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1. Scope of Supply

SGT-400 gas turbine generator set , comprising :

1.1 Driven Unit

1.1.1 Generator

- AC Generator,
  - 11 kV
  - 3 phase,
  - 50Hz
  - 4 pole,
  - 0.8 power factor,
  - Cylindrical pole brushless type
  - Filter ventilated
  - Class 'F' insulation with class 'F' total temperature rise
- Generator bearing temperature instrumentation
- Lubricating oil piping from gas turbine to driven unit

1.2 Gas Turbine Package

1.2.1 Gas Turbine Engine

- Core Engine – twin shaft design
- Gas Generator
  - Air Inlet Casing
  - Compressor Rotor
  - Compressor Stator with Variable Guide Vanes
  - Centre casing
  - Combustion System – Dry Low Emissions (DLE)
  - Compressor Turbine Rotor
  - Compressor Turbine Stator
- Power Turbine
  - Hot Gas Interduct
  - Power Turbine Rotor
  - Power Turbine Stator
  - Output Shaft Drive
  - Exhaust Outlet Casing
- Engine arranged for hot end drive
- Engine bearing temperature instrumentation

1.2.2 Underbase

- Underbase – fabricated carbon steel construction, arranged for multi-point mounting
- Mounting assemblies for the gas turbine core, auxiliary gearbox, auxiliaries, and driven unit (separate underbase)
- Integral lubricating oil tank – carbon steel

1.2.3 Start System

- Hydraulic Motor and Pump - AC electric motor driven

1.2.4 Gears, Couplings and Guards

- Main speed reducing gearbox – epicyclic type, output shaft speed 1500 rpm
- Gearbox seismic vibration instrumentation
- Auxiliary gearbox incorporating drives for start system and lubricating oil pump
- Drive coupling – high speed - flexible element dry type – Turbine to gearbox

- Drive coupling - low speed - flexible element dry type - Gearbox to AC generator
- Coupling guard - high speed (carbon steel) - turbine to gearbox
- Coupling guard - low speed (carbon steel) - gearbox to driven unit

1.2.5 Lubricating Oil System

- Integral mineral oil lubricating system serving the gas turbine, gearbox and driven unit
  - Lubricating oil pump main - gas turbine gearbox driven
  - Lubricating oil pump auxiliary - AC motor driven
  - Lubricating oil pump emergency - DC motor driven
- Lubricating oil system filter
  - Duplex filter arrangement
  - Continuous flow transfer valves
  - Conforms to API 614
  - Filter body - carbon steel
  - Differential pressure indicator
- Temperature and Smart type pressure & level transmitters - aluminium bodies
- Lubricating oil tank immersion heater
- Lubricating oil system breather
  - Lubricating oil breather oil mist eliminator
  - Lubricating oil breather ducting – austenitic stainless steel
- Lubricating oil system cooler
  - Airblast Simplex Lubricating Oil Cooler – package roof mounted
  - Cooler Fan – single (100% duty)
  - Suitable for a non-hazardous area
  - Lubricating oil cooler piping supply and return - austenitic stainless steel

1.2.6 Gas Fuel System

- Pilot fuel flow control system with actuator and integrated pressure transmitters
- Main fuel flow control system with actuator and integrated pressure transmitters
- Rapid-acting gas shut-off valves (2-off)
- Temperature transmitter - aluminium body
- Gas fuel block and vent valve assembly - off package

1.2.7 Liquid Fuel System

- Low pressure fuel filter
- Fuel flow control valve
- Liquid fuel purge system
- Thermal relief valve
- Liquid fuel pump, AC motor driven - Zone 2 motor
- Temperature and Smart type pressure transmitters - aluminium bodies
- Block valve – Siemens standard – off package
- Gas ignition system module - Siemens standard - off package
  - Propane start module (for stable and reliable start on liquid fuel)
  - Propane start storage bottle rack – 1 rack for all 4 turbines (bottles to be sourced locally)

1.2.8 Acoustic Enclosure

- Acoustic enclosure - painted carbon steel, fitted over gas turbine; gearbox and auxiliaries
- Doors for personnel access and maintenance
- 85dB(A)
- Integral lifting beam for maintenance
- Internal lighting
- Acoustic system transmitters - Siemens standard smart type – aluminium

1.2.9 Acoustic Enclosure Ventilation System

- Ventilation air inlet filter pad type 304L stainless steel
- Ventilation inlet and outlet dampers – 304L stainless steel – air operated

- Ventilation fan – single – AC electric motor driven – Zone 2
- Ventilation air system – negative pressure
- Ventilation air silencer – 304L stainless steel
- Ventilation air inlet and outlet ducting – 304L stainless steel
- Integral support for turbine enclosure ventilation system

1.2.10 Gas Detection System

- Gas detection equipment, comprising :-
  - 2 - I.R. point gas detectors (vent outlet)

1.2.11 Fire Protection System

- Fire protection equipment, comprising :-
  - 3 - I.R. multi-spectrum flame detectors
  - 2 - Heat detectors
  - Single sounder/beacon (end of package)
  - 1 - Beacon (inside package)
  - Status indicator (end of package)
  - 1 - MAC (Manual Alarm Contact)

1.2.12 Fire Extinguishant

- Single shot CO_2 fire protection system – in accordance with NFPA12
- Cylinders housed in a weatherproof cabinet
- Extinguishant system distribution pipework and nozzles
- Piping from cabinet to package

1.2.13 Combustion Air Inlet System

- Combustion air filter – simple static element – painted carbon steel
- Combustion air filter - weather hood
- Combustion air filter – mist eliminator
- Combustion air filter –EPA filter stage
- Combustion air silencer – painted carbon steel
- Combustion air inlet ducting – painted carbon steel
- Integral support for combustion air inlet system
- Maintenance access platform and ladder – combustion filter

1.2.14 Combustion Exhaust System

- Exhaust diffuser – ferritic stainless steel – horizontal orientation
- Exhaust silencer – ferritic stainless steel hot section – painted carbon steel outer casing
- Exhaust stack – ferritic stainless steel – vertical orientation
- Thermal insulation and aluminium cladding – personnel protection only

1.2.15 Package Electrical Systems

- Control Panel Shelter – (Local Electrical Room)
- Designed to provide environmental protection for the SGT400 package control panels and its operators. Fully equipped with lighting, power and environmental controls consisting of:
  - 400V AC – Package Motors and Heaters supply
  - 230V 50Hz distribution board
  - Internal and External lighting
  - Industrial 230V 50Hz outlet
  - Air conditioning/heat pump unit capable of maintaining control room at 20°C in all ambient conditions
  - A baseplate designed to support the control panel shelter and internal tread plates which will attach to the end of the SGT400 package driver unit baseplate to allow for a single point lift of the driver package
- A single control panel cubicle with support frame
  - The combined control panel will consist of a battery charger, unit control panel for turbine and generator control and monitoring and motor control centre
- Batteries – VRLA type, sized to ensure a safe rundown of the turbine and driven unit in an emergency

1.2.16 Package Auxiliaries

- Turbine compressor – mobile cleaning system – 316 Stainless Steel tank – on and off line wash
- Drains Tank on package
- Auxiliary module pressure & level transmitters - Smart type - aluminium bodies
- Instrument tagging – Arrow tags - Siemens standard P&ID references
- Package finish to Siemens onshore standard

1.3 Control System

1.3.1 Package Control System Hardware

- Unit Control System section – simplex, incorporating a Siemens SIMATIC PLC platform
- Control and monitoring of the package systems
- Control system located on-package
- Standard start-stop and load control functions – on-package control panel
- Operator display language - English
- Machinery vibration monitoring - Bently Nevada 1701 system
- Ethernet TCP/IP communications data link to DCS
- Generator Control Panel section containing :-
  - Automatic voltage regulator
  - Synchronising facility – automatic & manual with check synchroniser
- Generator metering equipment and electrical protection

1.3.2 Siemens Turbomachinery Applications – Remote Monitoring System – STA-RMS™

- STA-RMS allows improved support for engine operators
  - Required operation during warranty period and thereafter with Long Term Programme (LTP) service contracts
- Siemens common Remote Service Platform secure communication through Virtual Private Network (VPN) via customer's internet service
- STA-RMS primary functions:
  - Automatic transfer of engine operation data to Remote Diagnostics Centre allowing:
    - Routine monitoring
    - Predictive trending
    - Anomaly detection
    - Improved downtime prediction and scheduling
    - Access to historic data
    - Fleet and unit performance overview
    - Driven unit monitoring
    - Customer notifications and performance reports
  - Remote access to the Human Machine Interface allowing:
    - Direct operation of the Human Machine Interface by Siemens' support personnel
    - Software updates during fault rectification helpdesk call
    - Faster troubleshooting and support

1.4 Testing

1.4.1 Testing Gas Turbine

- Gas turbine core engine test– Siemens standard

1.4.2 Driven Unit Test

- Manufacturer's standard works acceptance test of AC Generator

1.5.2 Installation and Maintenance Equipment

- Roll-off equipment - Gas Turbine power turbine
- Roll-off trolley – Gas Turbine core engine removal
- Maintenance equipment
  - Power turbine barring gear
  - Core lifting equipment
  - Semi-gantry crane
  - Auxiliary gearbox support
- Installation tool kit comprising of a cabinet containing common hand tools
- Holding down fixings – GT and driven unit package
- Holding down fixings – off-package equipment
- Selection of paints for site repairs

1.6 Drawings and Documentation

- Standard set of certified information and approval drawings in the English language
- Operator manual - English language - CD only
- Maintenance manual - English language - CD only
- Driven unit manual - English language - CD only

1.9 Spares

1.9.1 Commissioning Equipment and Tools

- Commissioning equipment and tools

1.9.2 Commissioning Spares

Commissioning spares

1.10 Quality Assurance

1.10.1 Contract QA Programme

- Contract quality assurance programme – English language

2. Exclusions

- All items not specifically listed in this Proposal

3. Technical Data

3.1 Gas Turbine Performance

	Siemens						
	SGT400 Generator Package (N)						
	12.9MWe Large PT Nozzle						
	Gas Fuel						
Inlet Temp (C)	-20	-10	0	15	30	45	
Altitude (m)	0	0	0	0	0	0	
Ambient Press (bar a)	1.013	1.013	1.013	1.013	1.013	1.013	
Humidity (%)	60	60	60	60	60	60	
Power (%)	100	100	100	100	100	100	
Inlet Loss (mm H_2O)	100	100	100	100	100	100	
Exhaust Loss (mmH_2O)	75	75	75	75	75	75	
Gearbox Efficiency (%)	99	99	99	99	99	99	
Generator Efficiency (%)	97	97	97	97	97	97	
Combustor Type	DLE	DLE	DLE	DLE	DLE	DLE	
Fuel Type	Gas	Gas	Gas	Gas	Gas	Gas	
Fuel File	stdgas	stdgas	stdgas	stdgas	stdgas	stdgas	
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500	9500	
Generator Output (kW)	**12953**	**13221**	**13008**	**12517**	**10980**	**9441**	
Heat Input (kW)	37554	37663	37389	36693	33545	30580	
Heat Rate (kJ/kW.h)	10437	10255	10347	10553	10998	11660	
Exhaust Flow (kg/s)	44.52	43.56	42.27	40.08	36.6	32.93	
Exhaust Temp. (C)	479.2	493.9	515.4	547.1	567	591.8	
Comp.Exit Pres. (bar a)	17.13	17.32	16.99	16.37	15.01	13.6	

Liquid Fuel						
Inlet Temp (C)	-20	-10	0	15	30	45
Altitude (m)	0	0	0	0	0	0
Ambient Press (bar a)	1.013	1.013	1.013	1.013	1.013	1.013
Humidity (%)	60	60	60	60	60	60
Power (%)	100	100	100	100	100	100
Inlet Loss (mm H_2O)	100	100	100	100	100	100
Exhaust Loss (mmH_2O)	75	75	75	75	75	75
Gearbox Efficiency (%)	99	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE	DLE
Fuel Type	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
Fuel File	stdoil	stdoil	stdoil	stdoil	stdoil	stdoil
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500	9500
Generator Output (kW)	**13023**	**13253**	**12866**	**11327**	**9708**	**8377**
Heat Input (kW)	37421	37997	37316	34056	30729	28065
Heat Rate (kJ/kW.h)	10344	10321	10441	10823	11395	12060
Exhaust Flow (kg/s)	44.6	43.66	42.16	38.64	34.85	31.6
Exhaust Temp. (C)	479.9	504.8	524.6	542.1	563.7	584.7
Comp.Exit Pres. (bar a)	17.36	17.35	16.9	15.54	14.08	12.84

Heat Input Guarantee: Not more than 103% of above values

Heat Rate Guarantee: Not more than 103% of above values

Rating Method: Fixed Power Rating

3.1.1 Gas Turbine Performance Guarantee

1. Datum Conditions

Inlet air temperature	15°C
Ambient pressure	1.013(bara)
Relative humidity	60%
Assumed intake duct losses	100 mm H_2O
Assumed exhaust duct losses	75 mm H_2O
Gearbox efficiency	99%
Generator efficiency	97%

Gas fuel - Siemens' standard reference composition as below:

Name - "stdgas.dat"		
Constituents		(% vol)
Carbon Dioxide	CO2	0.5
Methane	CH4	94.2
Ethane	C2H6	3.2
Propane	C3H8	0.6
i-Butane	i-C4H10	0.1
n-Butane	n-C4H10	0.1
i-Pentane	i-C5H12	0.1
Nitrogen	N2	1.2
Total		100.0
LCV kJ/Kg		48160

Liquid fuel - Siemens' standard reference composition as below:

Name - "stdoil.dat"	
Lower calorific value (kJ/KG)	42530.00
Specific gravity at 288K	0.86

2. Guarantee Conditions

a.) Unless otherwise agreed the tests to establish the guaranteed performance shall be performed at Siemens' facility and conducted in accordance with Siemens' test procedure (which is generally in accordance with ISO 2314). For tests performed elsewhere they shall be conducted in accordance with Siemens site test procedure, including amendments to the procedure which are agreed in writing before commencement of the tests.

b.) Methods of correction for varying duct losses, ambient temperature, ambient pressure, and tolerance to cover errors in observation and measurement shall be agreed before commencement of the tests.

c.) Any site performance tests shall, be carried out by a Siemens authorised person when the goods are in a new (less than 750 fired hours per gas turbine) and clean condition and in proper working order using the fuel(s) as agreed in the Contract and reflected in the procedure. Immediately prior to commencement of the performance test(s) the gas generator shall be cleaned by a cold crank wash in a manner acceptable to Siemens. During the site performance test, the pressure drop across key components such as the combustion air inlet filter, downstream air inlet ductwork, and other major items of equipment must be measured.

d.) The stated output of the gas turbine for guarantee purposes is measured before any auxiliary losses.

e.) Inlet air temperature means the average air temperature recorded by the instruments in the turbine inlet casing.

3 Liability

As defined in the section of the Commercial Proposal titled 'Performance Guarantee'.

4 Guarantees

Power Output

Subject to the conditions set out in paragraph number 2 above, Siemens guarantee that the base rated power output at full load of the gas turbine generating set on test when operating at the datum conditions as set out in paragraph number 1 above shall be as follows:

Power output as measured at generator terminals

Gas fuel **12517 kW**

Tolerance on gas fuel = -3%

Liquid fuel **11327 kW**

Tolerance on liquid fuel = -3%

Heat Rate

Subject to the conditions set out in paragraph number 2 above, Siemens guarantee that the heat rate at base rated full load output of the gas turbine generator set on test when operating at the datum conditions as set out in paragraph number 1 above shall be as follows:

Heat rate (calculated using power output, as measured at generator terminals)

Gas fuel **10553 kJ/kW.h**

Tolerance on gas fuel = +3%

Liquid fuel **10823 kJ/kW.h**

Tolerance on liquid fuel =+3%

3.2 Data Sheets

3.2.1 AC Generator Data Sheets

A5E41515837A-AA Generator Data Sheets

3.2.2 Gas Turbine Site Performance Test Procedure

Please refer to attached site performance test procedure TSP00174A on the following page.

3.3 Package Noise Level Definition

Outdoor Location Package

Each gas turbine package, as reflected in the Siemens' scope of supply, has an average package noise level of 85dB(A), assuming free field conditions, and a background noise level at least 10 dB(A) below the measured average.

This figure is the Average Sound Pressure Level (SPL), measured at various points equispaced around the package, at a distance of 1m from the package plan view envelope, and a height of 1.5m from the datum bottom flange of the package underbase. It is assumed the Combustion Exhaust has a minimum stack height of 15m above the same datum.

3.4 Package Ambient Temperature Requirements

Unless stated otherwise this Gas Turbine package has been configured to operate within an ambient temperature range of:

- Minimum -20° C
- Maximum +43° C

Care must be taken with the placement of any package equipment with respect to other local factors contributing to a variation in temperature outside of this range, which may affect performance of the gas turbine.

3.5 Electrical Utilities (Typical)

SGT400 LOAD LIST

400 V Loads									
Description	**Note**	**Tag**	**Phases**	**Type**	**Load (kW)**	**Start**	**Run**	**Stop**	**Stopped**
Hydraulic Start Pump Driver Motor	1	XM3	3	Star/Delta	110	X	-		-
Auxiliary Lub Oil Pump Motor	2	XM1	3	DOL Starter	15		-	X	
Oil Mist Eliminator Fan Motor	2	XM46	3	DOL Starter	7.5	X	X	X	
Turbine Enclosure Vent Outlet Fan	2	XM6	3	DOL Starter	55	X	X	X	-
Water Wash Pump Drive Motor	5	XM15	3	Feeder	10	Wash Cycle			
Air Blast Lub Oil Cooler Fan		XM11	3	DOL Starter	13	X	X	X	-
Liquid Fuel Pump Motor - (Disabled)		XM5	3	DOL Starter	18.5	Not Required			
Lub Oil Tank Immersion Heater	4	IH1	3	Contactor Feeder	9	-	-	-	X
Feeder - 230V Transformer		T1		Feeder	12.5	X	X	-	-
				Total kVA		**263.9**	**109.8**	**248.3**	**34.0**
				Total Current / A		**420.8**	**173.5**	**398.2**	**54.5**

[1] Starter motor (110kW) short time rated. Start system governs load and is rated at approx. 200kW
[2] To Be Confirmed
[3] Reducing battery charger rated at 4.4 kVA nominal, maximum input current = 15.5 A @ 254 V
[5] When operated

"Start" - The turbine begins a start sequence.
"Run" - The turbine is running normally
"Stop" - The turbine begins a stop sequence.
"Stopped" - The turbine is not running.

Voltage variation for MCC during normal operation according to BS EN 60439, i.e. rated input voltage ±10 %
Frequency variation for MCC during normal operation according to BS EN 60439, i.e. rated frequency ±2 %
Voltage variation for AC Motors during nonnal operation according to BS EN 60034, i.e. rated voltage ±10 %
Frequency variation for AC Motors during normal operation according to BS EN 60034, i.e. rated frequency +3 % & -5 %
Voltage variation for package DC loads to be between 18 and 28 V

Rev History	Date	Revision	Alteration
	24-May-17	2	Revised motor ratings

3.6 Lubricating Oil Data

For lubricating oil specification, please refer to Siemens' Fluids Specification 65/0027 attached.

The required grade of oil is ISO VG46, further details of which can be found in the Fluids Specification. Oils of other viscosities should only be used with prior reference to Siemens.

Lubricating oil capacities

Maximum operating level (Running)	5,118 Litres
Minimum operating (Retention)	4,290 Litres
Working capacity	2,599 Litres

- Maximum operating level - Maximum oil level in the tank when running (does not include run down capacity)
- Minimum operating level - Minimum oil level in the tank when running (used to calculate retention time). This is the level quoted when a "retention time" is stated.
- Working capacity - Volume of oil between minimum operating level and pump suction.

3.7 Air Data

For air specification, please refer to the Siemens' fluids specification 65/0027

3.7.1 Instrument Air Supply

Pressure

Siemens require instrument air to be supplied to the interface at a minimum pressure of 5.5 barg and maximum pressure of 6.9 barg, to ensure optimum valve actuation. The minimum supply pressure must be maintained to avoid unplanned shut-down of the package.

Please note that unless stated otherwise the Gas Turbine package design does not include instrument air pressure regulation or pressure relief. These considerations are to be incorporated into the Customer's air supply. The instrument air system design pressure is 9.5 barg.

Please also refer to Siemens' Tie-in Schedule for connection details and supply limits.

Air Quality

The instrument air must be to the quality requirements set out in ISO 8573-1:2010 [4:2:3]

Temperature

The maximum allowed temperature of the instrument air is 65°C.

The Siemens dew point requirement is -40°C at 1 bar, please note that the supply dew point becomes higher with increasing pressure. As a minimum the air must be supplied at 10°C above dew point or at a minimum of -20°C whichever is the greater.

3.7.2 Instrument Air Flow

For air specification, please refer to the Siemens' fluids specification 65/0027 attached. All flow rates given below are normalised to 0 °C and 1.013 bara.

Valve Actuation (total for all air operated on-package and off-package valves)

Requirement:	30 Nm^3/h maximum, 0.15 Nm^3 total during turbine start
	3 Nm^3/h continuous flow for valve positioning

Purge and Seal Air

Operating condition		**Turbine Start**	**Turbine Shutdown**			**Off line compressor wash**
Duration		10 min*	1 min	20 min	Until GT cool	1 hour
Seal Air	70 Nm^3/h	X	X	X	X	X
Burner Purge Air (liquid fuel and dual fuel only)						
Phase 1	230 Nm^3/h		X			
Phase 2	140 Nm^3/h			X		X
Phase 3	110 Nm^3/h				X	
Gas Fuel Start	140 Nm^3/h	2 min				
Liquid Fuel Start	110 Nm^3/h	2 min				

* Dependent on purge time

3.8 Fluid Data

Fluids must be in accordance with the Siemens' Fluids Specification 65/0027 which is available upon request. Siemens require fluids to be supplied to the consumers.

Wash Module

Recommended frequency - (on line wash)	Every 72 hours running time typical **
Recommended frequency - (off line wash)	During engine shutdown. Usually required every 3 months with regular on line washing, every week for off line wash only.
Quantity of wash fluid	42 litres

Recommended cleaning fluids: -

a)	ZOK-MX
b)	R-MC Power Guard

Cleaning fluid dilute with demineralised water in a ratio of 1 part fluid to 4 parts water, to make up the above quantity

Following off line wash, a rinse cycle is carried out with the same quantity of demineralised water only.

** Wash frequency dependent on site conditions, running regime and combustion filter selection.

3.9 Fuel Data

Fuel must be provided in accordance with the Siemens' Fluids Specification 65/0027 attached.

Gas Fuel Supply Requirements

Siemens require gas fuel to be supplied to the terminal point at site border.

Supply pressure - maximum	28 bar g
Supply pressure - minimum	To be advised when all fuel conditions known
Temperatures shall be as follows:-	
Supply temperature – maximum (design)	120°C (105°C if coalescer filter fitted)
Supply temperature - minimum	2.5°C or 20°C above hydrocarbon dew point, whichever is the greater
Nominal Lower calorific value (LCV)	35 MJ/Nm^3
Wobbe index range (at gas supply temperature)	37 – 49 MJ/Nm^3

Liquid Fuel Supply Requirements

Siemens require liquid fuel to be supplied to the Gas Turbine connection (Please note different terminal point if liquid fuel option is selected)

Siemens require liquid fuel to be supplied to the Gas Turbine connection.

Supply pressure - maximum	3.0 bar g
Supply pressure - minimum	1.0 bar g
Temperatures shall be as follows:-	
Supply temperature - maximum	60°C
Supply temperature - minimum	0°C

Liquid Fuel Gas Assist Supply Requirements

Supply pressure - max	0.4 bar g
Supply pressure - min	0.1 bar g
Nominal flow rate	0.009 kg/s (with supply regulator set point of 0.135 bar g)
Flow maximum design	0.0245 kg/s
Usage	0.54 kg per start (approx. 60 second period)

Note: Liquid fuel gas assist can be Natural Gas (as Fuel Gas) or Propane

3.10 Liquid Fuel Operating Guidelines

Introduction:

The successful operation of industrial gas turbines on liquid fuels requires careful attention to be paid to both the conditions of the liquid fuel supply and to the gas turbine running philosophy.

The aim of this section is to detail the recommended practices that should be applied in order to maximise operation and minimise impact on gas turbine reliability and availability when operating on liquid fuel.

These notes and guidelines are generally applicable to the Dry Low Emissions (DLE) combustion system applied to the Siemens SGT-100, SGT-200, SGT-300 and SGT-400 industrial gas turbine products and are based on extensive operational experience with a wide variety of distillate fuels, operational loads and ambient conditions.

Liquid Fuel Composition:

Siemens apply a common standard when assessing the suitability of liquid fuels. All fluids including liquid fuel are to be supplied to the gas turbine package in accordance with Siemens' Fluids Specification 65/0027.

This specification has been based on a number of recognised international standards for diesel fuels, such as EN590, ASTM D975 and ISO 4261. Maintaining fluids to this standard provides a sound basis for achieving acceptable long term operation, therefore sound quality control procedures for procuring; handling and storage of fluids are paramount.

Liquid Fuel Operational Standards:

DLE configured gas turbines have been optimised with maximum efficiency and low emissions, when running continuously on liquid fuel between full load and around 70% load.

Operation at non-optimised design conditions, for example low load operation (<40%), can adversely affect engine operation, and reduce starting success and overall reliability. Typical problems include the presence of carbon build-up, formed from unburnt fuel due to the lower combustion efficiency associated with low loads.

It must be stressed these issues described are generic across all makes of gas turbines and are related to the physics of spray combustion.

For extended low load running additional maintenance aspects may need to be adopted, such as; modified shutdown procedures, provision of spare burner components and agreed interventions, such as the burners being removed and cleaned.

Operation at high loads, where combustion efficiency is high, results in an optimal operation and can also be used as one of the methods to clear the associated carbon build up from prior operation at lower loads.

Where multiple engines operate on a load sharing basis, the minimum number of engines should be used to maximise the output per turbine (i.e. above 70% of the maximum achievable load)

The following methods are recommended for removing carbon build on a running engine:

a. Liquid fuel only engine:
   Prior to a normal shutdown the gas turbine should be operated at its optimised design condition for a minimum of 45 minutes, ideally one hour at full load, before initiating the shut-down procedure.
b. Dual fuel engine:
   Prior to a normal shutdown and where gas fuel is available, the gas turbine should be changed over from liquid fuel operation to gas fuel operation and allowed to run for a minimum of 45 minutes, ideally one hour, at full load or above 50% before initiating the shut-down procedure.

Such operations allow any carbon deposits to burn off, extending the full load running period will increase the beneficial results.

Note that on all packages the liquid burners, air assist passages and gas fuel pilot injection are purged with air on shutdown.

Liquid Fuel Supply Quality:

General fuel handling recommendations are provided to ensure that the appropriate quality of fuel is consistently supplied to the gas turbine.

1. A customer liquid fuel supply quality control procedure should ensure fuel is provided compliant with Siemens Fluids Specification 65/0027 latest issue. A copy of this procedure should be provided to Siemens for information, lack of such details and information may impact any future warranty
2. Procurement, transfer, storage and handling of fuels should be defined and comply with best industry practice
3. The Liquid fuel supply quality control procedure should include, but not be limited to:
   i) Procurement policy and standard
   Procurement of liquid fuel must be from an approved customer vendor to an agreed standard, meeting the Siemens Fluids Specification

   ii) Delivery acceptance
   Process including simple "Clear & Bright" visual checks and avoidance of mixed or incompatible liquid fuels from different process sources

   iii) Storage quality and fuel polishing/ conditioning
   Procedures to ensure long term quality control of fuel including:-
   - Minimising occurrence of water
   - Water separation/ regular water draining
   - Microbial growth prevention measures/ use of microbial inhibitors
   - Defined frequency of fuel polishing after storage periods relative to the fuel shelf life
   - Minimising occurrence/introduction of contaminants (especially during fuel transfers)

   Provision of a fuel storage tank designed to best industry practice and at the necessary quality standard including:-
   - Floating suction
   - Corrosive resistant materials (and/or lined) to be rust free and clean
   - Leak free and well maintained (with access for cleaning)
   - Sludge take off and sufficient "settling" time
   - Transfer to a local "day tank" may be considered, noting the same points above for design

   iv) Use of winter and summer fuels
   Including control and usage of alternative grades, storage, mixing, etc.

4. Liquid fuel forwarding systems should include fuel treatment equipment as standard; preferably a centrifuge, or at least a coalescing filter, multiple lines will allow regular servicing.

Recommended Spares

When necessary, spare parts for the liquid fuel DLE system (as detailed below) are added into the commissioning spares kit and included as part of the scope of supply

- Pilot Burner Assembly Full set per site
- Liquid Lances Full set per engine
- Igniters Full set per site

Please refer to section "Scope of Supply / Spares" for details of included spares for this project.

For applications where there is an initial period of liquid fuel operation such as a module yard test prior to offshore location / operation, or a period of time prior to gas availability; it is recommended that once the period of liquid fuel operation is completed and gas fuel is available that the liquid pilot burners and lances are changed to new or cleaned parts.