS TURBINE PERFORMANCE SHALL BE IN ACCORDANCE WITH TEST PROCEDURES WHICH ARE MUTUALLY AGREED UPON.



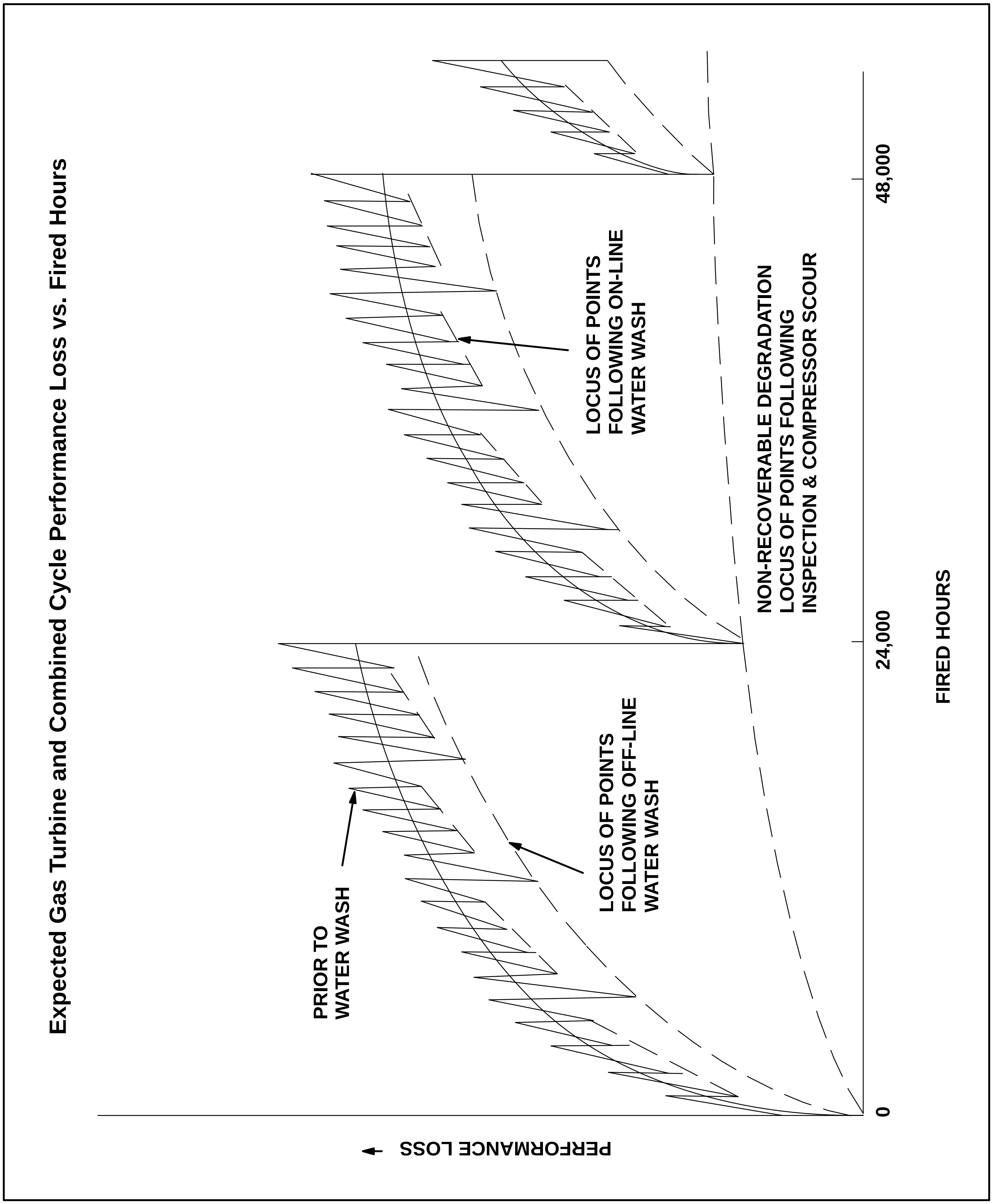
R. BUSWELL
REV A FEB. 9, 1995

519HA744


Expected Performance Loss vs. Fired Hours Operation
Before Water Wash
After On-Line Water Wash
After Off-Line Water Wash
After Major Inspection
And Compressor Scour
Fired Hours
Performance Degradation



Expected Gas Turbine and Combined Cycle Performance Loss vs. Fired Hours


Expected Gas Turbine and Combined Cycle Performance Loss vs. Fired Hours
PRIOR TO WATER WASH
LOCUS OF POINTS FOLLOWING OFF-LINE WATER WASH
LOCUS OF POINTS FOLLOWING ON-LINE WATER WASH
NON-RECOVERABLE DEGRADATION LOCUS OF POINTS FOLLOWING INSPECTION & COMPRESSOR SCOUR
PERFORMANCE LOSS
0
24,000
48,000
FIRED HOURS

GENERAL ELECTRIC GAS TURBINE ALTITUDE CORRECTION CURVE

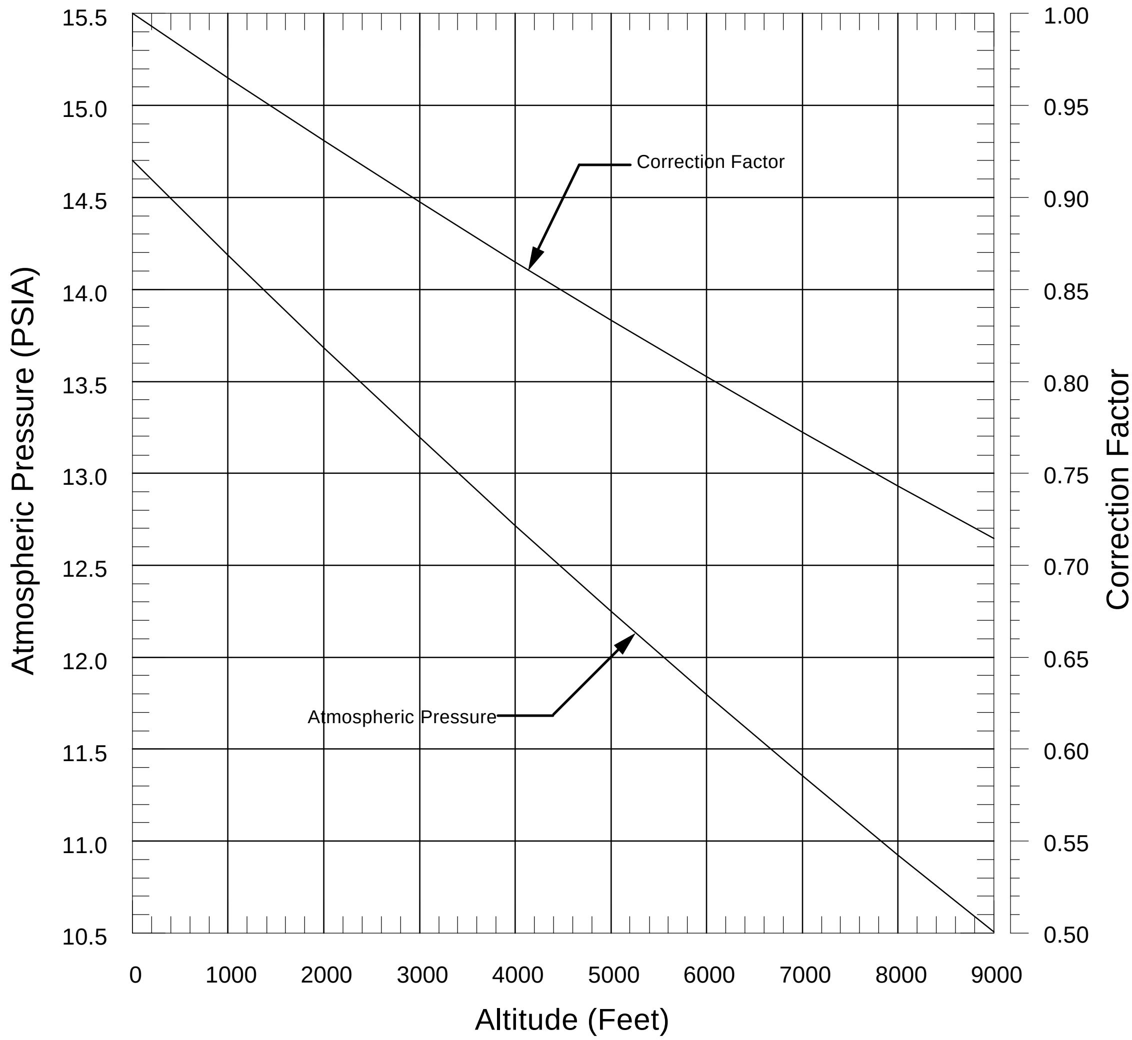
ALTITUDE VS ATMOSPHERIC PRESSURE

AND

ALTITUDE VS CORRECTION FACTOR

FOR GASTURBINE OUTPUT, FUEL CONSUMPTION, AND EXHAUST FLOW

NOTES:
1. Exhaust Temperature, Heat Rate, and Thermal Efficiency are not affected by altitude.
2. Correction Factor = P(atm)/14.7



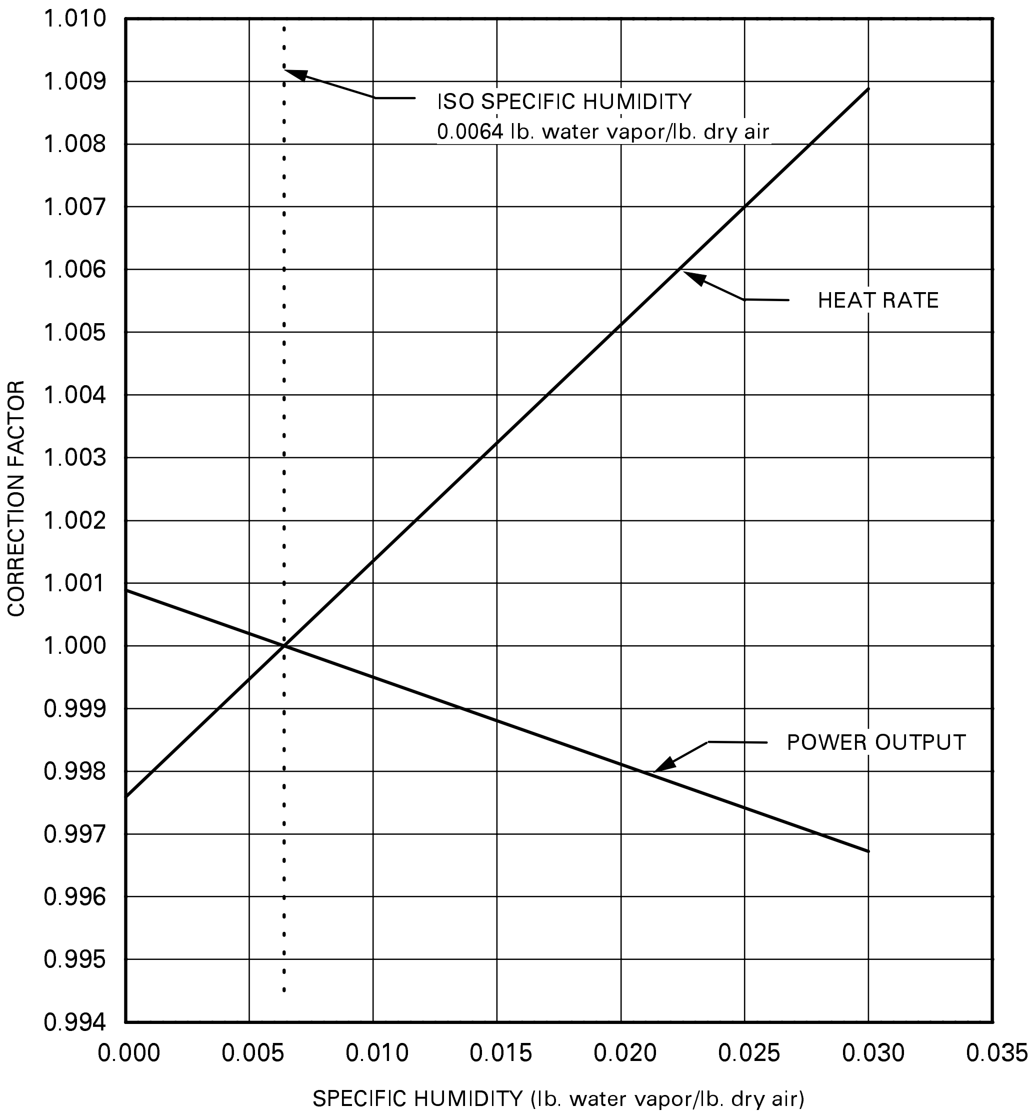
Gajipara H. N.
6/30/99

416HA662
Rev-B

General Electric MS6001, MS7001 And MS9001 Gas Turbines

Corrections To Output And Heat Rate
For Non-Iso Specific Humidity Conditions

For Operation At Base Load On Exhaust
Temperature Control Curve



10/10/89
DA JAQUEWAY

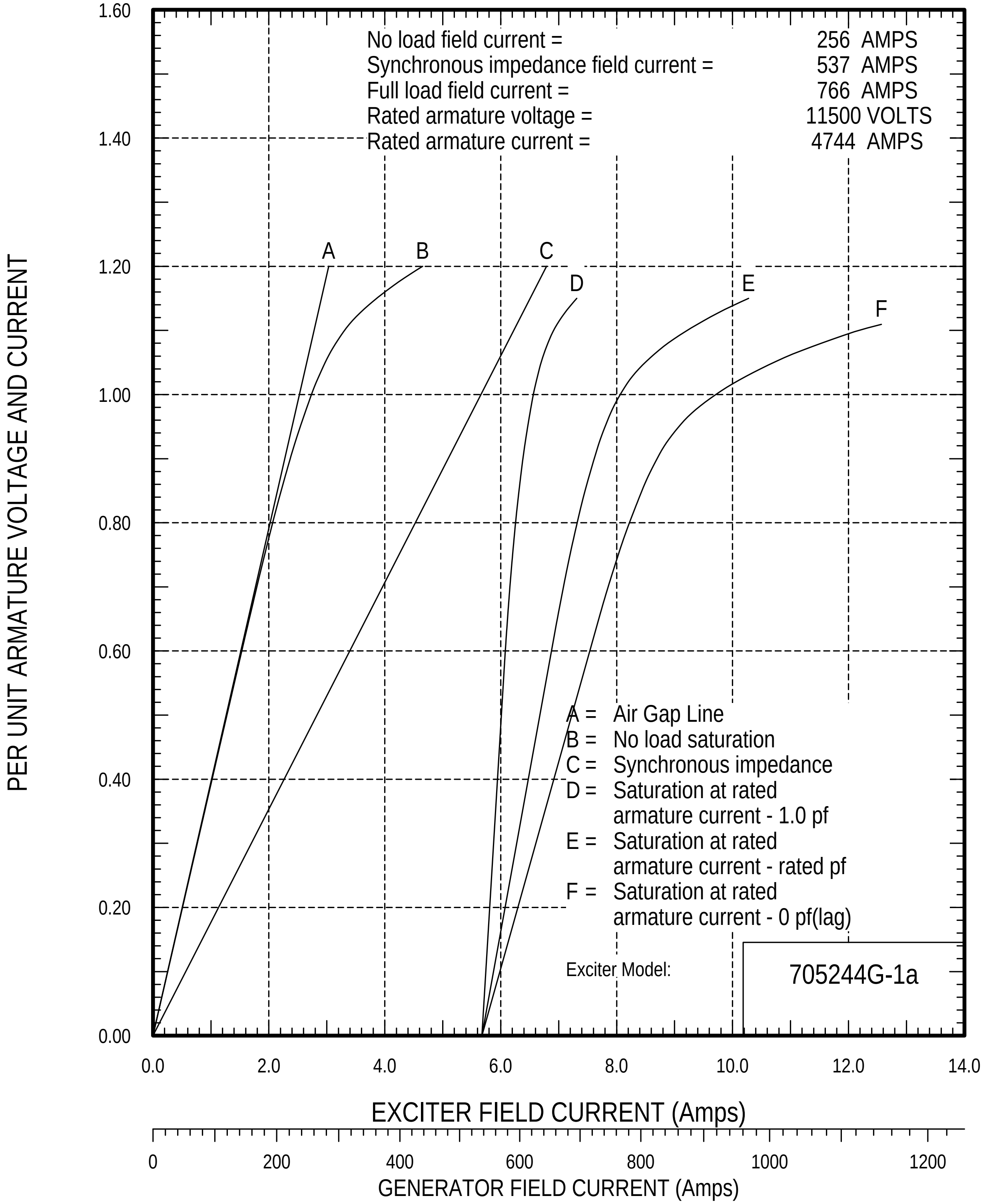
498HA697
REV B

ESTIMATED SATURATION AND SYNCHRONOUS IMPEDANCE CURVES

2 Pole 3000 RPM 94500 kVA 11500 Volts 0.850 PF

0.460 SCR 275 Volts Excitation

40 Deg. C Cold Gas 39 Ft. Altitude

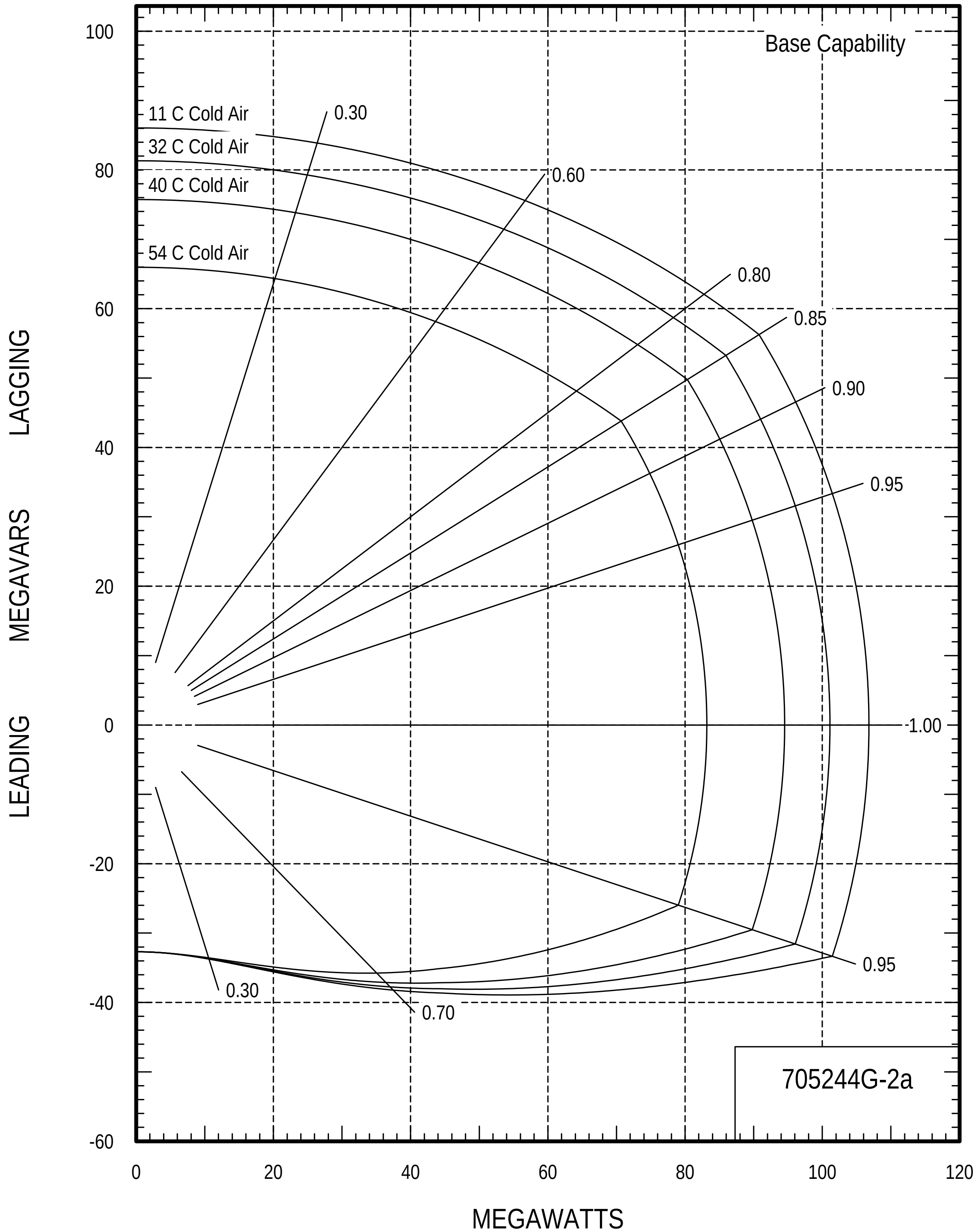


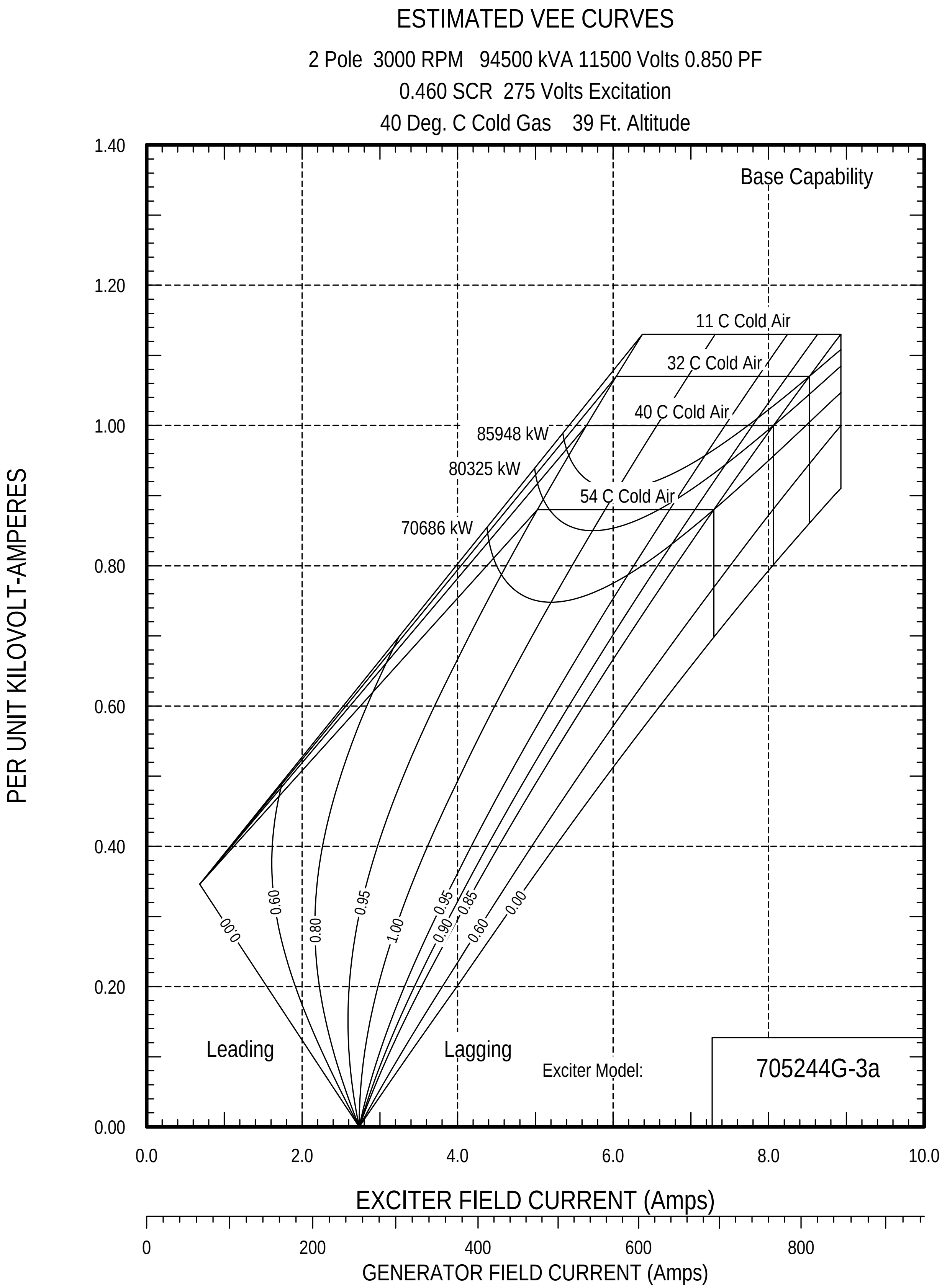
ESTIMATED REACTIVE CAPABILITY CURVES

2 Pole 3000 RPM 94500 kVA 11500 Volts 0.850 PF

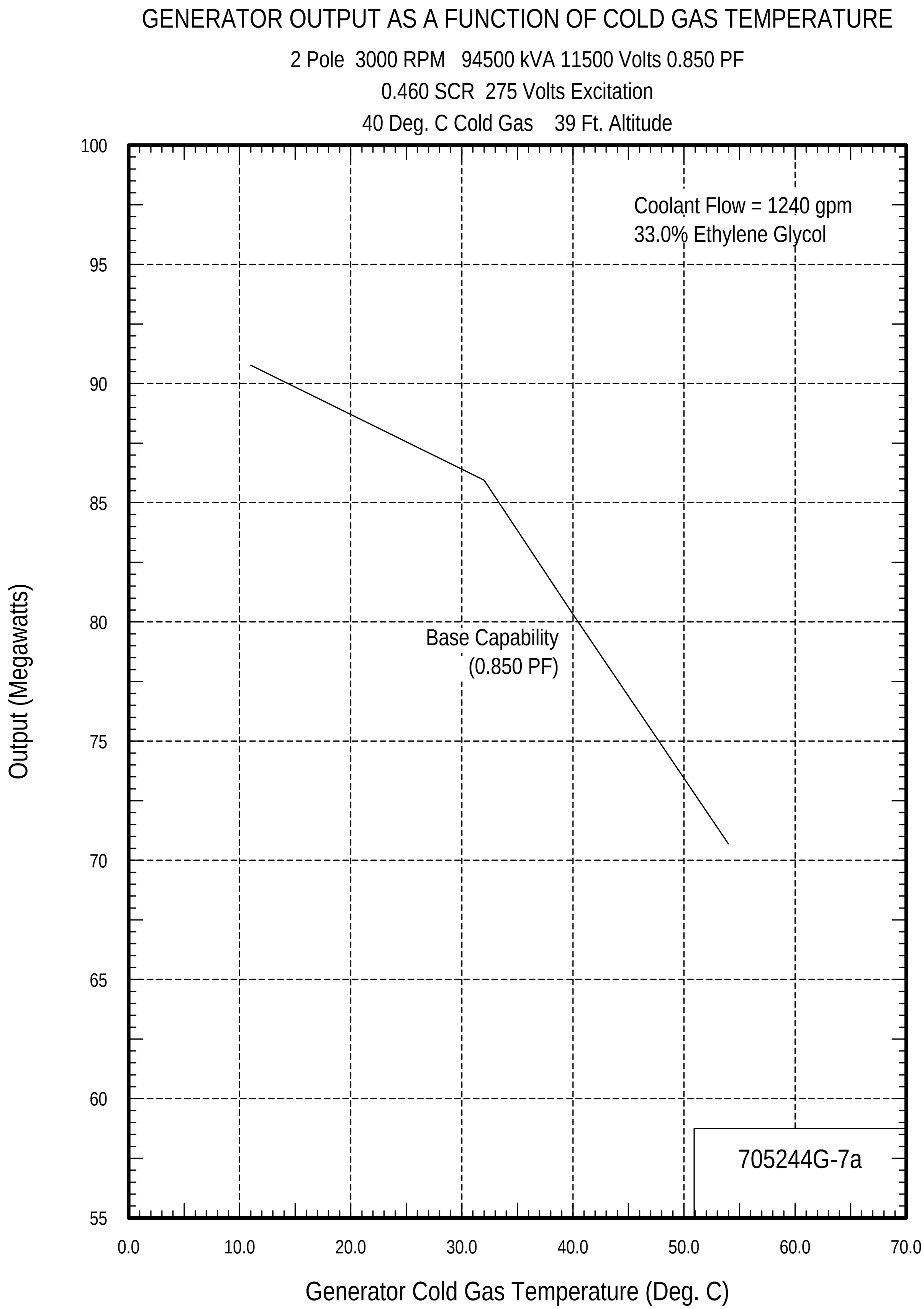
0.460 SCR 275 Volts Excitation

40 Deg. C Cold Gas 39 Ft. Altitude





ESTIMATED VEE CURVES
2 Pole 3000 RPM 94500 kVA 11500 Volts 0.850 PF
0.460 SCR 275 Volts Excitation
40 Deg. C Cold Gas 39 Ft. Altitude
Base Capability
11 C Cold Air
32 C Cold Air
40 C Cold Air
85948 kW
80325 kW
54 C Cold Air
70686 kW
0.00
0.60
0.80
0.95
1.00
0.95
0.90
0.85
0.60
0.00
Leading
Lagging
Exciter Model:
705244G-3a
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
PER UNIT KILOVOLT-AMPERES
0.0
2.0
4.0
6.0
8.0
10.0
EXCITER FIELD CURRENT (Amps)
0
200
400
600
800
GENERATOR FIELD CURRENT (Amps)

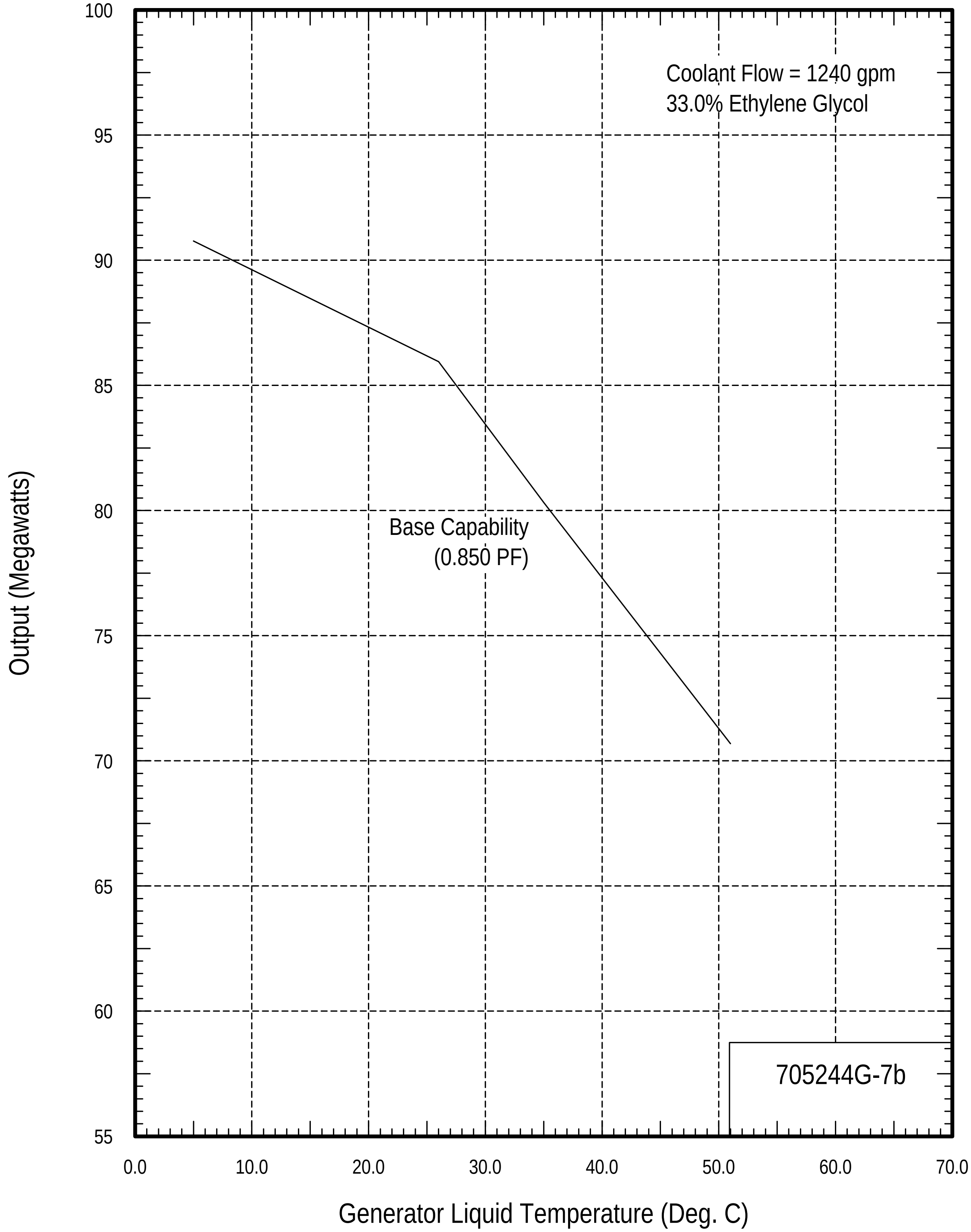

GENERATOR OUTPUT AS A FUNCTION OF COLD GAS TEMPERATURE
2 Pole 3000 RPM 94500 kVA 11500 Volts 0.850 PF
0.460 SCR 275 Volts Excitation
40 Deg. C Cold Gas 39 Ft. Altitude
Coolant Flow = 1240 gpm
33.0% Ethylene Glycol
Base Capability
(0.850 PF)
705244G-7a
Output (Megawatts)
100
95
90
85
80
75
70
65
60
55
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Generator Cold Gas Temperature (Deg. C)

GENERATOR OUTPUT AS A FUNCTION OF LIQUID TEMPERATURE

2 Pole 3000 RPM 94500 kVA 11500 Volts 0.850 PF

0.460 SCR 275 Volts Excitation

40 Deg. C Cold Gas 39 Ft. Altitude



4.2.2 Estimated Generator Data

Rating	
Project Name	Centrales de la Costa Power Plants
Generator type	6FA
Electrical Design Number	705244G
KVA	94500 kVA
Power Factor Leading	0.95
Power Factor Lagging	0.85
KW	80325 kW
RPM	3000 RPM
Rated Voltage	11500 Volts
Line Current	4744 Amps
Cooling System (OV / TEWAC / H2)	TEWAC / Air
SCR	0.46
Site Altitude	39 Ft
Rated H2 Temp	40 C
Exciter (Design Amps / KW / Voltage)	909 A / 250 kW / 275 V
Exciter (IGNL / IFNL / IFFL)	237 / 256 / 766
Rating (i.e., ANSI / IEC)	IEC
Temperature Class (i.e., B)	B
Coolant (Type / FF / Flow)	33% Ethylene Glycol / 0.0010 / 1240 GPM
Guaranteed I2 SQ.T (s)	8
TIF (L-L / L-N / Residual)	0. / 0.001 / 0.001
Field Resistance @ 25 C	0.2270
Armature Resistance @ 25 C	0.001550
No-Load Saturation factor (S1.0 / S1.2)	0.0820 / 0.5428
Losses	
Fan & Wind	304
Core	129
Load	232
I2R Arm	133
I2R Field	169
Misc	4
Exciter	33
Bearings	170
Total	1175
Efficiency	98.56%

Direct Axis Reactances (PU, Rounded)	
Synchronous (XD)	2.27
Transient Sat (X'DV)	0.240
Transient Unsat (X'DI)	0.260
Subtransient Sat (X"DV)	0.155
Subtransient Unsat (X"DI)	0.195
Negative Sequence Sat (X2V)	0.154
Negative Sequence Unsat (X2I)	0.193
Zero Sequence Sat (X0V)	0.112
Zero Sequence Unsat (X0I)	0.112
Armature Leakage Sat (XLV)	0.139
Armature Leakage Unsat (XLI)	0.144
Quaturature Axis Reactances (PU, Rounded)	
Synchronous (XQ)	2.16
Transient (X'Q)	0.48
Subtransient Sat (X"QV)	0.16
Subtransient Unsat (X"QI)	0.20
Hipots	
Armature / Field (Volts)	24000 / 2410
Resistances (Per Unit)	
Armature (DC) (RA)	0.001428
Positive Sequence (R1)	0.0039
Negative Sequence (R2)	0.0228
Zero Sequence (R0)	0.0120
Time Constants (Seconds)	
Direct:	
Transient, Open Circuit (T'DO)	9.855
Transient, 3 Phase (T'D3)	0.946
Transient, Line – Line (T'D2)	1.610
Transient, Line – Neutral (T'D1)	1.976
Subtransient (T"DO)	0.048
Subtransient (T"D)	0.031
Armature (TA2 = TA3)	0.401
Armature (TA1)	0.312
Quadrature:	
Transient (T'Q)	0.131
Transient, Open Circuit (T'Q0)	0.595
Subtransient (T"Q)	0.031
Subtransient (T"Q0)	0.095

5. Plant Operating Philosophy

5.1 Introduction

This section describes the start-up, on-line operation and shutdown of a gas turbine unit.

The following paragraphs briefly describe the general operating philosophy and operator's responsibilities for gas turbine unit operation. The description is of a general nature. Specifics may vary pending detail design definition.

5.1.1 Gas Turbine Unit Mode of Operation

The gas turbine unit can be started from the control panel of the gas turbine control system. Plant permissive circuits must be satisfied that the unit is capable of coming to full speed and synchronizing to the system. Systems must be placed in the ready to start mode:

- MCC breakers set in automatic mode
- Cooling water module local disconnect switches closed
- Fuel systems made ready
- Gas turbine/generator permissive to start systems ready

5.1.2 Starting and Loading

All starting is done automatically, with the operator given the opportunity to hold the start-up sequence at either the crank (pre-ignition) or fire (post-ignition, pre-accelerate) points of the start-up. An "Auto" mode selection results in a start without any holds.

Either before issuing a start command, or during the start, the operator may make the following selections:

- Select or disable the automatic synchronization capability of the gas turbine control system. Auto synch utilizes the proven micro-synchronizer first introduced in the SPEEDTRONIC™ controller. The micro-synchronizer provides extremely accurate and repeatable breaker closures based on phase angle, slip, the slip's rate of change and the response time of the breaker which is stored in the system memory.
- Selection of Pre-selected (Intermediate) Load or Base Load. If a selection is made, the unit will automatically load to the selected point and control there. If no selection is made, the unit will load to a low load referred to as "Spinning Reserve" after synchronization. The turbine governor is automatically regulated to maintain the megawatt setting assigned to "Spinning Reserve".

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5.1.3 Operating

Once the unit is on line, it may be controlled either manually or automatically from the gas turbine control system operator interface.

Manual control is provided by the governor raise/lower control displayed on the operator interface screen. Automatic operation is switched on when the operator selects load points (pre-select or base) from the turbine control interface.

For a fully automatic start with automatic loading to base load, the operator selects the “Auto” operating mode, enables auto synchronization and selects “Base” load. Given a “Start” signal, the unit will then start, synchronize and load to Base load with no further input on the part of the operator.

5.1.4 Shutdown

On shutdown, the system will automatically unload, coast down and initiate slow speed rotation until proper wheelspace cooldown temperatures are reached.

6. Test Philosophy

6.1 Gas Turbine Unit Performance Test Philosophy

6.1.1 General

Performance guarantees for the gas turbine unit are indicated in the Performance Data chapter. Compliance with these guarantees is determined by an input/output test for the unit. The test includes measurements of additional parameters required to assure that the unit is operating at contract conditions and to enable correction of measured performance to the basis for guarantee conditions.

The performance guarantees apply to equipment in new and clean condition.

This test must be conducted as soon as possible after the initial start-up. The compressor is cleaned per the Compressor Cleaning specification found in the Reference Documents chapter and inspected by the GE representative. The GE representative will be the sole judge with respect to condition of the gas turbine at the time of testing.

Performance test technicians are provided by the customer. GE prepares a detailed test specification that is submitted to the customer for mutual agreement. GE provides the technical direction of the tests. In addition, GE performs calculations to determine performance relative to the guarantees and prepares a test report for submittal to the customer.

Instrumentation tolerances are applied to the results of the test based on the accuracy of the individual test measurements and the contract requirements. An analysis of the test measurement uncertainty to be applied is made when the detailed test procedure is complete.

6.1.2 Procedure

Testing is conducted on the gas turbine in accordance with the Field Performance Testing Procedure included in the Reference Documents chapter of this proposal. The gas turbine is brought to steady-state test conditions prior to conducting performance testing. The test includes a demonstration of electrical output, heat rate, and other parameters specified in the proposal. Sufficient data is recorded to determine the equipment performance and to correct it to performance guarantee basis conditions. Corrections are made for operating and climatic conditions that may deviate from the contract performance guarantee.

6.1.3 Performance Evaluation

The gas turbine unit performance test is conducted as described above. Adjustments are made for variation in gas turbine operating conditions as follows:

Gas Turbine Power

$$kW_{SC} = kW_{GT} * kW_{AD}$$

Heat Consumption

$$HC_{GT}$$

Heat Rate

$$HR_{SC} = \frac{HC_{GT} * HR_{AD}}{kW_{GT}}$$

Symbol	Description
kW_{SC}	Gas turbine-generator measured electrical output (kW) at new and clean conditions and corrected to guarantee site conditions.
kW_{GT}	Gas turbine-generator measured equipment output (kW) at new and clean conditions.
kW_{AD}	Gas turbine output corrections to guarantee basis conditions.
HC_{GT}	Gas turbine heat consumption (10^6 kJ/h) calculated from fuel flow and lower heating value measured during tests.
HR_{SC}	Gas turbine heat rate calculated from measured output and heat consumption corrected to guarantee basis site conditions.
HR_{AD}	Gas turbine heat rate corrections to guarantee basis site conditions.

The test procedure includes correction factors and curves for test variations in ambient temperature, ambient pressure, ambient relative humidity, generator power factor, grid frequency, inlet and exhaust pressure drop, fuel properties, ageing and gas turbine diluent injection if required. These factors are used to correct the measured performance data from actual operating conditions to rated contract conditions.

Output guarantees will be satisfied if the corrected and adjusted output (kWsc) surrounded by the uncertainty interval encompasses the guaranteed plant output or falls above it. Heat rate guarantee will be satisfied if the corrected and adjusted test heat rate (HRsc) surrounded by the uncertainty interval encompasses the guaranteed plant heat rate or falls below it.

At the conclusion of the tests, GE will perform calculations to determine performance relative to guarantee and will issue a report covering the entire testing program.

7. Scope, Limits and Exclusion of Supply

7.1 Gas Turbine Generator Unit, Each Including:

7.1.1 The Gas Turbine Package Consisting of:

7.1.1.1 The Gas Turbine Compartment:

- Multi-stages, axial flow compressor
- Modulated inlet guide vanes
- Three-stages turbine
- Multi-chambers combustion system
- Dual gas/liquid combustion system with DLN combustors
- Ignition system with spark plugs and U.V. flame detectors
- Boroscope openings for maintenance inspection
- Seismic type vibration sensors on bearing caps for protection
- Thermocouples for measuring exhaust temperature
- Thermocouples on bearing drains
- Thermocouples on bearing metal
- Generator with SFC
- Exhaust frame blowers
- On/off line compressor wet washing system
- Water injection system for NOx control with liquid fuel

7.1.1.2 The Auxiliary Systems and Separate Skids:

- Lubricating oil system with:
  - Separate module
  - Duplex lube oil filters
  - Duplex lube oil to water heat exchangers
  - ASME code without stamp U for lube oil cooler and lube oil filter
  - Main AC motor-driven lube oil pump
  - Full flow AC motor-driven auxiliary lube oil pump
  - One (1) partial flow 125V DC motor driven emergency lube oil pump
  - Lube oil tank
  - Lube oil mist eliminator with dual extraction fans
  - Lube oil heater

- Hydraulic oil system with:
  - Two (2 x 100%) AC motor driven hydraulic oil pump
  - Duplex hydraulic oil filters
- Gas fuel system with (separate module):
  - One (1 x 100%) gas fuel filter
  - Gas fuel stop and control valves
- Liquid fuel system with:
  - Separate module
  - One (1 x 100%) high pressure fuel pump
  - Flow divider
- Atomizing air system with:
  - Separate module
  - One (1 x 100%) atomizing air cooler
  - One (1 x 100%) atomizing air compressor
- Water Injection For NOx Level Reduction With:
  - Separate module
  - One (1 x 100%) AC motor driven pump
  - Single filter
  - Flow metering system
  - Flow control valve

7.1.1.3 Couplings:

- Gas Turbine Load Coupling for GE Elin Generator

7.1.1.4 Load Gear:

- Load gear box mounted between the gas turbine and the generator:
  - High efficiency load gear
  - Load gear
  - Separate base
  - Lubricating system integral with gas turbine
  - Seismic type vibration sensors on bearing caps for protection
  - Thermocouples on bearing drains
  - GT rotor turning gear with electrical motor

7.1.1.5 Gas Turbine Packaging

- Lagging and enclosures
  - Enlarged acoustical enclosure around gas turbine compartment
  - On-base enclosure for gas fuel and lube oil module
  - On-base enclosure for liquid fuel/atomizing air/water injection module
  - Load gear compartment acoustical enclosure
  - Compartment ventilation and heating
  - Dual vent fans (2 x 100%)
  - Extra painting for corrosive and/or salt environment

- Gas detection system
  - Turbine compartment
  - Gas fuel compartment
- Fire detection and protection system with:
  - Thermic detectors

7.1.2 Generator

7.1.2.1 General Information

- Totally enclosed water-to-air cooled (TEWAC) generator
- Outdoor installation
- 50 Hz generator frequency
- Generator voltage 11.5 kV
- 0.85 power factor (lagging)
- Capability to 0.95 power factor (leading)
- Class “F” armature and rotor insulation
- Class “B” temperature rise, armature and rotor winding
- Generator bearings
  - Pedestal bearing support
  - Tilting pad bearings
  - Roll out bearing capability without removing rotor
  - Insulated collector end bearing
  - Offline bearing insulation check with isolated rotor
- Monitoring Devices
  - Two (2) velocity vibration probes at turbine end, one (1) at collector end
  - Provisions for key phasor-generator
  - Permanently mounted flux probe (stator wedge)
  - Proximity vibration probes
    - Two (2) probes per bearing at 45° angle
- Generator Field
  - Direct cooled field
  - Two-pole field
  - Finger type amortissuers

7.1.2.2 Generator Gas Coolers

- Cooler assembly shipped separate
- Generator gas cooler configuration
  - Two (2) horizontally mounted duplex coolers
  - Coolers located on generator roof
  - Cooler piping connections on left side as viewed from collector end
  - Single wall cooler tubes
  - Raised cooler face flanges
  - Plate fins

- Generator gas cooling system characteristics
  - Coolant temperature
    - 20°F approach
  - Generator capacity with one section out of service 80% with Class “F” rise
  - TEMA class C coolers
  - Maximum cooler pressure capability - 125 psi
  - Coolant 66% water and 33% ethylene glycol by volume
  - Fouling factor 0.0005
- Generator gas cooler construction materials
  - 90-10 copper-nickel tubes
  - Carbon steel tube sheets
  - Carbon steel waterbox and coupling flanges with epoxy coating
  - Aluminum cooler tube fins

7.1.2.3 Generator Lube Oil Systems and Equipment

- Bearing lube oil system
  - Generator lube oil system integral with turbine
  - Pre-fabricated factory fitted lube oil pipe
  - Sight flow indicator
- Lube oil system piping materials
  - Stainless steel lube oil feed pipe
  - Stainless steel lube oil drain pipe
  - Welded oil piping

7.1.2.4 Generator Temperature Devices

- Stator winding temperature devices
  - 100 ohm platinum RTDs (resistance temperature detector)
  - Dual element RTDs
  - Ungrounded RTDs
  - Twelve (12) stator slot RTDs
- Gas path temperature devices
  - 100 ohm platinum gas path RTDs
  - Dual element temperature sensors
  - Two (2) cold gas
  - Two (2) hot gas
- Bearing temperature devices
  - 100 ohm platinum RTDs
  - Dual element temperature sensors
  - Two (2) bearing metal temperature sensors per bearing
- Collector temperature devices
  - 100 ohm platinum RTDs
  - Dual element temperature sensors
  - Collector air inlet temperature sensor

  - Collector air outlet temperature sensor
- Lube oil system temperature devices
  - 100 ohm platinum RTDs
  - Dual element temperature sensors
  - One (1) bearing drain temperature sensor per drain

7.1.2.5 Generator Packaging, Enclosures, and Compartments

- Paint and preservation
  - Epoxy based primer
  - Neutral tie
- Collector compartment/enclosure
  - Collector compartment/enclosure shipped installed
- Compartment lighting and outlets
  - AC lighting
    - Collector compartment
- Foundation hardware
  - Generator shims and plates
  - Generator centerline alignment guide
  - Generator alignment key(s) - collector end
  - Generator alignment key(s) - turbine end

7.1.2.6 Electrical Equipment

- Heaters
  - Generator stator heaters
  - Generator collector heaters

7.1.2.7 Generator Acoustic Protection

- Acoustic barrier wall around Generator

7.1.3 The Gas Turbine Generator Control Equipment:

The Gas Turbine Generator Control Equipment is Located into an air conditioned Turbine Control Compartment (TCC) designed for outdoor installation and consisting of:

- SPEEDTRONIC™ Mark VIe turbine control panel
  - including proximitor monitoring
- Local operator interface <HMI> server including: Desktop computer with 21" LCD color display Keyboard & mouse
- Dot matrix printer for local HMI
- Generator control, excitation, regulation and protection panel with:
- One (1) digital automatic channel and one (1) digital manual channel
- One (1) power circuit to feed the exciter field.

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- One (1) digital generator protection relay.
  - Power system stabilizer (PSS) system software
    - study
    - tests/tuning on site
  - Modbus interface
  - Protection settings calculation
  - Generator gross output meter active and reactive power class 0.2 (could be located in the auxiliary cubicle if lack of space in the generator control panel)
- Unit AC/DC Motor Control Center, withdrawable type
- Unit AC/DC sub-distribution panel, non- withdrawable
- 125 VDC Sealed Lead Acid unit battery 4x50% with 4x50% battery chargers
- The battery and/or the charger(s) associated is located inside a dedicated battery container
- One (1) Gas detection rack

7.2 Off-Base Unit Mechanical Auxiliaries Including:

7.2.1 The Inlet Air System, for Each Unit, with:

- Up & forward orientation
- Static Multi-stage type air filter with:
  - Gas Turbine Anti Icing system
  - Weather louvers
  - Pre-filter
  - Coalescer filters
  - High efficiency filters
- Inlet bleed heating manifold
- Ducting and inlet silencer
- Supporting steel structure
- Extra painting for corrosive and/or salt environment

7.2.2 The Axial Exhaust System with:

- Expansion joint between the exhaust diffuser and the transition piece including low frequency silencer
- Exhaust duct personnel protection around Low Frequency silencer only

7.2.3 The Gas Fuel Off-Base System Including:

- Duplex coalescing filter, manual drain
- Heat insulation for duplex coalescing filter
- Electrical tracing for duplex coalescing filter
- Shut off and vent valve skid, gas piloting system stainless steel
- Heat insulation for shut off valve and vent valve skid
- Electrical tracing for shut off valve and vent valve skid
- Gas flow meter

7.2.4 The Light Liquid Fuel Forwarding System Including:

Skids are suitable for installation in hazardous area classified zone 2.

- One (1) LDO forwarding skid with:
  - Two (2) full flow AC motor driven forwarding pumps
- Extra painting for corrosive ambient conditions

7.2.5 The Light Liquid Fuel Filtering System Including

Skids are suitable for installation in hazardous area classified zone 1.

- One (1) LDO filtering skid with:
  - Two (2) filters with synthetic cartridges Beta 17=200
  - One (1) fuel accumulator
  - One (1) volumetric flow meter with by-pass
  - One (1) stop valve
- Extra painting for corrosive ambient conditions
- Pulse transmitter added on the oval wheels fuel totalizer for remote indication of totalized flow or actual flow

7.2.6 Sump Tank

The sump tank is preassembled and includes:

For Simple Liquid:

- One (1) steel tank (1 m3 capacity) electrical pump and heater

7.2.7 Off-Base Cooling Loop for Gas Turbine and Generator Cooling Systems Including:

- One (1) battery of water to air fin fan coolers with AC motor driven fans (with 100% capacity)
  - With one (1) extra motor fan for the complete battery
- Two (2 x 100%) AC motor driven water pumps (on closed circuit loop) and valves
- Atmospheric expansion tank with level, filling plug with steel structure

7.2.8 Fire Protection for Gas Turbine Unit Including:

- One (1) H.P. CO2 bottles rack:
  - Under shelter
  - With remote weighting device
- Unit fire protection panel installed:
  - in TCC
- Equipment designed with specific treatment for aggressive site conditions
- C02 Bottle charge:
  - Double HP CO2 bottles only for one CO2 concentration test with cylinder valves not connected (range storage condition -18°C to 45°C)

7.2.9 One (1) Washing Skid Including:

- Compressor (On & Off-Line) Washing Skid with:
  - Water tank 4m3 stainless steel
  - First charge of Detergent supplied by GE

7.2.10 Off-Base Interconnecting Piping Including:

- Gas Fuel Off-Base piping including:
  - Interconnecting piping between gas filtering skid, shut off valve skid and the gas module
- Liquid Fuel piping Including:
  - Interconnecting piping between filtering skid and GT
- Inlet Air system:
  - Interconnecting bleed -heating piping
- Off-Base Cooling piping Including:
  - Interconnecting piping among the fin-fan cooling module, G.T and generator
- Lube oil piping Including:
  - Interconnecting piping between lube oil module and generator + load gear
- Washing Skid piping including:
  - Interconnecting piping between washing skid and the gas turbine
- Draining piping Including:
  - Piping draining for GTG group
- Air Processing piping Including:
  - Interconnecting piping for Air Processing
- Other requirements:
  - Piping heat tracing

7.3 Off-Base Unit Electrical Auxiliaries Including:

7.3.1 Connection Between Generator Package and GNAC, GLAC by:

- Metal enclosed air insulated non segregated phase bus bars

7.3.2 Connection Between GLAC and 52G:

- Isolated phase bus bars (IPB) provided with a limit of six (6) Meters per phase and nine (9) Elbows
- Due to the wind conditions, isolated phase bus bar need to be located on the ground

7.3.3 One (1) Generator Line Accessory Compartment, Designed for Outdoor Installation, Consisting of:

- PT's and CT's
- Capacitors and lightning arrestors

7.3.4 One (1) Generator Neutral Accessory Compartment, Designed for Outdoor Installation, Consisting of:

- CT's
- Generator grounding

7.3.5 One (1) Generator Circuit Breaker, Pkg Type, Consisting of:

- SF6 circuit breaker with mechanical control mechanism
- One (1) earthing switch (generator side)
- One (1) starting disconnector on generator side
- Due to the wind conditions, Generator Circuit Breaker need to be located on the ground. A wind protection (by others) by means of concrete wall (civil works) is required in order to protect the GCB from the wind.

7.3.6 One (1) Static Frequency Converter, Consisting of:

- One (1) transformer (dry type) two windings rated to feed SFC (located in the SFC container)
- One (1) Static Frequency converter located in a container

7.3.7 Off Base Low Voltage Cabling with a Maximum of 50 Meters Including:

- Low voltage power, control and instrumentation cables between GE supplied equipments
  - With the exception of the cables from/to forwarding skid
- Optical fiber for remote

7.4 Remote Control & Monitoring

- One (1) Remote HMI with 21" LCD color display and with dot matrix printer

7.5 Miscellaneous

- The following consumables:
  - First charge of lubricating oil plus 10%
  - First charge of anti corrosion & anti freeze product for the closed cooling system
- Control, power and measure cables between the supplied equipment
  - Excluding cabling up to the liquid fuel forwarding skid
- Anchoring and base plates for turbo generator
- Anchoring, base plates for Fuel gas/lube oil module
- Anchoring, base plates for Liquid fuel-air atomization-water injection module
- Embedded pieces for turbo generator
- Template for anchor bolts positioning
- Touch up products for primary coat on external surfaces of equipment (supplied by GE, to be applied on site by others)
- Painting products for final coat on external surfaces of equipment (supplied by GE, to be applied on site by others)

- Special tools for the gas turbine including (one [1] set per site):
  - Installation tools list
  - Major inspection tool kit for GT for casing dismantling
  - Load gear handling spreader
- No load gas turbine factory tests according to Manufacturer's standard
- Generator test according to manufacturer's standard

7.6 Services

- End Of Manufacturing Report (EOMR) containing inspection & test records as per Contract Manufacturing Quality Plan (Tab.19) in English language on the following support:
  - CD-ROM (two [2] sets)
- Transportation as per commercial section
- Installation commissioning site testing in respect of the fire protection system are excluded from GE's scope of supply

7.7 Terminal Points

7.7.1 Mechanical

- Air
  - Inlet face of the gas turbine air filter
- Exhaust Gas
  - Outlet flange of the low frequency silencer (without expansion joint)
- Gas Fuel
  - Inlet flange of the coalescing filter
  - Vent connections
- Liquid Fuel
  - Inlet and outlet flanges of the LDO forwarding skid
  - Outlet flange on the LDO filtering skid for the recirculation to storage
  - Inlet flange of the LDO filtering skid
- Cooling Water (Closed Circuit)
  - Filling connection on the expansion water tank
- Demineralized Water (NOx Control)
  - Inlet flange of water injection skid
  - Outlet flange on the skid for water recirculation to storage
- Washing Water (ON/OFF Line)
  - Filling connection on washing water tank
- Detergent (OFF Line Compressor Washing)
  - Filling connection on washing detergent tank
- Lube Oil
  - Inlet and outlet connection on lube oil tank for filling and emptying
- Compressed Air (Instrument / Service)
  - Inlet connection on the bleed heating control valve

- Sump
  - Outlet flanges of the sump pump
- Condensates
  - Outlet flange on gas fuel coalescing filter
- Heating Water
  - Inlet and outlet flanges of water to air heat exchanger (anti-icing system)
- Ventilation
  - Inlet and outlet openings on the acoustical enclosures

7.7.2 Electrical

- Medium Voltage (11,5kV)
  - Outgoing terminals of the main circuit breaker
  - 52G Starting Disconnector
  - Incoming and Outgoing terminals of the SFC Container
- Low Voltage (400 VAC) terminal points
  - Incoming circuit breaker terminals on GT MCC
  - Terminals of the liquid fuel forwarding skid
  - Terminals of the Atomizing Air Compressor
- Earthing
  - Terminal points on GTG base frame and various auxiliaries

7.8 Supplied by Others

7.8.1 Mechanical

- Exhaust Gas:
  - Exhaust duct & stack
  - joint downstream our limit of supply
  - Exhaust emission measurement instrumentation
- Gas Fuel System:
  - Gas fuel treatment station including: primary filter and / or separator, pressure boosters, pressure reducing valve, heater, tariff metering, condensate tank, vent stack, flare (if any)
  - Gas fuel density or calorific value measurements
- Liquid Fuel System:
  - Fuel oil heater (if needed)
  - Liquid fuel unloading, metering, storage tanks, low pressure forwarding pump and treatment station (if any)
- Fire Fighting System:
  - Site fire protection and detection system
- Compressed air system (service and control) (if any)
- Water circuit for anti-icing system

- Washing water (if any) and oily water drain system including water recovery pit, piping from connecting flange near the GT base, water treatment before discharge in sewage system (if any)
- Any crane and / or lifting facilities
- Machine shop equipment (if any)
- Laboratory equipment (if any)
- Turbine hall ventilation (if any)
- Various vents to be piped outside the turbine hall (if any)

7.8.2 Electrical

- MCC auxiliary transformer
- Unit step-up / step down transformer
- All LV cables other than those used for interconnection between the supplied equipment
  - With the exception of cabling up to the liquid fuel forwarding skid which is out of our supply
- All MV and HV cables
- MV cable between SFC container and Generator Circuit Breaker
- Any MV and / or LV site switchboard
- Emergency diesel generating set and black start equipment
- Grounding grid and connections to the grounding cable
- Lightning protection
- Site lighting, fencing
- Cathodic protection
- Wind protections for Generator Circuit Breaker

7.8.3 Miscellaneous & Services

- Any generator type test
- Any on site painting product application
- All consumable, chemicals during erection, commissioning, testing and running of the unit(s)
- Soil investigation, analysis and factual report
- Any civil work, concrete structure, road, including design studies (except guide drawings for the supplied equipment)
- Grouting compound for GT unit(s)
- All environmental permits and / or approvals such as (but not limited to) air, waste, fluids, coastal zone, noise, hydrology study
- All governmental permits and / or approvals such as (but not limited to) construction permit, environmental impact statements, licenses, exemptions
- Any other equipment or service not clearly indicated in our Scope of supply

8. Description of Equipment

8.1 Description of Gas Turbine and Auxiliary Equipment

8.1.1 Description of Gas Turbine

8.1.1.1 General

The MS 6111 FA gas turbine utilizes the advanced technology developed during the design of MS 7001F/FA. The configuration is a single shaft, bolted rotor with the generator connected to the gas turbine through a speed reduction gear at the compressor or "cold" end. This feature provides for an axial exhaust to optimize the plant arrangement for combined cycle or waste heat recovery applications. The major features of the MS 6111 FA are described below.

8.1.1.1.1 Compressor

The compressor is an 18 stage axial flow design with 1 row of modulating inlet guide vanes and a pressure ratio of 15.8:1 in ISO conditions. Interstage extraction is used for cooling and sealing air (turbine nozzles, wheelspaces) and for compressor surge control during start-up. Construction employs 15 full length tie bolts that compress the discs at the bolt circle thereby forming a rigid rotor. The discs are centered by means of rabbets. The compressor blades are attached to the discs with locked-in dovetails. High strength, corrosion resistant GTD450 stainless steel blading material is provided on the first nine stages. The remaining blading, except stage 17 stator and EGV, is of high strength AISI 403+Cb alloy. Stage 17 stator and EGV are cast from high strength 403CB. Because the blading material in the compressor has high corrosion resistance, a coating is not required. The compressor wheel webs are coated with corrosion resistant paint.

8.1.1.1.2 Combustion System

A reverse flow, six chambers second generation Dry Low NOx (DLN-2.6) combustion system is standard with six fuel nozzles per chamber. Two (2) retractable spark plugs and four flame detectors are a standard part of the combustion system. Crossfire tubes connect each combustion chamber to adjacent chambers on both sides. Transition pieces are cooled by air impingement. Thermal barrier coatings are applied to the inner walls of the combustion liners and transition pieces for longer inspection intervals. Each chamber, liner and transition piece can be individually replaced.

8.1.1.1.3 Turbine Section

The turbine section has three (3) stages with air-cooling on all three (3) nozzle stages and the first and second bucket stages. The first stage bucket has an advanced cooling system to withstand the higher firing temperature. It utilizes turbulated serpentine passages with cooling air discharging through the tip, leading and trailing edges.

The buckets are designed with long shanks to isolate the turbine wheel rim from the hot gas path and integral tip shrouds are incorporated on the second and third stages to eliminate bucket fatigue concerns and to improve heat rate. The first stage has a separate, two (2) piece casing shroud that permits reduced tip clearances.

The rotor is a single shaft, two (2) bearing design with high torque capability incorporating internal air-cooling for the turbine section. Both the compressor and turbine sections are constructed of individually rabbeted discs held with bolts. Each turbine wheel is prestressed with a hot spin process to reduce the operating stresses. The direction of shaft rotation is counter-clockwise when facing the gas turbine output flange (compressor forward shaft flange). The load gear reverses the direction of rotation as it drives the generator rotor. For field changeout, the gas turbine rotor is handled as one (1) piece. The turbine buckets (rotating blades) can be changed in sets or individually without any field balancing of the rotor.

8.1.1.1.4 Casings

The five turbine and compressor casings are horizontally split for ease of inspection and maintenance. Borescope holes are located in the compressor and turbine sections to facilitate visual inspections. For combustion, one (1) element shall be disassembled (detector, spark plug, fuel nozzle) to enable visual inspection. The number 1 bearing (journal and thrust) is accessed by removing the top half of the compressor inlet casing. The number 2 journal bearing is readily accessible and removal of the turbine casing is not required for bearing maintenance.

Exhaust Diffuser

One (1) of the special features of the "F/FA" family is the axial, in-line diffuser for optimum performance in both heat recovery and simple cycle applications. There are no elbows or turns between the turbine and the exhaust system. The profile reduces the pressure drop and improves performance

Controls

The PG 6111FA features the Mark VI Speedtronic™ control system. This microprocessor system provides protection and control of critical functions and can be integrated with power station control systems. Typical control processes include automated start-up, shutdown, fuel transfer, speed/load control, and Dry Low NOx operation. Protective functions include speed/load, bearing vibrations, and critical temperatures.

8.1.1.2 Turbine Base and Supports

8.1.1.2.1 Turbine Base

The base that supports the gas turbine is a structural steel frame fabricated of steel beams and plate. The base frame forms a bed upon which the six vertical supports for the turbine are mounted.

8.1.1.2.2 Turbine Supports

The gas turbine is mounted to its base by six vertical supports. The two (2) at the forward end of the compressor casing are fixed while the four at the turbine exhaust frame and diffuser are pivoted to accommodate thermal expansion of the casing.

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8.1.1.2.3 Turbine Enclosure

Gas turbine enclosure consists of several sections forming an all weather protective housing which surrounds each compartment base. The enclosure serves many functions which include airborne noise reduction, thermal insulation, equipment access and walkways for inspection and maintenance.

Protection systems include fire protection, hazardous gas dilution and detection, and emergency systems.

8.1.1.3 Compressor

The axial flow compressor consists of a rotor and a stator casing. The first two (2) stages are designed using transonic flow techniques. A single stage of modulating inlet guide vanes and selective bleeds are used to prevent surge at start-up.

8.1.1.3.1 Compressor Rotor

The compressor rotor assembly has eighteen stages and consists of a forward stub shaft, on which are mounted the stage zero rotor blades, sixteen blade and wheel assemblies for stages 1 to 16 and an aft stub shaft on which are mounted the stage 17 rotor blades. The entire assembly is held together by fifteen axial bolts arranged around the bolting circle. The wheels are positioned radially by rabbets. Transmission of torque is accomplished by the face friction at the bolting flange. Flange surfaces are grit blasted for increased torque transmission capability.

Each wheel and the wheel portion of each stub shaft have broached slots around the periphery. The rotor blades are inserted into these slots and they are held in axial position by staking each end of the slot. Selective positioning of the wheel is made during assembly to reduce the rotor balance correction. Each wheel is individually balanced before assembly.

After assembly, the compressor rotor is dynamically balanced and again after the compressor and turbine rotors are married they are precision balanced prior to assembly into the stator.

The forward stub shaft is machined to provide the forward and aft thrust bearing faces and the journal for the number 1 bearing.

Blading

The airfoil shaped compressor rotor blades are designed to compress air efficiently at high blade tip velocities. These forged blades are attached to their wheels by dovetail connections. The dovetail is accurately machined to maintain each blade in the desired location on the wheel.

Stator blades utilize square bases for mounting in the casing slots. Blade stages 0 through 4 are mounted by the axial dovetails into blade ring segments. The blade ring segments are inserted into circumferential grooves in the casing and are held in place with locking keys. Stages 5 through 16 are mounted on individual rectangular bases that are inserted directly into circumferential grooves in the casings. Stage 17 and the exit guide vane are cast segments. Blades are configured individually or in multi-blade segments. High strength, corrosion resistant GTD450 stainless steel blading material is provided on the first nine stages. The remaining blading, except stage 17 stator and EGV, is of high strength AISI 403+Cb alloy. Stage 17 stator and EGV are cast from high strength AISI 403+Cb.

No coating is required for erosion and corrosion protection because of the excellent properties of the custom GTD450 material is used for the variable inlet guide vanes and stages 0-8.

For start-up and part load the variable inlet guide vanes are controlled per a schedule in the control specification are in appropriate position for maintaining stable aerodynamic performance.

8.1.1.3.2 Compressor Stator

The casing supports 18 stages of compressor blading plus the inlet and the exit guide vanes. It is composed of three (3) major subassemblies: (1) the inlet casing, (2) the compressor casing and (3) the compressor discharge casing. These components, in conjunction with the turbine shell and exhaust frame/diffuser constitute the outer wall of the gas path annulus. The casing bore is maintained to close tolerances with respect to the rotor blade tips for maximum aerodynamic efficiency. Borescope ports are located throughout the machine for component inspection. All casings are horizontally split for ease of handling and maintenance.

8.1.1.3.2.1 Inlet Casing

The inlet casing is located at the forward end of the gas turbine. Its prime function is to direct the air uniformly from the inlet plenum into the compressor. The inlet casing also supports the separate number 1 thrust bearing assembly. Variable inlet guide vanes are located at the aft end of the inlet casing.

8.1.1.3.2.2 Compressor Casing

The compressor casing contains the zero through 12th compressor stages. Extraction ports in the casing allow bleeds to the exhaust plenum during start-up and extraction of air to cool the second and third stage nozzles.

8.1.1.3.2.3 Compressor Discharge Casing

The compressor discharge casing consists of two (2) cylinders, one (1) is a continuation of the compressor casing and the other is an inner cylinder that surrounds the compressor aft stub shaft. These two (2) cylinders are connected by radial struts. A diffuser is formed by the tapered annulus between the outer and inner cylinders. This casing contains the 13th through 17th stage compressor stators and one (1) row of exit guide vanes. It also provides an inner support for the first stage turbine nozzle assembly via the support ring as well as support of the combustion components.

8.1.1.3.3 Compressor Air Extraction

During start-up and operation of the gas turbine, air is extracted from various stages of the axial flow compressor to cool the turbine parts subject to high operating temperatures, to prevent undesirable aerodynamic behavior during start-up and shut-down and to provide an air supply for air-operated valves.

8.1.1.3.3.1 9th Stage Air

Air extracted from connections in the upper and lower half of the casing at the 9th stage is used to cool the stage 3 turbine nozzles and wheel spaces. During start-up and shutdown, it is externally piped to the exhaust plenum for surge control.

8.1.1.3.3.2 13th Stage Air

The 13th stage bleed air is used for cooling the second stage nozzles.

8.1.1.3.3 17th Stage Air

Air extracted from the compressor 17th stage flows radially inward between the stage 17 wheel and the aft stub shaft (stage 18) and then flows aft through axial holes in the compressor aft stub shaft and turbine forward shaft. It flows to the turbine rotor bore through guide vanes after which the air is used to cool the turbine stage 1 and stage 2 buckets.

8.1.1.3.3.4 Compressor Discharge Air

Air extracted from the compressor discharge plenum is used for cooling the stage 1 nozzle vane, retaining ring and shrouds and:

bleed heating

for liquid fuel atomizing air

A continuous purge is accomplished by the use of pigtails between the air extraction manifold and the fuel nozzles.

For dual fuel units, air extracted is also used to purge the premix gas fuel nozzles during operation on liquid fuel.

8.1.1.3.4 Compressor Washing System

Compressor washing may be used for restore compressor efficiency lost due to compressor fouling. The compressor should be washed with either a detergent solution for oil deposits or plain water for water soluble deposits such as salts. Liquid is sprayed into the compressor inlet from nozzles located around the entire circumference on the wall of the compressor inlet bell mouth. It is supplied from an off-base water wash skid, which consists of water and detergent tanks, a water system pump and immersion heaters, with all electrical controls mounted on the skid.

8.1.1.4 Dry Low NOx Combustion System

8.1.1.4.1 General Description

Development of DLN combustion systems permitted to achieve low levels of NOx output without the addition of water or steam when burning gas fuel. This technology has been first advanced with the introduction of DLN-II on the MS7001FA gas turbines during 1993. Successful demonstration on the MS7001FA provides the basis for application of the DLN-II system on the MS9001FA and the MS6001FA. A new step was achieved in 1998 with the introduction of the DLN 2.6 technology on the MS7001FA, to further improve the NOx emissions. The MS 6111FA (6FA+e) features the DLN 2.6 technology. This DLN system is also able to burn liquid distillate fuel. Nox abatement is achieved with water injection.

The MS7001FA and MS6001FA systems are similar in many respects. The flow per can is only a few % less for the 6FA compared to the 7FA. The « head end » components (end cover, fuel nozzles, and cap) are identical. Differences in machine airflow are accommodated by varying the number of chambers, from 14 for the 7FA to 6 for the 6FA. Crossfire tube and transition piece details are different. In support of the development program, a specific 6FA+e laboratory tests have been performed to demonstrate emissions, dynamics and cooling performances.

8.1.1.4.2 Combustion Chambers and Transition Pieces

Thermal barrier coatings are applied to the inner walls of the combustion liners for longer part lives.

Transition pieces direct the hot gases from the liners to the turbine nozzles. The transition pieces for a 6FA unit are impingement cooled by a perforated cooling shell. The internal surface of the transition piece has a thermal barrier coating.

8.1.1.4.3 Spark Plugs

Combustion is initiated by discharge from two (2) retractable electrode spark plugs each in a different combustion chamber. At the time of firing, a spark at one (1) or both of these plugs ignites a chamber. The remaining chambers are ignited by crossfire through the tubes that interconnect the reaction zones of the remaining chambers. As rotor speed and the air flow increase, chamber pressure rises causing the spark plugs to retract, and the electrodes are removed from the combustion zone for longer life.

No LP gas torch ignitor system is required with this design.

8.1.1.4.4 Flame Detectors

The control system continuously monitors for presence or absence of flame. Detectors are SiC technology. Four water-cooled flame detectors are installed in three (3) different combustors. Two (2) detectors in chamber number 6 and one (1) detector in chambers number 1 and number 2

Crossfire Tubes

The six combustion chambers are interconnected by means of crossfire tubes. These tubes enable flame from the fired chambers containing spark plugs to propagate to the unfired chambers.

8.1.1.4.5 Fuel Nozzles

8.1.1.4.5.1 General

Each of the six combustion chambers on the MS6111FA DLN 2.6 system has five circumferentially and one (1) central arranged fuel nozzles mounted on the combustor end covers and extending into the combustion liners.

Distillate oil passages are included for dual fuel applications. Oil operation is possible therefore water injection may be required for NOx control.

Atomizing air is provided by an off-base compressor which is only running on liquid fuel operation. A continuous purge flow is provided for the atomizing air, oil and water injection passages when running gas.

8.1.1.4.5.2 Dry Low NOx Combustion System

8.1.1.4.6 Water Injection

The thermal NOx are generated in the “flame front” of the liner at the highest temperature zone.

The NOx generation is tightly linked to the temperature and any slight temperature drop involves a significant decrease of the NOx without affecting the combustion efficiency.

The water injection in the liner is made to reduce the temperature in the primary zone.

The injection rate (water to fuel ratio) is a function of the requested reduction of the NOx emission level.

The water injection affects the gas turbine performances.

The water injection device is associated to each fuel nozzle assembly.

The necessary water flow is introduced in the fuel nozzle assembly in order to reach a proper distribution of the water into the highest temperature zones.

On the out face of the combustion chamber cover, connecting device is arranged to connect each nozzle to the water manifold.

8.1.1.5 Turbine Section

8.1.1.5.1 General

The three-stage turbine section is the assembly in which the energy contained in the hot pressurized gas produced by the compressor and combustion section is converted to mechanical energy. The major turbine section components are the turbine rotor, turbine shell, exhaust frame, exhaust diffuser, nozzles and diaphragms, stationary shrouds, and aft (number 2) bearing assembly.

8.1.1.5.2 Turbine Rotor

8.1.1.5.2.1 Structure

The turbine rotor assembly consists of a forward shaft, three (3) turbine wheels (with 92 buckets on each), two (2) turbine spacer wheels and an aft turbine shaft, which includes the number 2 bearing journal.

The forward shaft extends from the compressor rotor aft stub shaft flange to the first stage turbine wheel. All turbine wheels are subjected to a hot spinning process to reduce operational stresses at the bore. Each turbine wheel is axially separated from the adjacent stage(s) with a spacer wheel. The 1-2 spacer wheel faces incorporate radial slots for cooling air passages and the outer surface is machined to form labyrinth seals for interstage gas sealing. Selective positioning of rotor members is performed during assembly to minimize balance corrections of the assembled rotor. Concentricity control is achieved with mating rabbets on the turbine wheels, spacers and shafts. The turbine rotor components are held in compression by bolts. Rotor torque is transmitted by friction force on the wheel faces due to bolt compression. The frictional force is further enhanced by grit blasting of flange surfaces.

8.1.1.5.2.2 Turbine Cooling

The turbine rotor is cooled by means of a positive flow of relatively cool air extracted from the 17th stage of the compressor. This air is used to cool the 1st and 2nd stage buckets plus the rotor wheels and spacers.

8.1.1.5.2.3 Bucket Design and Cooling

The first stage buckets have forced air convection cooling adapted from aircraft engine designs. Turbulent airflow is forced through integral cast-in serpentine passages and is discharged from holes at the tip and at the trailing edge of the bucket. Cooling for the second stage bucket is via radial holes drilled with a shaped tube electrochemical machining (STEM) process. The third stage buckets do not need to be air-cooled.

The second and third stage buckets have integral tip shrouds which interlock from bucket to bucket to provide both vibration damping and seal teeth that reduce the tip leakage flow.

Turbine buckets are attached to the wheel with fir tree dovetail roots that fit into matching cutouts at the rim of the turbine wheel. The bucket airfoils are connected to the dovetails by shanks. These shanks separate the wheel from the hot gases which reduces the temperature at the dovetail. The turbine rotor assembly is arranged so that the buckets can be replaced without unstacking the wheels, spacers, and stub shaft assemblies. Buckets are selectively positioned (moment weight) such that they can be replaced individually or in sets without having to rebalance the wheel assembly.

The buckets are made of GTD-111 with hot corrosion resistance provided by a coating of PLASMAGUARD (TM) with InPlus (TM) on stages 1 and 2. The stage 1 and 2 blades are directionally solidified, while stage 3 has equiaxed grains. Stage 1 features also a Thermal Barrier Coating.

8.1.1.5.3 Turbine Stator

8.1.1.5.3.1 Structure

The turbine shell and the exhaust frame constitute the MS6001FA gas turbine stator structure. The turbine nozzles, and shrouds are internally supported from these components.

As with the compressor, all these casings are horizontally split for ease of handling and maintenance, with the exception of the aft diffuser.

8.1.1.5.3.2 Turbine Shell

The turbine shell supports and provides the axial and radial positions of the shrouds and nozzles relative to the turbine buckets. This positioning is critical to gas turbine performance. Borescope ports are provided for inspection of buckets and nozzles.

8.1.1.5.3.3 Nozzles

The turbine section has three (3) stages of nozzles (stationary vanes) with air-cooling provided to all three (3) stages. The first stage nozzle incorporates Thermal Barrier Coating. The first and second stage nozzles are cooled by a combination of film (gas path surface), impingement, and convection in the vane and sidewall regions. The third stage has only convection cooling.

Stage 1 nozzles are cooled by compressor discharge air, stage 2 nozzles are cooled by stage 13 compressor extraction air and stage 3 nozzles are cooled by stage 9 air.

Both the first and second stage nozzles consist of 24 segments with two (2) vanes in each segment. The third stage has 20 segments with three (3) vanes in each segment.

First stage turbine nozzle segments are contained by a retaining ring which remains centered in the turbine shell. The second and third stage nozzle segments are held in circumferential position by radial pins from the shell into axial slots in the nozzle outer sidewall.

8.1.1.5.3.4 Diaphragms

Because of the high-pressure drop across the nozzle, seals are located at both the inside and outside diameters to prevent loss of system energy by leakage. The second and third stage nozzle segments have diaphragms attached at the inner diameter. These diaphragms limit air leakage between the inner sidewall of the nozzles and the turbine rotor.

Minimum radial clearance between stationary parts (diaphragm and nozzles) and the moving rotor are essential for maintaining low interstage leakage and achieving high turbine efficiency. This is achieved by means of honeycomb type seals. The honeycomb material is installed on the diaphragm and teeth are machined into the rotor surface such that they operate with a minimal gap to the honeycomb material. Because the honeycomb material is easily machined by the moving rotor teeth if a rub should occur, a tighter seal can be achieved without risk of damage to the rotor.

8.1.1.5.3.5 Shrouds

The primary function of a shroud is to minimize bucket tip leakage. The secondary function of the shroud is to provide a high thermal resistance between the hot gas and the relatively cool turbine shell. With this, the shell-cooling load is drastically reduced, the shell diameter is controlled, the shell roundness is maintained, and the important turbine clearances are assured. The casing shroud is a curved, annular segment positioned by radial pins in the shell. Adjacent segments are sealed with interlocking tongue and groove joints..

8.1.1.5.3.6 Exhaust Frame

The exhaust frame is bolted to the aft flange of the turbine shell. Structurally, the frame consists of an outer cylinder and an inner cylinder interconnected with ten radial struts. The number 2 bearing is supported from the inner cylinder.

The axial exhaust diffuser is formed by the outer and inner cylinders. Gases from the third stage turbine enter the diffuser where the velocity is reduced by diffusion and pressure is recovered, improving performance. The twenty-one exhaust thermocouples used for turbine control are mounted in the gas path of the exhaust frame assembly.

The exhaust frame, number 2 bearing diffuser tunnel are cooled by two (2) off-base motor driven blower.

8.1.1.5.3.7 Aft Diffuser

The aft diffuser receives the exhaust gas from the exhaust frame. It is the only stator structure which is not split at a horizontal joint.

8.1.1.6 Bearings

8.1.1.6.1 General

The MS6111FA gas turbine unit contains two (2) journal bearings to support the gas turbine rotor and one (1) dual direction thrust bearing to maintain the rotor-to-stator axial position. The bearings are located in two (2) housings: one (1) at the inlet, and one (1) at the center of the exhaust frame. All bearings are pressure-lubricated by oil supplied from the main lubricating oil system. The number 1 bearing (journal and thrust) is accessed by removing the top half of the compressor inlet casing. The number 2 journal bearing is readily accessible through the tunnel along the centerline of the exhaust diffuser; removal of the turbine casing is not required for bearing maintenance. Protection includes vibration sensors pads metal thermocouples and drain oil temperature thermocouples.

The tilting pad journal bearing is composed of two (2) major components: the pads and a retaining ring. The retaining ring serves to locate and support the pads. It is horizontally split member that contains the pad support pins, adjusting shims, oil feed orifices, and oil discharge seals. The support pins and shims transmit the loads generated at the pad surfaces and are used to set the bearing clearance. An anti-rotation pin extends from one edge of the lower half of the rectangular ring. This pin locates the bearing within its housing and serves to prevent the bearing from rotating with the shaft. This bearing housing is cooled with air supplied by an off-base motor driven blower via the exhaust diffuser tunnel.

8.1.1.6.2 Number 1 Bearing

The number 1 bearing assembly is located at the center of the inlet casing assembly and it contains three (3) bearings: the active or loaded thrust bearing, the inactive or unloaded thrust bearing, and the journal bearing. The assembly also contains a floating or ring shaft seal, labyrinth seals, and a housing in which the components are installed. The components are keyed to the housing to prevent rotation. The number 1 tilting pad radial bearing assembly is centerline supported from the inner cylinder of the inlet casing. The lower half of the bearing assembly supports the forward stub shaft of the compressor rotor. The bearing housing upper half is a separate casting bolted on the inlet compressor casing lower half. The lower half bearing housing is part of the inlet compressor casing casting.

8.1.1.6.3 Number 2 Bearing

The number 2 bearing assembly consists of a tilting pad bearing and a bearing housing. The individual pads are assembled so that converging passages are created between each pad and the bearing surface. These converging passages generate a high-pressure oil film beneath each pad that produces a symmetrical loading or "clamping effect" on the bearing surface. The clamping action helps maintain shaft stability. Because the pads are point-pivoted, they are free to move in two (2) directions, which makes them capable of tolerating both offset and angular shaft misalignment.

8.1.1.6.4 Lubrication Flow Path

The two (2) main turbine bearings are pressure lubricated with oil supplied by the lube oil module. As a protective measure, oil feed piping, where practical, is run inside the oil drain piping. This procedure is referred to as a double piping and the rationale is that in the event of a pipeline leak, oil will not be lost or sprayed on nearby equipment thus eliminating a potential safety hazard.

Oil enters the bearing housing inlet, and flows into an annulus around the bearing liner. The oil then flows through machined slots in the liner to the bearing surface. The oil drain system is maintained at negative pressure by the lube oil module to prevent oil from escaping along the turbine shaft.

8.1.1.7 Instrumentation Equipment

8.1.1.7.1 Seismic Vibration Sensors

8.1.1.7.1.1 General

The complete shaft assembly (turbine, load gear) is equipped with vertical seismic vibration sensors monitored by the GT control panel.

8.1.1.7.1.2 Gas Turbine

- Two (2) vibration sensors are located on N°1 bearing housing
- Two (2) vibration sensors are located on N°2 bearing housing.

8.1.1.7.2 Bearing Metal Temperature Detectors

8.1.1.7.2.1 Gas Turbine

- Two (2) dual element thermocouples are embedded in N°1 journal bearing's babbitt metal.
- Two (2) dual element thermocouples are embedded in N°2 journal bearing's babbitt metal.
- Two (2) dual element thermocouples are embedded in thrust active N°1 bearing babbitt metal.
- Two (2) dual element thermocouples are embedded in thrust inactive N°1 bearing babbitt metal.

8.1.1.7.2.2 Load Gear

- Pinion

The two (2) bearings of the pinion shaft are equipped with two (2) dual element thermocouples embedded in bearings's babbitt metal.

- Bull

The two (2) bearings of the bull shaft are equipped with two (2) dual element thermocouples embedded in bearing's babbitt metal.

8.1.1.7.3 Non Contacting Vibration Probes

8.1.1.7.3.1 General

In addition to the standard seismic vibration sensors as described in § 7.1, a non-contacting vibration detector system is provided.

8.1.1.7.3.2 Gas Turbine

The gas turbine bearings are equipped with the following equipment:

- N°1 bearing
  - One (1) proximity radial probe X
  - One (1) proximity radial probe Y (90 degrees apart)
  - One (1) duplex thrust axial probe Z
  - One (1) Keyphasor
- N°2 bearing
  - One (1) proximity radial probe X
  - One (1) proximity radial probe Y (90 degrees apart)

8.1.1.7.3.3 Load Gear

- Pinion bearings

Each bearing is equipped with the following proximity probes:

- One (1) radial probe X
- One (1) radial probe Y (90 degrees apart)

- Bull bearings

Each bearing is equipped with the following proximity probes:

- One (1) radial probe X
- One (1) radial probe Y (90 degrees apart)

In addition, a keyphasor is provided on the low speed shaft of the gear.

8.1.1.7.3.4 System Components

- Proximity transducer system includes the following:
  - Extension cable
  - Proximitor
- Monitor system, installed in an electrical cubicle, including a local display system. Vibration read out is available on the gas turbine control panel.

8.1.1.8 Gas Turbine Special Tools

8.1.1.8.1 Gas Turbine Commissioning Tools

One (1) set of tools per site.

Commissioning tools are provided in order to support teams during commissioning operations. It includes:

- pressure and temperature instrumentation,
- alignment fixture.

DESIGNATION	Qt
COMMISSIONING TOOLS	
ACCUM. CHARGING EQUIPMENT PARKER	1
ACCUM. CHARGING EQUIPMENT OLAER	1
PRESSURE GAUGE 0-6 BARS	1
PRESSURE GAUGE 0-16 BARS	1
PRESSURE GAUGE 0-160 BARS	1
DIFF. PRESS. GAUGE 0-1,75 BARS	1
DIFF. PRESS. GAUGE 0-7 BARS	1
TEST GAUGE CONNECT. LG. 2 M	5
THERMOMETER 5”LG:4;0-300°C	1
ALIGNEMENT TOOL	1

8.1.1.8.2 Special GT Maintenance Tools List

8.1.1.8.2.1 Major Inspection Tool Kit for GT Casing Dismantling

One (1) set of tools per site.

Kit for major inspection, including casing, nozzle, transition piece and bearing dismantling tools.

DESIGNATION	Qt
INSPECTION TOOLS	
PULLEY, 2&3 STG-NOZZLE DISASSEMBLY	1
GUIDE PINS AND JACKING BOLTS	1
BEARING GUIDE BRACKETS	1
FIXTURE ASSEMBLY TRANSITION PIECE	1
BEARING DISASSEMBLY TOOL KIT	1

8.1.1.8.2.2 Load Gear Handling Spreader

One (1) set of tools per site.

Kit for load gear major inspection, including rotors & upper half casing lifting beams (6T capacity).

8.1.2 Description of Accessory Modules

8.1.2.1 General

Gas turbine accessories are installed in modular fashion and are driven by electric motors, thereby allowing maximum flexibility in plant layout. The design of the MS6111FA has had a focus on operating reliability and maintainability.

8.1.2.2 Lubrication System

The lubrication system for the gas turbine, the load gear and the generator are incorporated in a common system. It includes the lubricating oil system module, interconnecting piping and components supplied with lubricant in other modules.

8.1.2.2.1 Lubricating Oil System Module

8.1.2.2.1.1 Lubricating Oil Reservoir

The oil reservoir has a nominal capacity of 17245 liters and is mounted within the base. It is equipped with lube oil level transmitter to indicate: high alarm and low alarm. Also, oil tank thermocouples, oil heaters, pressure switch, oil filling connection and oil reservoir drains are mounted on the reservoir.

8.1.2.2.1.2 Lubricating Oil Pumps

The lubricating oil system module includes the following equipment:

- A main lubricating oil pump driven by an AC motor
- An auxiliary lubricating pump driven by an AC motor
- A partial flow 125 V DC motor driven emergency lubricating oil pump

8.1.2.2.1.3 Lubricating Oil Heat Exchangers

Duplex plate and frame heat exchangers with associated transfer valve are mounted in the module.

8.1.2.2.1.4 Lubricating Oil Filters

Dual full flow oil filters with associated transfer valve are mounted in the module. The replaceable filter cartridges Beta 40 = 75 are part of the lubricating system module. A differential pressure switch is used to detect the filter clogging.

8.1.2.2.1.5 Lubricating Oil Reservoir Vent Demister System

A single full capacity mist eliminator is supplied by two (2) AC motor driven fans and is vented to atmosphere.

8.1.2.2.1.6 Additional Equipment

Also mounted on the lubricating system module skid are a lube oil bearing header pressure regulating valve, lube oil header thermocouples, lube oil bearing header pressure switch and transmitter, lube oil sample taps upstream of the heat exchangers and downstream of the filters.

8.1.2.2.2 Interconnect Piping

Carbon steel piping and flanges upstream lube oil filter. Stainless steel piping and carbon steel flanges downstream lube oil filter.

8.1.2.2.3 Equipment Supplied with Lubricating Oil

Lubricating oil is supplied from the reservoir to the gas turbine, the load gear, hydraulic supply and the generator.

8.1.2.2.3.1 Atomizing Air Module

Lube oil is supplied to the atomizing air compressor which is equipped with lube oil switch and sights glass in the bearing drains.

8.1.2.2.3.2 Gas Turbine Module

Lube oil is supplied to the two (2) bearings. The number 1 bearing consists of a journal bearing and two (2) thrust bearings, referred to as the active and inactive thrust bearings. The number 2 bearing is only a journal bearing. Thermocouples and sights glass are provided in all of the bearing drains.

8.1.2.2.3.3 Load Gear Module

The load gear bearings and gear mesh are supplied with lube oil for two (2) high speed (pinion) journal bearings, two (2) low speed (bull) journal bearings, the gear mesh and the turning gear. Two (2) drains on gear casing and one (1) thermocouple on each drain.

8.1.2.2.3.4 Generator Module

The generator also has two (2) journal bearings which are supplied with lube oil. Additionally, thermocouples are provided in both bearing drains and two (2) pressure switches are provided for the supply header.

8.1.2.2.4 Oil Mist Separator

The oil mist eliminator consists in the following components:

- Two (2) electric motor blowers
- The necessary instrumentation and valving

The control is directly depending on the gas turbine control system.

8.1.2.3 Starting and Cool Down Systems

The starting and cool down system consists of a static frequency converter (SFC). It includes a power thyristor frequency converter to bring the turbine to self sustaining speed during the starting cycle. The SFC is connected to the generator armature winding, the field winding being fed by the static excitation device through rings and brushes. It includes a thyristor gates bridge on the network side which receives power from the network in the form of alternating current and delivers it to the intermediate loop in the form of direct current. Also, there is a thyristor gates bridge on the machine side which receives power from the intermediate loop in the form of direct current and delivers it to the armature winding of generator. A loop connects the two (2) bridges and includes a smoothing reactor.

The SFC is fed from the starting transformer which is connected to the switchgear.

8.1.2.4 Fuel System

The MS6111FA gas turbine is equipped with a dual fuel system for burning either natural gas or liquid fuel. The gas turbine may be started on either fuel but not on combined fuels. Fuel changeover from gas to oil can be automatically initiated on loss of gas fuel pressure when gas is established as the primary fuel. Fuel changeover back to the primary fuel is manually initiated.

8.1.2.4.1 Gas Fuel System

8.1.2.4.1.1 Gas Fuel Module

The fuel gas module is contained on the accessory base which is located adjacent to the gas turbine module.

The fuel gas skid has a conical fuel gas strainer. Several components of hydraulic equipment are also mounted on the gas fuel system to actuate the Stop/Ratio Valve and the Gas Control Valve. For each valve there is one (1) filter, one (1) servo valve, one (1) trip relay and one (1) actuator valve.

A pneumatic stop valve is also mounted on the gas fuel system.

Instruments for control, indication and protection of the fuel gas system include one (1) differential pressure switch, three (3) fuel gas temperature thermocouples, two (2) pressure switch and one (1) pressure transmitter for low pressure detection, and three (3) fuel gas interstage pressure transmitters. Each of the gas fuel control valves the stop/speed ratio valve and the stop valves are mounted with LVDT's to indicate valve position.

8.1.2.4.1.2 Gas Turbine Module

The fuel gas is piped up to the gas turbine module. Four manifolds (PM1, PM2, PM3, Q) distribute the fuel to each of the six combustors.

8.1.2.4.2 Liquid Fuel System

8.1.2.4.2.1 Liquid Fuel Module

The liquid fuel module has an inlet isolating valve. Fuel flow is supplied by a single 100% capacity screw-type positive displacement AC motor driven fuel pumps with a discharge pressure relief valve. There is a liquid fuel main flow control valve, liquid fuel main stop valve, flow divider metering system with magnetic pick-ups providing system feedback, selector valve assembly for reading individual fuel nozzle pressures. Stainless steel piping is used on the liquid fuel module with carbon steel flanges and fittings downstream of the low pressure filter (strainer).

8.1.2.4.2.2 Gas Turbine Module

Piping from the liquid fuel module to the gas turbine module is also made of stainless steel. On base stainless steel piping is used up to the six fuel nozzles. False drain valves are provided for combustion chambers, turbine shell and exhaust system.

8.1.2.4.3 Atomizing Air System

Air is extracted from the gas turbine compressor discharge and is used to atomize the liquid fuel in each fuel nozzle. The Atomizing Air/liquid fuel module includes an atomizing air cooler, two (2) cooler discharge thermocouples, air/liquid separator, atomizing air compressor inlet filter with differential pressure switch, one (1) AC motor driven atomizing air compressor with differential pressure switches and transmitter, three (3) motor operated valves and one (1) atomizing air compressor discharge thermocouple. On gas fuel operation, a non boosted (without compressor) purge system is used for liquid fuel nozzles.

8.1.2.5 Hydraulic Oil System

The high pressure hydraulic system provides high pressure oil to all hydraulic control system components.

8.1.2.5.1 Lubricating Oil Module

Mounted on the lube oil module are two (2) AC motor driven high pressure hydraulic oil pumps, each equipped with a pressure compensator. These feed two (2) hydraulic supply manifolds which each have relief valves and a control air bleed valve. Two (2) hydraulic supply main filters, a transfer valve, and filter differential pressure switch are also installed along with instruments for control, indication, and protection of the system. These include an hydraulic supply system discharge pressure switch.

8.1.2.5.2 Gas Turbine Module

The inlet guide vane control system includes a control oil hydraulic accumulator, inlet guide vane actuator, hydraulic filter, IGV actuator electro-hydraulic servo valve and IGV actuator hydraulic trip relay.

8.1.2.5.3 Gas Fuel Module

Several components of hydraulic equipment are also mounted on the gas fuel system to actuate the Stop/Ratio Valve and the Gas Control Valve. For each valve there is one (1) filter, one (1) servo valve, one (1) trip relay and one (1) actuator valve.

Liquid Fuel Module

On the liquid fuel/atomizing air module there is one (1) liquid fuel control valve actuator filter, one (1) liquid fuel flow control valve electro-hydraulic servo valve (three [3] coils), one (1) liquid fuel stop valve actuator filter and a liquid fuel stop valve hydraulic trip relay.

8.1.2.6 Cooling Fan System

The cooling fan module contains the fans and blowers to cool the enclosed spaces around the turbine. There are two (2) turbine exhaust frame cooling blowers, two (2) turbine compartment ventilating fans, two (2) number 2 bearing cavity cooling blowers.

8.1.2.7 Fire Detection and Protection System

The fire protection system is automatic with four zones, each equipped with fire detection and control components.

8.1.2.7.1 Zone 1: Load Compartment and Turbine Compartment

The load compartment is isolated from the turbine compartment by a bulkhead. Each of these areas is vented independently of one another. The gas turbine compartment has ten (10) fire detectors, initial discharge nozzles, extended discharge nozzles. A manual release push button exists outside enclosure near each access door. In the load compartment, there are four (4) fire detectors, an initial discharge nozzle and an extended discharge nozzle.

8.1.2.7.2 Zone 2: Number 2 Bearing Area

The N°2 bearing area, which includes the inner barrel of the exhaust frame and diffuser surrounding the bearing housing.

In the number 2 bearing area, there are four fire detectors, an initial discharge nozzle and an extended discharge nozzle.

8.1.2.7.3 Zone 3: Accessory Module

The accessory module includes two (2) separate compartments: the lube/hydraulic compartment and gas compartment. Both of these are separated by a bulkhead and have separate vent systems. A manual release push button exists outside enclosure near each access door.

In the accessory module compartment, there are eight fire detectors, initial discharge nozzles and extended discharge nozzles.

8.1.2.7.4 Zone 4: Liquid Fuel/Atomizing Air Module

The Liquid fuel/atomizing air compartment includes two (2) separate compartments: the liquid fuel compartment and the atomizing air compartment. Both of these are separated by a bulkhead and have separate vent systems. A manual release push button exists outside enclosure near each access door.

In the liquid fuel/atomizing air module compartment, there are eight fire detectors, initial discharge nozzle and extended discharge nozzle.

8.1.2.7.5 Cooling Water System

Cooling water is supplied to the lube oil cooling system and the four flame detectors.

Cooling water is supplied to the atomizing air module too.

A three way valve regulates cooling water flow through the lube oil cooling system to maintain lube oil temperature range during operation.

8.1.3 Description of the Acoustical Enclosure

8.1.3.1 Gas Turbine Enclosure General Description

The main purpose of the acoustical enclosure is the reduction of the noise generated by the gas turbine to a compatible level with the project requirements.

The gas turbine acoustic enclosure contains different adjacent sections forming an outdoor or indoor protective housing.

The gas turbine acoustical enclosure is divided into three (3) compartments:

Load gear compartment

Turbine compartment

Exhaust diffuser compartment.

In addition, the acoustic enclosure includes the following functions:

- protection of the personnel from heat radiation
- fire protection with fire extinguishing media containment
- ventilation to remove the heat and achieve enough air changes
- heating to maintain the internal temperature at the required level and/or avoid condensation phenomena when the gas turbine is stopped
- weather protection during turbine operation and small maintenance work (in case of outdoor installation)

8.1.3.2 Gas Turbine Enclosure Characteristics

The gas turbine off base acoustic enclosure is installed on a foundation block common with the gas turbine pedestal.

The acoustic enclosure consists of:

- a steel structure made of vertical columns, horizontal members and wind bracing
- acoustical roof and wall panels with turbine section removable roof to facilitate maintenance operations
- pipe penetration sealing system
- internal partition walls to separate the load gear and the diffuser compartments from the turbine compartment
- internal platform inside the load gear and turbine compartments
- fans installed on roof with access facilities
- The acoustic panels are composed of:
  - an outer painted steel sheet
  - a perforated inner steel sheet
  - a compound with the required acoustic property sandwiched between the inner and outer sheets

One (1) door is provided on each side of the load gear, turbine and exhaust diffuser compartments.

8.1.3.3 Gas Turbine Enclosure Equipements

8.1.3.3.1 Lighting and Sockets

- AC Lighting:
  - Load gear compartment is equipped with AC lighting system giving a minimum illumination value of 200 Lux at access locations.

- DC Lighting:
  - Load gear compartment is equipped with DC security lighting system giving a minimum illumination value of 50 Lux at access locations.
  - Turbine compartment is equipped with DC security lighting system giving a minimum illumination value of 50 Lux at access locations.
- Turbine compartment lights are mounted externally with a window that will provide illumination inside the compartment.
- Sockets:
- 16A convenience sockets are located close to some doors for small hand tool and portable lamp use.

8.1.3.3.2 Lifting Device

A manual traveling crane is provided for routine maintenance operation of load gear box.

8.1.3.3.3 Painting

Painting system of all external surfaces of enclosure exposed to a very aggressive environment (maritime, industrial, corrosive), is re-enforced. Please refer to GE specification ST001 enclosed.

8.1.3.3.4 Fire Detection and Protection

Duplicate thermal fire detectors are installed inside the load gear and gas turbine compartments and are wired on two (2) loops such that CO2 is discharged only when one (1) detector of one loop and one (1) detector of the other loop are both activated.

When the fire detection operates an alarm is activated, the unit is tripped and the ventilation fans are stopped, the dampers on air inlet openings close by gravity, CO2 is discharged by piping and nozzles in the load gear and turbine compartments.

8.1.3.3.5 Heating and Ventilation System

Electric space heaters are provided in the load gear and the turbine compartments, to maintain suitable temperature and anti condensation preservation during stand by periods at low ambient temperature.

Duplicate fans ensures the ventilation of the compartments to remove the heat radiated by the equipment and achieve the minimum required air changes.

8.1.3.3.6 Gas Detection

A gas leakage detection system with triplicate gas sensors suitable for the detection of natural gas is provided for turbine compartment.

Two (2) levels of gas detection are provided by the turbine control system, one (1) high level (5% of LEL) to signal an alarm and one (1) high-high level (8% of LEL) to initiate a turbine trip, 2/3 voting shall avoid spurious trip.

8.1.3.4 Auxiliary Module Enclosure(s)

Lube oil and gas module enclosure forms a weather protective housing mounted on the module base.

Lube oil and gas module enclosure provides thermal insulation, acoustic attenuation and fire extinguishing media containment.

Liquid Fuel, Air Atomizing and Water Injection enclosure forms a weather protective housing mounted on the module base.

Liquid Fuel, Air Atomizing and Water Injection enclosure provides thermal insulation, acoustic attenuation and fire extinguishing media containment

Auxiliary module enclosure(s) contain the following equipments:

- Doors for access to equipments during routine inspections and maintenance.
- Electric heaters are provided to maintain suitable operating temperature, and anti condensation preservation during stand by periods.
- Duplicate ventilation fans for lube oil compartment and for gas compartment.
- Lube oil compartment is equipped with AC lighting system giving a minimum illumination value of 200 Lux, and DC security lighting system giving a minimum illumination value of 50 Lux at access locations.
- Gas compartment is equipped with DC security lighting system giving a minimum illumination value of 50 Lux at access locations, light is mounted externally with a window that will provide illumination inside the compartment.

A gas leakage detection system with triplicate gas sensors suitable for the detection of natural gas is provided for gas module compartment.

Two (2) levels of gas detection are provided by the turbine control system, one (1) high level (5% of LEL) to signal an alarm and one (1) high-high level (8% of LEL) to initiate a turbine trip, 2/3 voting shall avoid spurious trip.

- Duplicate ventilation fans for Liquid Fuel compartment and for Air Atomizing Water Injection compartment.
- Liquid Fuel compartment and Air Atomizing Water Injection compartment are equipped with AC lighting system giving a minimum illumination value of 200 Lux, and DC security lighting system giving a minimum illumination value of 50 Lux at access locations.
- 16A convenience sockets are located close to some doors for small hand tool and portable lamp use.

Filtration of the ventilation air may be necessary for some sites where severe atmospheric pollution is present. This requirement will be met by filtering the air as it enters the respective compartment ventilation systems. Simple washable metallic filter elements is used. The filtration system includes a solenoid actuated by-pass system that will allow un-filtered air to enter the system in the event of filter blockage. The by-pass system will be controlled by a differential pressure switch installed across the filters. This switch will be used to signal an alarm and to initiate the operation of the by-pass damper solenoid actuator. When energized the solenoid actuator will hold the filter by-pass damper in the closed position . When de-energised the solenoid actuator will allow the by pass damper to open and allow the ventilation air to by-pass the filters. This system is to be designed for easy access and maintenance.

8.1.4 Description of the Inlet and Exhaust Systems

8.1.4.1 Inlet System

The turbine air inlet system is the means of receiving, filtering, and directing the ambient air flow into the inlet of the compressor. The system consists of an inlet filter house, ducting, silencing, elbows and inlet plenum. The ducting and silencing that come out from the filter house pass over the acoustical enclosure and down into the inlet plenum. This arrangement requires minimum plot area and provides easy access to the various compartments.

Maintenance requirements are minimal and consist of annual inspection of the inlet equipment. Any entrapped foreign material should be removed. Rust and oxidation spots should be scraped and repainted.

The inlet filter house includes:

8.1.4.1.1.1 Weather Louvers

The louvers provide weather protection from injection of rain. Due to the change in direction of the air flow, liquid droplets gather on the louver and are separated from the air.

8.1.4.1.1.2 Pre-Filter

The pre-filter panels (efficiency class G4 according to EN 7779) are located between the weather hoods and the coalescer filter. The panels are made of synthetic media fit in a plastic frame and are held in place by an easy access, metal retaining frame.

[E1BI05D] The pre-filter panels (efficiency class G4 according to EN 7779) are located between the weather louvers and the coalescer filter. The panels are made of synthetic media fit in a plastic frame and are held in place by an easy access, metal retaining frame.

8.1.4.1.1.3 Coalescer

The coalescer pad consists of glass fibers impregnated with a water resistant binder that enables the media to maintain its thickness and resiliency while saturated with water and arranged in pads. The coalescer gathers the tiny droplets into larger drops which either run on the front face of the pad or are maintained suspended inside the pad until they evaporate.

8.1.4.1.1.4 High Efficiency Media Filter

This last filter stage is intended to be used for long service hours in contaminated atmospheres.

The media is packaged in individual cells.

The change out period for this filter is to be determined by the actual customer's operation. It is expected that a full change out will be required once a year.

The media itself is made up of glass fibers. The media is packaged in a frame with faces guards and header flange on the air entering . These are in turn secured to a stainless steel frame-work that is an integral part of the inlet compartment.

8.1.4.1.1.5 Anti-Icing

This system increases compressor inlet air temperature (5°C typical).

The Anti-icing protection is assured by hot water heat exchanger install up stream of inlet filter.

8.1.4.1.1.6 Dry Low NOx Heating System

Dry Low NOx combustion system can require adjustment of the Inlet Guide Vane (I.G.V) angle during certain operational modes and loads conditions.

Reduced IGV angles increases the pressure drop across the first stage stator blades and could lead to ice formation under certain ambient conditions.

The Dry Low NOx Inlet heating system regulates compressor discharge bleed flow through a control valve and into a manifold located in the compressor inlet air stream.

The inlet bleed heat system is controlled as a function of IGV angle.

8.1.4.1.2 Inlet Ducting and Silencing

The silencers are of baffle-type construction to attenuate the high-frequency tones from the compressor. Elbows and transition sections are partially acoustical lined to aid in noise reduction.

The inlet plenum is a sheet metal "box" type structure that is mounted on the turbine base and encloses the compressor inlet casing. Its top side is connected to the inlet ducting. It is mounted and welded to the I-beam turbine base.

8.1.4.2 Axial Exhaust System

The exhaust system is that portion of the turbine in which the gases used to drive the turbine are redirected before being released to atmosphere or to the exhaust heat recovery equipment.

The exhaust system includes :

8.1.4.2.1 Exhaust Duct Screen

The exhaust duct screen is of a fence installed along the exhaust system that ensures personal protection from heat radiation.

8.1.4.2.2 Generator Acoustic Barrier Wall

The main purpose of the generator acoustical barrier wall is the reduction of the noise. It ensures also personal protection from heat radiation.

8.1.5 Description of Off-Base Mechanical Auxiliary

8.1.5.1 Fuel Gas Equipment

8.1.5.1.1 Fuel Gas Filtering

8.1.5.1.1.1 Duplex (2x100%) Coalescing Filter, Manual Drain

Vertical carbon steel pressure vessel, ASME VIII div.1 without U stamp, (located close to GT unit), fitted with condensate level monitoring system, including:

- 1st Stage: baffle plate
- 2nd Stage: filtration and coalescing cartridges

This system removes the solids over 0.3 microns with 99.99% efficiency and liquids over 0.3 microns with 99.50% efficiency. Instrumentation is in accordance with IEC or CENELEC.

Heat insulation for personal protection and/or to maintain the gas temperature during GT stop

Electrical tracing

8.1.5.1.1.2 Shut Off Valve and Vent Valve Skid

The shut off valve cut the Gas turbine feeding line in case of GT stop, GT fire detection or GT gas detection and the vent valve depressurizes the GT inlet gas pipe. The shut off valve must be at maximum 25 meters of the GT and in outdoor installation.

- One (1) Shut off valve (piloted by fuel gas), with spring return pneumatic actuator and open/closed limit switches for valve monitoring system, one (1) Vent valve (piloted by fuel gas), with spring return pneumatic actuator and open/closed limit switches for valve monitoring system. The valves are in accordance with API 6D, API 607, body in carbon steel, ball in stainless steel. Instrumentation is in accordance with IEC or CENELEC.

Heat insulation for personal protection and/or to maintain the gas temperature during GT stop.

Electrical tracing

8.1.5.2 Fuel Oil Equipment Forwarding

8.1.5.2.1 Light Distillate Oil Forwarding Skid

8.1.5.2.1.1 General

The fuel oil forwarding skid feeds light distillate oil to the gas turbine at a pressure consistent with the gas turbine fuel supply requirements.

8.1.5.2.1.2 Equipment

The fuel oil forwarding skid is preassembled and includes:

- Two (2) 100 % fuel forwarding centrifugal pumps (one [1] duty/one [1] standby) each designed for the maximum fuel flow necessary to the gas turbine and driven by an AC motor.
- skid suitable for installation in hazardous area classified zone 2.

- One (1) suction strainer upstream each pump, nominal filtration size : 1.5 mm.
- One (1) relief valve.
- One (1) complete set of piping including valves, gauges and fittings of all lines terminating at the skid boundary.

Extra painting for corrosive ambient conditions.

8.1.5.3 Fuel Oil Equipment - Filtering

8.1.5.3.1 Light Distillate Oil Filtering Skid

8.1.5.3.1.1 General

The fuel oil filtering skid provides light distillate fuel oil filtration and pressure regulation upstream the turbine unit. Skid is suitable for installation in hazardous area classified zone 1. Compressed air is needed.

8.1.5.3.1.2 Equipment

The fuel oil filtering skid is preassembled and includes:

- One (1) fuel pressure regulating valve.
- Two (2) fuel filters (one [1] duty/one [1] standby)Synthetic filter cartridges rating: Beta 17=200
- One (1) pressure metering panel board including:
  - One (1) pressure switch and one (1) pressure gauge (fuel pressure control).
  - One (1) differential pressure switch and one (1) differential pressure gauge for filter clogging monitoring.
- One (1) fuel accumulator.
- One (1) volumetric flow meter with:
  - Two (2) isolating and one (1) by pass valves. Local indication of totalized fuel flow.
  - One (1) pulse transmitter for remote indication.
- One (1) automatic skid outlet stop valve. One (1) complete set of piping including valves and fittings of all lines terminating at the skid boundary.
- The electrical equipment is suitable for hazardous area classified zone 1.
- Extra painting for corrosive ambient conditions.
- Pulse transmitter added on the oval wheels fuel totalizer for remote indication of totalized flow or actual flow.

8.1.5.4 Sump Tank

8.1.5.4.1 General

The sump tank allows to drain liquid fuel from combustion system and from exhaust plenum in case of false start.

8.1.5.4.2 Equipment

The sump tank is preassembled and includes:

— One (1) steel tank (1 m3 capacity) electrical pump and heater

8.1.5.5 Off-Base Cooling System

8.1.5.5.1 General

A closed water loop is used to evacuate the heat losses from:

- The lubricating oil circuit common to the Gas Turbine and the Generator
- The Gas Turbine atomizing air
- The Generator inner cooling air

The closed cooling water loop configuration is as follow:

- Generator and Gas Turbine in serial, cold water to Generator in first.

The Off-Base cooling water system consists of:

- The fin fan coolers which assume heat transfer from closed cooling water to ambient air
- The expansion tank which ensure minimal pressure at water pump suction and compensates water volume variations due to dilatations and eventual leakage.
- Water pumps to circulate water-cooling
- The connecting pipes, instrumentation and isolating valves

8.1.5.5.2 Fin Fan Coolers

The fin fan coolers consists of one (1) or several modules. The number and length of modules and number of motor-fans are determined according to the site conditions and the Gas Turbine unit working duty.

This thermal design includes an additional capacity of one (1) motor fan in extra for the whole Fin Fan Coolers battery.

The fin fan module is in accordance with the standard noise level.

Each module consists of:

- One (1) heat exchanger battery in horizontal position with fin tubes bundle made of seamless cooper tubes and (in most cases) aluminum fins.
- Motor fan units normally installed above the heat exchanger and each of them equipped with its own plenum chamber: this configuration is called Induced Draft. Each fan wheel is directly mounted onto the end shaft motor and the fan blades are made of aluminum.
- steel support structure.
- pipes between water headers and heat exchanger equipped with isolating butterfly valves.

The whole set of modules is supplied with:

- Ladders and walkways for access to the motor fan units
- Cold and hot water headers pipes for interconnection of the required modules and connection with the cooling water circuit
- and vent piping
- Instrumentation with :
  - One (1) pressure gauge and one (1) thermometer on the hot water inlet header
  - One (1) thermometer and one (1) thermocouple on the cold water outlet header

8.1.5.5.3 Water Pumps Skid

This skid includes two (2) water pumps (2x100% i.e. one [1] in service, the other in stand-by).

Each centrifugal type pump, is driven by an AC electrical motor through a flexible spacer coupling. Each pump unit is installed on its own steel frame. The suction and discharge flanges of each pump are connected to piping by means of anti-vibratile coupling

The suction line of each pump includes one (1) isolating butterfly valve and one (1) strainer. The discharge line of each pump includes one (1) isolating butterfly valve and one (1) non-return valve.

Installed in parallel with the pumps, a small pot allows the chemicals make up to the cooling water during pump operation.

The common discharge pipe of the water pump skid is equipped with one (1) pressure gauge, one (1) low pressure switch and one (1) orifice plate between flanges (each of them equipped with pressure test point with ball valves).

The pumping module is in accordance with the standard noise level.

8.1.5.5.4 Atmospheric Expansion Tank

The atmospheric type expansion tank is installed at 6 meters height on its own steel structure support.

This 0.9 m3 capacity tank is fitted with one (1) local level indicator combined with a low level switch for remote indication and a connection pipe for making up.

8.1.5.6 Fire Protection

8.1.5.6.1 General

A high pressure CO2 bottles system assures the fire protection.

Materials for corrosive site conditions: Nickel for the CO2 cylinder valves, AISI 316 for the check valve and flexible hoses and aluminum for cylinder supports and weighting system.

The equipment will be located outside, under a shelter.

Remote weighting device provided

The role of the fire protection system is to inject automatically the required quantity of CO2 into the protected zones to extinguish a fire and to maintain the concentration of CO2 in these zones at a level high enough to prevent re-ignition of the fire during the cool-down period.

Initiation of the system will automatically trip the unit; provide an alarm, trip ventilation fans and close ventilation openings.

Following zones of the gas turbine are protected.

Zone 1: the internal volume of gas turbine and load gear compartment.

Zone 2: the internal volume of bearing 2.

Zone 3: the internal volume of Oil and GAS MODULE compartment

Zone 4: the internal volume of liquid fuel, atomization/water and injection air compartment

8.1.5.6.2 Design Assumptions

The fire protection system is designed in accordance with NFPA 12/2005.

Full compliance with NFPA 12 will be possible provided that:

- installation and commissioning of the fire protection system, and of other related equipment and systems (including, for example, equipment enclosures, ventilation systems, etc.), is carried out in accordance with the corresponding installation and commissioning manuals, and
- testing of the completed system is carried out in accordance with the relevant specifications, including GE's installation and commissioning manuals which are in accordance with the installation and commissioning requirements of the NFPA 12.

The CO_2 emission is made in 2 steps:

8.1.5.6.2.1 Initial Discharge

The system reaches the concentration of CO_2 required by the current standard within the minute after detection of the fire.

8.1.5.6.2.2 Extended Discharge

The extended discharge maintains a non-combustible atmosphere during the period of possible fire re-ignition

Extended time discharge by GT TYPE	Type of Compartment
40mn	GT and Load Compartment
20mn	Oil and GAZ MODULE Compartment
60mn	Bearing 2
20mn	Liquid fuel Compartment Atomization / Water Injection Air Compartment

8.1.5.6.3 Scope

The main equipment of the gas turbine fire protection system is:

- The CO2 storage including:
  - High pressure CO2 bottles
  - A manifold for each type of emission
  - A release system.
- A fire detection system consisting of several thermo switch detectors as follows:

Quantity of Gas detector by GT TYPE	Type of Compartment
4 detectors 316°C	Load Compartment
10 detectors 316°C	GT Compartment
4 detectors 163°C	Gas/Oil Compartment
4 detectors 316°C	Bearing 2
4 detectors 163°C	Liquid fuel Compartment
4 detectors 163°C	Atomization / water injection Air Compartment

The fire protection is automatically released on a two (2) of two (2) voting basis. The fire detectors are arranged in two (2) loops:

- One (1) loop energized: fire pre-alarm
- Two (2) loops energized: fire alarm, with GT trip and CO2 release.

8.1.5.6.4 Operation

8.1.5.6.4.1 Manual Operation on Fire Protection System

In case of fire being detected by operator before actuation of the fire detection thermostats, the system can be actuated manually from the CO2 storage.

8.1.5.6.4.2 Fire Protection System Inhibition

The fire protection system can be inhibited during stand-by of the gas turbine for maintenance, etc ...

8.1.5.6.4.3 Fire Protection Panel

The fire protection panel will be installed in PEECC (operating temperature range (-5/+40degC).

8.1.5.6.4.4 C02 Bottle Charge

Double HP C02 bottles only for one (1) CO2 concentration test with cylinder valves not connected.

8.1.5.7 Water Injection Skid

An assembled water injection skid located near the gas turbine takes water from the customer storage facility and delivery it at the proper pressure and flow rate to the gas turbine.

To prevent hot corrosion of the gas turbine blading or turbine fooling, demineralized water is used.

1. One (1) AC motor-driven water injection centrifugal pump.
2. One (1) Control valve.
3. One (1) one pump inlet strainer.
4. One flow measurement device (flowmeter).
5. One (1) HP filter (Beta 40 = 75) downstream the pump with differential pressure switch.
6. One (1) solenoid stop valve.
7. One (1) on base return line to the storage tank.
8. The necessary instrumentation: pressure and water flow measurement.
9. One (1) valve to control the water distribution to the different stages of the Dry Low NOx combustor.

The control of the system is directly depending from the gas turbine control system (SPEEDTRONIC™).

8.1.5.8 Washing Skid

8.1.5.8.1 General

The washing skid is used:

1. During normal operation of the unit for washing the compressor in case of fouling to restore clean condition performance.
2. After a shutdown of the unit when a long period of stand-by is foreseen, GE recommends off-line washing sequence. The detergent contains elements that prevent blades corrosion during stand-by periods.

All hot surfaces (Tank, on base piping) are insulated for safety reason, except when an enclosure is supplied by GE.

8.1.5.8.2 Composition of Unit

8.1.5.8.2.1 The On/Off-Line Compressor Washing Unit is Pre-Assembled and Includes:

8.1.5.8.2.1.1 One (1) Washing Module Including:

- One (1) water pump (centrifugal type)
- One (1) strainer upstream the pump
- One (1) venturi ejector for detergent injection
- One (1) detergent tank (230 litres) with filling flange and, drainage valve and one (1) visual level indicator
- One (1) detergent flow meter
- One (1) pressure gauge (downstream the pump)
- Two (2) pressure switches (downstream and upstream the pump)
- One (1) water flow switch
- One (1) remote controlled valve on the detergent line
- One (1) terminal board and electrical panel

8.1.5.8.2.1.2 One (1) Water Tank (4 m3 Capacity), Made of Stainless Steel (AISI 304L) Including:

- One (1) heater (25 kW) for water heating
- Temperature controller
- One (1) low level switch and float valve
- One (1) visual level indicator
- One (1) filling flange
- One (1) drain valve
- One (1) temperature visual indicator

8.1.5.9 Off-Base Interconnecting Piping Including:

8.1.5.9.1 Gas Fuel System:

Stainless steel and carbon steel with welding following ASME section IX, non-prefabricated, shop primary painted (carbon steel piping only).

8.1.5.9.2 Liquid Fuel System:

Stainless steel and carbon steel with welding following ASME section IX, non-prefabricated, shop primary painted (carbon steel piping only).

8.1.5.9.3 Inlet Air System:

Stainless steel with welding following ASME section IX, non-prefabricated.

8.1.5.9.4 Off-Base Cooling System:

Carbon steel with welding following ASME section IX, non-prefabricated, shop primary painted.

8.1.5.9.5 Lube Oil System:

Stainless steel and carbon steel with welding following ASME section IX, non-prefabricated, shop primary painted (carbon steel piping only).

8.1.5.9.6 Washing System:

Stainless steel with welding following ASME section IX, non-prefabricated

8.1.5.9.7 Draining System:

Carbon steel with welding following ASME section IX, non-prefabricated, shop primary painted.

8.1.5.9.8 Air Processing Unit System:

Stainless steel and carbon steel with welding following ASME section IX, non-prefabricated, shop primary painted (carbon steel piping only).

8.2 Description Of Generator and Electrical Auxiliary Equipment

8.2.1 Description of the Load Gearbox

8.2.1.1 General

The gas turbine rotation speed being higher than the generator rotation speed, the mechanical power is transmitted through a speed reducing gear.

The load gear is a horizontal offset, high speed, precision and double helical reduction gear. The pinion is driven by the gas turbine.

An AC motor driven built in turning gear for shaft line breakaway and low speed turning is mounted on the load gear. In addition, there is a manual turning gear device for inspection.

The pinion is driven by the gas turbine through a flexible coupling.

A built in turning gear for breakaway is mounted on the high speed pinion generator side.

8.2.1.2 Casing

The gear casing is fabricated construction designed for high rigidity to maintain rotor alignment under extreme load conditions and to obtain maximum bearing support stiffness.

The casing is divided into upper and lower sections joined on the horizontal centerlines of the shafts. The lower casing shall provide support to foundation interface.

Bearing caps and seats are integral with the casings.

A covered opening is provided in the casing to facilitate inspection of the gear.

Provisions for anchor bolts are made in gear casing and sole plates to allow for torque in securing casing to foundation.

8.2.1.3 Gear

Gears are of the double helix type:

- The pinion is an one-piece alloy steel forging with the teeth cut integral with the shaft.

The gear wheel is a one-piece alloy steel forging with the teeth cut integral with the shaft.

Pinion and gear wheel are heat treated after being rough machined to the approximate final contours.

Tooth surfaces are finished by grinding.

All rotors are dynamically balanced.

Gear mesh are case carburized.

8.2.1.4 Bearings

The pinion and gear bearings are steel backed, babbitt lined and securely held within the bearing body to prevent axial or rotary movement. Bearings are split horizontally so as to facilitate disassembly.

Each gear shaft and pinion shaft are supported by sleeve bearings designed to provide maximum oil film damping and stiffness in order to prevent rotor critical speed and unstability phenomena from occurring at operational conditions.

The cooling of bearing is optimized and realized by a separate oil system.

8.2.1.5 Lubrication

All bearings are pressure lubricated by lubrication oil supplied from the gas turbine lube oil system.

Gear mesh lubrication is accomplished by means of oil nozzles which discharge the oil adequately to provide an oil film across the entire width of gear mesh.

8.2.1.6 Instrumentation on the Load Gear

Tapped holes closed by caps are provisioned on the casing for fitting the instrumentation.

The load gear is connected to an GE generator.

Three (3) seismic detectors are located with two (2) on the pinion casing at turbine end (radial and axial vibration) and one (1) located at the horizontal joint of the Bull gear at the generator end (horizontal vibration).

The load gearbox is provided with the following instrumentation:

- Two (2) non-contacting vibration probes on each bearing of the load gear placed to measure on the loaded area.
- Two (2) seismic sensors on the high speed shaft end on the casing measuring in vertical and axial directions and one (1) on the low speed shaft end casing measuring in horizontal direction.
- One (1) single element thermocouple in each gearbox oil drain.
- Two (2) dual element thermocouples at each bearing of the load gear placed to measure the loaded area.

8.2.2 Description of the Generator

8.2.2.1 Electrical Rating

The generator is designed for continuous operation. The generator is constructed to withstand per ANSI or IEC standards, without harm, all normal conditions of operation, as well as transient conditions such as system faults, load rejection and mal–synchronization.

The armature and field windings of the generator are designed with insulation systems that are proven Class “F” materials.

Temperature detectors installed in the generator permit the measurement of the stator winding and gas temperatures. The temperature rise limits, per ANSI or IEC standards (as applicable), will be limited to the following, throughout the allowable operating range:

- Class “B” temperature rise limits

The generator is designed to exceed the turbine capability as stated in the performance section of this proposal.

8.2.2.2 Packaging

The generator is a three (3) phase, synchronous machine designed for compactness and ease of service and maintenance. The machine is designed for continuous operation at rated conditions as well as providing maximum protection against damage due to abnormal operating conditions, per ANSI or IEC standards.

Location permitting, the generator will ship with the major components factory assembled:

- Generator rotor
- Collector compartment

All generator wiring, including winding and gas Resistance Temperature Detectors (RTDs), bearing metal and drain temperature detectors (as applicable), and vibration detection systems are terminated on the main unit with level separation provided.

- Feed piping between the bearings is stainless steel and mounted on the units to a common header

8.2.2.3 Terminal Arrangement

All lead connections terminate at the excitation end of the generator. Customer line connections and the generator neutral tie make-up is made external to the main generator stator frame.

The main armature leads are brought out of the upper side portion of the stator and are suitable for connection to bus bars. The leads exit the frame through insulated terminal plates, which clamp and support the leads. Line leads exit either the left or right side with the neutral leads exiting the opposite side.

8.2.2.4 Stator Frame Fabrication

The stator frame is a simple structure, designed to support the stator core and winding, while providing guidance to the airflow in the machine. The combined core and frame are designed to have a 4-nodal natural frequency well removed from 100 Hz or 120 Hz

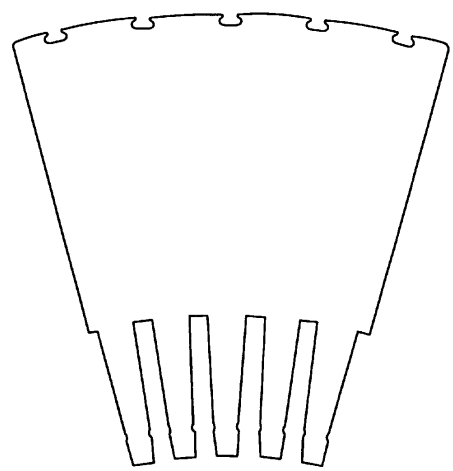
The stator core is mounted rigidly in the stator frame. The core is designed to transmit extremely low levels of vibration to the structure casing.

Isolation of the core vibration from the remainder of the structure is accomplished through the use of flexible pads between the feet on the stator core frame and the base structure.

8.2.2.4.1 Stator Core

The core is constructed from laminated, silicon steel. The laminations are coated on both sides to ensure electrical insulation and reduce the possibility of localized heating resulting from circulation currents.

Stator Punching
(Typical)



The overall core is designed to have a natural frequency in excess of 170 hertz, well above the critical two (2) -per-rev electromagnetic stimulus from the rotor. The axial length of the core is made up of many individual segments separated by radial ventilation ducts. The ducts at the core ends are made of stainless steel to reduce heating from end fringing flux. The flanges are made of cast iron to minimize losses. To ensure compactness, the unit receives periodic pressing during stacking and a final press in excess of 700 tons after stacking.

8.2.2.4.2 Armature Winding

The armature winding is a three (3) phase, two (2) circuit design consisting of "Class F" insulated bars. The stator bar stator ground insulation is protected with a semi-conducting armor in the slot and well proven voltage grading system on the end arms.

The ends of the bars are pre-cut and solidified prior to insulation to allow strap brazing connections on each end after the bars are assembled.

The bars are secured in the slot with side ripple springs (SRS) to provide circumferential force and with a top ripple spring (TRS) for additional mechanical restraint in the radial direction. The end winding support structure consists of glass binding bands, radial rings, and the conformable resin-impregnated felt pads and glass roving to provide the rigid structure required for system electrical transients.

8.2.2.5 Ventilation

The generator is cooled by an internally recirculating gas stream that dissipates generator heat through gas-to-water heat exchangers. The ventilation system is completely self contained, including the gas coolers within the structure.

Ventilation fans are mounted at each end of the rotor. The fans provide cooling gas for the stator winding and core. Cooling of the stator core is accomplished by forcing gas through the radial ducts formed by the space blocks in the punchings. The axial length of the core is made up of many individual segments separated by the radial ventilation ducts. This arrangement results in substantially uniform cooling of the windings and core.

The rotor winding, which is a directly cooled radial flow design, is self-pumping and does not rely on the fan for airflow. The rotor is cooled externally by the gas flowing along the gap over the rotor surface, and internally by gas that flows through subslots under the field coils within the rotor body and passes directly through cooling ducts in the copper coils and wedges

After the gas has passed through the generator, it is then directed to two (2) duplex horizontally mounted gas-to-water heat exchangers. After the heat is removed, cold gas is returned and recirculated.

Water inlet, outlet and vent pipe connections for the generator coolers are made externally to the machine. The method of sealing is such that the water boxes and covers can be removed to clean a cooler without opening the generator ventilation circuit.

8.2.2.6 Rotor

The rotor is machined from a single-piece, high-strength alloy steel forging. The retaining ring is nonmagnetic 18 Cr 18 Mn stainless steel for low losses and high stress-corrosion resistance. The rings are shrunk onto the rotor body, thus eliminating any risk of top turn breakage. A snap ring is used to secure the retaining ring to the rotor body, which minimizes the stresses in the tip of the retaining ring. An illustration of the rotor is provided below.

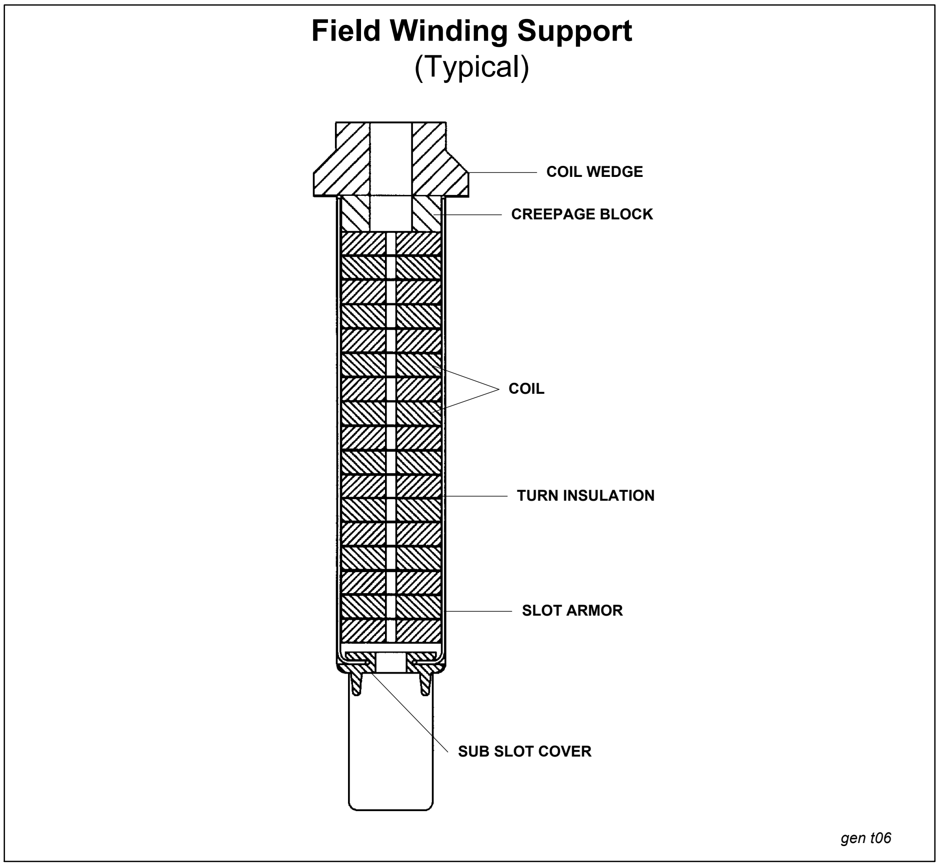
Axial slots are machined radially in the main body of the shaft to locate and retain the coils. The axial vent slots machined under the main coil slots are narrower than the main slots and provide the direct radial cooling of the field copper.

Depending on the design, wedges may be stainless steel, or a combination of aluminum, stainless steel, and magnetic steel.

A shrunk-on coupling is assembled after the collector rings are on, and provides the interface point to the flex-coupling connection to the turning gear. This arrangement is used with a static start system.

8.2.2.6.1 Field Assembly

The field consists of several coils per pole with turns made from high conductivity copper. Each turn has slots punched in the slot portion of the winding to provide direct cooling of the field.



The slot armor used in the slots is a Class ""F"" rigid epoxy glass design. An insulated cover is positioned at the bottom of each slot armor and on top of the subslot. The cover will provide the required creepage between the lower turns and the shaft. Epoxy glass insulation strips are used between each coil turn. A pre-molded glass retaining ring insulation is utilized over the end windings and a partial amortisseur is assembled under the rings to form a low resistance circuit for eddy currents to flow.

The rotor is designed to accommodate static start hardware utilizing slot amortisseurs.

The entire rotor assembly is balanced up to 20% over operating speed.

The rotor slot armor, and all the insulation materials in contact with the winding, are full class F materials and are proven reliable materials through use on other generator designs.

8.2.2.7 Pedestal Mounted Bearings

The unit is equipped with pedestal mounted bearings designed to support the rotor. The bearing is a tilt-pad design.

The two (2) lower pads are equipped with dual element temperature detectors. Provisions for velocity type vibration sensors are provided on the surface of the bearing caps. Provisions for proximity probes are also on the bearing cap at 45 degree angles from top dead center.

The bearing at the exciter end of the generator is electrically insulated from the generator frame to prevent the flow of shaft currents.

8.2.2.8 Lubrication System

Lubrication for the generator bearings is supplied from the turbine lubrication system. Generator bearing oil feed and drain interconnecting lines are provided, and have a flanged connection at the turbine end of the generator package for connection to the turbine package.

8.2.2.9 Starting of the Gas Turbine Through the Generator

The generator is used as a starting motor for the gas turbine.

It is driven by a static frequency converter.

During the standstill or the starting sequences, the supply of the generator field winding is made by means of a small slip-ring system.

The brushes rub against the rings only during the starting sequence. The brushes contact the rings at the beginning of the sequence and are lifted at the end of the sequence by an electrical solenoid energized by the remotely located control system. Brush wear and carbon dust are limited considerably.

8.2.3 Description of Off-Base Electrical Auxiliary

8.3 Generator Accessory Compartment

8.3.1 GNAC (Generator Neutral Accessory Compartment)

8.3.1.1 Description

The GNAC is designed for outdoor operation (IP 54).

Location could be on the right side, or on the left side of the generator (depending on site configuration).

Low voltage wiring for power and instrumentation are terminated on terminal boards located in a separated junction box accessible by means of doors.

Anticondensation heaters are provided.

8.3.1.2 Generator Star Point Grounding

The generator star point is grounded through a resistor limiting the current to 10 Amp. for 30 seconds.

One current transformer associated with generator ground fault relay is supplied.

- Primary 5 Amp
- Secondary 1 Amp class 1

8.3.1.3 Measurement of the Stator Currents

Each bar is equipped with one (1) current transformer, encapsulated primary traversing bar type rated, 17.5 kV insulating class having the following characteristics:

- 5 500/ 1/1 Amp., PX Class for protections, generator differential protection and if applicable generator block protection

8.3.2 GLAC (Generator Line Accessory Compartment)

8.3.2.1 Description

The GLAC is designed for outdoor operation (IP 54).

Its location could be on the left side, or on the right side of the generator (depending on the site configuration).

It includes the necessary components for the following functions:

- CT's and VT's for generator monitoring and protection
- Surge capacitors and lightning arrestors

Low voltage wiring for power and instrumentation are terminated on terminal boards located in a separated junction box (including the MCB's for voltage measuring protection) accessible by means of doors.

Anti-condensation heaters are provided.

8.3.2.2 Measurement of the Stator Currents

Each bar is equipped with one (1) current transformer, encapsulated primary traversing bar type rated, 17.5 kV insulating class.

having the following characteristics:

- 5500/ 1/1 Amp class 0.2 for metering and voltage regulation and PX class for generator differential protection

8.3.2.3 Generator Voltage Measurement

This function is performed by means of one (1) set of three (3) single voltage transformers encapsulated with two (2) secondary windings; fix type having an insulating class of 17.5 kV. These voltage transformers are protected by means of MCB's at their secondary side.

They have the following characteristics:

- Primary (generator rated voltage/$\sqrt{3}$) Volts
- Secondary (100/$\sqrt{3}$) Volts
- Accuracy:
  - class 3P for the generator protective relays
  - class 0.2 for metering, synchronization and AVR

8.3.2.4 Generator Surge Protection

One (1) set of three (3) lightning arrestors (Metal oxide) and three (3) surge capacitors are provided, having the following characteristics:

- Lightning arrestors:
  - Standard: IEC 60099.4
  - Type: Continuous operating voltage
  - Rated voltage: adapted to the voltage on duty
  - Nominal discharge current: 10 Ka
- Surge capacitors:
  - Type: single phase, stationary, indoor use
  - Rated voltage: 17.5 kV
  - Capacity: 0.25 μF

8.3.2.5 GLAC Outgoing

The GLAC is designed for a connection to the circuit breaker or to the transformer terminals by means of metal enclosed bus.

8.3.2.6 Others

The 3 phases are segregated by means of metal sheets.

8.3.2.7 Non Segregated Medium Voltage Bus Duct between Generator and GLAC/GNAC

The connection from generator to the GNAC and GLAC is made by means of a bus duct.

The bus duct is a rectangle type, enclosed current conductor with air insulation and with supporting elements which have high mechanical and electro insulating resistance.

Each conductor is simple-supported (it is enable to perform longitudinal movements) by cast resin insulators. The enclosure is made of aluminum and the electrical conductors are made of aluminum or copper.

The enclosure could be supported by adequate support or self-supported.

- The bus duct basis rated as follows:
  - Nominal voltage: 11.5 kV or 13.8kV
  - Rated insulation level: 17,5 kV
- Power frequency withstand for one minute: 38 kV rms
- Basic impulse level BIL (wave 1,2/50) 95 kV peak
  - Rated current (In) 4430A at 40°C
- Short circuit current (thermal withstand)
  - Main connection: 55 kA rms 1s
- Short circuit current (mechanical withstand)
- Main connection: 140 kA peak

8.3.2.8 Description of Medium Voltage Isolated Phase Bus duct

8.3.2.8.1 General

The isolated-phase bus consists in an assembly of rigid conductors, complete with connections, joints and isolating supports, contained in earthed aluminum enclosures. Each phase conductor is enclosed by an individual aluminum enclosure separated from adjacent conductor enclosure by an air space.

Due to the wind conditions, the Isolated Phase Bus ducts will have to be located directly on the ground.

8.3.2.8.2 Isolated Phase Bus Duct Basic Data

The isolated-phase bus is used to connect the generator (GLAC if applicable) the Static Frequency Converter (if applicable) and the unit circuit breaker.

- The isolated phase basis rated as follows:
  - Nominal voltage: 11,5 kV or 13,8kV
  - Rated insulation level: 17,5 kV
- Power frequency withstand for one minute: 38 kV rms
- Basic impulse level BIL (wave 1,2/50) 95 kV peak
  - Main connection rated current (In) 4430A (40°C)
- Short circuit current (thermal withstand)
  - Main connection: 55 kA rms 1s
- Short circuit current (mechanical withstand)
  - Main connection: 140 kA peak

8.3.2.9 Description of Unit Circuit Breaker

8.3.2.9.1 General

The circuit breaker is made up of three (3) poles operated by a mechanical control (spring). Each pole is housed in an aluminum enclosure connected to the bus bar enclosure by welding. This provides a physically and electrically continuous envelope linking the generator and the transformer.

8.3.2.9.2 Circuit Breaker Data

- The unit circuit breaker is rated as follows:
  - Rated maximum voltage: IEC 17.5 kV
  - Rated current: (40°C) 6300 A
  - Breaking capacity: 63 kA
  - Rated shortime withstand current (3s): 63 kA
  - Rated shortime peak value: 173 kA
  - Rated dielectric withstand at power frequency: 60 kV
  - Rated dielectric withstand at full wave impulse: 125 kV peak

8.3.2.9.2.1 Line Disconnector

- The line disconnector is rated as follows:
  - rated short time withstand current: 63kA 3s
  - rated short time withstand current peak: 173 kA
  - rated normal current: (40°C) 6300 A
  - insulation level: 60 kV / 125 kV
  - electrical control mechanism

8.3.2.9.2.2 Earthing Switch (Generator Side)

- The earthing switch (generator side) is rated as follows:
  - rated short time withstand current: 63 kA 3s
  - rated short time withstand current peak: 173 kA
  - insulation level: 60kV/125kV
  - electrical control mechanism

8.3.2.9.2.3 Voltage Transformers

3 voltage transformers (main transformer side) without primary fuses and an antiresonance resistor are supplied with the circuit breaker.

8.3.2.9.2.4 Surge Arrestors

Three (3) surge arrestors (main transformer side) are supplied with the circuit breaker.

8.3.2.9.2.5 Starting Disconnector

- A starting disconnector on generator side is supplied with the following characteristics:
  - rated normal current: 2000A
  - insulation level: 38kV/95kV
  - electrical control mechanism

8.3.2.10 Static Frequency Converter (SFC)

8.3.2.10.1 Description of The Static Frequency Converter

8.3.2.10.1.1 General

The static frequency converter (SFC) used for starting the gas turbine shaft line supplies the generator at variable frequency, at reduced voltage and at reduced field.

The gas turbine start-up sequence is fully automatic in operation. The generator is used in “motor” mode and brings the shaftline to an adequate percentage of the nominal speed during the starting cycle.

At this adequate percentage of the nominal speed, the SFC is uncoupled and the gas turbine accelerates alone the shaftline up to 100% of nominal speed.

At 100% of nominal speed the generator is energized at its nominal voltage and is ready for the coupling sequence with the network.

In addition to the starting function the SFC is also used to bring the unit at the adequate speed during the washing cycle.

8.3.2.10.1.2 Starting System Equipment

The starting system equipment is housed in an enclosure which is normally located adjacent to the generator compartment. The enclosure is suitable for outdoor installation in the specified site climatic conditions. Heating, air conditioning, lighting and convenience power outlets are provided for protection of the equipment inside the enclosure.

The main parts of the system are the following:

- One (1) control-monitoring cubicle
- One (1) DC link reactor
- One (1) off-load switch on the machine side
- Measuring and protection devices (VT's – CT's)

8.3.2.10.1.3 Basic Principle

The starting static frequency converter is fed through a voltage adaptation transformer.

The starting static frequency converter is fed through a incoming power transformer located inside the SFC container.

The starting SFC is an indirect frequency converter working as a load commutated inverter (LCI) divided into three (3) main equipments.

- One (1) thyristor rectifier bridge (the network bridge) supplied by the voltage adaptation transformer,
- One (1) thyristor inverter bridge (the machine bridge) connected to the generator through a disconnector switch,
- One (1) intermediate DC circuit, the reactor of which ensures decoupling between the network and machine bridges.

The proposed system includes a pulse generator for starting. Autosynchronous monitoring is carried out entirely by processing the signals taken from the synchronous motor start through voltage transformers.

When running in motor mode the generator rotor is supplied with direct current from a system which includes:

- The thyristor bridge used when running in generator mode.
- The automatic system which supply the field rotor with direct current via rings and brushes. Brushes are applied against the rings at the beginning of the starting or washing cycles and are lifted at the end of the cycles.

8.3.2.10.1.4 Functions

The starting SFC is designed to perform the following functions:

- Turbine starting:
  - The turning device provides the breakaway torque of the shaftline; then the SFC brings the shaftline up to the self sustaining speed of the gas turbine.
- Washing (off-line):
  - During this sequence the SFC maintains the shaftline at a low constant speed

8.3.2.10.1.5 Description and Construction Criteria

The complete equipment is installed inside an air-conditioned enclosure suitable for outdoor installation.

Inside this enclosure two (2) separated groups of equipment have to be considered:

- The power equipment
- The auxiliary and control equipment.

8.3.2.10.1.5.1 The Power Equipment

The DC link smoothing reactor and the power thyristor module are the “power” components of the SFC.

The power thyristor module or network/machine unit includes the thyristor legs of the bridges, their protection systems, the connections and the measuring devices (current transformers, potential tranformers).

The DC link-smoothing reactor is usually made of an air-cooled iron core equipped with a maximum temperature sensor. The reactor has the function of limiting current waviness in the intermediate continuous current circuit.

One (1) three (3) poles off load disconnecting switch, motorized, is provided to connect the SFC circuits and the generator stator. The disconnector is equipped with an earthing device on the SFC side.

The SFC incoming power transformer is located inside SFC container. The transformer is dry type.

8.3.2.10.1.5.2 The Auxiliary and Control Equipment

FC control and protections is accomplished by using all necessary commands, signals, alarms instruments and auxiliary circuits provided with the unit. The auxiliary circuits are composed of transducers; the relay logic, PLC circuits and the interface cards.

The control performs the following main functions:

- Converter fixed frequency phase shifter network side
- Converter variable frequency phase shifter machine side (in the two [2] operating modalities): pulsing regime and natural communication)
- Speed regulator with internal current regulation loop
- Variable frequency converter partialisation angle control
- Protections

- Operating logic (PLC)
- Converter interface (thyristor ignition pulse generation, CT's and VT's signals acquisition)
- Field interface
- Diagnostic and user interface

8.3.2.10.1.6 SFC Technical Specification

8.3.2.10.1.6.1 General Characteristics

- Applicable standards: IEC, IEEE
- Rated starting power: 2250 kW
- Rectifier:
  - Quantity: 1
  - No load input voltage: 1550 Volts
- Inverter:
  - Quantity: 1
  - Output voltage: 0V– 1450 V
- Smoothing reactor:
  - Quantity: 1
  - Type: Dry type, iron reactor
- SFC incoming power transformer:
  - Quantity: 1
  - Type: Dry type, rated power 3.2MVA
- Type of control: Microprocessor

8.3.2.11 Description of the Cabling System

8.3.2.11.1 Cabling System Between GTG, Modules, GT MCC and Supplied Cubicles

8.3.2.11.1.1 General

The cabling system consists of:

- Power cables with connection fittings (glands, terminals, ...)
- Control and measure/instrumentation and data processing cables with connection fittings (glands, terminals, ...)

All cables will be in accordance with IEC standard suitable for outdoor use (protective sheath UV stabilized). All cables will be hydrocarbon resistant, flame retardant (according to IEC 60332-1)and low smoke (IEC 61034) and water resistant AD7 (temporary submerged IEC 60529).

Cable installation and segregation principles.

All the cables will be suitable to be laid in embedded PVC ducts and on some additional cable trays at the junction of the cable pits and the equipment, as well as on some structures such as air filter or stack.

8.3.2.11.1.2 LV Power Cables

LV power cables will have a minimum cross section of 2.5 mm2.

- Standard: IEC 60502-1, IEC 60228
- Cable type: XLPE/PVC power cable rated voltage 0,6/1kV
- Insulation: Cross link polyethylene (XLPE)
- Conductors: Plain copper stranded according to IEC 60228 class 2
- Identification: Manufacturer's standard

8.3.2.11.1.3 Control Cables

Control cables will have a minimum cross section of 1.5 mm2.

- Standard: IEC 60502/1, IEC 60228
- Cable type: XLPE/PVC control cable rated voltage 500V
- Insulation: Cross link polyethylene (XLPE)
- Conductors: Plain copper stranded according to IEC 60228 class 2
- Identification:
  - 1 to 5 cores: supplier standard
  - 6 and more cores: black cores numbered from 1 to n-1 (the last core being green/yellow)

8.3.2.11.1.4 Measure/Instrumentation Cables (Except Thermocouple Extension Cables)

Measure/instrumentation cables will have a minimum cross section included between 0.75 and 1 mm2.

- Standard: IEC 60228,
- Insulation: Polyethylene (PE) or cross-linked polyethylene (XLPE)
- Conductors: Stranded Plain copper
- Identification: Manufacturer's standard

8.3.2.11.1.5 Thermocouple Extension Cables

The thermocouple extension cables will have a cross section of 1 mm2 (single pair cable) and 0.5 mm2 (multipair cable).

- Standard: IEC 60584. class 1, IEC 60228 class 2
- Insulation: Polyethylene (PE) or cross-linked polyethylene (XLPE
- Conductors: Copper-Constantan (T type) or Chromel (nickel chromium)-Alumel (nickel alloy) (K type)
- Identification: T type (brown(+) copper / white(-) constantan) K type (green(+) chromel / white(-) constantan)

8.3.2.11.1.6 Data Processing Cables

The data processing cables will be of:

- The coaxial 50 Ohm for ETHERNET links and 93 Ohm for ARCNET links.
- Standard: RG 58 C/U (MIL-C-17D) / 50-3-1 (IEC 60096, IEC 60332-1) ETHERNET or RG62 A/U (MIL C 17D) ARCNET
- Insulation: Polyethylene
- Identification: Manufacturer's standard

8.3.2.11.1.7 Optical Cables

The optical cables will have a core diameter of 62.5 / 125micron:

- Fiber type: multi-mode
- Coating diameter 500 microns cladding diameter 125 microns
- Tight buffer material: Hard elastomeric 900 microns diameter
- Identification: Color code standard supplier

8.3.2.11.1.8 High Temperature Cables

- High temperature cables are used when the permanent working ambient temperature is high. They are halogen free non corrosives non toxicity (see IEC 60754 part 1 and 2), fire resistant (IEC 60331), low smoke (IEC 60034),AD7 water resistant (temporary submerged IEC 60529), flame retardant (IEC 60332-1 and IEC 60332-3) and hydrocarbon resistant.

8.4 Description of Control and Auxiliary Equipment

8.4.1 Description of Gas Turbine Control Equipment

8.4.1.1 Gas Turbine Control System (Mark VIe)

8.4.1.1.1 Introduction

The SPEEDTRONIC™ Mark VIe turbine control is the latest state-of-the-art control for GE turbines with a heritage of more than 30 years of successful operation of electronic turbine control systems. It is designed as a complete integrated control, protection, and monitoring system for generator and mechanical drive applications of gas and steam turbines. It is also an ideal platform for integrating all power island and balance of plant controls. Hardware and software are designed with close coordination between GE's turbine design engineering and controls engineering to insure that your control system provides the optimum turbine performance and you receive a true "system" solution. With Mark VIe, you receive the benefits of GE's unmatched experience with an advanced turbine control platform.

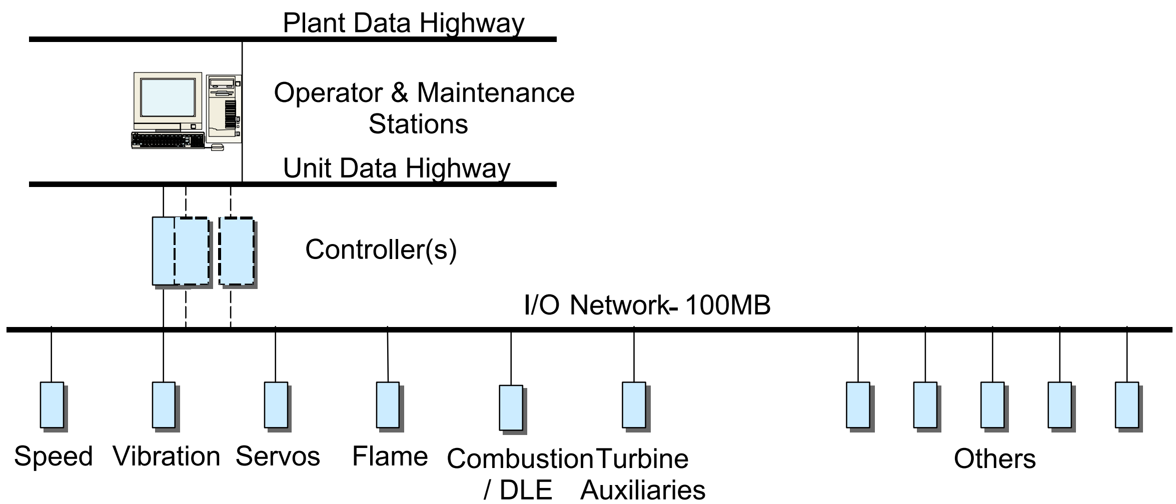
8.4.1.1.2 Mark VIe Architecture

A Compact PCIR based Controller communicates with networked I/O over one or multiple Ethernet networks. The Controller rack consists of a main processor and one or two (2) power supplies. A QNXR real time, multitasking operating system is used for the main processor and I/O. Application software is provided in a configurable control block language and is stored in non-volatile memory. It conforms to IEEE-854 32-bit floating point format.

IONet is a dedicated, full-duplex, point-to-point protocol that provides a deterministic, high-speed 100MB communications network. It is used to communicate between the main processor(s) and networked I/O blocks, called I/O Packs.

Each I/O Pack is mounted on a termination board with barrier or box type terminal blocks. The I/O Pack contains two (2) Ethernet ports, a power supply, a local processor, and a data acquisition card. Computation power grows as I/O packs are added to the control system enabling an overall control system frame rate of 10ms. The local processors in each I/O Pack execute algorithms at higher rates as required for the application. Each I/O Pack contains an AMD Au1000 266Mhz processor. GE manufactures the I/O Pack boards with surface mounted technology and conformal coats them per IPC-CC-830.

Typical System architecture



8.4.1.1.3 Triple Redundancy

Triple redundant systems are available to protect against soft or partial failures of devices that continue to run but with incorrect signals/data. These systems “out vote” a failed component with a 2-out-of-3 selection of the signal. Application software in all three (3) controllers runs on the voted value of the signal while diagnostics identify the failed device.

Controllers are continuously online and read input data directly from IONet. Redundant systems transmit inputs from redundant I/O packs on IONets to redundant controllers. Outputs are transmitted to an output I/O pack that selects either the first healthy signal or the signal of choice. Three (3) output packs can be provided to vote output signals for mission-critical field devices.

Diagnostics monitor all system components and provide an alarm identifying faults. This enables maintenance personnel to perform on-line repair and extend the mean-time-between-forced-outages (MTBFO). Note that every I/O Pack communicates directly on the IONet, which enables each I/O Pack to be replaced without affecting any other I/O in the system. Also, the I/O Pack can be replaced without disconnecting any field wiring.

8.4.1.1.4 Mark VIe Control Configuration

The control system provides complete monitoring control and protection for Gas Turbine-Generator and Auxiliary systems. The scope of control is broken down into three (3) sections:

- Control
- Sequencing
- Protection

8.4.1.1.4.1 Control

- Start-up control

The control panel will provide the necessary sequences and protections to insure the cranking of the shaft, ventilation before firing, firing, and acceleration of the Gas Turbine up to Full Speed No Load.

- Speed/load set-point and governor

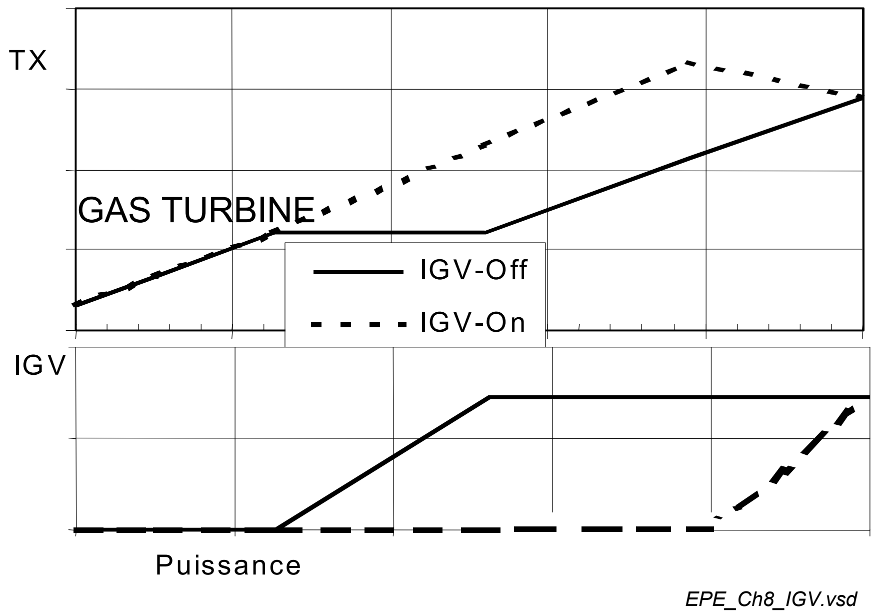
This function allows to control the gas turbine speed and the load once the breaker is closed. The speed/load loop controls speed after the turbine has been brought to governed speed. The speed control circuit compares turbine shaft speed to the digital set-point, and regulates FSR to maintain the speed driven by the digital set-point.

- Temperature Control

A temperature control system is required, to control fuel flow to the gas turbine to maintain operating temperatures within design thermal stress limitations of turbine parts. The highest temperature attained in the gas turbine occurs in the combustion chambers and that same gas temperature occurs at the turbine inlet. This temperature must be limited by the control system. The temperature control system is designed to measure and control turbine exhaust temperature because it is impractical to measure temperatures in the combustion chambers or at the turbine inlet directly.

According to whether the machine is in simple cycle or combined cycle, the privileged way followed in loading will be different. Thus, in simple cycle, the optimal efficiency on gas turbine is required whereas in combined cycle, optimal efficiency on all the power station is required. Therefore the sequence of opening or closing of IGV is not the same one.

In simple cycle, the sequence known as " IGV-off " is used whereas in combined cycle, sequence " IGV one " is used:



IGV-Off sequence: One goes up in load with mini IGV until the temperature exhaust reaches 700F (371°C). Then, the IGV are gradually open with consign to keep the temperature exhaust equal to 700°F. When the angle of maximum IGV is reached, this isotherm is left to gradually join the base curve.

IGV-ON sequence: Loading with mini IGV until the partial load control curve is reached. This curve can be the same curve that the base one (standard chamber or MNQC), or a particular curve (DLN chamber - the particular curves are built in order to avoid unstable zones of combustion). The IGV are then gradually opened with exhaust temperature consign corresponding to the control curve in partial load. When the maximum angle of IGV is reached, the base load curve is finally joined.

In a general way, the partial load control curves are built to keep the firing temperature quasi-constant at the time of the opening of the IGV. This is why, even in simple cycle, the machines equipped with DLN chamber go up in load while following preferably the IGV ON sequence. Combustion in premix is done thus on a greater range of load.

8.4.1.1.4.1.1 Fuel Control

- DLN 2.6

The dry low NOx 2.6 (DLN-2.6) control system regulates the distribution of fuel delivered to a multi-nozzle, total premix combustor arrangement. The fuel flow distribution to each combustion chamber fuel nozzle assembly is calculated to maintain unit load and fuel split for optimal turbine emissions. The DLN 2.6 Combustion system consists of six fuel nozzles per combustion can, each operating as a fully premixed combustor, five located radially, one located in the center. The center nozzle, identified as PM1, (PreMix 1), two (2) outer nozzles located adjacent to the crossfire tubes, identified as PM2, (PreMix 2), and the remaining three (3) outer nozzles, identified as PM3, (PreMix 3). Another fuel passage, located in the airflow upstream of the premix nozzles, circumferentially around the combustion can, is identified as the quaternary fuel pegs.

- Control
  - Anti-Icing

Anti-icing of inlet filters, inlet duct walls, trash screen, compressor bell-mouth, inlet guide vanes and other inlet components are occasionally required for gas turbine applications in a cold, humid ambient environments. In order to avoid ice, we need to bleed hot gas from the compressor stage. This system usually features an inlet bleed heat injection manifold upstream of the inlet filters.

- Power Factor Control

The PF setpoint and the calculated feedback based on MVAR and MW operating setpoint develop an error signal, which is then input to comparators with some dead-band, to allow for a steady state error. The comparator logical outputs are then passed to the appropriate raise or lower contacts, after some time delay, to allow settling in the closed loop voltage control. The PF control is enabled only if the turbine load is above a minimum value.

- Var Control

The Var control is accomplished by sending excitation raise and lower commands to the Exciter from the turbine control panel through hardwired contacts. The raise and lower commands are pulses. The VAR setpoint and the measured feedback develop an error signal, which is then input to comparators with some dead-band, to allow for a steady state error. The comparator logical outputs are then passed to the appropriate raise or lower contacts, after some time delay, to allow settling in the closed loop voltage control. These raise and lower commands are the same functions that are normal operator interfaces to the excitation system. The action of the VAR control is to in fact emulate the same action that an operator would take to adjust var output, only in an automated fashion.

- Compressor Water Washing

Gas turbines can experience a loss of performance during operation as result of deposits of contaminants on internal components. The dry contaminants that pass through the filters as well as wet contaminants, such as hydrocarbon fumes, have to be removed from the compressor by washing with a water detergent solution followed by a water rinse.

- Comp Pressure & Ex-Temp Control

Gas turbine combustion reference temperature is determined by the measured parameters of exhaust temperature and CPD. In case of CPD failure, a backup function is included which uses fuel consumption (proportional to FSR) or output (in Megawatts).

8.4.1.1.4.2 Sequencing

- Start-up, Purge, Ignition, Running and Shutdown
  - General

Starting the gas turbine involves proper sequencing of command signals to the accessories, starting device and fuel control system. Since a safe and successful start-up depends on proper functioning of almost all of the gas turbine equipment, it is important to verify the state of selected devices in sequence. Much of the control logic circuitry is associated not only with actuating control devices, but enabling protective circuits, and obtaining permissive conditions before proceeding. Start-up and shutdown cycle improvements have been included to reduce low cycle fatigue of hot gas path parts.

- Speed detectors

An important part of the start-up/shutdown sequence control of the turbine is proper speed sensing. This is necessary for the logic sequences in start-up and shutdown of the gas turbine.

- Start-up Control

The start-up control operates as an open loop control in the use of preset levels of the fuel command signal, FSR. The levels set are “FIRE”, “WARM-UP”, and “ACCELERATE LIMIT”. Start-up control FSR signals operate through a minimum value gate to insure that speed control and temperature control can limit FSR if required. During the starting sequence, rates of increase in speed and exhaust temperature are restricted to protect the turbine parts from excessive mechanical and thermal stresses.

- Control Mode Display
  - Display Condition
  - START-UP Start-up Program
  - ACCEL Acceleration Control
  - DROOP SPEED Speed Control
  - TEMP Temperature Control
- Fired shutdown

A normal shut-down is initiated by selecting STOP from the control panel followed by execute.

- Purge and Ignition

During start-up sequence, the starting means will hold the turbine speed at a constant value before firing, this is done to force four changes of exhaust duct air to insure no combustible mixture is in the exhaust. The duration of this purge time will depend on the volume of the exhaust duct and may vary between an open cycle and a combined cycle configuration. When the purge timer is completed, the firing timer is initiated and the fuel flow set to the firing value. When flame detectors indicate flame is established in the combustors, the fuel flow is set to the warm-up value. The warm-up time is provided to minimize the thermal stresses during start-up.

- Droop-Isochrone Mode

Droop speed control is based on the fact that the power grid to which the generator is connected, will hold a synchronous generator speed at grid frequency. The turbine load will be proportional to the difference between the grid frequency and speed/load setpoint.

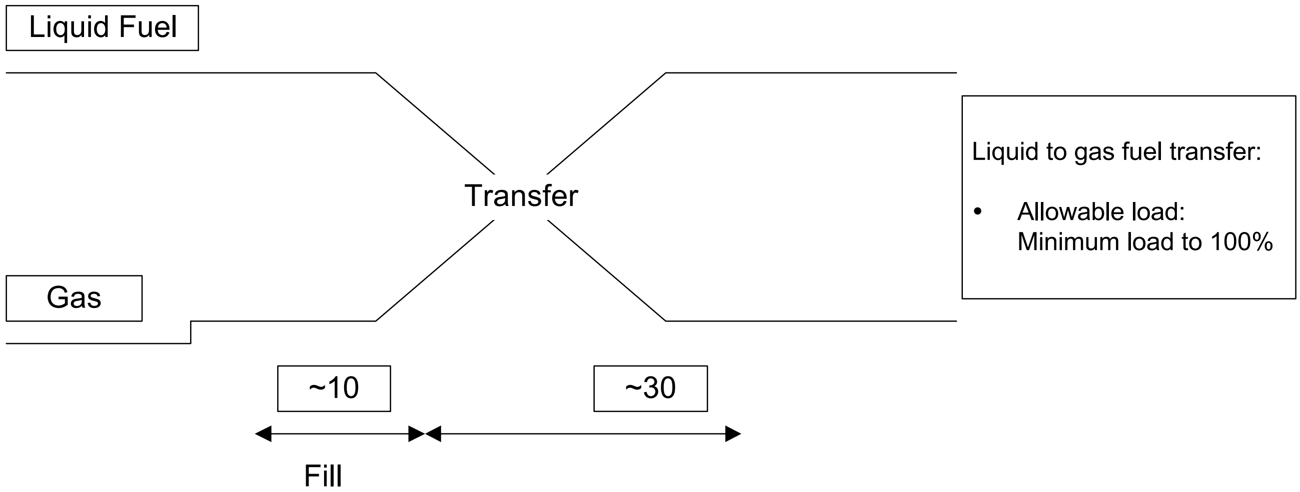
Isochronous control mode is used when the turbine is operating on an isolating grid. The turbine load will be proportional to the difference between the frequency setpoint and the actual frequency of the grid.

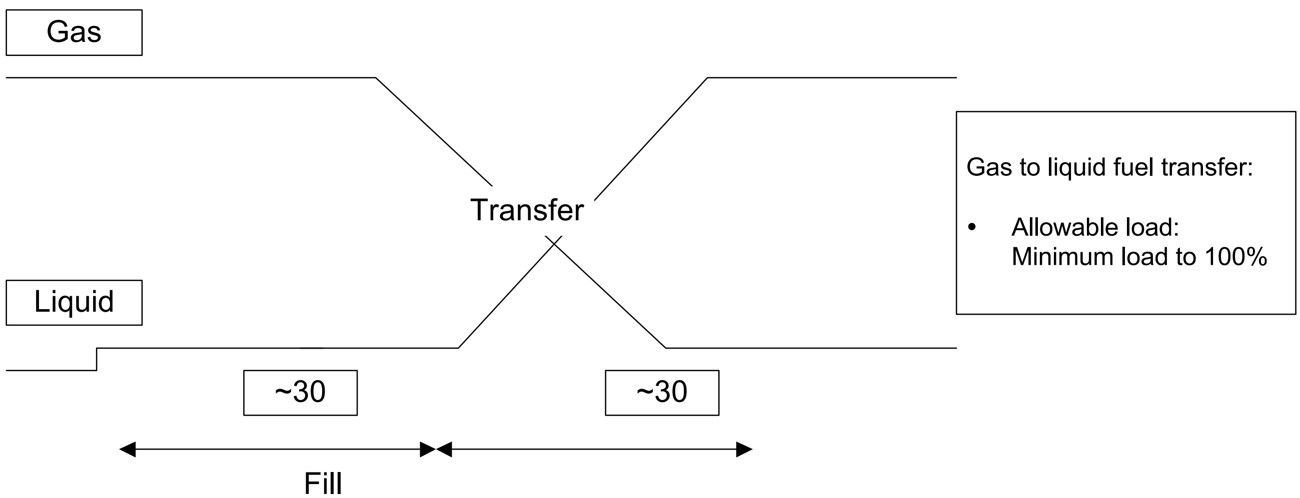
- Constant Settable Droop

Constant Settable Droop Speed/Load control represents a method of formulating the gas turbine droop response as a function of the unit power output. This method of speed/load control is applied to units where the fuel stroke reference (FSR) is not predictable as a function of the gas turbine output power. Standard droop control utilizes the approximate linear relationship between FSR and the gas turbine power output as the basis for reacting to variations in electrical grid frequency. Constant Settable Droop Speed/Load Control is a method where gas turbine megawatt output is used as a control parameter to formulate the turbine droop response to electrical grid perturbations.

Dual redundant megawatt transducers are required at a minimum to provide megawatt feedback to the Constant Settable Droop sequencing.

- Fuel Changeover





Fuel changeover can be manually initiated using the display on the <HMI>. When transferring from one fuel to the other, there is a 30-second delay before the transfer begins for the gas-to-distillate transfer, the delay allows for filling the liquid fuel lines. For the distillate-to-gas transfer, the delay allows time for the speed ratio valve (and gas control valve) to modulate the inter volume gas pressure before the transfer begins. Once started, fuel transfer takes approximately 30 seconds.

- Automatic Fuel Transfer on Gas Fuel Fault

In the event of fuel gas fault (typically low pressure or low temperature), turbine operation will automatically transfer to liquid fuel. The transfer will occur with no delay for line filling. To return to gas fuel operation after an automatic transfer, manually reselect gas fuel.

8.4.1.1.4.3 Protections

- General (Refer to the Scheme Below)

The protection of the turbine against potential damaging conditions is provided by redundant controllers: critical protection sensors are triple redundant and voted all the processors. An independent overspeed protective module provides triple redundant hardwired detection and shutdown on overspeed along with flames detection.

- Over-Speed, Redundant Electronic

Over-speed protection consists of three (3) magnetic pick-ups which provide electrical pulses to the Controllers which compare the pulse rate to a pre-set level.

- Over-Temperature Protection

The over temperature system protects the gas turbine against possible damage caused by overfiring.

It is a back-up system which operates only after failure of the speed and temperature override loops.

Under normal operating conditions, the exhaust temperature control system reacts to regulate fuel flow when the firing temperature limit is reached. In certain failure modes however, exhaust temperature and fuel flow can exceed control limits. With such circumstances the overtemperature protection system provides an over-temperature alarm annunciation prior to tripping the gas turbine. This allows the operator to unload the gas turbine to avoid the trip.

- Vibration Protection

The vibration protection system employed for gas turbine units is designed to adequately protect the unit while maintaining a high level of unit running reliability and starting availability.

Multiple vibration sensors are mounted on the rotor bearing housings of the gas turbine and generator, and if applicable, on the load gear bearings. The Speedtronic™ vibration protection has the standard capability for 12 vibration sensor inputs that are classified and processed in the following four groups:

1. Gas Turbine Vibration Sensors
2. Load Gear Vibration Sensors
3. Generator or Driven Load Vibration Sensors
4. Miscellaneous Vibration Sensors (Spare Group)

- Flame detection and protection

The SPEEDTRONIC™ flame detectors perform two (2) functions, one during the starting sequence and the other in the protective system. During a normal start-up the flame detectors indicate when a flame has been established in the combustion chamber, and allow the start-up sequence to continue. Should the flame detectors indicate a loss of flame condition while the gas turbine is running, fuel is immediately shut off. This avoids the possible accumulation of an explosive mixture in the turbine and any exhaust heat recovery equipment which may be installed. The flame detector system, used with the SPEEDTRONIC™ system, detects flame by sensing ultraviolet radiation (UV).

- Dew Point Protection

GE currently requires the Gas Fuel supplied to the FG1 connection to be superheated. The requirements and basis of this superheat are defined in Specification GEI-41040. If sufficient superheat is not supplied, liquid hydrocarbons may condense out of the gas fuel stream and result in damage to hardware. Therefore, a three-tiered protection strategy will be implemented to Alarm, Shutdown and Trip the Gas turbine, if there is insufficient superheat.

As stated in GEI-41040, GE will require a temperature input signal from the customer into the Speedtronic™ Controller. This should be a 4-20mA analog signal from the Plant Level control system.

The temperature should represent the gas fuel temperature downstream of any Gas Pressure Regulating Stations or Gas Compressors, but upstream of any heating equipment recommended in GER-3942. This temperature will be referred to as the "unconditioned gas temperature." GE recommends that the temperature measuring device contain redundancy.

GE will use the unconditioned gas temperature signal, along with the Hydrocarbon Dew point breakpoint described in GEI-41040 to determine if sufficient superheat is being supplied. An alternate method to the hydrocarbon dew point breakpoint is for the customer to supply a signal to the Speedtronic™ Controller for the Hydrocarbon dew point. Once again, this signal should be a 4-20mA analog signal from the Plant Level control system. In this case, GE will use the unconditioned gas temperature signal and the hydrocarbon dew point signal, to determine is sufficient superheat is being supplied.

The Speedtronic™ Controller will provide an alarm, when the risk of liquid hydrocarbon condensation is approximately three (3) defects per million opportunities. (6 Sigma) This level is equal to the superheat values contained in GEI-41040. The operator should check to insure that all of the necessary heaters are operational when this alarm becomes active. This alarm will be active above 50% turbine speed.

The Speedtronic™ Controller will provide a load runback and normal shutdown command, when the risk of liquid hydrocarbon condensation is approximately 1350 defects per million opportunities. (3 Sigma) This level is approximately equal to 75% of the Alarm Level. The operator should check to insure that all of the necessary heaters are operational when the unit begins the load runback. If sufficient superheat can be re-established during the load runback then the unit will continue to operate. The load runback and shutdown command will become active at Full Speed No Load during turbine start-up.

The Speedtronic™ Controller will provide trip command, when the risk of liquid hydrocarbon condensation is approximately 500,000 defects per million opportunities. (0 Sigma) This level is approximately equal to 20% of the Alarm Level. This condition presents a high risk of liquid hydrocarbon condensation and potential damage to hardware. The trip command will become active at Full Speed No Load during turbine start-up.

This protection strategy does not contain any field adjustable values. If a one time change in Gas Fuel Supply condition occurs, that may result in crossing the hydrocarbon dew point break point described in GEI-41040, GE Engineering will need to be contacted. If the hydrocarbon dew point is expected to have significant variation, especially at or near the hydrocarbon dew point break point described in GEI-41040, then the use of a continuous Hydrocarbon dew point analyzer is recommended.

A 4-20mA analog signal from the Plant Level control system that represents the gas fuel temperature downstream of any Gas Pressure Regulating Stations or Gas Compressors, but upstream of any heating equipment recommended in GER-3942.

OR

A 4-20mA analog signal from the Plant Level control system that represents the real time measurement of the Hydrocarbon dew point in the fuel line.

Liquids in the Fuel

GE will require a Digital input signal from the Plant Level control system that represents a High-High liquid level indication from the closest gas processing equipment, upstream of the FG1. This signal should come from the conditioning device that is closest to the FG1 connection and has the ability to sense liquid levels. This signal should indicate the condition when the level in the equipment has reached a fault level, typically a High-High Level. It is highly recommended that this signal come from a redundant device. This signal will be used to Trip the Gas Turbine when it is activated. It is also highly recommended that a lower level device, indicating a High Level condition, be utilized in the overall plant control (not the Speedtronic™ Controller) to signal an Alarm condition.

Digital input signal from the Plant Level control system that represents a High-High liquid level indication from the closest gas processing equipment, upstream of the FG1.

- Combustion Monitoring Function

Monitoring of the exhaust thermocouples to detect combustion problems is performed by the SPEEDTRONIC™ software coupled with solid state analog devices for interfacing with the primary controls and protective devices. The primary function of the combustion monitor is to reduce the likelihood of extended damage to the gas turbine if the combustion system deteriorates. The monitor does this by examining the temperature control system exhaust temperature thermocouples and compressor discharge temperature thermocouples. From changes that may occur in the pattern of the thermocouple readings, warning and protective signals are generated by the combustion monitor and sent to the gas turbine control panel.

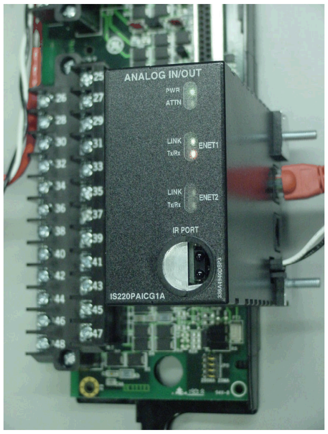
8.4.1.1.5 I/O Interface

One or multiple I/O packs are mounted on each board to digitize the sensor signal, perform algorithms, and communicate with a separate controller that contains the main processor.

I/O packs have a local processor board that runs a QNX operating system and a data acquisition board that is unique to the type of input device. Local processors execute algorithms at faster speeds than the overall control system. An infrared transceiver is useful for low-level diagnostics. I/O values can be monitored, I/O pack host/function names can be programmed, and error statuses can be checked. This requires a Windows-based diagnostic tool on a laptop or a handheld pc.

The I/O Processor contains a temperature sensor that is accurate to within ±2°C. Detection of an excessive temperature generates a diagnostic alarm and the logic is available in the database (signal space) to facilitate additional control action or unique process alarm messages. In addition, the temperature is continuously available in the database.

A power supply provides a regulated 28 Vdc power feed to each I/O pack. The negative side of the 28 Vdc is grounded through the I/O pack metal enclosure and its mounting base. The positive side has solid-state circuit protection built-into the I/O pack with a nominal 2A trip point. On-line repair is possible by removing the 28Vdc connector, replacing the I/O pack, reinserting the power connector, and downloading software from the software maintenance tools.

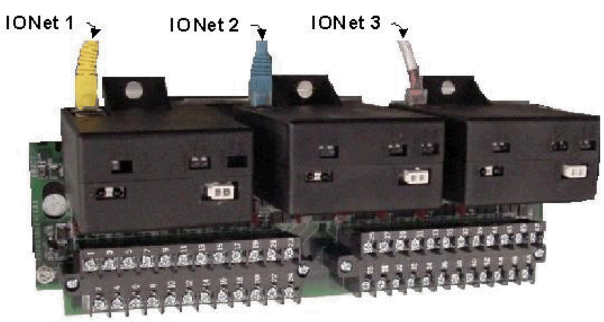


Features

- On-line Repair per I/O Block
- Operation –30C to 65C; Accuracy spec. 0 to 60C
- NFPA Class 1, Division 2 with Local Temperature Sensor
- Infrared Transceiver for Low Level Diagnostics
  - Monitor I/O Values, Set I/O Pack Host/Function Names, Error Status
  - IrComm and/or IrDA SIR Protocols up to 115kB
  - Requires Windows Based Diagnostic Tools on Laptop or Handheld PC
  - Ethernet TSM Support

8.4.1.1.5.1 Terminal Blocks

Signal flow begins with a sensor connected to a terminal block on a board. Boards contain two (2) 24 point, barrier type, removable, terminal blocks. Each point can accept two (2) 3.0 mm2 (#12AWG) wires with 300 V insulation per point with spade or ring type lugs. In addition, captive clamps are provided for terminating bare wires. Screw spacing is 9.53mm (0.375") minimum, center-to-center.



Features

- 2 Barrier Type Blocks / Board
- Removable Blocks
- Surface Mounted Board
- Some "Fanned" I/O
- Full Compliment of I/O Types

8.4.1.1.5.2 I/O Types

Two (2) types of I/O are available. General purpose I/O is used for both turbine applications and process control and turbine-specific I/O is used for direct interface to the unique sensors and actuators on turbines. This reduces or eliminates a substantial amount of interposing instrumentation. As a result, many potential single point failures are eliminated in the most critical area for improved running reliability and reduced long-term maintenance. Direct interface to the sensors and actuators also enables the diagnostics to directly interrogate the devices on the equipment for maximum effectiveness. This data is used to analyze device and system performance. Also, fewer spare parts are needed.

8.4.1.1.5.2.1 General Purpose I/O

I/O packs for discrete inputs and outputs have LEDs for each point. Contact output ratings vary between magnetic relays, solid-state relays, solenoid application, and class 1, division 2 rating. Please refer to Mark VI e System Guide GEH-6721 for these details. The following table lists only general-purpose relay selections. Relay arrangements and ratings for specific hydraulic trip solenoid arrangements are described in the System Guide.

- Discrete Input

A PDIA I/O pack provides the electrical interface between one or two (2) I/O Ethernet networks and a discrete input terminal board. The pack contains a processor board common to all Mark VIe distributed I/O packs and an acquisition board specific to the discrete input function. The pack accepts up to 24 contact inputs and terminal board specific feedback signals. System input to the pack is through dual RJ45 Ethernet connectors and a three-pin power input. Discrete signal input is through a DC-37 pin connector that connects directly with the associated terminal board connector. In the Mark VIe system, the PDIA I/O packs plug into the TBCI. The contact input terminal board (TBCI) accepts 24 dry contact inputs wired to two (2) barrier type terminal blocks. Dc power is wired into TBCI for contact excitation. The contact inputs have noise suppression circuitry to protect against surge and high frequency noise.

- Discrete Outputs

A PDOA provides the electrical interface between one (1) or two (2) I/O Ethernet networks and a discrete output terminal board. The pack contains a processor board common to all Mark VIe distributed I/O packs and an acquisition board specific to the discrete output function. The pack is capable of controlling up to 12 relays and accepts terminal board specific feedback. Input to the pack is through dual RJ45 Ethernet connectors and a three-pin power input. Output is through a DC-37 pin connector that connects directly with the associated terminal board connector. In the Mark VIe system, the PDOA I/O packs work with the TRLY board.

- Analog I/O

The PAIC I/O pack provides the electrical interface between one or two (2) I/O Ethernet® networks and an analog input terminal board. The pack contains a processor board common to all Mark VIe distributed I/O packs and an acquisition board specific to the analog input function. The pack is capable of handling up to 10 analog inputs, the first eight of which can be configured as ± 5 V or ± 10 V inputs, or 0-20 mA current loop inputs. The last two (2) inputs may be configured as ± 1 mA or 0-20 mA current inputs. The load terminal resistors for current loop inputs are located on the terminal board and voltage is sensed across these resistors by the PAIC. Input to the pack is through dual RJ45 Ethernet connectors and a three-pin power input. Output is through a DC-37pin connector that connects directly with the associated terminal board connector.

- Temperature Inputs

The PTCC provides the electrical interface between one or two (2) I/O Ethernet networks and a thermocouple input terminal board. The pack contains a processor board common to all Mark VIe distributed I/O packs and an acquisition board specific to the thermocouple input function. The pack is capable of handling up to 12 thermocouple inputs. In the TMR configuration with the TBTCH1B terminal board, three (3) packs are used with three (3) cold junctions, but only 12 thermocouples are available. Input to the pack is through dual RJ45 Ethernet connectors and a three-pin power input. Output is through a DC-37 pin connector that mates directly with the associated terminal board connector. In the Mark VIe system, the PTCC I/O pack works with the TBTC board. The thermocouple terminal board TBTC accepts 24 type E, J, K, S, or T thermocouple inputs. These inputs are wired to two (2) barrier-type blocks on the terminal board. Communication with the I/O processor is through DC-type connectors.

8.4.1.1.5.2.2 Turbine Specific I/O

A variety of I/O types are used for the unique sensors and actuators used on turbines. This I/O varies with the turbine class and application.

- Speed Sensors

Redundant, passive, magnetic, speed sensors are normally used for reliability. Input circuits have sufficient sensitivity to detect a 2 rpm rotation while the turbine is on turning gear. This enables the diagnostics to begin monitoring the health of the sensors prior to starting the turbine.

- Overspeed Protection

Backup electronic overspeed protection is a common feature in modern control systems. GE's system is fast and reliable, and also features Ethernet links to pass detailed diagnostic data back to maintenance stations on the network.

- Vibration Protection

GE has provided built-in vibration trip protection as part of the basic turbine control since the 1960's. Today, a wide variety of sensors can be monitored including seismic probes, proximity probes, velomiters, and accelerometers. Vibration data is part of the turbine database, which provides a cohesive picture of vibration in relation to the current and past operating conditions of the equipment. Standard diagnostics monitor the composite vibration, 1X and 2X components, and the phase angle. Radial and axial monitoring of generator, compressor, and pump bearings is normally integrated into the system.

- Synchronizing

A typical Mark VIe provides automatic synchronizing, a manual synch scope display on the operator station, and backup synch check protection in the "turbine" control. Voltage matching and subsequent var/power factor control are communicated to the GE exciter over the redundant 100MB Ethernet highway.

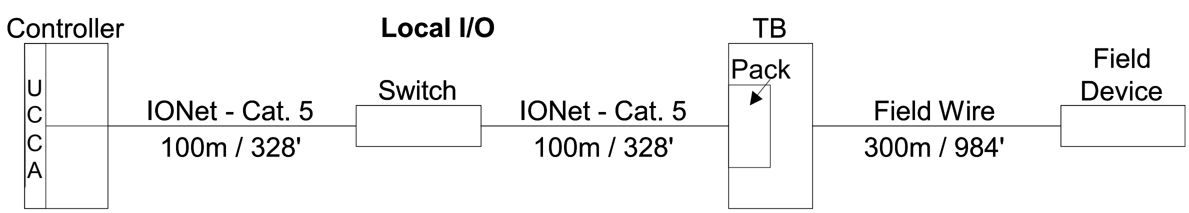
- Servo Control

Servo valves can be controlled with traditional current drivers for coils on the valve actuators or with communication links. A valve stroke reference is calculated in the Controller(s), which drive the control valves. To preserve the fault tolerance of these critical outputs, individual I/O Packs drive separate / redundant coils on the valve actuators, monitor the position feedback with LVDTs, and regulate the fast inner valve loop directly inside each I/O Pack.

8.4.1.1.5.3 IONet

Communication between the controller and the I/O packs is performed with the internal IONet. This is a 100 MB Ethernet network. Ethernet Global Data (EGD) and other protocols are used for communication. EGD is based on the UDP/IP standard (RFC 768). EGD packets are broadcast at the system frame rate from the controller to the I/O packs, which respond with input data.

IONet conforms to the IEEE 802.3 standard. A star topology is used with the controller on one end, a network switch in the middle, and I/O packs at the end.



Maximum IONet distances including field devices

Industrial grade switches are used for the IONet that meet the codes, standards, performance, and environmental criteria for industrial applications including an operating temperature of -40 to 85°C and class 1, div. 2. Switches have provision for redundant 10 to 30 V dc power sources (200/400 mA) and are mounted on a DIN rail. LEDs indicate the status of the IONet link, speed, activity, and duplex.

Operator and Maintenance Tools

8.4.1.1.5.4 Operator Interface

General

The operator interface is commonly referred to as the Human-Machine Interface (HMI). It is a PC with a Microsoft Windows-based operating system with client/server capability, a CIMPLICITY® graphics display system and software maintenance tools (ToolboxST). It can be applied as:

- Primary operator interface for one unit or the entire plant
- Gateway for communications to other systems
- Maintenance station gateway
- Engineers station

The HMI can be re-initialized or replaced with the process running with no impact on the control system. It communicates with the main processor board in the Mark VIe Controller(s) through the Unit Data Highway (UDH) and to third party control and monitoring systems via the Plant Data Highway (PDH). Data management between redundant Controllers is transparent to the HMI, which communicates exclusively with the designated Controller. All analog and digital data in the Mark VIe is accessible for screens, including high-resolution time tags for alarms and events.

System (process) alarms and diagnostic alarms for fault conditions are time tagged at frame rate in the Controller(s) and transmitted to the HMI alarm management system. System events are time tagged at frame rate, and Sequence of Events (SOE) for contact inputs are time tagged at 1ms in the I/O Packs. Alarms can be sorted according to ID, Resource, Device, Time, and Priority. Operators can add comments to alarm messages or link specific alarm messages to supporting graphics.

A standard alarm/event log is provided that stores all alarms and events for 30 days and can be sorted either in chronological order or according to the frequency of occurrence. In addition, a trip history is provided that stores the key control parameters and alarms/events for the last 30 trips. This includes 128 points (typical) and 200 alarms, events, and SOE points.

Data is displayed in either English or Metric engineering units with a one second refresh and one second to repaint a typical display graphic. Operator commands can be issued by incrementing/decrementing a setpoint or entering a numerical value for the new setpoint. Responses to these commands can be observed on the screen one second from the time the command was issued. Security for HMI users is important to restrict access to certain maintenance functions, such as editors and tuning capability, and to limit certain operations. A system called “User Accounts” is provided to limit access or use of particular HMI features. This is done through the Windows User Manager administration program that supports five (5) user account levels.

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HMI Product Features

GE Fanuc's CIMPLICITY® HMI system serves as the basic core system, which is then enhanced by the addition of power plant control hardware and software from GE Industrial Systems. The HMI system includes the system Toolbox for maintenance, software interface for the Mark VIe and a number of product features which are unmatched by other monitoring and control systems. These features bring value to the user of power plant control, and include the following:

8.4.1.1.5.4.1.1 Graphics - CimEdit and CimView

The key functions of the HMI system are performed by its graphic system, which provides the operator with process visualization and control in a real-time environment. In the HMI system, this important interface is accomplished through CimEdit, a graphics editing package, and CimView, a high performance runtime viewing package.

CimEdit is an object-oriented program that creates and maintains the graphic screen displays that represent the plant systems to the operators. Powerful editing and animation tools, with the familiar Windows environment, provide an intuitive interface that is easy to use.

CimView is the run-time portion of the HMI system, where the operator sees the process information displayed in graphic and textual formats. With CimView, the operators can view the system screens and screens from other applications via OLE automation, run scripts, get descriptions of object actions, and display system and object help.

8.4.1.1.5.4.1.2 Functions Facilities

The operator interface, <HMI>, consists of a commercial grade PC, color monitor, cursor positioning device, keyboard, and printer, all installed in a panel. It can be used as the sole operator interface or as a local maintenance work station with all operator control and monitoring coming from communication links with a plant Distributed Control System (DCS) if any.

The Interface Operator is used for monitoring the operation of the turbine and the driven device, issuing commands to the control panel, (e.g. to view/acknowledge/reset alarm messages, advertise operator displays or maintenance and diagnostic displays, control parameters, etc …).

Following facilities are available on operators' interfaces:

- The main display shows the machine with important parameters such as shaft speed, exhaust temperature, fuel command, flame on-off, operating mode selected, control mode for fuel (speed, temperature, start-up) and a field showing three (3) alarms that have not been acknowledged.
- Various commands and operator's screen control list.
- An alarm management and log prints display, with alarm's time tags.
- Administrative display's (menu for various functions access)
- Diagnostics displays providing information on the machine condition and control system healthy.
- The monitoring and diagnostics can be performed in the following fields:
  - Power sources check in
    - Power distribution check in
    - Battery earth fault.
  - Display of following values:

- Thermocouple circuits
- Vibration transducers
- LVDT signals
- Servovalve current feedback
- Loopback testing (4-20 mA inputs)
- Tests on relay drivers
- Flame detectors UV light level
- Synchronization tests
- Trip contact status monitor
- Voting mismatch.

The logging printer 150 cps, dot matrix type provides an alarm log, event log, historical trip log and the ability to print hardcopies.

Commands may be given to the turbine and driven device, for example:

- Master control function:
- Start - Stop - Fast Load Start - Cooldown.
- Load control function:
- Base - Peak (if applicable) - Preselected - Droop - Isochrone.
- Speed / Load set point function:
- Raise - Lower.
- Fuel types (if applicable):
- Gas / Mix / Distillate.

8.4.1.1.5.4.1.3 Display Facilities

Many displays may be accessed for different view, such as:

- Data Display - The operator's normal display:

A menu of data can be selected by the keyboard to create a display which shows all key gas turbine parameters that are relevant to a particular mode (e.g. start-up - shut down - running - etc ...). Once a useful display is made, it can be saved and named for easy recall.

- Alarm Display:

System (process) alarms and diagnostics alarms for fault conditions are time tagged at frame rate in the Mark VIe control and transmitted to the HMI alarm management system. System events are time tagged at frame rate, and Sequence of Events (SOE) for contact inputs are time tagged at 1ms on the contact input card in the Control Module. Alarms can be sorted according to ID, Resource, Device, Time, and Priority. Operators can add comments to alarm messages or link specific alarm messages to supporting graphics.

- Load Display:

This view shows the load status (e.g. circuit breaker, kVA, MW, MVARS, temperatures, GT general diagram, etc ...). It presents a concise summary of plant information and is intended for general monitoring.

8.4.1.1.5.4.1.3.1 Colour Graphic Monitor Interface

The following displays are provided on the screen:

- Counters:
  - Total fired hours
  - Starts counter
  - Emergency stops counter
- Normal:
  - All normal operating data, automatically sequenced between shutdown status, start-up status and run status. First 3 unacknowledged alarms also appear on normal display.
- Alarm System (diagnostic):
  - Separate alarm list assessing status of the control panel hardware for use in troubleshooting, repair, etc., same features as alarms (operating).

8.4.1.1.5.4.1.3.2 Mark VIe Applicable Software

The Mark VIe is a fully programmable control system. Application software is created from in-house software automation tools which select proven GE control and protection algorithms and integrate them with the I/O, sequencing, and displays for each application. A library of software is provided with general-purpose blocks, math blocks, macros, and application specific blocks. It uses 32-bit floating point data (IEEE-854) in a QNX operating system with real-time applications, multitasking, priority-driven preemptive scheduling, and fast context switching.

8.4.1.1.5.4.1.3.3 Real Time Plot

Any Gas Control Panel data base points shall be easily selected for creation of a real time plot. The plot shall appear like a strip chart recorder with the oldest points disappearing at the left side of the screen and new points being added on the right side.

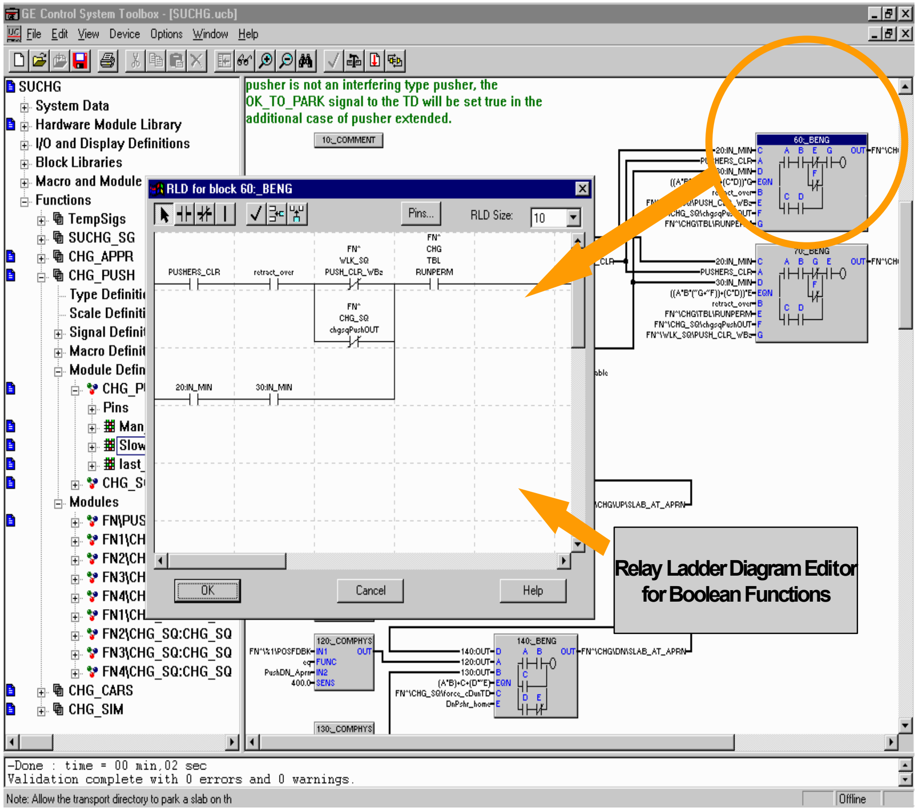
The HMI shall be capable of providing small windows with real time plots that could be called up by clicking on point name when in any display.

8.4.1.1.5.5 Software Maintenance Tools (ToolboxST)

The Mark VIe is a fully programmable control system. Application software is maintained by in-house software automation tools that select proven GE control and protection algorithms and integrate them with the I/O, sequencing, and displays for each application. A library of software is provided with general-purpose blocks, math blocks, macros (user blocks), and application specific blocks.

Changes to the application software can be made with multi-level password protection and downloaded to the controller(s) while the system is running without rebooting the main processors. In redundant control systems, the application software in each controller is identical and is represented as a single program to maintenance personnel. Downloads of changes are automatically distributed to the redundant controllers by the control system, and any discrepancies between the controllers are monitored by diagnostics. All application software is stored in the controller(s) in non-volatile memory.

Application software is executed sequentially and represented in its dynamic state in function block and ladder diagram format. Maintenance personnel can add, delete, or change analog loops, sequencing, I/O assignments, and tuning constants. To simplify editing, data points can be selected, dragged, and dropped on the screen from one block to another. Other features include logic forcing, analog forcing, and trending at frame rate.



- Same Maintenance Tools
  - Mark VI
  - Gen. Excitation Control
  - Static Starter
- Programmable
- Floating Point
- Dynamic Data
- Math Blocks
- Macros
- Editors For:
  - Application Software
  - I/O Assignments
  - Tuning Constants
- Password Protection
- Diagnostics Access
- Trending
- Forcing
  - Logic Data
  - Analog Data

Application software documentation is created directly from source code and can be compiled and printed at the site. This includes the application software diagram, I/O assignments, the settings of tuning constants, etc. The software maintenance tools (Control Systems Toolbox) are available for use in the HMI or as a separate software package on a Windows-based PC. The same tools are used for GE Generator Excitation Systems and Static Starters.

8.4.1.1.6 Diagnostics

I/O Packs contain system (software) limit checking, high/low (hardware) limit checking, and comprehensive diagnostics for abnormal hardware conditions. System limit checking consists of two (2) limits for every analog input signal, which can be set in engineering units for high/high, high/low, or low/low with the I/O configuration editor. In addition, each input limit can be set for latching/non-latching and enable/disable. Logic outputs from system limit checking are generated per frame and are available in the database (signal space) for use in control sequencing and alarm messages.

High/low (hardware) limit checking is provided for each analog input. These limits are not configurable and are selected to be outside the normal control requirements range but inside the linear hardware operational range (before the hardware reaches saturation). Diagnostic messages for hardware limit checks and all other hardware diagnostics for the card can be accessed with the software maintenance tools. A composite logic output is provided in the database for each I/O Pack, and another logic output is provided to indicate a high/low (hardware) limit fault of any analog input or the associated communications for that signal.

The alarm management system collects and time stamps diagnostic alarm messages at frame rate in the Controller(s) and displays the alarms on the HMI. Communication links to a plant DCS can contain both the software (system) diagnostics and composite hardware diagnostics.

Diagnostic LEDs are provided on I/O packs as previously shown for the Analog I/O pack. Standard LEDs indicate: power status, attention (abnormality detected), Ethernet link connected, and Ethernet link communicating. LEDs on discrete I/O packs also indicate the status of each point. All boards feature an electronic ID that contains the board name, revision, and a unique serial number. When power is applied to the I/O processor, it reads the ID of the terminal board, application card, and itself. It then uses this information for a start permissive, diagnostics, and system asset management. Since the terminal boards can be mounted remote at the equipment, local temperature sensors monitor the temperature at each I/O pack. Excessive temperature causes an alarm message. The alarm state and current temperature value are available for display and for use in the application software.

8.4.1.1.7 Communication

8.4.1.1.7.1 General

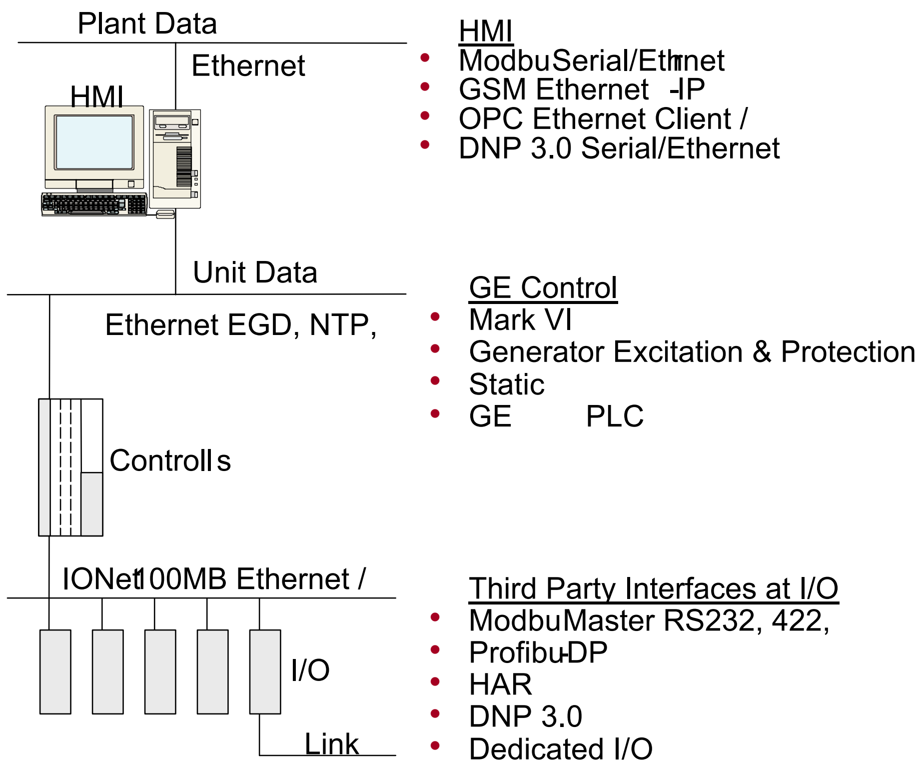
There are three (3) levels of communications:

- Internal Mark VIe Communications between its Controller(s) and I/O Packs
- Unit Level Communications between GE controls
- External Communications between Mark VIe and third party interfaces

Communications within a Mark VIe using IONet were discussed earlier. Communications between GE control systems is performed on the Unit Data Highway (UDH). This is an Ethernet based LAN with peer-to-peer communications. It uses Ethernet Global Data (EGD), which is a message based protocol with support for sharing information with multiple nodes based on the UDP/IP standard (RFC 768). Data can be broadcast to peer control systems with 4K of data shared with up to 10 nodes at 10ms. A variety of other protocols are used with EGD to optimize communication performance.

Control loops are normally closed within each unit control. Variations of this exist such as transmitting setpoints between turbine and generator controls for voltage matching and var/power factor control. Trips between units are normally hardwired even if the trip signals are passed between units on a redundant UDH.

Typical Third Party Interfaces



The UDH interface is located on the main processor board in the Mark VIe Controller. It is the same board that executes the application software and controls the IONet. This all-in-one design reduces failure points and maximizes data throughput. Network topologies conform to Ethernet IEEE 802.3 standards. External communications between Mark VIe and third party I/O and control /monitoring systems can be provided either from I/O Packs on the IONet or from a HMI.

8.4.1.1.7.2 Time Synchronization

Time synchronization is available to synchronize all controls and HMI's to a Global Time Source (GTS). Typical GTS's are Global Positioning Satellite (GPS) receivers such as the StarTime GPS Clock or other time processing hardware. Preferred time sources are Universal Time Coordinated (UTC) or GPS; however, the time synchronization option also supports a GTS using local time. The GTS supplies a time link network to one or more HMI's with a time/frequency processor board. When the HMI receives the time signal, it is sent to the Mark VIe(s) using Network Time Protocol (NTP), which synchronizes the units to within +/-1ms time coherence. Time sources that are supported include IRIG-A, IRIG-B, 2137, NASA-36, and local signals.

8.4.1.1.7.3 Typical Alarms List

The list below is a typical one which may be finalized according final design.

Alarm messages (1):

Alarms are logged as they occur with 62 ms resolution. These information are available for the operator on the display and on the printer.

The list below is a typical one which may be finalized according final design:

- System Failure - Check Diagnostic Alarms
- Fuel Hydraulic Trip Pressure Low
- Hydraulic Protective Trouble
- Aux. Lube oil Pump motor Running
- Aux. Lube oil Pump motor Running
- Aux. Hydraulic oil Pump motor Running
- Hydraulic Supply Pressure Low
- Lube oil Level High
- Lube oil Level Low
- Lube oil Pressure Low
- Emergency Lube oil Pump Motor Running
- Lube Oil Tank Temp Low
- Lube Oil Header Temp High
- Loss of Flame Trip
- Exhaust Thermocouple Trouble
- Cooling water level low
- Failure to Ignite
- Chamber flamed out during shutdown
- Exhaust Temperature High
- Flame Detector Trouble
- Air inlet filter differential pressure
- Turbine Incomplete Sequence
- Failure to Start
- Fire protection system trouble
- Fire in Turbine or Accessory Area
- Starting Device Protective Lockout
- Cooldown system trouble
- Starting motor overload
- FSR Gag Not At Max. Limit
- Customer trip
- Turbine Compartment Temp High
- Vibration Transducer Fault
- Master Protective Start-up Lockout
- 20 % Speed and no Flame
- Compressor Bleed Valve Position Trouble
- MCC Undervoltage
- Battery charger AC Undervoltage
- Battery DC Undervoltage
- Battery 125 DC Ground
- DC Motor Undervoltage (lube oil)

- Auxiliary Motor Overload
- Manual Trip
- Low Lube Oil Pressure Trip
- Underspeed Trip
- High Vibration Trip Level
- Start-up Fuel Flow Excessive Trip
- High Exhaust Temp Spread Trip
- Exhaust Over-temperature Trip
- Electrical Overspeed Trip
- Starting Device Trip
- Lube Oil Header Temp High Trip
- Off-line diagnostic running
- Wheelspace Temp Differential High
- Wheelspace Temperature High
- Fuel Pressure Low (if applicable)
- Fuel Pressure High (if applicable)
- Vibration Detectors Trouble
- Vibration Sensors Inoperative or Disabled
- High Vibration Alarm Level
- Lube oil Temperature Switch Trouble
- Lube Oil Pressure Switch Trouble
- Fuel Hydraulic Pressure Switch Trouble
- Fire Detector System Trouble
- Main Lube Oil Filter Differential Pressure high
- Hydraulic filter Differential Pressure high.

Turbine trip log:

If a trip occurs, the trip log captures all key control parameters and alarm messages at the time of the trip and at several time intervals preceding the trip. (Typically 38 pre-trip samples for 63 parameters, three [3] post-trip samples for 63 parameters and up to 63 alarms captured at the time of the trip).

8.4.1.1.8 Codes and Standards

ISO 9001 in accordance with Tick IT by Lloyd's Register Quality Assurance Limited. ISO 9000-3 Quality Management and Quality Assurance Standards, Part 3: Guidelines for the Application of ISO 9001 to Development Supply and Maintenance of Software.

- Safety Standards
  - UL 508A Safety Standard Industrial Control Equipment
  - CSA 22.2 No. 14 Industrial Control Equipment

- Printed Wire Board Assemblies
  - UL 796 Printed Circuit Boards
  - UL recognized PWB manufacturer, UL file number E110691
  - ANSI IPC guidelines
  - ANSI IPC/EIA guidelines
- Electromagnetic Compatibility (EMC) Directive 89/336/EEC
  - EN 50081-2 Generic Emissions Standards
  - EN 50082-2:1994 Generic Immunity Industrial Environment
  - EN 55011 Radiated and Conducted Emissions
  - IEC 61000-4-2:1995 Electrostatic Discharge Susceptibility
  - IEC 6100-4-3: 1997 Radiated RF Immunity
  - IEC 6100-4-4: 1995 Electrical Fast Transient Susceptibility
  - IEC 6100-4-5: 1995 Surge Immunity
  - IEC 61000-4-6: 1995 Conducted RF Immunity
  - IEC 61000-4-11: 1994 Voltage Variation, Dips, and Interruptions
  - ANSI/IEEE C37.90.1 Surge
- Low Voltage Directive 72/23/EEC
  - EN 61010-1 Safety of Electrical Equipment, Industrial Machines
  - IEC 529 Intrusion Protection Codes / NEMA 1 / IP 20
  - Reference the Mark VI Systems Manual GEH-6421, chapter 5 for additional codes and standards.
- ATEX Directive 94/9/EC
  - ISO 9001: In accordance with Tick IT by Quality Management Institute (QMI)
  - ISO 9000-3: Software certified to Quality Management and Quality Assurance Standards, Part 3: Guidelines for the Application of ISO 9001 to Development, Supply, and Maintenance of Software

8.4.1.1.9 Environment

The control is designed for operation in an air-conditioned equipment room with convection cooling. Special cabinets can be provided for operation in other types of environments.

Temperature:

Operating 0 to +45 C +32 to +113 F

Storage -40 to +70 C -40 to +158 F

The control can be operated at 50°C during maintenance periods to repair air-conditioning systems. It is recommended that the electronics be operated in a controlled environment to maximize the mean-time-between-failure (MTBF) on the components.

Purchased commercial control room equipment such as PCs, monitors, and printers are typically capable of operating in a control room ambient of 0 to +40°C with convection cooling.

- Humidity

5 to 95% non-condensing

Exceeds EN50178: 1994

- Elevation

Exceeds EN50178: 1994

- Gas Contaminants

EN50178: 1994 Section A.6.1.4 Table A.2 (m)

- Dust Contaminants

Exceeds IEC 529: 1989-11 (IP-20)

- Seismic Universal Building Code (UBC)

Section 2312 Zone 4

8.4.2 Description of Generator Control Equipment

8.4.2.1 General:

This cubicle includes the following functions:

- Excitation power circuits
- Voltage regulation
- Generator protection
- Control

This equipment is used for the control of the generator.

8.4.2.2 Structure:

Freestanding cubicle, protection degree IP 21, equipped with the necessary lifting facilities.

Cabinet equiped with heater resistor, thermostat, light & plugs.

Doors are foreseen for the easy access to the different devices implemented inside the cubicle. The opening of the doors are of 90° maximum with a mechanical stop at 90°. The doors are key locked.

All devices have easy removal for replacement.

8.4.2.3 Description:

Generator excitation voltage is supplied via a dry type transformer, from the MCC.

The transformer voltage is rectified through a rectifier bridge in normal operation mode. There is one other bridge for SFC mode, during the machine start-up, for generator direct excitation like synchronous motor.

The excitation system supplies the inductor of the rotating diode exciter.

8.4.2.3.1 Excitation Functions:

Starting Conditions are:

- Closing order received
- No tripping signal present
- Speed >90%

If the regulator is available, the closing order causes the closing of the field breaker and the increase of the stator voltage up to the automatic channel set point (automatic sequence).

- Flashing/Forcing System (supply change-over):

The same circuit is used either for flashing if needed (excitation transformer supplied by generator bus), or for forcing if excitation is fed by MCC (supply change-over). The necessary supply for this operation is taken from the battery: 125Vdc.

If excitation transformer fed by generator bus : the flashing circuit allows the stator voltage built up after that the turbine is at 90% of rated speed. When the stator voltage reaches about 50% of its rated value, this circuit is switched off, the power bridge is then in operation.

The flashing circuit is activated until the voltage threshold is reached, during that, a time delay relay monitors the maximum acceptable flashing time. When the relay acts, if the voltage is not over the set threshold, a tripping order is given to the excitation breaker.

If excitation transformer fed by MCC : the excitation supply is normally fed by the MCC 400 Vac circuit. If for any reason, this voltage is no more available, an under voltage relay connected to this bus will automatically switch over from the normal supply to a 400 Vac customer supply independent from our system. During this switch-over, a single-phase thyristor rectifier connected to the 125 Vdc battery allows the excitation generator at an intermediate field current, this to avoid any loss of excitation. The forcing is validated only when the excitation breaker is closed and generator breaker is closed.

- Boosting:

The excitation power circuit is fed by excitation transformer. If stand by circuit is not secured during transient conditions (i.e. short circuits), the excitation supply voltage is no more sufficient to maintain the excitation value, this circuit is therefore triggered to permit the activation at 70% of stator voltage of the excitation ceiling.

The supply of the boosting circuit is taken from the 125 Vdc battery.

The boosting is stopped as soon as the stator voltage reaches 80% of rated stator voltage. The duration of the boosting sequence is limited by the excitation ceiling time. If the stator voltage stays under the high threshold after the ceiling time delay (about 10 seconds), the excitation system is tripped. Typical ceiling values is 1.6 pu.

- Field Breaker Opening:

The field breaker opening will be allowed only if the unit breaker open position acknowledgement is given to the excitation system. This is to avoid the generator from running under asynchronous mode.

- Rotating Diode Fault (74DR):

The rotating diode fault detection is able to detect exciter diode fault. This detection is carried out by rotating earth fault detection. If the threshold is reached, the excitation system is tripped.

- Over-Excitation:

The excitation current level is controlled by the automatic voltage regulator (permanent limitation: 1,1*Ifn and ceiling limitation: 1,6 Ifn for typical values). In case of generator non-eliminated fault or regulation failure, the excitation current level may exceed the permanent limitation.

A protection relay connected to a shunt measures the current and ensures the following actions :

Gives a change over order to the regulation to go to manual regulation if the threshold is reached for more than 12 seconds typical time.

Gives a trip order to the excitation breaker if the threshold is reached for more than 14 seconds typical time.

Rectifier Bridge Back-Up:

A second rectifier bridge can be added to improve the availability of the excitation system. This device has the same characteristics than the first one. The first bridge is selected for normal operation. The second one is remained in stand-by mode. If a fault occurs in one of the two (2) rectifier bridges, the second will carry out the full load of the excitation system.

8.4.2.3.2 Regulation Functions:

This system function is to regulate the generator stator voltage by adjusting its field current.

The excitation field current value is permanently controlled by the generator regulation.

- The regulation system functions are to :
  - Adjust the generator stator voltage
  - Be active for the stability of energy evacuation to the grid
  - Have a good response time on troubles (short circuits...)
  - Keep the generator in its stability area
- The regulation is divided in two (2) channels :
  - Automatic channel including the stator voltage regulation (Digital Voltage Regulator) with the four following realized functions :
    - Excitation current limitation
    - Under excitation limitation
    - Volt / Hertz limitation
    - Line droop compensation
  - Manual channel including the manual excitation current loop (Digital Current Regulator)
- Regulator performances :
  - Automatic regulation set point range: 90 % to 110 % typical of rated voltage, accuracy: +/- 0.5%
  - Manual regulation set point range: 30 % of no load to 110 % of rated excitation current; accuracy: +/- 0.5%
  - Line droop compensation setting value : 0 to +/- 10 %
  - Excitation current permanent limitation setting to 1.1*Ifn
  - Over-excitation ceiling setting to 1.6 Ifn for 10 s (typical setting)
  - Frequency range limit: 5 Hz to 90 Hz

- Display & keyboard :

A regulation display device is required to permit easy access for normal operation, tests and maintenance. This display will indicate status, measurements, alarms and faults dedicated to the regulation purpose.

- Optional Functions :
  - Stator current limitation
  - Stator voltage limitation
  - Power System Stabilizer (PSS) software enable
  - Power System Stabilizer (PSS) study
  - Power System Stabilizer (PSS) tuning on site

8.4.2.3.3 Protection Functions:

The protection system function is to protect the generator.

The protection system includes the necessary treatment, interface display and control for the trips and alarms initiation.

- Measurement:

All currents, voltages measured and calculated values can be displayed. The measurement card includes necessary filtering and calibrating circuits.

- Display & Keyboard:

A protection display device is required to permit easy access for normal operation, tests and maintenance. This display will indicate status; measurements, alarms and faults dedicated to the protection purpose.

- Watch-Dog and Cold Tests:

Cold tests are carried out by the relay when it is energized.

Continuous self-monitoring, in the form of a watchdog, memory checks and analog input module tests, is performed. In case of a failure, the relay will either lockout or attempts a recovery, depending on the type of failure detected.

- Field protection functions:
  - The field protection includes the following :
  - Protective relays in AVR:
    - Rotor Earth Fault (64F) logic treatment
    - Field Overcurrent (50/76)
    - Rotating Diode Fault (74DR)
- Generator protection functions:
  - The protection includes the following :
  - Generator protective relays:
    - Generator differential (87G)
    - Negative phase sequence (46)
    - Reverse power (32R)
    - Generator overvoltage (59)
    - 95% stator earth fault (51GN or 64G) by current

- Loss of excitation (40)
- Voltage restrained overcurrent (51V)
- Leads earth fault (64B)
- Overfluxing (59/81 or 24)
- Over & under frequency (81O-81U)
- Undervoltage (27)
- Balance voltage (60VTS)
- accidental energization (50/27)
- breaker failure (50BF)

- Calculation note for protection settings included

8.4.2.3.4 Control Functions:

The control system includes the necessary treatment and HMI interface for the included functions.

The control equipment is directly connected to the excitation, regulation and protection.

The control includes the following functions:

- Display for electrical data, alarms and status
- Manual synchro on the HMI
- Excitation Ammeter.
- Excitation Voltmeter
- Tripping relay monitoring for main breaker(s)
- AVR communication port
- Protection relay communication port
- Active and reactive energy meter classe 0,2

8.4.2.3.5 Wiring

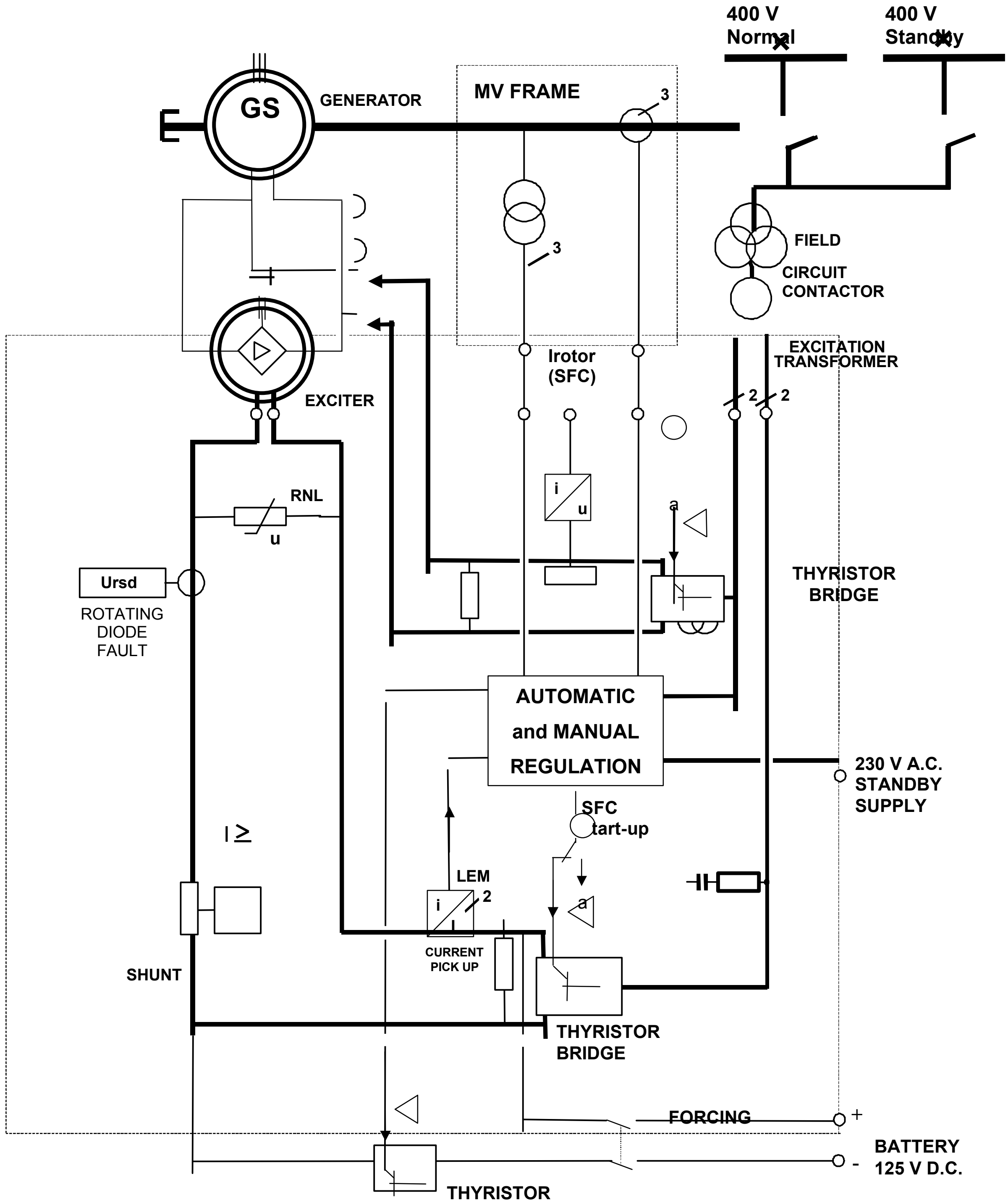
- Wiring entry:

All the external wiring coming to the cubicle is realized by the bottom. A gland plate (removable from indoor), sufficiently sized for the complete wiring, is installed.

- Wiring

PVC insulation	yellow-green for the ground wire grey for the others
Operating voltage	750 V rms.
Minimum section	1 mm² for control-command circuit

BRUSHLESS EXCITATION SCHEME



8.4.3 Description of Auxiliary Equipment

8.4.3.1 Description of Control Compartment

The Turbine Control Compartment (ISO container- refer to internal arrangement) is designed to house the following equipment:.

- Generator control panel
- Turbine Control Panel
- Motor Control Center (MCC)
- Human machine interface

8.4.3.1.1 Characteristics

8.4.3.1.2 Structure

The TCC is designed IP54 for outdoor use, except HVAC IP44. A single fabricated structural base is provided for the support of the equipment contained in the TCC.

The base is sufficiently rigid to permit, handling, and skidding during shipment and installation as a fully assembled unit except for the batteries.

Two (2) doors are provided in the electrical/control compartment. Each door is provided with an emergency release panic bar on the inside and keyed lockable (for the main entrance only) handle on the outside.

The removable floor of non-slipping type allows an easy wiring between the internal equipments.

8.4.3.1.3 Enclosure Lighting and Receptacles

Industrial type fluorescent lighting system is provided in the cubicles inside the TCC. It's controlled by two (2) switches located near each door.

125 VDC stand-by lighting is provided. It shall automatically be energized whenever the normal AC lighting power source is unavailable.

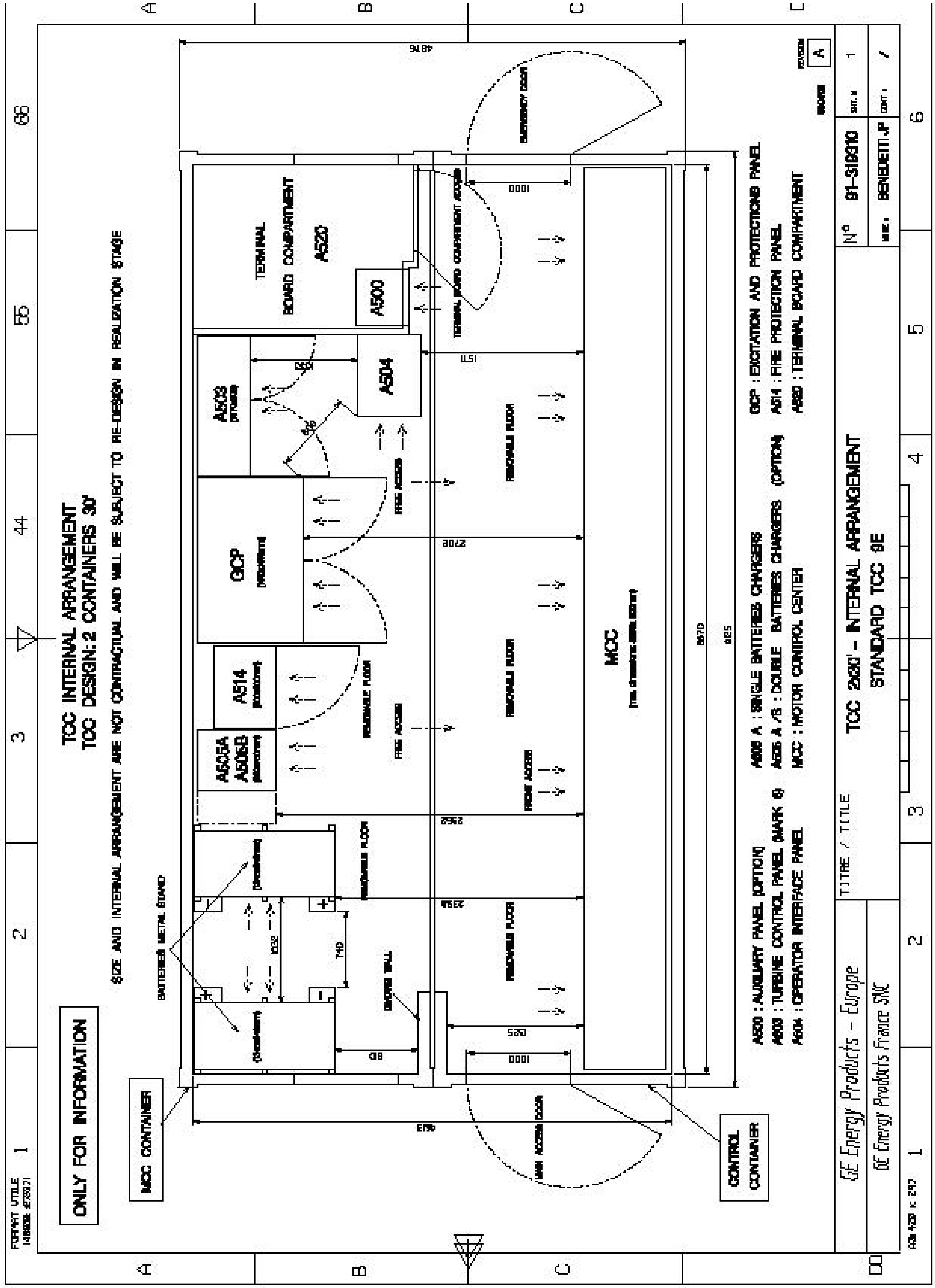
General purpose convenience outlet is provided.

8.4.3.1.4 Enclosure Heating, Ventilating and Cooling System

Two redundant (2x100%) space heaters and air conditioners are provided to maintain an ambient temperature inside the TCC under all combinations of site conditions. Temperature switch is furnished to provide over and under temperature alarms.

8.4.3.1.5 Wiring

All the external wiring is connected to the terminal board compartment excepted power cables connected directly to the MCC. The terminal type is dedicated to the different circuit: control, measures, safety and power.



TCC INTERNAL ARRANGEMENT
TCC DESIGN: 2 CONTAINERS 30'
SIZE AND INTERNAL ARRANGEMENT ARE NOT CONTRACTUAL AND WILL BE SUBJECT TO RE-DESIGN IN REALIZATION STAGE
ONLY FOR INFORMATION
MCC CONTAINER
CONTROL CONTAINER
BATTERIES METAL STAND
TERMINAL BOARD COMPARTMENT
A520
A500
A503
A504
GCP
A514
A505A
A505B
MCC
REMOVABLE FLOOR
FREE ACCESS
FRONT ACCESS
DIVIDING WALL
MAIN ACCESS DOOR
EMERGENCY DOOR
A500 : AUXILIARY PANEL (OPTION)
A503 : TURBINE CONTROL PANEL (MARK 6)
A504 : OPERATOR INTERFACE PANEL
A505 A : SINGLE BATTERIES CHARGERS
A505 A /B : DOUBLE BATTERIES CHARGERS (OPTION)
MCC : MOTOR CONTROL CENTER
GCP : EXCITATION AND PROTECTIONS PANEL
A514 : FIRE PROTECTION PANEL
A520 : TERMINAL BOARD COMPARTMENT
TITRE / TITLE
TCC 2X30' – INTERNAL ARRANGEMENT
STANDARD TCC 9E
GE Energy Products – Europe
GE Energy Products France SNC
BENEDETTI.JP
A

8.4.3.2 Description of Battery Container

The Battery Container (ISO container) is designed to house the following equipment:

- The unit batteries
- The air conditioning

8.4.3.2.1 Structure

The battery container is designed for outdoor use to withstand the site conditions (IP54). A single fabricated structural base is provided for the support of the equipment installed inside the container

The base is sufficiently rigid to permit, handling, and skidding during shipment and installation as a fully assembled unit except for the batteries

8.4.3.2.2 Enclosure Lighting and Receptacles

Industrial lighting system and one socket are installed inside the battery container

8.4.3.2.3 Enclosure Heating, Ventilating and Cooling System

One space heater and air conditioner are provided to maintain an adequate ambient temperature for the batteries inside the container under all combinations of site conditions. Temperature switch is installed to provide over and under temperature alarms

8.4.3.3 Description of the Motor Control Center (MCC)

8.4.3.3.1 General

The MCC is used to feed power to all the gas turbine auxiliaries. It is equipped with incoming column(s), outgoing drawers, and sub distribution panels (AC and DC).

8.4.3.3.1.1 Technical Data

8.4.3.3.1.1.1 Mechanical

- Protective degree: IP 32
- Form: 3b (IEC) for withdraw able section and incoming Breakers
- Incoming supply by cable
- Cable entry and outgoing on the bottom of the cubicle
- connecting access by Front Access.
- Seism: 0,4 g

8.4.3.3.1.1.2 Electrical

- Standard: IEC 60 439-1, IEC 60 947, IEC 60-695, IEC 61-641, IEC 60-073, IEC 60-364
- Vertical 1000A bare Copper bus bars
- Horizontal 1600A bare Copper bus bars
- Short circuit current main AC bus bar:
  - 50 kA –1 sec

- Short circuit current main DC busbar:
  - 42 kA –1 sec
- Rated insulation voltage: 1000V
- Number of phases: 3
- Neutral grounding mode: solidly grounded, not distributed

8.4.3.3.1.2 Description

8.4.3.3.1.2.1 Incoming Panel

The incoming panel is equipped with 2 open air circuit breakers mechanically and electrically interlocked. In case of under voltage fault on main Bus bar, the supply is automatically switched to the Standby breaker.

When the fault disappeared the supply switches back automatically on Normal circuit breaker.

8.4.3.3.1.2.2 Panel with Outgoing Withdrawable Feeders

All critical energy consumers are powered from the drawers. These drawers are equipped with:

- Fuses and contactors (with thermal protection)

All the drawers are controlled by input contacts coming from the associated skid or Speedtronic™.

Each drawer can be locally controlled from MCC front panel with a three (3) positions switch (Stop/Auto/Manu) and with 3 signal leds (ON/OFF/Fault).

8.4.3.3.1.2.3 AC Sub-Distribution Panel

- AC sub-Distribution

This sub-distribution is equipped with fixed circuit breakers or miniaturized circuit breakers and circuit breaker-contactors. This sub-distribution is fed by a transformer included in the MCC. The neutral for the sub-distribution is realized by this transformer.

Those feeders are used for lighting, panels and other auxiliaries, if necessary.

8.4.3.3.1.2.4 DC Sub-Distribution Panel

This subdistribution is supplied by unit battery and battery charger.

This part of subdistribution is used for Emergency lube oil pump, over excitation, turbine regulator and all Direct Current feeders.

8.4.3.3.1.2.5 AC UPS Sub-Distribution

This subdistribution is used mainly to energize Generator Control Panel and Speedtronic™ Human Machine Interface

8.4.3.3.1.2.6 Excitation System Supply

This equipment includes the following:

The excitation transformer, three (3) phases natural air cooled type with primary voltage fed by the MCC and rated power adapted to the type of generator.

The SFC starting transformer, three (3) phases natural air cooled type with primary voltage fed by the MCC and rated power adapted to the type of generator.

The transformer is provided with temperature sensors.

8.4.3.4 Description of Battery and Charger

8.4.3.4.1 Battery and Battery Chargers

Sequencing circuits and emergency functions are fed from the unit battery. Which is supplied from the battery chargers.

8.4.3.4.1.1 The Battery Chargers

The 4 battery chargers are fed from the a.c. auxiliary sub-distribution, and provides a regulated direct voltage, with current limitation by an electronic regulator and thyristor/diode units. Each Battery charger is associated with one dedicated battery.

Each one is suitable for 50% of the total battery capacity

There are two (2) operating modes which are selectable either from a keypad or programmable in automatic for floating/equalizing.

Output values of the charger:

- Automatic mode:
  - Floating-Equalizing: 2.27V/cell 136.2V
  - Nominal current (In):64 A*
- Manual mode:
  - Commissioning: 2.40V/cell: 144V (with consumers disconnected)

An AC UPS system, is supplied in order to mainly energize the Generator Control Panel and Speedtronic^{TM} Human Machine Interface (HMI). Its rated power is 3000VA.

8.4.3.4.1.2 The Unit Battery

The unit battery is composed of 4 batteries which represents 4x50% of total capacity required. Each battery is associated with its own battery charger. The unit battery is constituted with batteries stationary sealed gas recombinaison lead acid cells (Valve Regulated Lead Acid), the battery has the following characteristics:

- Floating voltage: 2.27 V/cell
- End voltage: 105 V
- Capacity: 4 x 366 Ah*
- Autonomy: 2 x 6 hours (twice the battery capacity necessary for a safe shutdown)

* A slight modification of the value is possible according to the supplier selected

9. Design Basis

9.1 Fuel System Design Conditions

9.1.1 Gas Fuel

The gas fuel shall have the physical and chemical characteristics required in the attached specification GEI-41040 and in the Design Basis.

Allowable gas fuel supply conditions at the inlet flange of the final coalescing filter (see filtration efficiency below)

- Pressure range: 27.05to 34.5 barg
- Temperature: GE currently requires the Gas Fuel supplied at terminal point connection to be superheated. The requirements and basis of this superheat are defined in Specification GEI-41040. If sufficient superheat is not supplied, liquid hydrocarbons may condense inside the gas fuel stream and result in damage to unit hardware.
- GE requires the use of a redundant continuous Hydrocarbon dew point analyzer which shall be a 4-20mA analog signal from the plant level control system that represents the real time measurement of the Hydrocarbon dew point of the gas fuel.
- Minimum temperature based on the contractual gas composition below is calculated in order to be compliant with GEI-41040 regarding the hydrocarbon dew point, the water dew point and the maximum Modified Wobbe Index requirement.
- Maximum temperature: Consistent with range of Modified Wobbe Index variation

Gas fuel name	Natural Gas
Maximum hydrocarbon dew point (°C)	-42
Maximum moisture dew point (°C)	-3.9
Calculated minimum temperature (°C)	6.9
Calculated maximum temperature (°C)	69.1
Modified Wobbe Index range (min/max) (Btu.scf-1.R-1/2)	48.17 to 53.24

- Maximum Transient supply pressure excursions are limited to either 1% per second ramp or 5% step. The 1% per second ramp is applicable over the range of minimum required pressure to maximum operating pressure. The 5% step is applicable over the range of minimum required pressure to 95% of maximum operating pressure and with a maximum of one 5% step change in 5 seconds.

Note: Transient Supply Pressure operation applies to brief periods associated with pressure control mode transfers such as transfer between gas fuel pressure regulating valves, gas compressor changeovers or gas supply source changeovers, or rapid fuel demand transients such as Gas Turbine load rejections or trips.

- The steady state gas supply pressure regulation at any operating point within the gas turbine capability shall remain within more or less 1 % pressure at a rate not to exceed more or less 0.25 % / sec over the range of minimum required pressure to maximum operating pressure.
- In case of use of a pressure boosting compressor, no oil content shall be present in the fuel gas.
- Filtration efficiency (absolute removal efficiencies): all solid particles whose size is greater than 0.3 microns shall be filtered with an efficiency of 99.99% and all liquid particles whose size is greater than 0.3 microns shall be filtered with an efficiency of 99.5%.
- Wobbe index variations:
  - Wobbe index variation range, with temperature correction, shall not be more than more or less 5% during start up sequence.
  - Wobbe index variation range, with temperature correction, shall not be more than more or less 5% during normal operation.
  - During normal operation, the wobbe index variation of the gas fuel with temperature correction shall not be more than +/- 0.15% per second and temperature rise shall not exceed 1°C/s

MWI = LHV / Sqrt (Sg * T)

Where:

LHV: Low Heating Value (Btu/Scf)

Sg: Specific gravity relative to air

T: absolute Temperature (°Rankine)

The gas fuel analysis used as design criteria and for performance calculation is as per :

Gas Fuel Composition	
Fuel Description	
Constituent	Volume %
N2 Nitrogen	1.427
CO2 Carbon Dioxide	0.638
CH4 Methane	95.36
C2H6 Ethane	2.355
C3H8 Propane	0.161
N-C4H10 Normal Butane	0.022
I-C4H10 Iso-Butane	0.017
N-C5H12 Normal Pentane	0.006

Gas Fuel Composition	
I-C5H12 Iso Pentane	0.006
C6H14 Hexane	0.004
C7H16 Heptane	0.002
C8H28 Octane	0.002

9.1.2 Light Distillate

Light distillate fuel shall be in accordance with specification GEI 41 047 category "true distillate-light", specially regarding trace metal contaminants.

Supply conditions at inlet flange of the light distillate forwarding pumps skid:

- Gravity flooded
- Minimum pressure: 8 mLC of required NPSH at 400 mm above the top of the forwarding skid pedestal
- Maximum pressure: 3 bar(g)
- Temperature: Higher than pour point and waxes melting point and consistent with the required viscosity
- Viscosity: 1.8 to 10 cSt (without downstream liquid fuel heating)

No isolating valves are permitted in the return piping between the filtering skid and the storage tank. The point of the discharge into the storage tank shall be above the maximum liquid level so that a rupture will not drain the tank. The minimum level in the storage tank shall be at least 0.5 m above the top of the forwarding skid pedestal.

A return piping between the filtering skid and the storage tank will be able to (refer to technical memo table) flow and sized for max 2.5 bar counter pressure at skid outlet flange (including tank height).

As the piping between the forwarding skid and the filtering skid is not included in the GEEPE scope, the maximum pressure drop between these two skids must not exceed 1 bar.

The light distillate fuel analysis used as design criteria and for performance calculation is as per :

Liquid Fuel Analysis	
Characteristics	
Lower Heating Value [kJ/kg]	42 566
Flash Point [°F / °C]	45°C
Carbon Residue Conradson s/10% [Wt (%)]	0.1
Sulfur [Wt (%)]	0.25
Viscosity at 40°C [cST]	2 to 4.5
H2O [vol(%)]	0.03
Ashes [ppm]	80
Vanadium + Lead [ppm]	0.5
Sodium + Potassium [ppm]	0.5

Liquid Fuel Analysis	
Aromatics content [%vol]	5 – 30
Olefins contents [%vol]	5
Density (15°C) [g/cm3]	0.82 – 0.89
90% Distillation temp [°C]	360

Fuel-bound Nitrogen information is not provided, and is assumed to be less than 0.015% weight. If actual value is higher, the NOx guarantee level will be affected.

The 90% distillation point of 360C is higher than normal and could result in smoke or soot in the exhaust emissions.

9.2 Lube Oil

The lube oil shall be in accordance with attached specification GEK 101941.

9.3 Washing Water

9.3.1 Compressor Washing Water (On-Off Line)

9.3.1.1 Water Quality

Compressor washing water shall be in accordance with GEK 107122.

Water quality required for compressor washing:

Refer to table 1 of GEK-107122

In addition to GEK-107122, following requirements should apply for on line water washing:

Silica : < 5 ppm

Conductivity : < 1 microS/cm

Chemical content of washing detergent:

- Refer to table 3 of GEK-107122

9.3.1.2 Water Requirements

Depending on the turbine frame, the flow adjustment and on the duration, the quantity of water required for a complete off-line washing sequence will vary from 1.5 m3 to 3.1 m3 for compressor washing. For details, please refer to GEK-107122.

Off-line water washing shall be done at a compressor inlet temperature not less than 4°C.

For each compressor on-line washing, 567l to 1475l of water will be necessary.

Between +10°C to -10°C antifreeze shall be added to water.

9.4 Cooling Water

9.4.1 Gas Turbine Or GT and Generator Cooling Water (for GEEPE Closed Circuit)

The cooling water quality for closed loop shall be in accordance with the specification GEI-41004.

9.5 Water for NOx Control

Water at the inlet flange of the injection skid should meet the following criteria, which are a summary of the water quality specifications furnished in the liquid fuel specifications GEI-41047 paragraph 5.2 and "Requirement for water/steam purity in GT; GEK-101944 associated with document GE-334A7731.

Quality: see document GE-334A7731

Supply conditions:

Pressure:	1 to 3 bar(g)
Flow:	Refer to the Performance Data chapter of this proposal

9.6 Compressed Air Quality

9.6.1 Compressed Air for Instrument

	Quality	Pressure	Flow
Bleed heating valve: Air consummation in stabilized operation	Dry	3.4 to 17.2 bar(g)	< 0.79 Nm3/h
Bleed heating valve: Air consummation in transient	Dry	3.4 to 17.2 bar(g)	21 10-3 Nm3 at 3 bar during 4 s
Water injection skid	Dry	6.2 to 8.3 bar (g)	
LDO filtering skid	Dry	4 to 10 barg	max 1Nm3/h

9.7 Electrical Auxiliary Consumptions

Power Station Electrical Auxiliary Consumptions are estimated values only for design and information purposes, and are not guaranteed. In these here below tables GE has considered maximum estimated values.

9.7.1 MCC supply:

	Values
During base load operation	924 kW in LV
During starting period	909 kW in LV
During stand-by period	250 kW in LV
During baring Period	557 kW in LV

9.7.2 Supplied from other source:

	Values
During base load operation	250 kW in MV
During starting period	2500 kW in MV
During stand-by period	0 kW

9.8 Noise Level Data

The average sound pressure level measured at a distance of 1 meter from the gas turbine turbine-generator set and at 1.5 m height above ground shall not exceed 85dB(A).

NOISE RELEVANT STANDARDS

Please refer to the “Codes and Standards” chapter.

TEMPORARY NOISE SOURCES

Are considered as temporary noise sources:

- The noise emissions emitted by the atmospheric safety relief vent valves

These temporary noise sources are not taken into account in our data or calculation.

9.9 Exhaust Data

Please refer to exhaust interface specifications:

N° 91-436 900 Exhaust Interface Specification (silencer outlet flange)

Note: Flow data in the document above are given only at base load operation, ISO conditions.

9.10 Voltage and Current Levels

11.5 kV Generator Outgoing

Rated voltage:	11,5 kV +/- 5%
Rated frequency:	50 Hz +/- 2%
Number of phases:	3
Neutral earthing mode:	MV resistance

6.6 kV Medium Voltage

Rated voltage:	6.6 kV
Rated frequency:	50 Hz
Number of phases:	3

Static Frequency Converter

In order to meet the international requirement regarding harmonic rejection, the short-circuit power at SFC transformer circuit breaker connection point has to be at least 125 MVA.

400 VAC Switchboard (Motor Control Center)

Rated voltage:	400 V +/- 10%
Rated frequency:	50 Hz +/- 2%
Number of phases:	3
Neutral earthing mode:	TNC (solidly earthed not distributed)
Maximum short circuit current (at busbar):	50 kA - 1 second

230VAC Sub-Distribution/115VAC(only required)

Rated voltage	230 V
Rated voltage variation range	±10%
Rated frequency	50 Hz ±2%
Number of phases	1
Rated power	40 kVA

230 VAC UPS

Rated voltage	230 V
Rated voltage variation range	±10%
Rated frequency	50 Hz ±2%
Number of phases	1
Rated power	3000 VA

125 V-DC Switchboard (Distribution)

Rated voltage:	125 V + 10% - 16%
Earthing mode:	Isolated

9.11 Codes and Standards

The used codes and standards for the Gas Turbine Generator and its auxiliaries are listed in the Codes and Standards chapter.

For others codes and standards not mentioned in this specification, Manufacturer standards shall apply.