POWSIM

THE USER MANUAL
FOR VERSION 1.2

Part B - Appendices

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APPENDIX A - Listing of computational results

File: *.RES

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 MAIN DATA , FILES : 2PR.PDT             V942.PGT
 OUTPUT FILE: RES.RES
 SUBCRITRICAL CYCLE WITH  3 PRESSURE LEVEL(S) , REHEATING AS PRESSURE LEVEL 2

 GAS TURBINE OUTPUT                          :  288482.000  kW
 STEAM TURBINE OUTPUT                        :  205854.500  kW
 TOTAL PUMP WORK                             :    4432.382  kW
 GAS TURBINE AUXILIARY POWER                 :    1504.000  kW
 STEAM TURBINE AUXILIARY POWER               :     514.636  kW
 TRANSFORMER LOSS                            :       0.000  kW
 TOTAL AUXILIARY POWER CONSUMPTION           :    6451.018  kW
 NET PLANT OUTPUT                            :  487885.500  kW
 COOLING WATER MASS FLOW                     :   11603.900  kg/s
 INLET EXHAUST TEMPERATURE                   :     600.000  C (-X)
 STACK TEMPERATURE                           :      92.388  C (-X)
 HRSG HEAT TRANSFER                          :  570920.800  kW
 TOTAL HRSG HEAT TRANSFER AREA               :  262221.800  m2
 GAS TURBINE EFFICIENCY                      :      32.377  %
 NET PLANT EFFICIENCY                        :      51.422  %
 STEAM CYCLE EXERGY EFFICIENCY               :      66.865  %
 GT POWER+EXHAUST EXERGY DIVIDED BY Qfuel    :      61.994  %
 STEAM CYCLE HEAT BALANCE ERROR     (OK !)   :      -0.701  kW
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Data files: *.PDT for steam cycle data and *.PGT for gas turbine data.
The filename of the this output file.
Cycle description

Generator terminal output
Generator terminal output

Power requirement for auxiliary equipment and all pumps

Temperature in front of HRSG, after supplementary firing if used.
The (-X) means steam quality when the given temperature is negative

Appears only if the heat transfer area is calculated (item 2 in the CALCULATION & OUTPUT menu)
Based on fuel lower heating value
Based on fuel lower heating value
Based on the gas turbine exhaust exergy
The plant efficiency if the steam cycle is a reversible process.
Computational heat balance error. Should be smaller than " 2 kW.
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EXHAUST GAS DATA

EXHAUST TEMPERATURE FROM GAS TURBINE	:	553.000	C (-X)
EXHAUST TEMPERATURE AFTER SUPPLEMENTARY FIRING	:	600.000	C (-X)
STACK TEMPERATURE	:	92.388	C (-X)
AVERAGE CP FOR EXHAUST GAS	:	1.117	kJ/(kg*K)
WATER VAPOUR DEW POINT	:	40.858	C
EXHAUST GAS MASS FLOW	:	1006.995	kg/s

The average Cp is for information only. POWSIM is calculating with a variable Cp.

The temparature at which the water vapour in the exhaust gas starts to condense.

	N2	Ar	CO2	O2	H2O	MW
BEHIND GAS TURBINE (mole %)	75.770	0.000	3.160	13.840	7.230	28.350
BEHIND GAS TURBINE (weight%)	74.870	0.000	4.906	15.621	4.603	
AFTER SUPL. FIRING (mole %)	75.617	0.000	3.356	13.407	7.620	28.325
AFTER SUPL. FIRING (weight%)	74.783	0.000	5.215	15.146	4.856	

N2=Nitrogen, Ar=Argon, CO2=Carbondioxide, O2=Oxygen, H2O=Water, MW=Molecular

Gas turbine exhaust gas composition on molecular basis and molecular weight

Gas turbine exhaust gas composition on weight basis

Gas composition on molecular basis after supplementary firing and molecular weight

Gas composition on weight basis after supplementary firing

T	Cp	H	T	Cp	H
600.000	1.183	664.360	340.000	1.113	365.629
590.000	1.180	652.592	330.000	1.110	354.390
580.000	1.178	640.824	320.000	1.108	343.345
570.000	1.175	629.056	310.000	1.105	332.388
560.000	1.172	617.287	300.000	1.103	321.431
550.000	1.170	605.519	290.000	1.100	310.475
540.000	1.167	593.751	280.000	1.098	299.518
	.			.	
	.			.	
	.			.	
460.000	1.146	501.374	200.000	1.079	212.435
450.000	1.143	489.871	190.000	1.077	201.691
440.000	1.140	478.367	180.000	1.075	190.947
430.000	1.138	466.864	170.000	1.073	180.203
420.000	1.135	455.541	160.000	1.072	169.459
410.000	1.132	444.302	150.000	1.070	158.714
400.000	1.129	433.063	140.000	1.068	147.970
390.000	1.127	421.824	130.000	1.066	137.226
380.000	1.124	410.585	120.000	1.064	126.599
370.000	1.121	399.346	110.000	1.063	116.026
360.000	1.119	388.107	100.000	1.061	105.453
350.000	1.116	376.868	90.375	1.060	95.277

T=temperature EC, Cp=specific heat capacity kJ/(kg*K), H=enthalpy kJ/kg

This is a table of temperatures, specific heat capacities $(dH/dT)_P$ and enthalpies for the exhaust gas heat recovery.

T=90.375 EC is the stack temperature

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HEAT RECOVERY STEAM GENERATOR

PRESSURE LEVEL #                              :          1
PINCH AT THIS PRESSURE LEVEL                  :     10.000  C (-X)
STEAM MASS-FLOW PRODUCED                      :    125.633  kg/s
LIVE STEAM PRESSURE                           :    110.000  bar
LIVE STEAM TEMPERATURE                        :    550.000  C (-X)
ENTHALPY SUPERHEATER OUTLET,LIVE STEAM        :   3489.748  kJ/kg
EVAPORATOR PRESSURE (PRESSURE IN DRUM)        :    115.500  bar
DRUM TEMPERATURE                              :    321.732  C (-X)
ENTHALPY EVAPORATOR OUTLET                    :   2698.432  kJ/kg
PRESSURE EVAPORATOR INLET                     :    121.000  bar
ENTHALPY ECONOMIZER OUTPUT (SUBCOOLED)        :   1455.068  kJ/kg
ECONOMIZER APPROACH TEMPERATURE               :      3.000  C (-X)
PRESSURE ECONOMIZER INLET , AFTER PUMP        :    121.000  bar
TEMPERATURE ECONOMIZER INLET , AFTER PUMP     :    155.612  C (-X)
ENTHALPY ECONOMIZER INLET , AFTER PUMP        :    663.721  kJ/kg
TEMP DIFF SUPERHEATING (EXHAUST/LIVE STEAM)   :     50.000  C (-X)
EXHAUST TEMPERATURE SUPERHEATER INLET         :    600.000  C (-X)
EXHAUST TEMPERATURE SUPERHEATER OUTLET        :    468.328  C (-X)
EXHAUST TEMPERATURE AT PINCH                  :    331.732  C (-X)
EXHAUST TEMPERATURE ECONOMIZER OUTLET         :    241.751  C (-X)

PRESSURE LEVEL #                              :          2
REHEATING STAGE
EXHAUST GAS SPLIT RATIO (REHEATER FRACTION)   :     35.645  %

STEAM MASS FLOW PRODUCED                      :    125.633  kg/s
LIVE STEAM PRESSURE                           :     30.000  bar
LIVE STEAM TEMPERATURE                        :    560.000  C (-X)
ENTHALPY REHEATER OUTLET,LIVE STEAM           :   3590.623  kJ/kg
PRESSURE REHEATER INLET                       :     31.500  bar
TEMPERATURE REHEATER INLET                    :    366.197  C (-X)
ENTHALPY REHEATER INLET                       :   3152.335  kJ/kg
TEMP DIFF SUPERHEATING (EXHAUST/LIVE STEAM)   :     40.000  C (-X)
EXHAUST TEMPERATURE REHEATER INLET            :    600.000  C (-X)
EXHAUST TEMPERATURE REHEATER OUTLET           :    468.328  C (-X)
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Pressure level number where #1 is the one with the highest pressure.

Temperature difference between the exhaust gas (between evaporator and economiser) and the drum.

Steam pressure leaving the superheater.

Temperature difference between exhaust and steam at the superheater hot end.

A message appears here if the pressure stage is a reheat stage or supercritical stage.

From a computational point of view the exhaust gas is splitted between the superheater and the reheater. This is the portion for the reheater.

The reheater inlet is the return from the high-pressure turbine.

PRESSURE LEVEL #	:	3	
PINCH AT THIS PRESSURE LEVEL	:	15.000	C (-X)
STEAM MASS-FLOW PRODUCED	:	34.304	kg/s
LIVE STEAM PRESSURE	:	5.000	bar
LIVE STEAM TEMPERATURE	:	221.751	C (-X)
ENTHALPY SUPERHEATER OUTLET,LIVE STEAM	:	2901.669	kJ/kg
EVAPORATOR PRESSURE (PRESSURE IN DRUM)	:	5.250	bar
DRUM TEMPERATURE	:	153.690	C (-X)
ENTHALPY EVAPORATOR OUTLET	:	2749.673	kJ/kg
PRESSURE EVAPORATOR INLET	:	5.500	bar
ENTHALPY ECONOMIZER OUTPUT (SUBCOOLED)	:	635.418	kJ/kg
ECONOMIZER APPROACH TEMPERATURE	:	3.000	C (-X)
PRESSURE ECONOMIZER INLET , AFTER PUMP	:	5.500	bar
TEMPERATURE ECONOMIZER INLET , AFTER PUMP	:	104.869	C (-X)
ENTHALPY ECONOMIZER INLET , AFTER PUMP	:	440.099	kJ/kg
TEMP DIFF SUPERHEATING (EXHAUST/LIVE STEAM)	:	20.000	C (-X)
EXHAUST TEMPERATURE SUPERHEATER INLET	:	241.751	C (-X)
EXHAUST TEMPERATURE SUPERHEATER OUTLET	:	237.025	C (-X)
EXHAUST TEMPERATURE AT PINCH	:	168.690	C (-X)
EXHAUST TEMPERATURE ECONOMIZER OUTLET	:	131.090	C (-X)

See explanation on page 4

DEAERATOR AND PREHEATING SYSTEM

DEAERATOR TEMPERATURE	:	104.810	C (-X)	The water in the deaerator is saturated, and therefore this is the saturation temperature
DEAERATOR PRESSURE	:	1.200	bar	and this is the saturation pressure.
MASS FLOW INTO DEAERATOR FROM FLASH TANK	:	3.831	kg/s	Steam flow rate required to obtain saturation state in deaerator.
PRESSURE LOSS IN PIPE FROM FLASH TANK	:	0.200	bar	
TEMPERATURE DIFFERENCE FEEDWATER/DEAERATOR	:	10.000	C (-X)	The water temperature at the preheater exit is below saturation temperature.
EXHAUST TEMPERATURE FEEDWATER HEATER INLET	:	131.090	C (-X)	
EXHAUST TEMPERATURE FEEDWATER HEATER OUTLET	:	92.388	C (-X)	
FEEDWATER HEATER INLET PRESSURE	:	5.200	bar	
FEEDWATER HEATER OUTLET PRESSURE	:	1.200	bar	
WATER TEMPERATURE FEEDWATER HEATER INLET	:	60.000	C (-X)	The feedwater inlet temperature - should be above the exhaust gas dew point.
WATER TEMPERATURE FEEDWATER HEATER OUTLET	:	94.810	C (-X)	
MASS FLOW CIRCULATED IN FEEDWATER HEATER	:	78.775	kg/s	To obtain the required feedwater inlet temperature, hot water is recirculated.
FLASH TANK PRESSURE	:	1.400	bar	
STEAM FRACTION IN FLASH TANK	:	7.924	%	
STEAM MASS FLOW OUT OF FLASH TANK	:	3.831	kg/s	
WATER MASS FLOW OUT OF FLASH TANK	:	44.514	kg/s	
MIXING TEMPERATURE BEFORE FEEDWATER HEATER	:	46.513	C (-X)	The liquid fraction from the flash is mixed with the condensate.

HRSG HEAT TRANSFER

Heat transfer in the heat recovery steam generator between exhaust gas and steam/water

PRESSURE LEVEL #	:	1	
HEAT TRANSFERRED IN SUPERHEATER	:	99415.2	kW
HEAT TRANSFERRED IN EVAPORATOR	:	155698.4	kW
HEAT TRANSFERRED IN ECONOMIZER	:	99419.0	kW
PRESSURE LEVEL #	:	2	
HEAT TRANSFERRED IN REHEATER	:	55063.3	kW
PRESSURE LEVEL #	:	3	
HEAT TRANSFERRED IN SUPERHEATER	:	5214.0	kW
HEAT TRANSFERRED IN EVAPORATOR	:	74151.4	kW
HEAT TRANSFERRED IN ECONOMIZER	:	40681.3	kW
HEAT TRANSFERRED IN FEEDWATER HEATER	:	41278.2	kW
SUM HRSG HEAT TRANSFERRED	:	570920.8	kW

HRSG HEAT TRANSFER AREA

The heat transfer are and LMTD are calculated with variable Cp for bothcold and hot fluid.

```
                        AREA     U-VALUE            LMTD           UATamb/W
-------------------------------------------------------------------------------
PRESSURE LEVEL #  : 1
SUPERHEATER       :   27777.  m2   50.0  W/(m2*K)   71.58  C (-X)   10.593
EVAPORATOR        :   59330.  m2   50.0  W/(m2*K)   52.49  C (-X)   22.626
ECONOMIZER        :   58249.  m2   50.0  W/(m2*K)   34.14  C (-X)   22.214

PRESSURE LEVEL #  : 2
REHEATER          :   15893.  m2   50.0  W/(m2*K)   69.29  C (-X)    6.061

PRESSURE LEVEL #  : 3
SUPERHEATER       :    2321.  m2   50.0  W/(m2*K)   44.93  C (-X)    0.885
EVAPORATOR        :   37216.  m2   50.0  W/(m2*K)   39.85  C (-X)   14.192
ECONOMIZER        :   37368.  m2   50.0  W/(m2*K)   21.77  C (-X)   14.251

FEEDWATER HEATER  :   24068.  m2   50.0  W/(m2*K)   34.30  C (-X)    9.179

TOTAL HEAT TRANSFER AREA:  262222.  m2              43.54  C (-X)   18.804
AREA/MWnet             :  763.061  m2/MW
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UATamb/W is a dimensionless quantity expressing the required UA per cycle power ouput.

In the rightmost column the UATamb/W are percentages of the total UATamb/W.

This is the total UATamb/W for the cycle.
This is the required heat transfer area per MW of steam cycle output.

STEAM TURBINE

TURBINE CASING #.		:	1		The expansion path is divided into sections which corresponds to the HRSG pressure levels.
GROSS WORK FOR THIS TURBINE CASING		:	42075.540	kW	
FRACTION OF STEAM TURBINE WORK		:	20.073	%	
ENTHALPY DROP		:	334.919	kJ/kg	Enthalpy drop from inlet to outlet of turbine section.
INNER EFFICIENCY		:	92.000	%	Isentropic efficiency for the section.
MASS FLOW		:	125.629	kg/s	
MASS FLOW THROUGH SEALS		:	0.004	kg/s	The portion of the section inlet mass flow which exergy is not converted to work.
INLET STATE	PRESSURE	:	104.500	bar	Section inlet state (stagnation)
	TEMPERATURE	:	546.766	C (-X)	
	ENTHALPY	:	3487.254	kJ/kg	
	VOLUME	:	0.03379	m3/kg	
	ENTROPY	:	6.722	kJ/(kg*K)	
OUTLET STATE	PRESSURE	:	32.445	bar	Section outlet state (stagnation)
	TEMPERATURE	:	367.001	C (-X)	
	ENTHALPY	:	3152.335	kJ/kg	
	VOLUME	:	0.08612	m3/kg	
	ENTROPY	:	6.768	kJ/(kg*K)	

TURBINE CASING #.		:	2	
GROSS WORK FOR THIS TURBINE CASING		:	59809.730	kW
FRACTION OF STEAM TURBINE WORK		:	28.533	%
ENTHALPY DROP		:	476.083	kJ/kg
INNER EFFICIENCY		:	88.000	%
MASS FLOW		:	125.629	kg/s
MASS FLOW THROUGH SEALS		:	0.004	kg/s
INLET STATE	PRESSURE	:	27.000	bar
	TEMPERATURE	:	557.764	C (-X)
	ENTHALPY	:	3588.381	kJ/kg
	VOLUME	:	0.13972	m3/kg
	ENTROPY	:	7.447	kJ/(kg*K)
OUTLET STATE	PRESSURE	:	4.825	bar
	TEMPERATURE	:	322.830	C (-X)
	ENTHALPY	:	3112.298	kJ/kg
	VOLUME	:	0.56427	m3/kg
	ENTROPY	:	7.559	kJ/(kg*K)

TURBINE CASING #.		:	3	
GROSS WORK FOR THIS TURBINE CASING		:	107729.700	kW
FRACTION OF STEAM TURBINE WORK		:	51.394	%
ENTHALPY DROP		:	692.757	kJ/kg
INNER EFFICIENCY		:	87.000	%
MASS FLOW		:	159.933	kg/s
MASS FLOW THROUGH SEALS		:	0.003	kg/s
INLET STATE	PRESSURE	:	4.650	bar
	TEMPERATURE	:	300.510	C (-X)
	ENTHALPY	:	3066.669	kJ/kg
	VOLUME	:	0.56292	m3/kg
	ENTROPY	:	7.498	kJ/(kg*K)
OUTLET STATE	PRESSURE	:	0.040	bar
	TEMPERATURE	:	-0.926	C (-X)
	ENTHALPY	:	2373.912	kJ/kg
	VOLUME	:	32.21883	m3/kg
	ENTROPY	:	7.878	kJ/(kg*K)

TURBINE CASING # : 3   (DETAILS)

STAGE #	1	2	3	4	5		The low pressure turbine (last turbine section) is calculated in 5 stages
INLET PRESS :	4.65	0.20	0.18	0.14	0.09	bar	Stage inlet pressure
OUTLET PRESS :	0.20	0.18	0.14	0.09	0.04	bar	Stage outlet pressure
INLET TEMPER :	300.510	-0.975	-0.970	-0.962	-0.951	C (-X)	Stage inlet temperature
OUTLET TEMPER:	-0.975	-0.970	-0.961	-0.947	-0.926	C (-X)	Stage outlet temperature
INLET ENTHAL :	3066.7	2549.9	2533.0	2505.1	2462.4	kJ/kg	Stage inlet enthalpy
OUTLET ENTHAL:	2549.9	2533.0	2503.2	2453.2	2373.9	kJ/kg	Stage outlet enthalpy
INLET ENTROPY:	7.50	7.73	7.74	7.76	7.82	kJ/(kg*K)	Stage inlet entropy
OUTLET ENTRO :	7.73	7.74	7.75	7.79	7.88	kJ/(kg*K)	Stage outlet entropy
MASS FLOW :	159.93	159.93	159.93	159.80	159.15	kg/s	Mass flow entering each stage
EFFICIENCY :	87.00	85.55	85.11	84.37	83.46	%	Isentropic efficiency for each stage. The efficiency is corrected for moisture.
WORK :	82646.	2705.	4768.	8297.	14089.	kW	Gross power output for each stage
DRAINED :	0.000	0.000	0.000	0.134	0.648	kg/s	Water drainage in front of each computational stage
FRACTION OUT :	0.000	0.000	0.000	2.151	7.628	%	The fraction of the moisture that is drained

LEAVING LOSS KJ/KG , KW :	30.000	4774.530	The low pressure turbine leaving loss - specific and total
TOTAL WORK LOW PRESSURE TURBINE :	107729.700 kW		
MECHANICAL & GENERATOR EFFICIENCY :	98.206 %		
TOTAL WORK OUTPUT STEAM TURBINE :	205854.500 kW		Steam turbine generator terminal power output

PUMPS

PRESSURE LEVEL #	:	1		Feedwater pump (high pressure)
FEEDWATER PUMP WORK	:	2094.084	kW	
ISENTROPIC EFFICIENCY	:	82.000	%	
MECHANICAL EFFICIENCY	:	92.000	%	
PUMP INLET PRESSURE	:	5.250	bar	
PUMP INLET ENTHALPY	:	648.386	kJ/kg	
PUMP OUTLET PRESSURE	:	121.000	bar	
PUMP OUTLET ENTHALPY	:	663.721	kJ/kg	
PUMP PRESSURE INCREASE	:	115.750	bar	
CIRCULATION PUMP WORK	:	553.001	kW	
PRESSURE LEVEL #	:	3		Feedwater pump (low pressure)
FEEDWATER PUMP WORK	:	130.075	kW	
ISENTROPIC EFFICIENCY	:	82.000	%	
MECHANICAL EFFICIENCY	:	92.000	%	
PUMP INLET PRESSURE	:	1.200	bar	
PUMP INLET ENTHALPY	:	439.524	kJ/kg	
PUMP OUTLET PRESSURE	:	5.500	bar	
PUMP OUTLET ENTHALPY	:	440.099	kJ/kg	
PUMP PRESSURE INCREASE	:	4.300	bar	
CIRCULATION PUMP WORK	:	4.979	kW	
COOLING WATER PUMP WORK	:	1508.937	kW	
ISENTROPIC EFFICIENCY	:	82.000	%	
MECHANICAL EFFICIENCY	:	92.000	%	
CONDENSATE PUMP WORK	:	128.072	kW	
ISENTROPIC EFFICIENCY	:	82.000	%	
MECHANICAL EFFICIENCY	:	92.000	%	
TOTAL PUMP WORK	:	4432.382	kW	

CONDENSER

CONDENSING TEMPERATURE	:	28.983	C (-X)	The temperature at which the steam from the low pressure turbine condenses.
COOLING WATER PRESSURE LOSS	:	10.000	METER H20	Condenser hot end temperature difference.
COOLING WATER PRESSURE LOSS	:	0.981	bar	
TERMINAL TEMPERATURE DIFFERENCE	:	11.483	C (-X)	
INLET COOLING WATER TEMPERATURE	:	10.000	C (-X)	
OUTLET COOLING WATER TEMPERATURE	:	17.500	C (-X)	
COOLING WATER MASS FLOW	:	11603.900	kg/s	
STEAM MASS FLOW TO CONDENSER	:	159.936	kg/s	
CONDENSER UA	:	24350.344	kW/K	Heat transfer divided by the log mean temperature difference
HEAT TRANSFERRED IN CONDENSER	:	363310.600	kW	

APPENDIX B - Results from heat balance and exergy calculations

File: *.XRY

All numbers are in kW. Different control volumes are considered (HRSG, steam turbine and condenser). Negative numbers are outgoing heat flows from the control volumes and positive numbers for ingoing heat flows.

HEAT BALANCE FOR STEAM CYCLE

HEAT RECOVERY STEAM GENERATOR............			
EXHAUST ENERGY IN	653192.100		Exhaust gas entering the heat recovery steam generator (HRSG)
EXHAUST ENERGY OUT	-82271.590		Exhaust gas to stack
FEEDWATER IN	19429.480		Feedwater coming from the condenser
LIVE STEAM OUT STAGE #1	-438426.400		Live steam going to the turbine at pressure level 1
LIVE STEAM OUT STAGE #2	-451099.600		Live steam going to the turbine at pressure level 2 (reheat steam for this case)
STEAM IN FROM REHEAT	396036.300		Steam return from high pressure turbine which is to be reheated
LIVE STEAM OUT STAGE #3	-99538.020		Live steam going to the turbine at pressure level 3 (low pressure steam for this case)
FEEDWATER PUMP #1	1926.557		Enthalpy increase at pressure level 1 (pump work multiplied with mechanical efficiency)
CIRCULATION PUMP #1	508.761		Enthalpy increase at pressure level 1 (pump work multiplied with mechanical efficiency)
FEEDWATER PUMP #3	119.669		Enthalpy increase at pressure level 3 (pump work multiplied with mechanical efficiency)
CIRCULATION PUMP #3	4.580		Enthalpy increase at pressure level 3 (pump work multiplied with mechanical efficiency)
CONDENSATE PUMP	117.826		Enthalpy increase at pressure level 1 (pump work multiplied with mechanical efficiency)
BALANCE FOR HRSG	-0.354	-0.0000619 %	Heat balance check for the HRSG. This number is usually less than 2 kW if the calculation was successful

TURBINE............			
LIVE STEAM IN	989064.100		Sum of steam coming from the HRSG
REHEAT STEAM TO HRSG	-396036.300		Steam going back to the HRSG for reheating
HEAT LOSS FROM LIVE STEAM PIPING	-667.400		Total heat loss from live steam pipes connecting the HRSG and steam turbine
HEAT LOSS FROM TURBINE	-5.177		
EXTRACTIONS FROM LP-TURBINE	-147.430		Water extractions from the steam turbine
OUT OF LP-TURBINE	-382592.700		Steam leaving the low pressure turbine
MECH. + GENERATORLOSS	-3760.490		Mechanical losses from the steam turbine and generator losses
NET POWER	-205854.500		Net power generated by the steam turbine
BALANCE FOR TURBINE	0.009	0.0000009 %	Heat balance check for the steam turbine.

CONDENSER.........			
OUT OF LP-TURBINE	382592.700		Steam from the low pressure turbine
EXTRACTIONS FROM LP-TURBINE	147.430		Water extractions from the steam turbine, which are mixed in the condenser pot
COOLING WATER IN	490166.600		Cooling water entering the condenser
COOLING WATER OUT	-853477.300	363310.600	Cooling water leaving the condenser - second number is the heat absorbed by the cooling water
CONDENSATE OUT	-19429.480		Condensate leaving the condenser and going to the HRSG
BALANCE	0.044	0.0000114 %	Heat balance check for the condenser

EXERGY ANALYSIS FOR THE HEAT RECOVERY STEAM GENERATOR

	EXERGY	PERCENTAGE
EXERGY IN EXHAUST	300469.2	100.000
FEEDWATER EXERGY	180.2	0.060
REHEAT RETURN	150737.5	50.167
PUMP WORK IN	2910.2	0.969
SUPERHEATER #1	-7016.1	2.335

EVAPORATOR #1	-9038.9	3.008
ECONOMIZER #1	-4679.6	1.557
CIRCULATION PUMP #1	-89.2	0.030
FEEDWATER PUMP #1	-403.1	0.134
REHEATER	-2780.6	0.925
SUPERHEATER #3	-575.7	0.192
EVAPORATOR #3	-5016.2	1.669
ECONOMIZER #3	-1653.8	0.550
CIRCULATION PUMP #3	-1.0	0.000
FEEDWATER PUMP #3	-23.8	0.008
FEEDWATER PREHEATER & CONDENSATE PUMP	-3666.4	1.220
FLASH TANK LOSS	-343.0	0.114
DEAREATOR LOSS	-157.3	0.052
FEEDWATER MIXING LOSS	-1253.6	0.417
STACK LOSS	-9471.6	3.152
TOTAL HRSG LOSSES	46169.6	15.366
LIVE STEAM EXERGY STAGE #1	-195947.2	65.214
LIVE STEAM EXERGY STAGE #2	-183321.0	61.012
LIVE STEAM EXERGY STAGE #3	-28859.3	9.605
BALANCE FOR HRSG	0.0	0.000

All numbers are in kW. The considered control volume is the HRSG. Negative numbers are outgoing exergy flows from the control volume and positive numbers for ingoing exergy flows.

Exhaust gas entering the HRSG. Defined as 100%.
Feedwater coming from the condenser
Steam return from the high pressure turbine which is to be reheated
Total pump work (feedwater pumps, circulation pumps and condensate pump)
Exergy loss for superheater at pressure level 1
Exergy loss for evaporator at pressure level 1
Exergy loss for economizer at pressure level 1
Exergy loss for circulation pump at pressure level 1
Exergy loss for feedwater pump at pressure level 1
Exergy loss reheater
Exergy loss for superheater at pressure level 3
Exergy loss for evaporator at pressure level 3
Exergy loss for economizer at pressure level 3
Exergy loss for circulation pump at pressure level 3
Exergy loss for feedwater pump at pressure level 3
Exergy loss for feewater preheater and condensate pump
Exergy loss for flashing
Exergy loss for deaeration
Exergy loss for the mixing of condensate and liquid fraction from the flash tank
Exergy loss for the rejection of exhaust gas to the ambient
Sum exergy losses for HRSG control volume
Exergy content live steam at pressure level 1
Exergy content live steam at pressure level 2 (reheat steam in this case)
Exergy content live steam at pressure level 3
Exergy balance check for HRSG volume

EXERGY ANALYSIS FOR TURBINE

All numbers are in kW. The considered control volume is the steam turbine sections. Negative numbers are outgoing exergy flows from the control volume and positive numbers for ingoing exergy flows.

		EXERGY	PERCENTAGES	
PRESSURE STAGE #	1			High pressure section
EXERGY IN LIVE STEAM		195947.2	65.214	Exergy entering the steam turbine section
LOSS IN LIVE STEAM PIPING		-1001.9	0.333	Exergy loss in live steam piping due to heat loss and pressure loss
LOSS OF STEAM TO SEALS		-5.8	0.002	Exergy loss for the steam which goes through the seals
EXERGY BEFORE EXPANSION		194939.4	64.878	Exergy content at the turbine section entrance
INTERNAL LOSSES IN TURBINE		-1662.6	0.553	Exergy loss when expanding the steam in the turbine
EXERGY AFTER EXPANSION		151201.3	50.322	Exergy content at the turbine section exit
MECH. AND GENERATOR		-754.8	0.251	Exergy loss because of mechanical losses and generator losses
TOTAL LOSSES		3425.2	1.140	Sum of exergy losses for the turbine section
NET POWER (STAGE)		-41320.7	13.752	Net power output from turbine section
BALANCE FOR SECTION		0.0	0.000	Exergy balance check for turbine section 1
PRESSURE STAGE #	2			Reheat section
EXERGY IN LIVE STEAM		183321.0	61.012	Exergy entering the steam turbine section
LOSS IN LIVE STEAM PIPING		-1914.4	0.637	Exergy loss in live steam piping due to heat loss and pressure loss
LOSS OF STEAM TO SEALS		-5.4	0.002	Exergy loss for the steam which goes through the seals
EXERGY BEFORE EXPANSION		181401.2	60.373	Exergy content at the turbine section entrance
INTERNAL LOSSES IN TURBINE		-4051.6	1.348	Exergy loss when expanding the steam in the turbine
EXERGY AFTER EXPANSION		117539.8	39.119	Exergy content at the turbine section exit
MECH. AND GENERATOR		-1073.0	0.357	Exergy loss because of mechanical losses and generator losses
TOTAL LOSSES		7044.4	2.344	Sum of exergy losses for the turbine section
NET POWER (STAGE)		-58736.7	19.548	Net power output from turbine section
BALANCE FOR SECTION		0.0	0.000	Exergy balance check for turbine section 2 (reheat section for this case)

PRESSURE STAGE # 3			Low pressure section
EXERGY IN LIVE STEAM	28859.3	9.605	Exergy entering the steam turbine section from the HRSG
STEAM FROM PRESSURE LEVEL ABOVE	117539.8	39.119	Exergy entering the steam turbine section from the previous section
STEAM FROM SEALS IN	3.5	0.001	Exergy entering the steam turbine section from the seals of the previous section
LOSS IN LIVE STEAM PIPING	-1243.4	0.414	Exergy loss in live steam piping due to heat loss and pressure loss
LOSS OF STEAM TO SEALS	-2.9	0.001	Exergy loss for the steam which goes through the seals
EXERGY BEFORE EXPANSION	145156.3	48.310	Exergy content at the turbine section entrance
INTERNAL LOSSES IN TURBINE	-15884.8	5.287	Exergy loss when expanding the steam in the turbine
EXERGY AFTER EXPANSION	16852.9	5.609	Exergy content at the turbine section exit
STAGE LOSS #1 LP-TURBINE	-10678.9	3.554	Exergy loss for stage 1 of the turbine section
STAGE LOSS #2 LP-TURBINE	-398.6	0.133	Exergy loss for stage 2 of the turbine section
STAGE LOSS #3 LP-TURBINE	-738.8	0.246	Exergy loss for stage 3 of the turbine section
EXTRACTION #2 LP-TURBINE	-1.2	0.000	Exergy loss for water extraction
STAGE LOSS #4 LP-TURBINE	-1398.7	0.465	Exergy loss for stage 4 of the turbine section
EXTRACTION #3 LP-TURBINE	-3.4	0.001	Exergy loss for water extraction
STAGE LOSS #5 LP-TURBINE	-2440.9	0.812	Exergy loss for stage 5 of the turbine section
LEAVING LOSS	-4688.9	1.561	Exergy loss becuase of the leaving loss
MECH. AND GENERATOR	-1932.7	0.643	Exergy loss because of mechanical losses and generator losses
TOTAL LOSSES	19063.8	6.345	Sum of exergy losses for the turbine section
NET POWER (STAGE)	-105797.0	35.211	Net power output from turbine section
BALANCE FOR SECTION	0.0	0.000	Exergy balance check for turbine section 3

EXERGY ANALYSIS FOR CONDENSER........(*)=LOSSES

STEAM FROM LP-TURBIN EXIT	17075.3	5.683	Exergy content of steam coming from the low pressure turbine
STEAM FROM EXTRACTIONS	4.7	0.002	Exergy content of water from the steam turbine water extractions
COOLING WATER IN	0.0	0.000	Exergy of the cooling water - zero if the temperature for ambient water equals that of the cooling water
COOLING WATER PUMP WORK	1508.9	0.502	
COOLING WATER PUMP LOSS *	-374.8	0.125	Exergy loss for cooling water pump
HEAT TRANSFER LOSS *	-19423.4	6.464	Condenser heat transfer loss
CONDENSER EXERGY REJECTION *	1384.9	-0.461	Exergy loss when rejecting the cooling water at a temperature above the ambient
CONDENSATE OUT	-180.2	0.060	Exergy content of the condensate going to the HRSG
TOTAL CONDENSER LOSS	18413.3	6.128	Sum exergy losses for condenser
BALANCE	-4.6	-0.025	Exergy balance check for condenser

EXERGY FROM GAS TURBINE	261942.8	87.178	Exergy content of exhaust gas leaving the gas turbine
EXERGY IN SUPPL. FUEL (LHV)	57798.2	19.236	Exergy of the fuel in supplementary firing - defined equal to the lower heating value
EXERGY AFTER SUPPL. FIRING	300469.2	100.000	Exergy content of exhaust gas entering the HRSG (defined as 100%)
EXERGY LOSS SUPPL. FIRING	19271.8	6.414	Exergy loss in supplementary firing
EFFICIENCY OF SUPL. FIRING	66.7		The exergy efficiency of converting fuel to heat by suplementary firing

EXERGY LOSS SUMMARY

This is a summary ("easy-to-read") of exergy losses without all the details

	EXERGY	
EXHAUST GAS EXERGY	300469.2	Exergy content of exhaust gas entering the HRSG
HRSG HEAT TRANSFER LOSSES	-34427.2	Sum of HRSG heat transfer losses and pressure drop losses
DEAERATOR-FLASHTANK-FEEDWATER MIXING	-1753.9	Exergy losses becuase of flashing and mixing
STACK LOSS	-9471.6	Exergy loss for the rejection of exhaust gas to the ambient
HRSG PUMPS	-517.0	Sum of exergy losses for feedwater pumps, circulation pumps and condensate pump
TURBINE LOSSES LEVEL #1	-2670.3	Exergy losses for steam turbine section 1
TURBINE LOSSES LEVEL #2	-5971.5	Exergy losses for steam turbine section 2
TURBINE LOSSES LEVEL #3	-21820.0	Exergy losses for steam turbine section 3
MECHANICAL AND GENERATOR LOSS	-3760.5	Exergy loss for mechanical losses and generator losses
CONDENSER LOSSES	-18413.3	Exergy losses for condenser
AUXILIARY POWER CONSUMPTION	-514.6	Auxiliary power consumption is regarded as an exergy loss
TRANSFORMER LOSS FOR STEAM CYCLE	0.0	Exergy loss for converting electricity to a higher voltage
SUM LOSSES	99319.8	Sum of above exergy losses
NET WORK (Steam Cycle)	200907.5	Net power output at the steam turbine generator terminals
EXERGY EFFICIENCY	66.865	Ratio between power output and exergy content of the exhaust gas entering the HRSG

MAIN EXERGY LOSSES SORTED BY SIZE

Column 1: exergy losses
Column 2: exergy loss as percentage of exergy content of the exhaust gas entering the HRSG
Column 3: exergy loss as percentage of the total exergy losses

	EXERGY	PERCENTAGES		
HRSG HEAT TRANSFER LOSSES	34427.2	11.458	34.663	Sum of HRSG heat transfer losses and pressure drop losses
TURBINE LOSSES LEVEL #3	21820.0	7.262	21.969	Exergy losses for steam turbine section 3
CONDENSER LOSSES	18413.3	6.128	18.539	Exergy losses for condenser
STACK LOSS	9471.6	3.152	9.536	Exergy loss for the rejection of exhaust gas to the ambient
TURBINE LOSSES LEVEL #2	5971.5	1.987	6.012	Exergy losses for steam turbine section 2
MECHANICAL AND GENERATOR LOSS	3760.5	1.252	3.786	Exergy loss for mechanical losses and generator losses
TURBINE LOSSES LEVEL #1	2670.3	0.889	2.689	Exergy losses for steam turbine section 1
DEAERATOR-FLASHTANK-FEEDWATER MIXING	1753.9	0.584	1.766	Exergy losses becuase of flashing and mixing
HRSG PUMPS	517.0	0.172	0.521	Sum of exergy losses for feedwater pumps, circulation pumps and condensate pump
AUXILIARY POWER CONSUMPTION	514.6	0.171	0.518	Auxiliary power consumption is regarded as an exergy loss
SUM LOSSES	99319.8	33.055	100.000	

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