SIEMENS

7.0 Technical Data

7.1 Turbine Performance

All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	1	2	3	4	5
Ambient Temp (C)	15	21	27	32	37
Inlet Temp (C)	15	21	27	32	37
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	13172	12524	11823	11262	10753
Heat Input (kW)	38037	36708	35320	34222	33259
Heat Rate (kJ/kW.h)	10395	10551	10754	10939	11134
Exhaust Flow (kg/s)	40.12	38.72	37.18	35.88	34.67
Exhaust Temp. (C)	560.5	567.7	576.2	583.9	591.7

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	6	7	8	9	10
Ambient Temp (C)	38	40	15	21	27
Inlet Temp (C)	38	40	15	21	27
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	2.2% CO2 Gas	2.2% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	10663	10475	12400	11665	10974
Heat Input (kW)	33096	32746	36301	34818	33440
Heat Rate (kJ/kW.h)	11173	11253	10539	10745	10969
Exhaust Flow (kg/s)	34.46	33.98	38.66	37.07	35.52
Exhaust Temp. (C)	593.2	596.5	560.3	568.8	577.8

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	11	12	13	14	15
Ambient Temp (C)	32	37	38	40	15
Inlet Temp (C)	32	37	38	40	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	Liquid
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	10449	9978	9892	9734	11143
Heat Input (kW)	32414	31519	31361	31077	33498
Heat Rate (kJ/kW.h)	11167	11371	11413	11493	10822
Exhaust Flow (kg/s)	34.3	33.15	32.94	32.54	36.94
Exhaust Temp. (C)	585.6	593.4	595	598.1	554.6

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	16	17	18	19	20
Ambient Temp (C)	21	27	32	37	38
Inlet Temp (C)	21	27	32	37	38
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	Liquid	Liquid	Liquid	Liquid	Liquid
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	10447	9815	9358	8935	8860
Heat Input (kW)	32080	30813	29919	29121	28985
Heat Rate (kJ/kW.h)	11054	11301	11509	11733	11777
Exhaust Flow (kg/s)	35.37	33.89	32.8	31.74	31.55
Exhaust Temp. (C)	563.4	572.4	579.9	587.7	589.2

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	21	22	23	24	25
Ambient Temp (C)	40	15	15	15	15
Inlet Temp (C)	40	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	90	80	70
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	Liquid	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	8716	13172	11854	10537	9220
Heat Input (kW)	28731	38037	34904	31869	29654
Heat Rate (kJ/kW.h)	11866	10395	10600	10888	11578
Exhaust Flow (kg/s)	31.18	40.12	38.37	36.49	34.71
Exhaust Temp. (C)	592.3	560.5	545.4	532.9	537.9

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	26	27	28	29	30
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	60	50	40	30	20
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	7903	6586	5269	3951	2634
Heat Input (kW)	27489	25190	22015	18539	15099
Heat Rate (kJ/kW.h)	12521	13769	15041	16892	20636
Exhaust Flow (kg/s)	32.97	31.07	28.79	26.33	23.35
Exhaust Temp. (C)	543.9	549.3	536	514	498

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	31	32	33	34	35
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	90	80	70	60
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	12400	11160	9920	8680	7440
Heat Input (kW)	36301	33369	30509	28425	26386
Heat Rate (kJ/kW.h)	10539	10764	11071	11789	12767
Exhaust Flow (kg/s)	38.66	36.95	35.18	33.57	31.95
Exhaust Temp. (C)	560.3	546.8	534.4	538.1	543.3

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	36	37	38	39	40
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	50	40	30	20	100
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	Liquid
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	6200	4960	3720	2480	11143
Heat Input (kW)	24204	21252	17954	14722	33498
Heat Rate (kJ/kW.h)	14053	15424	17374	21370	10822
Exhaust Flow (kg/s)	30.11	27.98	25.66	22.81	36.94
Exhaust Temp. (C)	548.8	536.7	514.6	500.7	554.6

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	41	42	43	44	45
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	90	80	70	60	50
Inlet Loss (mmH2O)	100	100	100	100	100
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	Liquid	Liquid	Liquid	Liquid	Liquid
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	10028	8914	7800	6686	5571
Heat Input (kW)	30911	28654	26851	24950	22946
Heat Rate (kJ/kW.h)	11096	11572	12392	13434	14827
Exhaust Flow (kg/s)	35.35	33.82	32.37	30.8	29.08
Exhaust Temp. (C)	543.1	537.9	543.3	548.1	553.1

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	46	47	48	49	50
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	40	30	20	100	100
Inlet Loss (mmH2O)	100	100	100	50	75
Exhaust Loss (mmH2O)	100	100	100	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	Liquid	Liquid	Liquid	2.2% CO2 Gas	2.2% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	4457	3343	2229	13282	13227
Heat Input (kW)	20020	17049	14079	38240	38139
Heat Rate (kJ/kW.h)	16170	18359	22738	10364	10380
Exhaust Flow (kg/s)	27.08	24.88	22.34	40.34	40.23
Exhaust Temp. (C)	534.5	515	498.6	559.6	560

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	51	52	53	54	55
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	125	150	100	100
Exhaust Loss (mmH2O)	100	100	100	50	75
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	13172	13117	13062	13211	13192
Heat Input (kW)	38037	37936	37835	38041	38041
Heat Rate (kJ/kW.h)	10395	10411	10427	10366	10381
Exhaust Flow (kg/s)	40.12	40.02	39.91	40.13	40.13
Exhaust Temp. (C)	560.5	560.9	561.4	559.6	560

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	56	57	58	59	60
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	100	100	50	75
Exhaust Loss (mmH2O)	100	125	150	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	2.2% CO2 Gas	2.2% CO2 Gas	2.2% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	13172	13152	13132	12505	12453
Heat Input (kW)	38037	38034	38031	36492	36397
Heat Rate (kJ/kW.h)	10395	10410	10425	10505	10521
Exhaust Flow (kg/s)	40.12	40.12	40.12	38.86	38.76
Exhaust Temp. (C)	560.5	560.9	561.4	559.4	559.8

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	61	62	63	64	65
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	125	150	100	100
Exhaust Loss (mmH2O)	100	100	100	50	75
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	12400	12347	12295	12439	12420
Heat Input (kW)	36301	36206	36110	36306	36304
Heat Rate (kJ/kW.h)	10539	10556	10573	10507	10522
Exhaust Flow (kg/s)	38.66	38.56	38.45	38.67	38.66
Exhaust Temp. (C)	560.3	560.7	561.2	559.4	559.8

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	66	67	68	69	70
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	100	100	50	75
Exhaust Loss (mmH2O)	100	125	150	100	100
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	1.7% CO2 Gas	1.7% CO2 Gas	1.7% CO2 Gas	Liquid	Liquid
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	12400	12380	12360	11245	11194
Heat Input (kW)	36301	36299	36297	33689	33594
Heat Rate (kJ/kW.h)	10539	10555	10571	10785	10803
Exhaust Flow (kg/s)	38.66	38.66	38.65	37.16	37.05
Exhaust Temp. (C)	560.3	560.7	561.2	553.6	554.1

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	71	72	73	74	75
Ambient Temp (C)	15	15	15	15	15
Inlet Temp (C)	15	15	15	15	15
Altitude (m)	5	5	5	5	5
Ambient Press (bar a)	1.012	1.012	1.012	1.012	1.012
Humidity (%)	92	92	92	92	92
Power (%)	100	100	100	100	100
Inlet Loss (mmH2O)	100	125	150	100	100
Exhaust Loss (mmH2O)	100	100	100	50	75
Gearbox Efficiency (%)	99	99	99	99	99
Generator Efficiency (%)	97	97	97	97	97
Combustor Type	DLE	DLE	DLE	DLE	DLE
Fuel Type	Liquid	Liquid	Liquid	Liquid	Liquid
PT Shaft Speed (rpm)	9500	9500	9500	9500	9500
RESULTS:					
Generator Output (kW)	11143	11093	11042	11185	11164
Heat Input (kW)	33498	33406	33312	33514	33507
Heat Rate (kJ/kW.h)	10822	10841	10860	10786	10804
Exhaust Flow (kg/s)	36.94	36.84	36.73	36.96	36.95
Exhaust Temp. (C)	554.6	555.1	555.6	553.6	554.1

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All values are expected, not guaranteed.

ENGINE PERFORMANCE PREDICTION
SGT-400 12.9MWe
Customer Cardon IV
Site/Project

CASE	76	77	78		
Ambient Temp (C)	15	15	15		
Inlet Temp (C)	15	15	15		
Altitude (m)	5	5	5		
Ambient Press (bar a)	1.012	1.012	1.012		
Humidity (%)	92	92	92		
Power (%)	100	100	100		
Inlet Loss (mmH2O)	100	100	100		
Exhaust Loss (mmH2O)	100	125	150		
Gearbox Efficiency (%)	99	99	99		
Generator Efficiency (%)	97	97	97		
Combustor Type	DLE	DLE	DLE		
Fuel Type	Liquid	Liquid	Liquid		
PT Shaft Speed (rpm)	9500	9500	9500		
RESULTS:					
Generator Output (kW)	11143	11123	11102		
Heat Input (kW)	33498	33494	33486		
Heat Rate (kJ/kW.h)	10822	10840	10858		
Exhaust Flow (kg/s)	36.94	36.94	36.93		
Exhaust Temp. (C)	554.6	555	555.5		

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7.2 SGT-400 Utilities List

7.2.1 Electrical Requirements

Description	Rating	Start	Run	Stop
Lubricating oil tank heater (per heater)	6 kW	X	-	-
Starter motor	112 kW	X	-	-
Turbine enclosure lighting	0.3 kW	When required		
Enclosure ventilation fan motor (per fan)	22 kW	X	X	X
Gen Vent fan motor (per fan)	30 kW	X	X	-
AC Lube oil pump motor	19 kW	X	-	X
Air Blast lube oil cooler fan motor (per fan)	7.5 kW	X	X	X
Lubrication oil mist eliminator fan motor	8 kW	X	X	X
Unit Control Panel - DC 24V	0.5 kW	X	X	X
DC lube oil pump motor	2.2 kW	When required		
Liquid Fuel pump motor	30kW	X	X	-
Waterwash module pump motor	3 kW	When required		
Waterwash module immersion heater	6 kW	When required		

7.2.2 Lube Oil Requirements

Lubrication Oil Specification

For the lubrication oil specification please refer to the Siemens Fluid Specification 65/0027.

The grade of the oil is ISO VG46. Oils of other viscosity grades should not be used without consulting with Siemens. The oil must be clean, free from water, suspended matter, sediment and any other impurities.

Maximum operating level	1487 US Gal (5652 L)
Minimum operating level (retention capacity)	1403 US Gal (5312 L)
Working capacity	1066 US Gal (4038 L)

Make-up oil - Maximum 7.9 gallons (30L) per week (approx) for continuous operation

7.2.3 Fuel Requirements

Gas Fuel

Gas Fuel must be provided in accordance with the Siemens Fluids specification 65-0027. Additional the requirements are as below.

Supply pressure: maximum	406 psig (28 barg)
Supply pressure: minimum	341 psig (23.5 barg) for 2.2% CO_2 Gas 286 psig (19.7 barg) for 1.7% CO_2 Gas
Temperatures to be as follows:	
Supply temperature: maximum	212°F (100°C)
Supply temperature: minimum	36.5°F (2.5°C), or 36°F (20°C) above hydrocarbon dew point, whichever is the greater.
Nominal Lower Calorific value (LCV)	35 MJ/Nm3
Wobbe Index range (at gas supply temperature)	37-49 MJ/Nm3

Liquid Fuel

Liquid fuel supply should be provided with a smooth pressure profile and maximum fluctuation of 0.1 bar/sec within the limits set below.

The following figures apply to liquid fuel at skid edge inlet flange.

Maximum Supply Pressure	2 barg
Minimum Supply Pressure	1 barg
Maximum Supply Temperature	60°C
Minimum Supply Temperature	0°C
Fuel Flowrate*	106 l/min

*Maximum for full load operation at site conditions, based on the composition given below

For detailed liquid fuel requirements, please refer to Siemens Fluids Specification 65/0027

Liquid Fuel Composition

Component	% weight
Carbon	86.7
Hydrogen	13
Sulphur	0.3
s.g.	0.862 @ 15 °C

LCV	42530 kJ/kg @ 15 °C

7.2.4 Air Requirements

The instrument air quality shall be in accordance with ISO 8573.1:2001 class 3.2.1. The supply pressure at the skid edge shall be 80-100 psig (5.5 - 6.9 barg), with a smooth pressure profile and maximum fluctuation of 1 bar/min. Temperature range shall be 32°F - 140°F (0 - 60°C).

On Skid Valves

Flow Rate:	60 Nm3/h (37.3 scfm)
Duration / Frequency:	0.5 second during turbine start
	0.5 second during turbine wash cycle

Gas Fuel Block and Bleed Valve - Off Skid (when provided)

Flow Rate:	35 Nm3/h (21.7 scfm)
Duration / Frequency:	0.5 seconds during turbine start

Turbine Labyrinth Seals

Flow Rate:	70 Nm3/h (43.5 scfm)
Duration / Frequency:	10 minutes (maximum) during turbine start
	2 hours (or until turbine is cool) on turbine shutdown
	1 hour during off-line wash cycle

Pulse Clean Filter

Flow Rate:	75 Nm3/h (46.6 scfm)
Duration / Frequency:	100 ms for each pulse, 1 pulse every 40 seconds during cleaning cycle. 66 pulses per cycle.

Notes

For detailed compressed air specification requirements, please refer to section 2 of Siemens Fluids Specification 65/0027

Air pressure must be available at the GT skid edge during operation to maintain valve positions. Failure of the instrument air supply during turbine operation will result in shutdown of the turbine package.

Under normal shutdown conditions, the air supply is maintained to pressurize the labyrinth seals in order to keep them clear of oil during lubrication of the adjacent bearings whilst cooling. The air pressure must be maintained during this cooling period to ensure oil does not migrate into the engine.

Frequency of washing requirements is dependent on site conditions and mode of operation by end user. For a 'cold' (off-line) wash, the engine must be cool (signal controlled by UCP) before a wash is carried out.

7.2.5 Fluid Requirements

Compressor Cleaning System

For Fluids specification, please refer to the Siemens Fluids specification 65-0027.

Recommended Frequency (Hot Wash)	Every 48 hours running time
Recommended Frequency (Cold Wash)	During Engine shutdown. Usually required every 3 months with regular hot washing, every week for cold wash only
Quantity of wash fluid	22.8 US Gal (86.3 liters)

Recommended cleaning fluids are as follows

Airworthy ZOK-MX

R-MC Power Guard

Cleaning fluid is to be diluted with demineralized water in a ratio of 1 part fluid to 4 parts water to make up the above quantity.

Following a cold wash, a rinse cycle is carried out with the same quantity of demineralized water only.

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8.0 Technical Description

8.1 Engine Core

The SGT-400 is a simple open-cycle non-regenerative twin shaft industrial gas turbine, with the output drive taken from the exhaust outlet (i.e. hot) end of the turbine.

The core engine includes the gas generator assembly and the power turbine assembly. Direction of rotation of the power turbine is counter-clockwise looking at the output flange.

The gas generator assembly includes the air inlet casing, compressor rotor, compressor stator, center casing, combustion system, compressor turbine stator and compressor turbine rotor assemblies.

The power turbine includes the hot gas interduct, power turbine stator and power turbine rotor assemblies, output drive shaft and the exhaust outlet.

Borescope access is provided for inspection of the compressor, the combustion system and the turbine hot path components.

Compressor

The compressor consists of a single spool 11 stage axial stage compressor. The first three stages are transonic with a maximum tip mach number of 1.10.

The first four stages of the compressor blading and internal surfaces of the compressor casing are protected with a ‘Sermetal’ corrosion resistant coating.

The rotor blades are fitted to the discs by means of machined dovetail roots.

The rotor construction consists of a series of discs coupled together by Hirth teeth which are held together by a central tension bolt to form the compressor rotor assembly. An additonal Hirth coupling connects the compressor rotor to the turbine stages to form the integrated gas turbine rotor assembly.

The rotor is supported by two tilting pad journal bearings, located at the compressor inlet and between the compressor and turbine stages respectively. Tilting pad thrust bearings are fitted to the bearing assembly at the compressor inlet end. There is one major and one minor thrust bearing.

A spring operated inter stage valve is provided for surge control of the compressor, and for compressor protection on load shedding.

The compressor casing is split horizontally and also midway along the compressor to facilitate inspection of the front of the compressor with the minimum of disassembly.

Compressor Turbine

The compressor turbine is a subsonic two-stage axial flow type, consisting of two rotor discs manufactured from IN-718, into which the rotor blades are fitted. The discs are bolted to a stub shaft by a central tension bolt to form the compressor turbine rotor assembly which in turn is directly coupled to the rear of the compressor rotor to form the gas generator rotor assembly.

The first stage rotor blades are internally cooled with cooling air supplied internally from the compressor to reduce metal temperatures using double triple pass passages. The second stage rotating blades are also cooled. The blades are coated to minimise the risk of corrosion.

The stator blade assembly is made up from segments of single piece investment castings and both stages are provided with cooling air supplied internally from the compressor to reduce metal temperatures. Sermetel coating is provided to increase corrosion resistance.

Power Turbine

The two-stage power turbine is of subsonic axial design, consisting of two high strength discs, manufactured of Inconel 718, provided with precision cast rotor blades, bolted to a solid output shaft by means of a tension bolt to form the power turbine rotor assembly.

Both the rotor and the stator blading is cast in IN 713 LC alloy. The PT1 blades are manufactured of CM 247 and PT2 blades of Inconel 738.

The rotor shaft is supported by two anti-whirl sleeve type journal bearings and provided with main and reverse thrust bearings. All bearings are located in a robust bearing housing, which is rigidly supported by the turbine diffuser and support assembly from the outer casing.

The power turbine is designed to be inherently safe, with the aerodynamic limiting speed being below the disc bursting speed.

Variable Inlet Guide Vanes

The compressor inlet guide vanes and the first three rows of the compressor stator blades are variable to maximize compressor efficiency and provide the necessary surge control.

The system is controlled by an electronically actuated assembly.

A 15 micron rated filter is fitted in the supply to the actuator.

A feedback transmitter is fitted to allow the position of the variable geometry guide vanes to be controlled by the turbine Unit Control Panel.

Air Inlet Casing

The standard arrangement of the air inlet casing has the air inlet phased vertically upwards.

A trash screen is fitted for additonal protection against debris in the inlet system.

A flexible joint is fitted to the air inlet casing flange to accommodate relative movements due to thermal expansion.

Combustion Chambers

The combustion system is designed for low exhaust emissions without the need for water or steam injection.

The combustion system employs six reverse flow tubular combustion chambers, symmetrically positioned around the turbine.

The combustion chambers are connected to the HP nozzle assembly by means of transition ducts.

The length of the combustion chamber is such that it protrudes outside the center casing. External cylindrical casings are therefore used to cover the combustion chamber liner.

Combustion chamber removal is achieved by removing the burner from the outer casing and sliding the combined burner/combustor out along its axis.

The main burner is a lean pre-mix design, which reduces flame temperature, and hence NOx levels. A pilot burner, fitted in the head of the combustion chamber provides fuel for ignition and transient operation. A small amount of pilot fuel may be required at load conditions to ensure flame stability during transient load changes.

With the DLE system, control of CO emissions at part load is achieved by means of modulating the bleed air from compressor exit, thereby controlling the air/fuel mixture in the combustion zone.

The positioning of the combustors is such that the fitting of cross-light tubes is not practical. Each combustor therefore has its own high-energy igniter unit fitted, which is non-retractable.

Igniters

Six high energy igniter units (one for each combustion chamber) are fitted and are powered from a single igniter power unit. The power unit is in an junction box rated for a Class 1 Division 2 area.

Burners

Burners, capable of burning either gas or liquid fuel, are provided to give clean DLE combustion from start-up through to full load. 2 sets of burners are provided – one for burning 2.2% CO_2 gas and liquid fuel and one for burning 1.7% CO_2 gas. A burner changeout is required prior to changing the gas supply from one to the other.

The burners are readily accessible for removal or cleaning.

Instrumentation

Air inlet casing and compressor exit resistance temperature detectors (RTD's), interduct and exhaust duct thermocouples, are used by the turbine Unit Control Panel to derive the engine operating temperature.

In Additon the turbine exit thermocouples are used to monitor combustion conditions during start-up and on load, and will shut the turbine down in the event of one of the flames in the combustion chamber being extinguished.

Each bearing in the engine contains two embedded thermocouples (1 active, 1 redundant) for the monitoring of bearing metal temperatures.

Non-contacting vibration probes are fitted to monitor shaft vibration levels. 'X-Y' plane probes (1 active, 1 redundant) are fitted to the journal bearings and 'Z' plane to each shaft thrust bearing. The signals are processed in the turbine Unit Control Panel and monitored for warning and shutdown levels. The above are used in conjunction with key phasor probes for trouble shooting.

Four rotor speed probes are fitted in each of the gas generator and power turbine shafts. One to indicate turbine speed, one to indicate overspeed (Probe feeds 3 circuits, 2 out of 3 circuits sensing overspeed will trip the turbine), one to feed signals to the governor which also has overspeed protection capability and one redundant probe.

Engine Core Works Test

On completion of manufacture the turbine is subjected to a performance brake test on a slave frame and system in accordance with established Siemens Test Procedure. The purpose of this test is to verify engine power, efficiency, cycle temperatures and exhaust mass flow. All performance testing is carried out under the supervision of the Siemens Quality Control Department, to ensure satisfactory performance of the turbine unit and strict compliance with Quality Control procedures.

8.2 Underbase

The standard turbine single kid is fabricated of carbon steel, contains an integral lubricating oil tank and provides the support for the turbine, auxiliary gearbox, main gearbox, generator, and turbine auxiliary equipment.

The skid is arranged for multipoint mounting and is provided with mounting pads on the underside at the anchor bolt locations, lifting lugs and vertical alignment adjustment screws.

The paint finish is suitable for an onshore environment. Option is available for internally lined ferritic SS tank.

8.3 Lubricating Oil System

On Package Common Parts

The standard lubricating oil system is designed to supply oil to the engine, gearbox and generator. The lubricating oil for use in Siemens turbines is an ISO VG 46 oil in accordance with Siemens fluids specification 65/0027.

The lubricating oil tank is fabricated in carbon steel, and is an integral part of the underbase. The lubricating oil tank design is in general accordance with API 614 requirements. See Fluid Data Section in Technical Data for lubricating oil tank capacities.

There are no local gauges for monitoring oil pressures or temperatures on the engine package as standard. These functions will be monitored by the turbine Unit Control Panel, pressure signals originating from transmitters, and temperatures from type K thermocouples installed on the engine package.

The piping used in the lubricating oil system is made of stainless steel. All compression fittings are Swagelok austenitic stainless steel, double ferrule type fittings.

Following manufacturing and assembly, the system is flushed clean to API 614 standards. This procedure is detailed in Siemens standard Frame and Systems test procedure.

All electrical equipment in the lubricating oil system are suitable for use in Class 1, Division 2, Group D areas.

The lubricating oil usage is approximately 0.8-1.3 gallons per week (3-5 liters per week). The majority of this oil is lost through the lubricating oil tank breather.

Pumps

The main lubricating oil pump is mechanically driven by the main gearbox. The pump is a gear type and contains an integral relief valve. The lube oil pump has a capacity of 330 gallons per minute (1250 liters per minute) and is capable of delivering oil at a pressure of 100psig (6.9 barg).

Pre and post lubricating oil is supplied by a 2 pole AC motor driven pump. The pump is a gear type and contains an integral relief valve. The lubricating oil pump has a capacity of 240 gallons per minute (906 liters per minute) and is capable of delivering oil at a pressure of 100psig (6.9 barg).

In the event of a failure in the AC supply, the unit is fitted with a DC powered emergency pump which supplies oil to the hot bearing only, in order to prevent bearing damage on a shutdown. The pump is automatically started by means of a pressure switch. The pump is rated to deliver a flow of 21 gallons per minute (80 liters per minute) at a pressure of 30psig (2.04 barg) and 3000 rpm. This pump is automatically switched off when the thermocouples in the engine indicate that the engine temperature has dropped to 175°F (80°C).

Instrumentation

A pressure transmitter is installed to shut the engine down on low lubricating oil pressure when the supply to the engine falls below a set level

Pressure and Thermostatic Control Valve Assembly

Oil temperature is controlled by means of a thermostatic temperature control valve. The valve is set to start opening at a temperature of 105°F (41°C) and will be fully open at 120°F (49°C). Under normal operating conditions, the temperature of the oil supplied to the turbine will be 140°F (60°C).

A lubricating oil temperature alarm will be activated at a supply temperature of 150°F (66°C) and the set will shut down when the temperature reaches 165°F (74°C).

Oil pressure at the turbine bearing is controlled by means of a pressure control valve. The valve receives a signal from the bearing area and maintains the lubricating oil pressure at the bearing at 29 psig (2 bar g).

Immersion Heaters

Two lubricating oil tank heaters are supplied and are designed for 480 volt three phase electrical service. The heaters are fitted with integral thermal cut out switches. The minimum lubricating oil temperature required to start the turbine is 70°F (20°C). If extra heating is required in order to achieve the necessary start conditions, then the AC lubricating oil pump should be run in order to increase the oil temperature further.

Filter

A duplex type filter of rated to 10 microns is provided complete with a manual changeover valve which allows switching from one element to another with the turbine running.

The filters are designed to Siemens standards, which are suitable for the duty intended.

8.4 Lubricating Oil Cooler System

Cooler

A single air blast type lubricating oil cooler consisting of horizontally mounted coils, suitable for remote installation is supplied as standard.

Air Blast Lube Oil Cooler suitable for non hazardous area.

Non Return Valves

Non return valves for lubricating oil cooler piping are supplied to prevent oil draining back into the lubricating oil tank.

8.5 Engine Auxiliaries

On Package Breather Duct

The turbine lubricating oil system is vented to ensure the maintenance of correct pressure balance across internal seals. The breather piping vents the lubricating oil tank and engine casing to the top of the turbine enclosure.

Air Inlet Flexible Joint

A flexible joint of neoprene rubber polymer with a fine cotton inlay is fitted to combustion air inlet casing to accommodate movements due to thermal expansion.

Exhaust Diffuser

The turbine exhaust casing is lagged with an aluminized finish for thermal protection and is phased to allow the exhaust to leave the turbine horizontally right when looking upstream.

Exhaust Flexible Joint

A flexible joint of a multi-material resistant to high temperature is fitted to the radial exhaust collector casing to accommodate movements due to thermal expansion.

Compressor Discharge Pressure Transmitter

A pressure transmitter is fitted to the turbine centre casing to measure the turbine compressor discharge pressure. The output from this device is monitored on the turbine Unit Control Panel.

Water Wash Piping in Underbase

A wash facility is provided

a) to retard compressor fouling

b) to remove accumulated deposits

The system includes a fully piped spray rail with spray nozzles fitted in the turbine air inlet casing.

Compressor fouling is retarded by use of an on-line liquid wash which is carried out with the turbine running at any load. In order to maximise compressor efficiency it is recommended that this operation is carried out every 2 days.

Complete compressor cleaning is achieved by use of soak cleaning. To carry out this operation it is necessary to stop the turbine, allow it to cool and carry out the soak wash. During this sequence the compressor casing is partially filled with cleaning fluid and compressor rotated using the starter motor to ensure that it is completely cleaned. At the end of this automatic wash sequence the dirty fluid is drained via a manifold to the edge of the turbine underbase.

The operation of the water wash sequence is controlled from the turbine Unit Control Panel.

Compressor Wash Module

An off package mobile high pressure compressor wash module is supplied. This is sized for a single wash with manual initiation of the cleaning process.

The wash tank contains de-mineralized water and cleansing fluid tanks to provide the washing solution and has a capacity of 22.8 gallons (65 litres). The wash fluid is pre-heated to 140°F (60°C) before being injected into the engine at a rate of 3.42gpm (13 l/m) and a pressure of 870 psig (60 barg). This combination of high temperature and pressure results in optimum atomisation of the fluid, thus resulting in and efficient on-line compressor clean.

The module is connected to the liquid wash inlet connection on the turbine underbase.

Customer Connection References

Package Labeling

Identification and warning labelling of electrical devices, and other safety related equipment, on the external surfaces of the package (i.e. underbase, acoustic enclosure etc.) will be provided. These labels will comply with statutory requirements and provided in the English and Spanish language.

The symbols and sizes of all warning labels associated with personnel protection, (i.e. high voltage, CO_2, noise etc.), comply with internationally accepted standards. These are surface mounted with permanent stainless steel fasteners.

Skid Edge Service Connection Identification

Identification of the skid edge terminations is included. Siemens have provisioned for the stencilling of all the 'Service Connection Reference' abbreviations that are applicable to the equipment being offered. These are consistently used throughout all Siemens supplied documentation associated with the product (i.e. General Arrangement Drawings, Vents and drains reports, Manuals, Process and Instrumentation diagrams (P&ID's) etc.).

The stencilled labels will be conveniently located adjacent to the termination in a position which is either above, below or alongside the connection depending on space limitations.

Frame and Systems Test

Before despatch, each frame and system is tested in accordance with established Siemens Test Procedure. All testing is carried out under the supervision of the Siemens Quality Control Department, to ensure satisfactory performance of the turbine unit and strict compliance with Quality Control procedures. The purpose of this test is to ensure all systems are fully flushed, leak tested and functionally tested.

8.6 Lubricating Oil Breather System

Oil Mist Removal Device

A lubricating oil breather oil mist eliminator constructed from carbon steel (option available for SS) is provided for installation in the breather system to reduce the degree of oil mist being exhausted from the system. The maximum working temperature of the oil mist eliminator is 194°F (90°C).

The pressure drop is as follows:

Max 1" wg at 300 cfm (25.4mm wg at 510m^3/hr)

Max 2" wg at 540 cfm (50.8mm wg at 918m^3/hr)

8.7 Start System

Hydraulic Start

The turbine start sequence uses an AC electric motor driving a hydraulic pump, which provides hydrostatic power to a hydraulic motor mounted on the gearbox. The drive is through an automatically engaging SSS clutch.

On achieving turbine start, and at a pre-set speed, the swash plate on the hydraulic pump is set to zero and the AC motor stopped.

8.8 Fuel System

Gas Fuel System

Common Parts

The gas fuel system supplied will be suitable for use with the Dry Low Emission combustion system.

A gas fuel system suitable for burning customer supplied 2.2% CO2 and 1.7% CO2 gas is provided. A burner change out will be required to burn the 1.7% CO2 gas due to the difference in Wobbe index. The system is fully piped and installed within the turbine underbase with all necessary equipment to control the fuel flow according to the load requirements.

The gas must be supplied to the turbine at the supply temperatures and pressures defined by Siemens and are dependent on the lower calorific value (LCV) of the fuel supplied. For information purposes typical gas pressures and lower calorific value are shown in the technical data section of this proposal.

All equipment complies with Class 1 Division 2 Group D area requirements.

Fast Acting Ball Valves

The gas fuel enters the turbine via two fire safe shut-off ball valves before passing to the fuel metering system. The purpose of these valves is to be able to isolate the fuel system from the gas supply piping. A vent valve is provided between the ball valves piped back to the skid edge.

Metering Equipment

The fuel metering system is by means of a star valve which has the ability to meter the correct amount of fuel to the engine under all load conditions as well as start up The valve is positioned via an actuator which receives signals from the turbine control system

The low load fuel metering system is by means of a pilot star valve which has the ability to meter the correct amount of fuel to the engine start up and low load. This operates in parallel with the main star valve. The valve is positioned via an actuator which receives signals from the turbine control system

On Package Pressure Transmitters

Pressure transmitters are fitted upstream and downstream of the fuel metering valve to maintain the correct differential pressure across it.

Liquid Fuel System

Common Parts

A liquid fuel system suitable for burning liquid distillate is provided. The system is of modular design being fully assembled and installed within the turbine underbase with all necessary equipment to control the fuel flow according to the load requirements. All equipment complies with Class 1, Division 2 classified area requirements.

Package mounted Filter

Package mounted fuel filter is included. This filter is the final level of fuel filtration prior to entering the gas turbine package. The filter is duplex to Siemens standards.

Liquid fuel startup assist system

To improve reliability of the system on liquid fuel startup, a gas fuel assisted design is being supplied. As a part of that, Siemens will provide the design necessary to add a small gas fuel line from the customer supplied off-skid piping to the liquid fuel system. The system will startup on gas and automatically switch over to liquid fuel. A gas fuel supply of 5-10 psig will be required for about 1 to 2 minutes.

8.9 Combustion Air Inlet

Inlet Filter

A three stage air intake filter complete with filter housing of stainless steel construction.

The filter features a vane separator, prefilter and a HEPA filter stage.

Inlet Filter Access

An external platform complete with handrail and kick-plate is provided to allow safe access to the air intake filter house. This is reached by a single caged access ladder.

Combustion Air Inlet System Support Structure

A steel structure is supplied to support the turbine combustion air inlet system and is suitably painted for an outdoor onshore environment.

Inlet silencer

An air intake silencer fabricated from stainless steel, to limit the combustion air inlet average aperture noise level to 85dB(A) (SPL) in free field conditions. Option available for acoustic system designed for lower noise levels.

8.10 Exhaust System

Secondary Diffuser

An exhaust diffuser of stainless steel construction is provided as a transition piece between the axially phased turbine exhaust outlet casing and the exhaust ducting.

Exhaust Silencer

An exhaust silencer of stainless steel construction is provided. It is deisgned to be mounted on steelwork in a vertical orientation and provide noise attenuation to meet the 85 dB(A) SPL at 1m (3ft) from the exhaust, 3, (5ft) above grade.

Exhaust Ducting and Stack

The exhaust ducting is fabricated of stainless, straight exhaust ducting is used to raise the exhaust level to 40ft (15m) above grade.

8.11 Gears, Couplings and Guards

Main Gearbox

The gearbox is a speed reducing gear to join the turbine to the generator and is supplied with lubricating oil from the turbine lubrication system.

The turbine input drive speed is 9,500 rpm and the output drive speed is 1,800 rpm for 60Hz AC Generator drive.

Auxiliary Gearbox

Auxiliary gearbox directly coupled to the gas generator.

The auxiliary gearbox casing is supported directly by the compressor inlet bearing housing.

The auxiliary gearbox contains auxiliary drives for the starter motor interface, lubricating oil pump.

Lubrication of the auxiliary gearbox is from the turbine lubricating oil system.

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Gearbox Vibration Probes

An accelerometer type vibration probe is fitted to the gearbox casing. Vibration levels are displayed on the turbine Unit Control Panel VDU.

Power Turbine Coupling and Guard

The coupling between the gas turbine and the main gearbox is a flexible type coupling assembly. The coupling guard is fabricated from a non-sparking type material.

Generator Coupling and Guard

The coupling between the main gearbox and the Generator is a torque quil shaft type coupling with a shear pin design.

8.12 Acoustic Enclosure

Acoustic Enclosure

The enclosure is fitted over the gas turbine and another one over gearbox and the generator and mounted on the underbase with a 18mm sandwich (soft-hard-soft) neoprene rubber seal between the two, in order to reduce structure borne noise. The enclosure is designed to attenuate the underbase mounted equipment to achieve the average package noise level to 85dB(A) (SPL), in free field conditions.

The enclosure consists of a load bearing carbon steel framework with hinged doors and panels of galvanised carbon steel construction with SS internals. The roof panel is constructed from unlagged carbon steel plate.

The insulation in the side panels is a non-flammable, non-hygroscopic sound absorbing material which is protected from oil and vapour ingression and retained by perforated sheet steel on the inside. Efficient seals are provided to retain noise and prevent the ingress of rain or dust.

The framework, sides, door panels, end panels and roof are painted to Siemens standard onshore finish.

The doors are positioned to enable access to the burners and filter elements.

Inspection windows are fitted on each side of the enclosure and include shutters to prevent UV signals from penetrating inside the enclosure.

An integral lifting beam is incorporated for removing the top half of the turbine and gearbox support pedestal.

The doors are closed during turbine operation. If opened inadvertently, the turbine will automatically shut-down due to loss of ventilation air flow.

Enclosure Lighting

Internal lighting is provided by flameproof lamps strategically located in the roof structure.

Extinguishant Retention Dampers

Airflow cut-off dampers are incorporated into the enclosure. They are fitted at the ventilation air inlet and air outlet ducts. These dampers close when CO_2 is released in order to maintain the CO_2 concentration.

The dampers are pneumatically operated by the CO_2 extinguishant gas. Once dampers have been actuated to close, the dampers must be manually opened.

Ventilation Failure Detection

A paddle switch is located in the ventilation inlet duct to monitor ventilation air flow through the negatively pressurised enclosure.

Enclosure Grounding

The acoustic enclosure structure, access doors and roof mounted external equipment are all grounded.

8.13 Acoustic Enclosure Ventilation

Silencers

The ventilation air system incorporates carbon steel inlet and outlet silencers to limit their individual average aperture noise level to 85dB(A) (SPL) in free field conditions.

Ventilation Fans

2 x 100% AC electric motor driven ventilation fans rated Class 1, Division 2, Group D area classification, mounted in duct to supply positive pressure to the enclosure.

Weatherhoods

Weatherhoods with bugscreens are provided for the inlet and outlet ventilation.

8.14 Fire and Gas System

Extinguishant Skid

A twin shot CO_2 fire extinguishing system is provided, consisting of two sets of twin 100lb (45 Kg) CO_2 (Total 4) cylinders to be located next to the turbine package, inter-connected and provided with a changeover valve, arranged to give a single discharge of extinguishant gas.

The extinguishant system is in compliance with NFPA 12.

The spray nozzles are positioned at strategic locations inside the upper part of the turbine enclosure.

A manually operated ’FIRE’ actuator is provided at the CO_2 cylinder position.

An ’alarm’ klaxon sounds and an amber warning light flashes when extinguishant gas is released.

The fire and gas system will be provided complete with a weighing device in order to monitor the state of charge of the fire extinguishing system.

Detection Equipment

Fire Detection System

Consisting of four ultra-violet flame detectors and three heat detectors, strategically located inside the upper part of the enclosure.

The voting logic is:

2 out of 4:- flame detector sensing fire; 'SHUTDOWN'

1 out of 3:- heat detector sensing fire; 'SHUTDOWN’

Gas Detection System

Consisting of two gas sensors mounted in the ventilation outlet. The voting logic is:

1 out of 2 at a single location 10% LEL:- Low level ’ALARM’ and ’WARNING’

1 out of 2 at a single location 20% LEL:- High level ’ALARM’ and ’SHUTDOWN’

Extinguishant Discharge Piping and Nozzles

Fire extinguishant system distribution piping of SS fabrication is supplied pre-piped to the extinguishant spray nozzles sited inside the upper part of the acoustic enclosure. The piping is terminated at a suitable point on the package to allow connection with the off-skid piping.

Fire & Gas Control Panel

The fire and gas control system chassis is located within the turbine Unit Control Panel. This chassis contains all the necessary control for the fire system.

8.15 Generator

A 4 pole 1800 rev/min, brushless AC generator rated to match the output curve of the gas turbine over the specified ambient temperature range is supplied. The generator would be equipped as follows:-

Bearings

Two pedestal mounted insulated sleeve type bearings.

Stator

Designed for high thermal dissipation, the stator is constructed with low loss silicon steel lamination. After being wound the stator is vacuum pressure impregnated

Rotor

A thermal treatment for stress release forming a compact silicon steel lamination core resulting in a high thermal dissipation

Enclosure

Open Drip Proof. (ODP)

Excitation

Overhung exciter, together with a shaft mounted permanent magnet generator (PMG) for excitation supply, foot mounted on an extension to the non-drive end chassis.

Auxiliary Junction Boxes

Auxiliary junction boxes for low voltage connections are supplied on the outside of the generator.

Lineside Cubicle

The lineside cubicle includes the three (3) surge capacitors and three (3) lightening arrestors, each 1 per phase

Neutral Cubicle

The neutral cubicle includes 11 CT's, 3 for generator protection, 3 for metering, 3 for customer differential protection, 1 for CCCT, and 1 for NGR

Monitoring devices

Pt100 RTDs (6 in the stator winding, 1 per bearing).

Two Vibration detectors in the X-Y configuration

8.16 On Package Electrical Equipment

On Package Wiring

The cabling employed in the wiring of the turbine package electrical components is of the following type:-

High Temperature Tray Cable:

1. Power Cables consisting of single and multiple conductor unshielded cables.
2. Control and Instrumentation cables consisting of sheilded pairs and triads.

The cables are specifically rated for Class 1 Division 2 Group D area classification.

All wiring specifications and practices complies with CSA, FM, and NEC standards.

Cabling on the underbase is separated, as far as practical, between DC, (non-IS), IS and AC.

Emergency stop push-buttons are located on each side of the turbine package and on the front panel of the turbine Unit Control Panel.

Junction Box for Engine DC Devices

The Engine DC device junction box is a distribution center for all the DC components on package.

Junction Box DC Power Supplies

The DC power supplies junction box, located off skid near the battery cabinet, distributes DC power to the Engine DC Junction Box, the emergency lube oil motor, the ecu, and the ignitors.

Junction Box for Gas Fuel

The gas fuel junction box contains all the gas fuel instrumentation.

Junction Box for Proximitors

The proximitors junction box contains all the wiring for the proximitors on the package.

Electrical Device Tagging

Siemens electrical device tags will be attached to all standard electrical devices that are identified on the Piping and Instrumentation Diagrams (P&ID's) supplied by Siemens. These stainless steel tags are marked with Siemens standard tag numbers only.

The tags will be attached close to the device on the connecting cable.

These tags are applicable for Siemens standard equipment only and will not include any contract specific requirements.

Cable Trays and Fixings

Cable trays are laid out to permit proper segregation of AC, DC and DC non-IS cabling and will drain off any spillage of fluids.

Package Grounding

On package items are separately grounded to suitable points on the turbine underbase, by appropriately sized cables.

8.17 Package Electrical Systems

Batteries and Charger Cabinet

The 24 volt battery system consists of 13 sealed lead acid cells, encapsulated in a plastic shell. The batteries have sufficient capacity to power the turbine Unit Control Panel and on package IO modules for up to 3 hours in the event of AC power loss.

The battery system has sufficient capacity to power the 125V DC lubricating oil pump for up to 3 hours in the event of AC power loss. An inverter is supplied as part of the battery system to lower the 24V DC supply from 125V DC.

The free standing cubicle is constructed of painted carbon steel of sufficient thickness, to ensure rigid assembly and designed to be drip and vermin proof. Enclosure needs to be located in a safe non-hazardous area, such as a control room. Access is via lockable front mounted doors. Undrilled detachable gland plates are fitted at the top and bottom of the cubicle. Removable eye bolts are to be fitted for lifting. Enclosure to be comprised of two (2) compartments; top for charger, bottom for batteries. Batteries to be mounted in multiple step trays.

8.18 Control System Hardware

Unit Control Panel

The unit control panel, located on-skid holds all the controls for the turbine system. It holds the PLC Control System, the Vibration Monitor, and the Fire and Gas Controller.

It is powered by the 24VDC UPS system, supplied by the battery charger cabinet.

STA-RDS – Siemens Turbomachinery Applications – Remote Diagnostic System

Equipment is provided to connect the control system to STA-RDS to allow remote support during commissioning and during the warranty period, and thereafter as part of any optional support agreement. The system is used for data collection and to provide online support if any problems occur. Information collected can provide the following services.

- Automatic recording of data values in control system
- Analysis of events
- Analysis of downtime
- Predictive trending
- Anomoly detection
- Software updates
- Accelerated troubleshooting support
- Customer notification reports
- Access to historic data
- Driven unit monitoring

Vibration Monitoring

Monitoring is provided for two displacement transducers on each of the radial bearings, and one transducer on each of the thrust bearings. Shaft phase detection monitoring is also provided for the turbine shafts. Readout of vibration levels is provided and displayed on one of the mimic display screens (see Human/machine Interface section).

Emergency Stop Button

An emergency stop button is located on the cabinet door and terminals are available for the connection of remote emergency stop buttons. These are independent of the PLC controller.

Emergency Stop Loop

An independent 'hard wired' emergency stop circuit provides an external means of tripping the turbine if one of the following systems causes the circuit to be broken.

Over-speed
Initiation of any emergency stops
System watchdog
Fire detected in turbine enclosure (where appropriate)
Gas detected in turbine enclosure (where appropriate)

Cabinet Wiring

PVC tri-rated cables are used for cabinet wiring. The terminals are laid out to provide separation of digital and analog signals and intrinsically safe (IS) and non-IS wiring. All 24V DC power supplies used for field devices are protected with circuit breakers. In additon, powered relay outputs to solenoids are individually protected.

Display Messages

The VDU displays status and alarm messages. The message function is indicated by its color as follows: -

Shutdown messages:	White letters on a red background
Warning messages:	Black letters on a yellow background
Inhibit start messages:	White letters on a blue background
Status messages:	Black letters on a white background

The VDU will display messages up to 45 characters long. Each message will be referenced by its occurrence time and a unique number, followed by a description, and where appropriate, a Siemens tag number. The messages are displayed in the order they occur with the latest at the top and the oldest at the bottom. Each message is moved down the VDU when a new message is added. Alarm messages are displayed flashing until the operator acknowledges them.

The alarm sequence follows the ISA-S18.1A-1

The shutdown sequence follows the ISA-S18.1M-1.

8.19 Generator Control Panel

The unit consists of a on-skid panel of fabricated steel construction located on skid. The panel is suitable for front access with bottom cable entry via an undrilled blank gland plate.

Grounding

Grounding strips are located near the bottom of the cubicle.

Metering

Meters are provided to display the following parameters:

- Generated frequency
- Generated voltage
- Generator current
- Generator megawatts
- Generator MVAR
- **Power Factor**
- **Kilowatt Hour meter (Class 1)**
- **Null balance**
- **Exciter field current (A)**
- **Exciter field current (V)**

Generator metering parameters are also provided on the turbine Unit Control Panel VDU.

Electrical Protection

The following electrical protection is provided:

- 32R, Reverse power
- 87G Differential protection across generator only (If differential protection is required across both the generator and transformer then a separate biased differential relay will be required. This is NOT included within the Siemens generator control panel)

- **51V Voltage dependent overcurrent**
- **59, Overvoltage**
- **27, Undervoltage**
- **40, Field failure**
- **46, Negative phase sequence**
- **Event recorder**
- **Disturbance recorder**
- **Power-on diagnostics and self monitoring (watchdog)**
- **51N, Standby earth fault**
- **81, Over / under frequency**

Note - It is the responsibility of the client to ensure that where required grid failure protection is fitted.

Synchronizing

1 - Synchronize initiate manual / auto selector
1 - Auto synchronize initiate timer
1 - Synchroscope (Rotary pattern)
1 - Double voltmeter
1 - Double frequency meter
1 - Synchronizing manual/off/auto selector (Lockable in off)
1 - Automatic synchronizer
1 - Check synchronizer
1 - Synchronizing CB selector switch grid incomer / generator CB
1 - Governor control switch raise/N/lower
1 - Generator circuit breaker trip/N/close switch
1 - Set of generator circuit breaker status lamps
1 - Set of grid circuit breaker status lamps
1 - Auto synchronize initiate pushbutton and timer
1 - Dead bus closure facility and enable/off keyswitch with spring return to off. (Key removable in off position only)

Automatic Voltage Regulator

- 1 - Automatic voltage regulator (Basler DECS 200 digital voltage regulator) incorporating:
- Micro processor based design
- Non-volatile memory
- 20 standard stability selections
- 0.2% Voltage Regulation
- Soft start capability
- Overvoltage protection
- User external control capability
- True RMS sensing, single or three phase
- Overexcitation protection
- Single or Three phase shunt or PMG power output
- Manual Excitation Control
- Voltage Matching
- Alpha Numeric Display
- Solid State Build up circuit
- External Alarm Contact
- VAR/Power Factor Regulation
- **Under/Over Excitation Limiting**
- **Windows Software**
- **Rated field Voltage: 125VDC**
- **Rated Continuous Field Current: 15Adc**
- **Minimum Field Resistance: 8.3 ohms**

Note - Power factor is measured at the generator terminals

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8.20 Drawings and Documentation

Certified Information

The following document schedule details the typical documents (when applicable) that are supplied by Siemens in English to the Purchaser as certified information. THE SUBMISSION DATES ARE FOLLOWING THE CUSTOMER KICK-OFF MEETING AND ARE BASED ON SIEMENS STANDARD EQUIPMENT ONLY. Where any equipment is non-standard, these submission dates will be reviewed and agreed upon.

Welding procedures and welder qualifications are not submitted, but are available for inspection.

Operating Instructions

Turbine Operating Instructions will be submitted upon or shortly following delivery of main equipment. The document will contain information and instructions for the safe starting, operation and stopping of the turbine.

The document contains no servicing information and can be used in conjunction with the Operating and Routine Maintenance Manual.

8.21 Installation and Maintenance Equipment

Site Touch up Paints

Set of touch up paints to required specification and banding tapes for pipe identification purposes.

9.0 Customer Support Services

9.1 Training

Siemens proposal includes **optional** training of customer personnel at Siemens training facility Lincoln.

Siemens offers multiple training courses arranged to fit the customer's needs. We offer the following proven detailed training courses:

Training A: Operation and Maintenance course (5 day course)

Aim of the course: To provide the delegates with the necessary skills and knowledge to operate and maintain a Siemens Small Gas Turbine. To enable the delegate to interface with the control system in order to carry out operational commands on the turbine system and to understand the requirements of the control system and turbine in order to operate the turbine competently. To give the delegate the skills necessary to plan and carry out routine maintenance. To create delegates capable of carrying out first line fault-finding on the turbine in order to gain maximum availability from the turbine package.

Expected delegate: The course is intended for a Customers operation and maintenance engineers. (10 delegates)

Duration of Course: 9 sessions over 5 days

Duration of each session: 3 hours

Scheme of work:

Session 1: What is a gas turbine, gas turbine components

Session 2: SGT Contract manuals explained, help desk and service bulletins, understanding Siemens' P&IDs, the Lube oil system

Session 3: GT enclosure and ventilation, the start system, gas fuel system

Session 4: Liquid fuel system, purge system, laser alignment overview

Session 5: Fire and gas monitoring, high and low pressure wash systems

Session 6: Routine maintenance, engine borescoping

Session 7: Factory tour (If located conducted at Siemens works)

Session 8: Control system components, MCC's, Start sequence, Practical exercises on the VCR

Session 9: GCP overview, core engine change out, DLE overview, HSE

Resources needed: Whiteboard, PowerPoint, test pieces, animations, video, simulators, drawings, handouts and images

Assessment methods: Observation, multi-choice tests, practical.

Training B: Controls(5 day course)

Title: The Controls system for the control of the Gas Turbine.

Aim of Course: To equip the delegate with the necessary skills to understand how the control system operates, its design, all its major components and how we implement it for gas turbine control.

Who for: The course is intended for experienced turbine operators or any technically qualified personnel with knowledge of turbo machinery. (10 delegates)

Duration of course: 9 sessions over 5 Days

Duration of each session: Each session will be three hours

Scheme of work:

Session 1: Introduction into health and safety, review the IDS and show mimics explain tags and tag boxes, review the navigation bar and explain what the instructions do, explain trending and Setpoint adjust utility.

Session 2: Go through IDS trending using the fault buttons on the simulator. Introduction into the control system explain what the cards do and explain the LED status lamps

Session 3: Explain the applications needed. Demonstrate how we connect to the system and how we find out the IP address. Explain the different data types used BOOL, INT,SINT,DINT and REAL. Go through tasks program and routine structure.

Session 4: Open a new project and create new tasks, explain the importance of the main routine. Show simple switch and coil on a rung and how to either upload or download also show how to edit online and offline

Session 5: Show how to write code in Ladder logic, demonstrate a simple program like a car park (this in turns lets the delegates use different instructions). Demonstrate the use of ladder logic instructions.

Session 6: Continue with the exercises for the remainder of the session. Explain the use of JSR and AFI show how to save software to hard disc and non-volatile memory.

Session 7: Continue with the exercise showing them this time how to write in Function block code.

Session 8: Configure and talk about controlnet explain its use and how to alias the outputs, show forcing, inputs and outputs.

Session 9: Explain the Sam module, what it does, how to communicate with it using Hyperterminal. Show and explain the SAM menu. Demonstrate the datalogger using the simulator and show Dataplot.

Resources needed: Powerpoint, simulators, interactive whiteboard, drawings, handouts, procedures, props.
Assessment Methods: Completion of tasks, question and answer, observation

9.2 Support Center Services

Siemens Customer Support Center provides professional and highly competent support services for Siemens and other gas turbine users throughout the Americas. Products serviced include the following equipment: TA, TB, SGT-100, SGT-200, SGT-300, SGT-400, SGT-500, SGT-600 and SGT-700 Prime Movers, skid & associated systems, auxiliary systems, controls and instrumentation.

Siemens provides the following services for the above equipment:

1. Supervise the complete Installation and Commissioning of new or relocated equipment
2. Perform routine service work
3. Provide troubleshooting services around the clock
4. Provide 'hands on' site training for User's operators and maintenance personnel
5. Provide complete gas turbine engine overhaul and repair
6. Provide service exchanges on a number of major turbine assemblies, allowing rapid servicing at site

Siemens also offers an advisory service to all operators to maximize the availability and maintain a full return on their gas turbine investment.
When on site services are required, the following hourly rates are applicable and are chargeable for every day from the date of departure from dispatch base to date of return.

List of Abbreviations

<u>Note</u>: The use of abbreviations has been minimized in the English translation of this manual, as many of Siemens' standard company abbreviations are based on the German term, which may confuse readers of the English version.

The following abbreviations are listed in alphabetical order.

Abbreviation	**Clear Text Term**
3i	Ideas, Innovations and Initiatives
BE	Business Excellence
BSC	Balanced Scorecard
BU	Business Unit
CA	Cost Accounting
CCM	Customer Complaint Management
CO	Communication
COGG	Compliance Officer
CR	Reporting, Controlling
CM	Contract Management
CRM	Customer Relationship Management
CSP	Customer Satisfaction Program
DF	Division Functions
Div	*Division*
E	Siemens Energy Sector Group
E O	Siemens Energy Sector Division Oil & Gas
E S	Siemens Energy Sector Division Energy Service
E S SO	Siemens Energy Service Division Business Unit Oil & Gas and Industrial Applications Services
E&A	Electrical & Automation
EBIT	Earnings before Interest and Taxes
EFA	*Entwicklung, Förderung, Anerkennung:* Development, Promotion and Reward; *staff dialogs with superiors for performance appraisal and definition of objective agreements. US equivalent: PDP dialog*
EHS	Health, safety and environmental affairs
EHS-O	EHS Officer
EIS	Purchasing Information System *("Einkaufsinformationsystem")*
EVA	Economic Value Added
FI	Finance
FM	Facility Management
GS	Global Strategy
HR	E O's central Human Resources office
HRS	E O's local Humans Resources offices at the respective company sites
I&K	information & knowledge
IMS	Integrated Management System
IT	Information technology
KCM	Key Commodity Manager
LOA	"Limits of Authority" (process)
LS	Local Service
MF	Manufacturing
MGM	Materials Group Manager
Mgmt	Management
M & S	Marketing & Sales
NC	Non-conformance (nonconformity)
NCC	Non Conformance Costs
OH&S	Occupational Health & Safety
OHSAS	Occupational Health & Safety Assessment Series
OE	Organizational unit
OEM	Original Equipment Manufacturer
OI	Organizational Instruction
OP	Order Processing
OPC	Operative Procurement
OTMS	Opportunity Tracking Management System
PACE	Finance reporting tool of Siemens E O
PCM	Preventive Crisis Management
PD	Process Description
PGM	*top*$^{+}$ Quality Program Manager

PLM	Product Lifecycle Management
PM	Project Manager
PMP	Performance Management Process
POC	Percentage of Completion
PRHB	Process Handbook
QB	*Qualitätsbeauftragter:* German for Quality Management Representative
QEHS	Quality, Environmental, Health and Safety Affairs
QM	Quality Management
REV	Review Board
RPH	Reference Process House
SCC	Safety Checklist Contractors
SCM	Supply Chain Management
SCO	Siemens Corporate Organization
SESIS	Siemens Environmental and Technical Safety Information System
SN	*Siemens Norm:* German for "Siemens Standard"
SOA	Sarbanes Oxley Act
SOA-O	Sarbanes Oxley Act Officer
SPC	Strategic Procurement
SPF	Siemens Process Framework
STL	*Standortleitung:* German for Site Management
top	Time Optimized Process (*Siemens wide initiative to improve processes with systematic tools*)
top+	Second version of *top* initiative
VGP	Value Generation Program
WC	Works Council
WF	Works Facilities
WI	Work Instruction

Major Changes to Rev. 3:

- Document completely revised due to changes in the organization in 2009.
- major changes are marked with a vertical line