OEM design points:		
Engine model	9171E	
shaft speed:rpm	3000	
ISO std-p:kpa	101.3	
ISO std-t:°C	15	
ISO std RH:	60%	
vapor/air:kg/kg	0.006	
design flow:kg/s	407.0	
compress-ratio:	12.30	
turbine firing t:°C	1124	
turbine exit t:°C	538	
ISO output:kWe	126040	
heat rate kj/kWh	10460	
compress stages	17	
stage pr-ratio:	1.159	
polytropic eff:	0.863	
turbine pr-ratio:	12.30	
turbine stages:	3	
stage pr-ratio:	2.308	
polytropic eff:	0.863	
specified fuel	methane	
CH_4 LHV:kj/kg	49997	
fuel/air ratio:	0.019	
fuel/H_2O fwd:kpa	1323	
fuel fwd temp:°C	56	
mechanical eff:	0.993	
combustor eff:	0.999	
alternator eff:	0.986	
Engine cooling ceof:		
total cmpr bleed	0.0713	
cmpr to stage3	0.0060	
cmpr to stage2	0.0063	
cmpr to stage1	0.0590	
nett cmbt inlet	0.9287	
total cmbt exit	0.9463	
Off-design GT exh flow		
exh gas:kg/kg	57.8	
exh air:kg/kg	57.5	
exh flow:kg/s	381.4	

Off-design conditions:		stn#
actual fuel apply	diesel-6	0
site ambient:kpa	101.3	
site amb temp:o(	33	1
relative humidity	85%	
vapor / air:kg/kg	0.027	
		2
Actual test corrections:		
air inlet filter Δp	1.0%	3
engine intake Δp	0.3%	
compr-exit Δp	0.2%	
combustor Δp	0.5%	4
exhaust exit Δp	3.0%	
actual cmpr pr	12.14	5
actual turbine pr	11.635	
actual fuel ratio	0.023	
actual cmpr eff	0.863	2
actual turb eff	0.863	3
actual cmbtr eff	0.999	
actual mech eff	0.993	
actual altern eff	0.986	4
actual flow:kg/s	373.5	5
engine cooling coef:		
total cmpr bleed	0.0713	
cmpr to stage3	0.0060	
cmpr to stage2	0.0063	
cmpr to stage1	0.0590	
nett cmbt inlet	0.9287	
total cmbt exit	0.9498	
Optional BOP functions:		
deNOx H_2O:kg/s	0	
H_2O/air:kg/kg	0.0000	
dN-H_2O:kj/kgk	4.2105	
Off-design GT exh energy		
exh heat:kj/kg	782	
exh energy:kj/s	298591	
engine thrust:N	122820	

Gas calculation	kpa	k	m^3/kg	R	cp	gamma
ISO standard air	101	288	0.825	288	1.009	1.400
ambient air inlet	101	306	0.905	292	1.027	1.396
air filter outlet	100	306	0.915	292	1.027	1.396
compressor inlet	100	306	0.917	292	1.027	1.396
compressor exit	1230	664	0.162	292	1.0957	1.3628
air exit diffuser	1228	664	0.162	292	1.096	1.363
combustor zone	1222	1397	0.340	297	1.304	1.295
deNOx water in	1222	1397	0.340	297	1.304	1.295
combustor exit	1215	1397	0.341	297	1.304	1.295
turbine SOT exit	1215	1348	0.329	297	1.304	1.295
turbine b/f cool	104	831	2.364	297	1.1890	1.3330
turbine aft cool	104	829	2.360	297	1.064	1.387
turbine exhaust	104	827	2.354	297	1.064	1.387

Flow parameter	Mach	flow:Q	A:m^2	V:m/s	Upit:m/s	Rpit:m
comp 1st stage	0.58	33.00	1.980	199	322	1.023
comp last stage	0.16	10.81	0.672	82	295	0.939
combust zone1	0.02	1.42	2.208	19	0	0.838
combust zone2	0.10	6.81	1.593	51	0	0.914
turbine 1st stage	0.16	10.10	1.061	112	335	1.068
turbine last stage	0.50	28.95	3.563	281	405	1.290

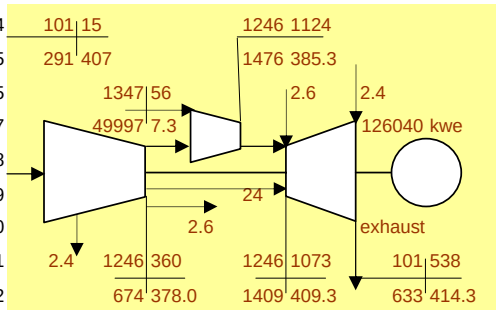
data evaluation	comp	turbine
isentropic ETA:	0.814	0.896
ref Tm gamma:	1.3628	1.3330
ref Tmean cp:	1.0957	1.1890

Engine sizing	comp	turbine
rotor-ϕ/blade-h	mm	mm
1st stage hub	1775	1974
1st stage pitch	2087	2154
1st stage tip	2400	2334
1st stage blade	312	180
last stage hub	1787	2112
last stage pitch	1915	2603
last stage tip	2043	3093
last stage blade:	128	490

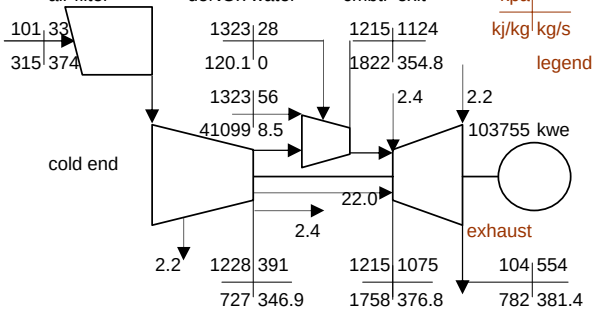
combustor evaluation	
inner comb vol:m	0.037
outer comb vol:m	0.096
zone-1 flow:kg/s	77.4
zone-2 flow:kg/s	57.7
zone-3 flow:kg/s	219.7

Performance Analysis:	
cmpr work:kWs	146977
turb power:kWs	250731
net power:kWe	103755
fuel flow rate:kg/	7.889
fuel rate:kg/kWh	0.274
heat efficiency:	0.320
heat rate:kj/kWh	11250

OEM design points: ISO 100% methane fuel



Off design (change fuel to Diesel)



HRSG-Dual Pressure (non RH); forced circulation-vertical flue flow; single steam flow-HP-exh mix LP-new to LP turbine

GT exhaust parameter

gt exit flow: kg/s	381.4
gt exit temp: °C	553.9
gt exit enth:kj/kg	781.7

HRSG design analysis:

heat transf eff	92.0%

HP design p&t profile:

		rated:
HP sph1:kpa	10674	10674
HP sph1:oC	523.6	523.6
sph1-appro:Dt°C	30.3	76.0
sph1:sph2 Δkpa	5.0%	NA
HP sph2:kpa	11208	NA
HP sph2:°C	460	460
sph2-appro:Δt°C	174.5	125
hpev>sph Δkpa	5.0%	NA
HP evap:kpa	11768	NA
HP evap:°C	323.2	319
hpev-pinch:Δt°C	8	8
hpec>evap Δkpa	5.0%	NA
HP econ:kpa	12356	NA
HP econ-exit:°C	305.0	305
hpec-appro:Δt°C	74.1	12

LP design p&t profile:

LP sph:kpa	552.7	552.7
LP sph:°C	283.7	283.7
lpsh-appro:Δt°C	103.3	38
lpev>sph Δkpa	20.0%	NA
LP evap:kpa	663.2	NA
LP evap:°C	162.8	NA
lpev-pinch:Δt°C	22.0	7.4
Deaerator:kpa	594	594
Deaerator:°C	146	146
LP econ:kpa	3200	NA
LP econ-exit:°C	161	NA
lpec-appro:Δt°C	105.6	20

Steam turbine design:

HP stm inlet:kpa	10515	10515
HP stm inlet:°C	520.0	530.6
LP stm inlet:kpa	482.2	482.2
LP stm inlet: °C	280.0	285.6
LP stm exh:kpa	5.71	8
LP stm exh:°C	35.3	NA

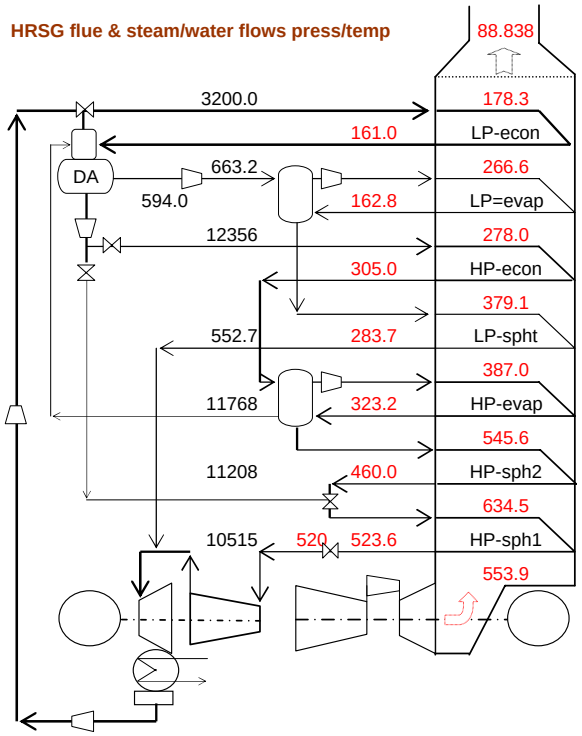
Stm turbine efficiency:

HP turbine	0.88	NA
LP turbine	0.845	NA
mechanical	0.993	NA
alternator	0.99	NA
exh loss:kj/kg	56	NA

HRSG flue gas flow parameters & steam evaporation calculations:

	<steam phase >>				<gas phase >>					m-flow
Heat exchange:	p:kpa	t:°C	st:kj/kg	liq:kj/kg	Q:kj/s	Tp:°C	Tp:kj/kg	ex:kj/kg	exit:°C	m:kg/s
HP sphtr-1	10674	523.6	3426.6		12167	553.9	656.8	752.3	634.5	69.79
HP sphtr-2	11208	460.0	3252.3		38960	634.5	765.6	658.3	545.6	
HP evaporator	11768	323.2	2694.0	1482.3	92458	331.2	372.4	435.3	387.0	69.79
HP economizer	12356	305.0		1369.1	47998	379.1	431.2	316.3	278.0	
LP superheater	552.7	283.7	3029.6		1344	387.0	441.2	432.1	379.1	4.98
LP evaporator	663.2	162.8	2759.7	687.6	10681	184.8	201.4	290.5	266.6	4.98
LP economizer	3200.0	161.0		681.3	39893	183.0	199.4	194.3	178.3	74.77
Deaerator	594.0	146.0		615.0		flue gas discharge temp:		88.838		
bfwp inlet	5.71	35.3		147.7		**Energy:Q=kj/s**	HP	LP	Total	
Evaporation	HP	LP	Total			energy utilized	143585	60023	243501	
Output:kg/hr	251227	17929	269155			counter balance	143585	60023	243501	

HRSG flue & steam/water flows press/temp



HRSG liq/stm states:

Cdn fw-in:kj/kgk	0.5087
Lp-econ in:°C	35.4
Lp-econ:kj/kgk	1.9494
D/A inlet:°C	158.4
D/A liq-s:kj/kjk	1.9269
Lp evap in:°C	158.5
Lp evap:kj/kgk	1.9269
Lp evap sat:°C	162.8
Hp econ in:°C	159.8
Hp econ:kj/kgk	3.2878
Hp econ out:°C	305.0
Hp evap in:°C	304.7
Hp evap sat:°C	323.2

Turbine steam states

HP stm-in:kj/kg	3419.3
HP exh stm:kpa	526.0
HP exh stm:°C	153.8
HP exh-h:kj/kg	2749.8
HP exh-s:kj/kjk	6.802
HP isen-δh:kj/kg	2735.5
correct θh:kj/kg	2821.0
LP stm-in:kj/kg	3023.9
Hp+Lp mix:kj/kg	2834.5
LP stm-in:°C	190.0
LP exh-s:kj/kgk	7.031
LP isen-δh:kj/kg	2264.2
correct θh:kj/kg	2381.9

attemperation:

rate	0.0%
t:°C	522
kpa	10674
kj/kg	3419

blow down:

HP rate	0.0%
LP rate	0.0%

Steam turbine proper output

kWe	HP	LP	Total
design	40880	29031	69911
actual	40880	29031	69911

GTCC Performance Evaluation

performance	design	actual
power kWe:	173665	173665
heat rate kj/kWh	6721	6721
combine heat eff	0.536	0.536
heat recovery eff	0.816	0.816

circulating water flow

CW inlet t°C	23
CW in/out Δt	8
CW exit t°C	31
CW flow kg/s	5255

R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH				
2	**Fuel analysis**			**Heat formation Δh_f table**				**Combustion reaction stoichiometric**						**Fluegas content by wt**						
3	carbon	0.871		**mole**	**mol wt**	**kj/mol**		**mole**	**C_xH_y**	**$C_xH_yO_z$**	**$C_xH_yN_z$**	**$C_xH_yS_z$**		second argument	temp					
4	hydroge	0.100		C	12.01	-717		C	13.0	3.0	4.0	4.0		reference temp	25.56					
5	oxygen	0.000		CO_2	44.01	394		H	17.9	6.0	4.0	4.0		reference press	101.56					
6	nitrogen	0.000		H	1.01	-218		O		1.0				zero enthalpy temp	0.01					
7	sulfur	0.021		H_2O(l)	18.02	286		N			2.0			gas mixture % by	weight					
8	moisture	0.005		H_2O(g)	18.02	242		S				1.0		carbon dioxide	0.035					
9	ash	0.003		O	16.00	-249		O_2	17.5	4.0	9.0	6.0		atmospheric nitro	0.748					
10	total	1.000		N	14.01	-473		CO_2	13.0	3.0	4.0	4.0		oxygen	0.152					
11	**Combustibles**			NO2	46.01	-33		H_2O	8.9	3.0	2.0	2.0		sulfur dioxide	0.000					
12	carbon	0.8777		S	32.06	-276		NO_2			2.0			water vapor	0.066					
13	hydroge	0.1012		SO_2	64.12	297		SO_2				1.0		total	1.000					
14	nitrogen	0.0000		$C_4H_4N_2$	80.09	140		**Molecular ratio**			**Combustion Analysis**			**Fuel fluegas analysis**						
15	sulfur	0.0212		C_4H_4S	84.14	81		H	C		std air mole wt	28.97		gas	m^3/kg					
16	total	1.0000		fuel	177.91	245		0.1004	0.0731		O2 fraction in air	0.21		CO_2	1.6253					
17	**Fuel-bond N_2/S**			**Benson Δh_f**		245		H/C	1.3735		fluegas constant	297		N_2	8.2743					
18	$C_4H_4N_2$	0.0000		group	cal/mol	kj/mol		17.86	13.00		theoret-air kg/kg	13.57		SO_2	0.0147					
19	C_4H_4S	0.0555		P: CH_3	10.01	41.91		N	S		prime zone t:k	2451		H_2O	0.1798					
20	**Heating value**			S: CH_2	4.99	20.89		0.0000	0.0007		2nd-zone t:k	1603		theoret-flue	10.094					
21	HHV	43318		T: CH	2.03	8.50		N/C	S/C		3rd zone t:k	1397		prime flue	14.108					
22	LHV	41099		Q: C	0.12	0.50		0.0000	0.0090		prime excess air	1.383		final actural flue	33.552					
23								N mole	S mole		2nd excess air:	1.856		theoret-air/flue	10.474					
24								0.0000	0.1174		total excess air:	3.240								

Engine design point evaluation (ISO CH_4)

	gas R	mT-cp	cp/cv	stg-pr	isen-eff	inlet-p	exit-p	inlet-T	exit-T
Compr	288	1.102	1.398	1.159	0.810	101	1246.3	288	658
Turbine	292	1.191	1.326	2.308	0.897	1246	101	1397	821

Engine	**compressor**		**turbine rotor**	
stage	**1st**	**last**	**1st**	**last**
Load	0.223	0.265	2.000	1.370
pr coef	1.085	0.878	0.440	0.510
flow Q	33.31	10.87	10.18	29.25
sizing	**1st**	**last**	**1st**	**last**
A:m^2	2.047	0.770	1.221	4.008
Rhub	0.888	0.893	0.987	1.056
Rpitch	1.044	0.957	1.077	1.301
Rtip	1.200	1.021	1.167	1.546
blade	0.312	0.128	0.180	0.490
hub/tip	0.740	0.875	0.845	0.683
speed	**1st**	**last**	**1st**	**last**
Mach	0.58	0.16	0.15	0.50
V:m/s	192	81	113	277
V/Upit	0.59	0.27	0.33	0.68
Uhub	279	281	310	332
Upitch	328	301	338	409
Utip	377	321	367	486
reMhub	0.80	0.57	0.45	0.77
reMpit	0.86	0.61	0.48	0.88
reMtip	0.94	0.64	0.52	1.00

Combustor	θair	z1-Xair	z2-Xair
gas state	17.235	1.305	1.780
flame-T	SOT	LHV	FAR
2472	1397	49997	0.0188

combustor flow	**design**	**off-des**
intensity:kW/m^3	24363	24436
zone-1 flow:kg/s	71.9	77.4
zone-2 flow:kg/s	70.1	57.7
zone-3 flow:kg/s	265.0	219.7

Off-design engine speed evaluation

	compressor		**turbine rotor**	
stage	**1st**	**last**	**1st**	**last**
pr coef	1.085	0.878	0.440	0.510
Mach	0.58	0.16	0.16	0.50
V/Upit	0.62	0.28	0.33	0.69
Uhub	279	281	310	332
Upitch	322	295	335	405
Utip	377	321	367	486
reMhub	0.80	0.57	0.45	0.76
reMpit	0.85	0.60	0.48	0.87
reMtip	0.94	0.64	0.53	0.98

Combustor design/off-design points

	design point		**off-design**	
zone	inner	outer	inner	outer
Load	1.500	1.500	1.500	1.500
Mach	0.020	0.100	0.020	0.100
flow:Q	1.432	6.868	1.421	6.814
A:m^2	2.614	1.154	2.197	1.098
V:m/s	20	51	19	51
flow:	163	222	135	220
vol:m^3	0.500	1.185	0.419	1.100
radius:m	0.912	0.963	0.836	0.889
length:m	0.549	1.231	0.501	1.237
time:sec	0.028	0.024	0.026	0.024

Fluegas NO_X emission Calculation

theroret-air kg/kg per LHV	13.487
theroret-air m^3/kg per LHV	10.431
fluegas kg/kg per LHV	14.487
fluegas m^3/kg per LHV	11.073
fluegas density kg/m^3	1.3083
primary combustion	
prime flugas NO_X kg/kg	0.0021
prime flugas NO_X mg/m^3	149.70
final combustion	
final fluegas NO_X kg/kg	0.005
final fluegas NO_X mg/m^3	149.70