Solstice Development Services

HELE Power Station

Cost and Efficiency Report

June 2017

Executive summary

Background

Solstice Development Services (SDS) has been retained by ACA Low Emissions Technologies Ltd to investigate the case for High Efficiency Low Emission (HELE) power stations in Australia's future power generation mix.

SDS has engaged GHD Pty Ltd (GHD) to support this investigation by providing information on performance and costs for a generic HELE plant in Australia.

This information includes:

- Likely performance for a new plant under typical Australian conditions,
- A range of capital cost estimates for a new plant, considering Australian labour costs, as well as utilising lower cost equipment from China,
- Benchmarks of the cost estimate methodology against reported costs for similar plants built in the last decade.

This report contains the information developed by GHD.

Plant and performance

The base case HELE plant is a 650 MW (sent out), wet cooled single unit generator. The boiler is fuelled by black coal and a typical Hunter Valley specification has been used for modelling. Steam conditions are 275 barg and 604 ℃ for the high pressure steam and 59 barg and 604 ℃ for the intermediate pressure steam.

A dry cooing system was also modelled as an alternative. The performance figures for both at an ambient temperature of 25 ℃ are presented in Table 1.

Table 1 Summary of performance figures

Parameter	Unit	Base case (wet cooling)	Dry cooling comparison case
Inputs and outputs			
Coal consumed	tph	195.6	201.4
Steam turbine output	MW	675.5	678.8
Auxiliary loads and losses	MW	25.5	28.8
Net (sent out) output	MW	650.0	650.0
CO_2 emissions	tph	505.3	520.3
Heat rate			
Heat rate (net, LHV)	kJ/kWh	8,396	8,646
Efficiency (net, LHV)	%	42.88	41.64
Heat rate (net, HHV)	kJ/kWh	8,704	8,963
Efficiency (net, HHV)	%	41.36	40.16

Capital costs

Preliminary cost estimates have been produced using Thermoflow's PEACE™ (Preliminary Engineering and Cost Estimation) software. This software uses a "factored cost" approach, which has recognised limitations on accuracy. The estimates are presented in Table 2.

Table 2 Summary of capital costs

Cost categories	Base case (wet cooling)	Dry cooling comparison case
Contractor's Internal Cost	US$1,121.8 M	US$1,162.1 M
Contractor's Soft & Miscellaneous Costs	US$211.7 M	US$224.9 M
Total - Contractor's Cost	**US$1,333.4 M**	**US$1,387.0 M**
Net Plant Output (MW)	650	650
Cost per kW - Contractor's	**US$2,051**	**US$2,134**

The 'Contractor's Cost' is the cost to build the plant, and excludes additional costs incurred by the owner (e.g. project development, finance and legal fees, interest during construction).

At an exchange rate of AU$1=US$0.75, the 'Contractor's Cost' for the base case would be AU$1.778b.

PEACE uses a number of cost multipliers to reflect the local cost of constructing a power station relative to the cost at the United States (US) reference location. The PEACE database contains default cost multipliers for different regions in the US as well as for various countries around the world. The default multipliers can be manually overridden by the user if there are better project specific figures available.

In addition to using the default Thermoflow cost factors for Australia, GHD has considered three alternative scenarios in order to assess the potential range of outcomes under different combinations of cost multiples. These three additional cases reflect consideration of:

1. A set of cost multipliers produced by WorleyParsons for a report published by CO2CRC for the Hunter Valley region of Australia[1] that include higher Australian labour costs,
2. Incorporation of a lower cost multiplier for 'Specialised Equipment' to reflect sourcing this equipment from China,
3. A combination of the above.

The costs for the alternative scenarios are shown in Table 3 and illustrate the potential cost savings from use of Chinese equipment.

[1] CO2CRC (et. al.) 2015, *Australian Power Generation Technology Report*

Table 3 Cost scenario results

Cost categories	Base Case - PEACE default factors for Australia	Alternative 1 – WorleyParsons amended factors	Alternative 2 – Base case factors amended for Chinese sourcing	Alternative 3 – Combination of alternatives 1 and 2
Total – Contractor's Cost	US$1,333.4 M	US$1,293.6 M	US$1,143.7 M	US$1,187.3 M
Net Plant Output (MW)	650	650	650	650
Cost per kW – Contractor's	US$2,051	US$1,990	US$1,760	US$1,827
Percentage of default cost	100%	97.0%	85.8%	89.1%

Benchmarking

A benchmarking exercise has been undertaken to compare publicly available cost information for existing projects against the estimates produced by PEACE. The intention of this benchmarking exercise is to provide a level of confidence in the PEACE estimates presented in this report based on the error margins calculated against known projects.

A report published by the IEA Clean Coal Centre (IEACCC) in 2016 states that 164 HELE plants were built between 2010 and 2016 across China, Japan, the UK and the EU, of which 142 were in China[2].

Publicly available information for HELE projects constructed over the last decade has been identified and used for this benchmarking exercise. To compare the reported costs to the PEACE estimates, the published cost figures have been escalated to 2016 costs using the Producer Price Index for the country in which the plant is located.

It should be noted that the public information is often not specific in relation to the configuration of the plant, what the stated cost covers, and the reliability of the source. Some assumptions have been made to address these uncertainties and they are reflected in the results.

The results from this benchmarking exercise are presented in Figure 1, which shows the percentage deviation of the published costs against the PEACE estimate.

[2] Dr Malgorzata Wiatros-Motyka 2016, *An overview of HELE technology deployment in the coal power plant fleets of China, EU, Japan and USA*, IEACCC

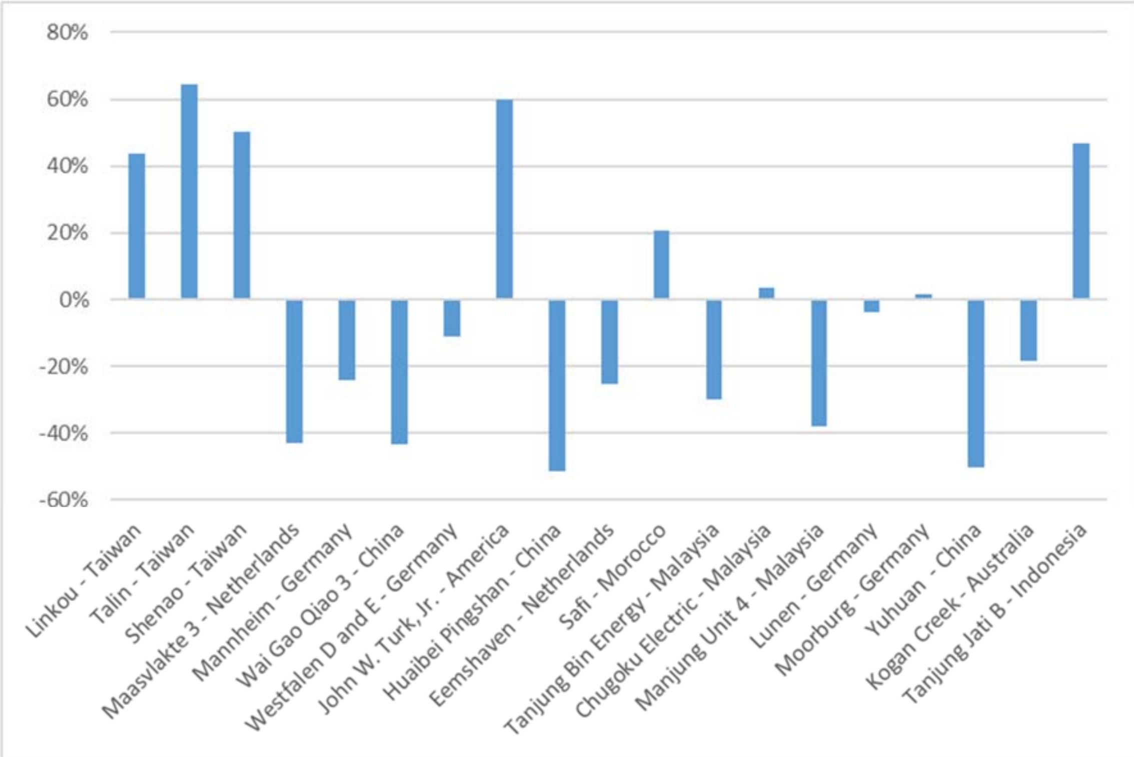

Figure 1 Benchmark project deviation from PEACE estimate

The following key points are noted:

- Three of the largest negative outliers are for projects that have been undertaken in China,
- Three of the four positive outliers are for three similar projects undertaken in Taiwan, and all present similar error percentages (approx. 40-60% higher than the cost predicted by PEACE),
- The remaining positive outlier is for the first and only ultra-supercritical (USC) project carried out in the United States,
- 12 out of the 17 benchmark projects are within (or close to) ±40% accuracy.

The same benchmarking methodology was used to compare the PEACE estimate with the reported cost of Kogan Creek Power Station. The PEACE estimate was approximately 18% higher than the escalated reported figure.

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1. Introduction

1.1 Background

Solstice Development Services (SDS) has been retained by ACA Low Emissions Technologies Ltd to investigate the case for High Efficiency Low Emission (HELE) power stations in Australia's future power generation mix.

SDS has engaged GHD Pty Ltd (GHD) to support this investigation by providing information on performance and costs for a generic HELE plant in Australia. This report contains the information developed by GHD.

While the term *HELE* is sometimes used to refer to supercritical (SC) plants as well as ultra-supercritical (USC) plants, it is used in this report exclusively as the latter (USC). As such, wherever the term HELE is used in this report, it is referring to USC coal-fired power plants, which are broadly defined as having high pressure steam conditions above 250 bar and 580 ℃.

As an indication of the progression and maturity of HELE technology globally, a table of HELE units installed across China, Japan, the EU and the US is presented below. It should be noted that the numbers presented in Table 4 are the number of units installed, not the number of unique locations or power plants.

Table 4 Number of installed HELE units in China, Japan, EU, and US[3]

	China	EU	Japan	US	Total
Pre-2000	0	1	8	0	9
2000-2009	40	3	13	0	56
2010-2016	142	18	3	1	164
Total	**182**	**22**	**24**	**1**	**229**

1.2 Purpose of this report

The purpose of this report is to provide objective estimates of the performance and capital cost of a HELE plant, and to benchmark those costs against publically available costs for HELE plants recently constructed overseas.

1.3 Scope and limitations

The scope of the investigation was to:

- Calculate the performance of a HELE plant using current technology and operating in Australia on black coal,
- Provide an estimate of the cost of constructing the plant in Australia using the PEACE output from STEAM PRO power plant modelling software,
- Comment on the potential cost reduction for a "brownfield" plant,
- Benchmark the PEACE estimated figures against publically available cost information for overseas plants.

The plant configuration was to be consistent with previous publically available studies to provide transparency and consistency in interpretation. No specific site was nominated, but it would be located in an area where there are aged existing coal-fired stations. As such there would be

[3] Dr Malgorzata Wiatros-Motyka 2016, *An overview of HELE technology deployment in the coal power plant fleets of China, EU, Japan and USA*, IEACCC

existing infrastructure and the opportunity for the new HELE plant to replace older coal-fired plants.

The performance and cost information has only considered the plant within the power station fenceline. The plant is based on current technology operating at USC steam conditions.

GHD does not have access to the PEACE database and cannot comment on the accuracy of the cost estimates. Benchmark costs have been included to provide comparative references.

This report has been prepared by GHD for SDS and may only be used and relied on by SDS for the purpose agreed between GHD and the SDS as set out in this section of this report.

GHD otherwise disclaims responsibility to any person other than SDS arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in this report and are subject to the scope limitations set out in this report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this section of this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has not been involved in the preparation of Solstice Development Service's Report (SDS Report) and has had no contribution to, or review of the SDS Report other than in this report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the SDS Report.

GHD has prepared the preliminary cost estimate set out in Section 2.3 to 2.6 of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The Cost Estimate has been prepared for the purpose of informing debate and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works or project can or will be undertaken at a cost which is the same or less than the Cost Estimate.

1.4 Assumptions

This report is based on the following assumptions:

- The HELE plant will only be required to operate as a base load power supplier. No features or costs have been included for other modes of operation,
- Australian low sulphur black coal will be used as fuel and a Flue Gas Desulpherisation system will not be required,
- A suitable, flat site with favourable geotechnical conditions is available,
- Existing environmental standards will be applicable. The site will be located in an area with aged existing power stations and with suitable planning requirements,

- Suitable off-site infrastructure/utilities will be located nearby,
- Information in reports quoted by GHD is correct and accurate. GHD has not tried to verify the accuracy of this information,
- Information sourced from public sources for benchmarking is suitably correct. GHD has not tried to verify the accuracy of this information, other than to try to obtain multiple references (which may be from the same source).

1.5 Acronyms and abbreviations

The following is a list of acronyms or abbreviations that have been used in this report.

Table 5 Acronyms and abbreviations

Acronym/abbreviation	Definition
Bara	Absolute pressure in bar
Barg	Gauge pressure in bar
CO2CRC	CO2CRC Ltd
ESP	Electrostatic Precipitators
HELE	High Efficiency Low Emissions
HP	High pressure
IDC	Interest During Construction
IP	Intermediate pressure
kJ	kilojoule
kWh	kilowatt hour
m	metre
MW	Megawatt
PEACE	Preliminary Engineering and Cost Estimation
PPI	Producer Price Index
SC	Supercritical
tph	Tonnes per hour
USC	Ultra-supercritical
USGC	United States Gulf Coast

2. Base case model and cost estimate

2.1 Base model and results

The base case model has been developed with the key parameters presented in Table 6.

Table 6 Base case model key parameters

Parameter	Value	Basis / comment
Output	650 MW (net)	Selected to match the USC plant size used in the Australian Power Generation Technology Report[4]. Considered to be an appropriate size for a HELE plant. Compatibility with Australian electricity grid has not been assessed because no specific location has been considered. The size selected is smaller than Kogan Creek single generation unit.
Cooling type	Wet cooling (natural draft cooling tower)	Many existing baseload coal-fired power plants in Australia have access to fresh water for wet cooling. It is assumed that that water currently being used by existing power stations will be transferred to the HELE plant and the existing plants retired. This aligns with the HELE objectives of achieving a highly efficient plant, it is considered reasonable that a site will be selected that provides wet cooling capability. An alternative of air cooling is considered in Section 2.2.
HP/IP steam temperature	604 ℃/604 ℃	Consistent with the CO2CRC steam conditions and within typical parameters for HELE technology (as confirmed by review of publicly available details of operational HELE plants – refer Table 7).
HP/IP steam pressure	276 bara/60 bara	HP steam pressure consistent with CO2CRC condition (275 barg). IP steam pressure selected as default by STEAM PRO and confirmed appropriate via review of published operating plant conditions (refer Table 8 for one example).
Nominal location	Hunter Valley	Consistent with the nominal location selected for the CO2CRC report and considered to be an appropriate location for a HELE plant to replace existing aging generators in the area.
Nominal fuel specification	Hunter Valley coal (from Thermoflow fuel library)	Consistent with a potential location and considered to be representative of Australian black coal.

[4] CO2CRC (et. al.) 2015, *Australian Power Generation Technology Report*

Table 7 Siemens published operating USC plant conditions[5]

Plant	Country	Power output	Main steam	Reheat steam	Commercial operation
Isogo	Japan	1 x 600 MW	251 bar / 600 ℃	610 ℃	2001
Yuhuan	China	4 x 1000 MW	262 bar / 600 ℃	600 ℃	2007
Wai Gao Qiao 3	China	2 x 1000 MW	270 bar / 600 ℃	600 ℃	2009
Westfalen	Germany	2 x 800 MW	275 bar / 600 ℃	610 ℃	2011
Eemshafen	Netherlands	2 x 800 MW	275 bar / 600 ℃	610 ℃	2012
Lunen	Germany	1 x 800 MW	270 bar / 600 ℃	610 ℃	2012
Mainz	Germany	1 x 800 MW	273 bar / 600 ℃	610 ℃	2013

Table 8 Manjung 4 published USC steam conditions[6]

Parameter	Value
Main steam flow	3226 tph
Superheater outlet pressure	282.4 bar
Superheater steam temperature	600 ℃
Feedwater temperature	304 ℃
Reheater steam flow	2687 tph
Reheater steam pressure	60.6 bar
Reheater steam temperature	605 ℃
Reheater inlet temperature	364 ℃

Using the parameters detailed in Table 6, a thermodynamic model was developed in STEAM PRO. STEAM PRO is part of an internationally recognised suite of power generation modelling programmes developed by Thermoflow Inc[7]. STEAM Pro has been developed for Rankin cycle systems such as coal-fired power stations. Software updates are issued annually.

The key technical characteristics of this model are presented in Table 9. Detailed modelling results are included in Appendix A.

[5] Siemens AG 2008, *USC Steam Turbine technology for maximum efficiency and operational flexibility*, POWER-GEN Asia 2008

[6] http://www.powerengineeringint.com/articles/print/volume-20/issue-8/power-report/manjung-4-an-ultra-supercritical-first-in-southeast-asia.html

[7] https://www.thermoflow.com/

Table 9 Base case model technical characteristics

Parameter	Unit	Value
Ambient conditions		
Reference ambient temperature (dry bulb)	℃	25
Reference ambient relative humidity	%	60
Elevation	m	111
Ambient pressure	bara	1
Steam conditions		
HP steam temperature	℃	604
HP steam pressure	bara	276
IP (reheat) steam temperature	℃	604
IP (reheat) steam pressure	bara	60
Inputs and Outputs		
Coal consumed	tph	195.6
Steam turbine output	MW	675.5
Auxiliary loads and losses	MW	25.5
Net electricity (sent out)	MW	650.0
CO_2 emissions	tph	505.3
Heat rate		
Heat rate (net, LHV)	kJ/kWh	8,396
Efficiency (net, LHV)	%	42.88
Heat rate (net, HHV)	kJ/kWh	8,704
Efficiency (net, HHV)	%	41.36

2.2 Alternative dry cooling model

As noted in Table 6, wet cooling has been selected for the base case model. In the event that a nominated plant location does not have a water supply sufficient to enable wet cooling, dry cooling or hybrid cooling (wet and dry) technologies will need to be used. To assess this, and to properly understand the impact of selecting wet cooling for the base case model, a comparison case using dry air cooled condensers has been developed. The key results from this comparison model are presented alongside the base case parameters in Table 10.

It is noted that the design parameters and design conditions (e.g. ambient conditions, steam temperatures/pressures, etc.) for the comparison case are the same as for the base case.

Table 10 shows that wet cooling achieves lower auxiliary loads and a higher efficiency than the dry cooling alternative. A wet cooled HELE plant will use less water per unit of electrical output than current coal-fired power stations in Australia. A dry cooled system will use significantly less water, but will have slightly lower efficiency.

Table 10 Dry cooling comparison

Parameter	Unit	Base case (wet cooling)	Dry cooling comparison case
Inputs and outputs			
Coal consumed	tph	195.6	201.4
Steam turbine output	MW	675.5	678.8
Aux. loads and losses	MW	25.5	28.8
Net (sent out) output	MW	650.0	650.0
CO_2 emissions	tph	505.3	520.3
Heat rate			
Heat rate (net, LHV)	kJ/kWh	8,396	8,646
Efficiency (net, LHV)	%	42.88	41.64
Heat rate (net, HHV)	kJ/kWh	8,704	8,963
Efficiency (net, HHV)	%	41.36	40.16

2.3 Preliminary cost estimate methodology

Preliminary cost estimation has been carried out using Thermoflow's PEACE™ (Preliminary Engineering and Cost Estimation) software. This software uses a 'factored cost' approach, which has recognised limitations on accuracy. This software is ideal for producing high level estimates for comparative and screening purposes, however is not intended to produce robust final cost figures for project execution. It is considered suitable for this report due to the generic nature of the estimate.

The methodology used in PEACE to develop the high level cost estimate is:

- Thermodynamic model developed using STEAM PRO and user supplied inputs as detailed in Section 2.1,
- STEAM PRO initialisation of PEACE-specific variables (i.e. design selections that have no bearing on the thermodynamic model developed in STEAM PRO but are used in the PEACE estimate process, such as type and size of on-site storage or buildings),
- User adjustment of PEACE specific variables (if known),
- Development of preliminary engineering and cost estimate using PEACE based on Thermoflow's reference cost information for low cost US-based reference plants in the US Gulf Coast (USGC) area,
- Adjustment of cost estimate from US-based reference location to a project-specific location using cost multipliers – this is discussed in detail in Section 2.4.

Note that all costs throughout this process have been analysed and are presented in US$ unless stated otherwise.

PEACE develops the preliminary cost estimate according to the following major categories:

- Contractor's internal costs (i.e. the cost to build the plant, including sub-categories such as 'Specialised Equipment', 'Other Equipment', 'Civil Works', 'Mechanical Works' etc.),
- Contractor's soft and miscellaneous costs (e.g. contractor's contingencies, profit, contractor's fee),
- Owner's soft and miscellaneous costs (e.g. development costs, permits, legal and financial costs, interest during construction).

To be consistent with existing industry publications, costs presented in this report are 'Contractor's Costs' and therefore do not include the 'Owner's soft and miscellaneous costs' listed above (unless stated otherwise).

2.4 Cost multipliers and sensitivity cases

PEACE uses a number of cost multipliers to reflect the local cost of constructing a power station relative to the cost at the US reference location. The PEACE database contains default cost multipliers for different regions in the US as well as for various countries around the world. The user can manually override the default multipliers if there is better project specific figures available.

Thermoflow's default cost multipliers for Australia are presented in Table 11.

Table 11 Thermoflow cost multipliers for Australia

Cost categories	Cost category definition	Australia cost multiplier
'Specialised Equipment'	Includes items that are typically manufactured or engineered by a relatively small number of specialised firms worldwide. These items are likely to be imported if the project is in a country with a less developed manufacturing industry. Examples are boilers, steam turbines, transformers etc.	1.3
'Other Equipment'	Includes equipment commonly used in a wide range of industries and is typically manufactured by many firms in many countries. These items are less likely to be imported if the project is in a country with some industrial base.	1.3
'Commodities'	Includes basic materials such as common pipes, concrete etc. These are the least likely to be imported if the project is in a country with some level of development.	1.3
'Labour Cost'	A multiplier that combines factors for productivity and hourly wages. A multiplier of 2.025 implies that it will cost 102.5% more to complete the same work in comparison to the reference site.	2.025

GHD has considered three alternative scenarios in order to assess the potential range of outcomes under different combinations of cost multiples. These alternative scenarios are:

1. Cost multipliers developed by WorleyParson for the CO2CRC Report,
2. Incorporation of a lower cost multiplier to reflect the lower cost of "Specialised Equipment" from China,
3. A combination of scenario 1 and 2.

2.4.1 WorleyParsons Regional Cost Study

For the CO2CRC report[8], a regional cost study was carried out by WorleyParsons to develop a set of cost factors for converting from a USGC cost basis to an Australian cost basis, as is required here. The most relevant output of the WorleyParsons study to the current work is the table shown in Table 12, displaying cost factors to convert from USGC reference costs to Hunter Valley costs.

[8] CO2CRC (et. al) 2015, *Australian Power Generation Technology Report*

Table 12 WorleyParsons Hunter Valley Cost factors[9]

	Hunter Valley vs. USGC			
Discipline	Labour productivity factor	Crew rate factor	Material cost factor	Currency exchange rate (A$:US$)
Civil	1.40	1.49	1.20	1.30
Electrical bulks	1.40	1.52	1.16	1.30
Electrical equipment	1.40	1.70	1.08 [a]	1.30
Insulation	1.40	1.65	1.02	1.30
Instrumentation and controls	1.40	1.70	1.08 [a]	1.30
Mechanical equipment	1.40	1.87	1.08 [a]	1.30
Piping and valves	1.40	1.80	1.07	1.30
Concrete	1.40	1.50	1.50	1.30
Structural steel	1.40	1.55	1.13 [b]	1.30

a: Based on US costs (inclusive of domestic freight), modified to include overseas freight at 8%
b: Based on US costs (inclusive of domestic freight), modified to include overseas freight at 8% and import duty at 5%

To use these figures as a benchmark against Thermoflow's built-in Australian cost multipliers it is necessary to convert them from discipline specific factors (which are not used by Thermoflow) to the four categories presented in Table 11.

It is noted that in addition to providing discipline specific crew rate factors as seen in Table 12, WorleyParsons calculated a *weighted average crew rate* based on a typical distribution of man-hours by crew for a project of this kind. For the Hunter Valley, WorleyParsons reported this weighted average crew rate cost factor as 1.73[10].

Using the above information, PEACE equivalent costs multipliers have been developed as presented in Table 13.

Table 13 PEACE equivalent cost multipliers of WorleyParsons factors

Cost categories	PEACE equivalent cost multipliers	Methodology for calculating equivalent factor
'Specialised Equipment'	1.08	Calculated as the average of the electrical equipment, instrumentation and controls, mechanical equipment, and piping and valves line items.
'Other Equipment'	1.08	As for 'Specialised Equipment'.
'Commodities'	1.20	Calculated as the average of civil, electrical bulks, insulation, concrete, and structural steel line items.
'Labour Cost'	2.422	Weighted average crew rate (1.73) multiplied by productivity factor (1.4) = 2.422.

[9] CO2CRC (et. al) 2015, *Australian Power Generation Technology Report*, Table 93

[10] CO2CRC (et. al) 2015, *Australian Power Generation Technology Report*, Table 96

2.4.2 Chinese equipment cost multipliers

The use of cost multipliers based on procurement of Chinese equipment has been considered as a sensitivity case. Thermoflow's default cost multipliers for China are presented in Table 14.

Table 14 Thermoflow default China cost multipliers

Cost categories	Thermoflow default China cost multipliers
'Specialised Equipment'	1.00
'Other Equipment'	0.65
'Commodities'	0.70
'Labour Cost'	0.54

In incorporating the procurement of Chinese equipment into an Australian project, the following was considered:

- Chinese cost multipliers for 'Other Equipment', 'Commodities', and 'Labour Cost' are not applicable as they will apply to a Chinese project only,
- Thermoflow's default China 'Specialised Equipment' multiplier of 1.0 indicates that it would cost the same to manufacture specialised equipment in China as it would in the USGC. At the same time, Thermoflow's 'Other Equipment' and 'Commodities' multipliers of 0.65 and 0.7 respectively would indicate that manufacturing costs are lower in China than in the USGC, as would be expected. Given the prevalence of 'Specialised Equipment' manufacturing capability in China, it is considered that a more appropriate factor for 'Specialised Equipment' would be 0.7,
- In their study, WorleyParsons added 8% overseas freight cost to the USGC 'Specialised Equipment' cost in order to buy US equipment and ship to Australia. If this methodology is applied to procurement of Chinese equipment, the resultant 'Specialised Equipment' cost multiplier would be approximately 0.8.

2.4.3 Summary of cost multiplier sensitivity cases

Based on the information presented in the preceding sections, a set of cost multiplier cases have been developed, as shown in Table 15.

Table 15 Cost multiplier cases

Cost categories	Thermoflow default Australia	WorleyParsons Hunter Valley	Thermoflow default, Chinese Specialised Equipment	WorleyParsons, Chinese Specialised Equipment
'Specialised Equipment'	1.3	1.08	0.8	0.8
'Other Equipment'	1.3	1.08	1.3	1.08
'Commodities'	1.3	1.2	1.3	1.2
'Labour Cost'	2.025	2.422	2.025	2.422

2.5 Preliminary capital cost estimate

2.5.1 Base case cost estimate

A base case cost estimate has been developed using the STEAM PRO model detailed in Table 6 and Table 9 and the Thermoflow default Australian cost multipliers presented in Table 15. The results from this process are presented in Table 16.

Table 16 Base cast cost estimate

Cost category	Cost (US$)
Contractor's Internal Cost	US$1,121.8 M
Contractor's Soft & Miscellaneous Costs	US$211.7 M
Contractor's Cost	**US$1,333.4 M**
Net Plant Output (MW)	650
Cost per kW - Contractor's	**US$2,051**

The 'Contractor's Cost' is the cost to build the plant, and excludes additional costs incurred by the owner (e.g. project development, finance and legal fees, interest during construction).

Note that these costs are all in US$. At an exchange rate of AU$1=US$0.75 the Contractor's Cost would be AU$1,778b.

2.5.2 Cost multiplier scenarios

The cost multiplier scenarios presented in Table 15 have been used to develop the cost estimate results presented in Table 17.

Table 17 Cost multiplier sensitivity case cost estimates

Cost categories	Thermoflow default Australia	WorleyParsons Hunter Valley	Thermoflow default, Chinese Specialised Equipment	WorleyParsons, Chinese Specialised Equipment
Contractor's internal cost	US$1,121.8 M	US$1,070.9 M	US$950.8 M	US$975.2 M
Contractor's Soft & Miscellaneous Costs	US$211.7 M	US$222.7 M	US$192.9 M	US$212.1 M
Contractor's Cost	**US$1,333.4 M**	**US$1,293.6 M**	**US$1,143.7 M**	**US$1,187.3 M**
Net Plant Output (MW)	650	650	650	650
Cost per kW - Contractor's	**US$2,051**	**US$1,990**	**US$1,760**	**US$1,827**
Percentage of default cost	100%	97.0%	85.8%	89.1%

The figures indicate that the costs calculated using the default figures and those in the WorleyParsons scenario are similar. Obtaining lower cost 'Specialised Equipment' from China may result in a 10-15% lower cost.

2.5.3 Dry cooling comparison

To consider the impact of dry cooling on the cost of a HELE project, a PEACE estimate was developed using the methodology detailed in the preceding sections and the dry cooling comparison model detailed in Section 2.1. The results of this exercise are presented in Table 18 against the base case cost estimate. Both of these estimates have been developed using the Thermoflow default cost multipliers for Australia.

Table 18 Dry cooling comparison case cost estimate

Cost categories	Base case (wet cooling)	Dry cooling comparison case
Contractor's Internal Cost	US$1,121.8 M	US$1,162.1 M
Contractor's Soft & Miscellaneous Costs	US$211.7 M	US$224.9 M
Contractor's Cost	**US$1,333.4 M**	**US$1,387.0 M**
Net Plant Output (MW)	650	650
Cost per kW - Contractor's	**US$2,051**	**US$2,134**

The dry cooled power station would cost approximately 4% more than a wet cooled plant with the same net output.

2.6 Potential brownfield plant cost savings

An assessment was undertaken to consider the possible cost savings that may be achieved if a new HELE plant is developed at an existing power plant location. It is envisaged that cost savings may be achievable in areas such as:

- Use of existing common infrastructure (buildings, roads, services, etc.),
- Reduction of cost from repurposing existing equipment (e.g. coal handling, stockpile),
- Use of existing ancillary equipment (e.g. black start generators).

To make this high level assessment, items in the PEACE cost estimate for the base case model were attributed one of the three following potential savings characteristics:

- 0% savings – no benefit of brownfield plant over greenfield plant,
- 50% savings – some cost savings achievable,
- 100% savings – cost can be mostly or totally negated.

The areas identified as presenting potential savings are detailed in Table 19. It should be noted that only areas attributed with 50% or 100% potential savings have been listed.

This assessment has been carried out using the base case model and the default Thermoflow Australia cost multipliers.

Table 19 Potential brownfield plant cost savings

Area	Potential cost saving	Value of saving
Specialised equipment		
Transmission voltage equipment	50%	US$7,355,000
Other equipment		
Demineralized Water tank	50%	US$32,000
Raw Water tank	50%	US$32,000

Neutralized Water tank	50%	US$22,000
Acid Storage tank	50%	US$5,000
Caustic Storage tank	50%	US$5,000
Dedicated Fire Protection Water Storage tank	50%	US$125,000
Station/Instrument Air Compressors	50%	US$508,000
Emergency/Black Start Gensets	100%	US$17,616,000
Coal handling equipment	50%	US$15,334,000
Ash handling equipment	50%	US$2,794,000
Civil		
Site work (e.g. clearing, grading, drainage, etc.)	50%	US$10,806,000
Excavation and backfill	50%	US$2,456,000
Roads, parking, walkways	50%	US$572,000
Buildings		
Admin, control room, warehouse	50%	US$1,422,000
Guard house	100%	US$37,000
Owner's soft costs		
Permits, licenses, fees	50%	US$13,334,000
Legal and financial costs	50%	US$13,334,000
Project admin and developer's fee	50%	US$6,667,000
Total	**5.8%**	**US$92,456,000**

This preliminary assessment indicates there is likely to be only a small savings (approx. 6%) in capital cost due reuse of existing facilities if a HELE plant was to be constructed near an existing power station. This figure also assumes there are no additional costs due to constraints or limitations caused by any existing infrastructure.

Any potential savings or avoided costs in infrastructure outside the power station (existing fuel supply, water supply, transmission system, roads, etc.) have not been considered in this assessment. These are generally considered to be included in any lower operational cost for those services (e.g. the cost of coal).

The potential savings presented above are proportional to the value of the project, and within the accuracy of the estimate, are therefore generally scalable with plant size. The scalability of these savings will be limited by the overall scale of the existing infrastructure in comparison to the scale of the new plant being built. For example, coal handling infrastructure of an existing 650 MW plant is not likely to be sufficient for a new build 1000 MW plant, and therefore the achievable savings will not scale proportionally.

2.7 Potential savings for carbon capture plant using Chinese sourced equipment

The majority of this report excludes consideration of a carbon capture plant as part of the HELE model. This subsection alone considers the cost and technical implications of inclusion of a carbon capture plant, in particular with regards to the scale of cost savings that may be achieved by sourcing Chinese specialised equipment.

The factors considered by the modified STEAM PRO model are:

- Additional steam loads and cooling loads of the carbon capture system,
- Additional parasitic loads,
- Cost of the carbon capture system using Australian cost factors,
- Potential cost savings that may be achieved on the basis that the specialised equipment components of the carbon capture plant can be sourced from China at the same relative cost as the remainder of the HELE plant.

The following limitations apply to the modelling undertaken for this exercise:

- The carbon capture model in STEAM PRO is not intended to serve as a detailed chemical and thermodynamic model of the process. Rather, the model, together with user-defined inputs, provides an estimate of the total auxiliary power, heat consumption, and cooling duty required by the process, and its impact on the overall combined cycle,
- The model does not consider the storage or disposal of the captured carbon,
- The cost estimates developed for the carbon capture plant are indicative only and are used exclusively to develop an order-of-magnitude estimate of the cost savings that may be achieved if specialised equipment can be sourced from China at a reduced cost.

The STEAM PRO model has been developed from the base case model (described in Section 2.1) using the following methodology:

- Base case model parameters used (refer Section 2.1),
- Net plant output maintained at 650 MW,
- Carbon capture plant added using STEAM PRO default values (assumes 90% effective carbon capture from flue gas),
- Indicative cost estimates developed using PEACE using cost factors detailed in Section 2.4.

The results from this process are shown in Table 20.

Table 20 Potential carbon capture cost savings achieved with Chinese equipment

Item	Thermoflow default Australian cost factors	Thermoflow default, Chinese Specialised Equipment	Percent saving achieved
Contractor's cost (US$/kW)	US$3,859	US$3,185	17%

3. Benchmarking

A benchmarking exercise has been undertaken to compare publicly available cost information for existing projects against the estimates produced by PEACE. One recently announced, but not constructed, plant has also been included. The intention of this benchmarking exercise is to provide a level of confidence in the PEACE estimates presented in this report based on the error margins calculated against known projects.

3.1 Methodology

Publicly available information for existing projects has been identified and used for this benchmarking exercise in the following way:

- Plant identified and confirmed to be based on HELE technology (i.e. USC steam conditions),
- Relevant available information recorded (size, location, year of operation),
- Cost information recorded if available, along with pertinent details required for benchmarking (i.e. reference year for cost information, currency of reported cost),
- Reported cost corrected from reported cost year to 2016 using the Producer Price Index (PPI) ratio for the country in which the plant is located between the reported year and 2016,
- Reported cost (corrected to 2016) converted from reported currency to US$ using the exchange rate as of April 2017.

Kogan Creek Power Station has also been included in this benchmarking exercise. Although it does not operate at USC conditions, it is the only coal-fired plant of similar size and technology built in Australia in the past decade.

Estimates have been developed using STEAM PRO and PEACE to compare to these benchmarked figures according to the following methodology:

- Base case model (as detailed in Section 2.1) adjusted to match the reported unit size, number of units, and location (all design parameters have been kept consistent with the base case model due to the lack of consistent comprehensive plant details across the benchmark projects),
- Cost multipliers (as discussed in 2.4) adjusted to the PEACE default values for that project location),
- Preliminary cost estimate produced by PEACE and recorded for comparison against publicly available information.

This process makes a number of assumptions which must be considered in the interpretation of the results. Many of these assumptions must be made due to the lack of comprehensive information available for the projects which would be required to improve the granularity of the process. These include:

- Plant configuration of all benchmark projects is assumed to be the same as the base case model developed for this exercise. This includes the cooling type (natural draft wet cooling tower has been assumed), emissions control technologies (electrostatic precipitators (ESP) have been used for particulate control), and no flue gas desulphurisation has been included as is consistent with Australian projects) and several others,

- It is assumed that the reported cost is the Owner's total cost (including Owner's fees such as Interest During Construction (IDC)), and therefore the comparison estimates developed using PEACE also include Owner's costs,
- It is assumed that PPI rates in the country of construction (rather than, for example, the country of equipment supply) are applicable to the project in order to correct the reported costs to a 2016 cost basis.

3.2 Results

The results from this process are presented in Table 21. A more detailed version of this results spreadsheet is provided in Appendix C, including information used to produce the final figures used in the benchmarking exercise (such as PPI values, reference year for reported cost figures, exchange rates etc.).

Figure 2 shows one of the key results from this exercise – the deviation of the benchmark projects from the PEACE preliminary cost estimate. In this figure, a positive percentage indicates that the benchmark project reported a cost that was higher than the PEACE estimate by that percentage. Similarly, a negative percentage indicates that the reported cost was lower than predicated by PEACE.

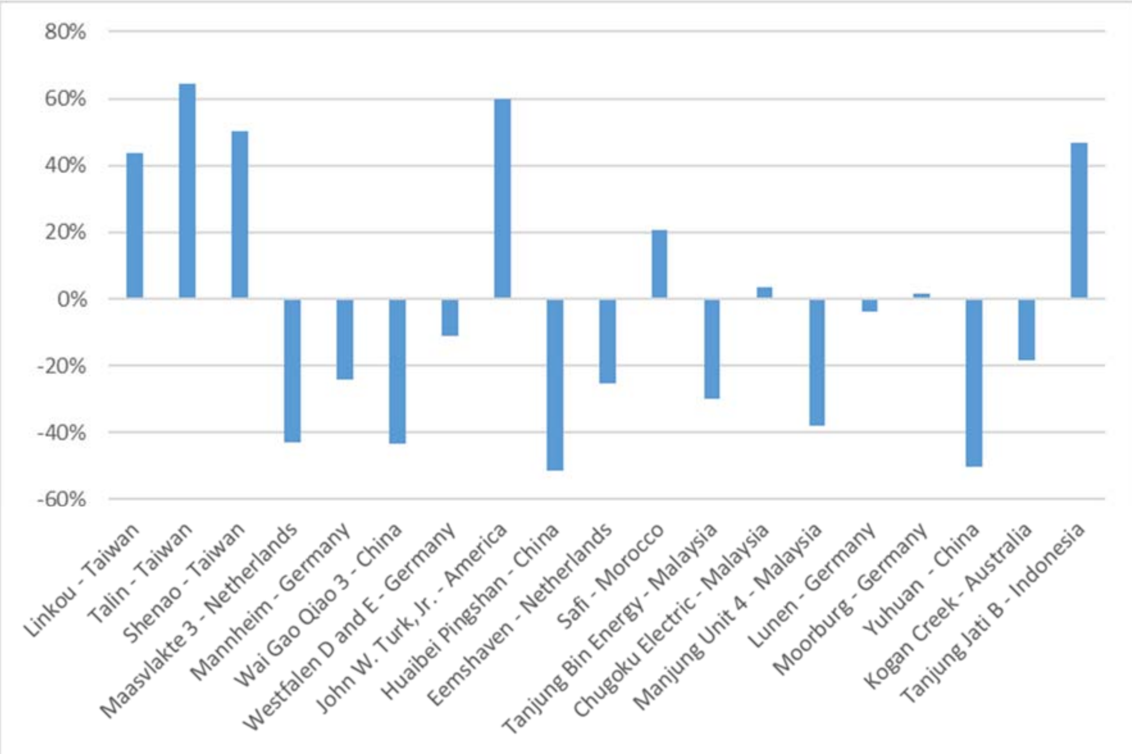


Figure 2 Benchmark project deviation from PEACE estimate

Table 21 PEACE benchmarking results

Publicly available plant details							PEACE estimate		
Plant Name	Location	Unit size (MW)	# units	Plant size (MW)	Cost in 2016 US$	US$ million/MW	Plant cost (US$)	US$ million/MW	Benchmark project deviation from PEACE
Linkou Power Station	Taiwan	800	3	2,400	US$5,284 M	$2.2	US$3,680 M	$1.5	44%
Talin Power Station	Taiwan	800	2	1,600	US$4,130 M	$2.6	US$2,510 M	$1.6	65%
Shenao Power Station	Taiwan	800	2	1,600	US$3,773 M	$2.4	US$2,510 M	$1.6	50%
Maasvlakte 3 Power Plant	Netherlands	1,100	1	1,100	US$1,098 M	$1.0	US$1,920 M	$1.7	-43%
Mannheim Power Plant	Germany	912	1	912	US$1,263 M	$1.4	US$1,670 M	$1.8	-24%
Wai Gao Qiao 3 Power Plant	China	1,000	2	2,000	US$1,296 M	$0.6	US$2,280 M	$1.1	-43%
Westfalen Units D and E	Germany	800	2	1,600	US$2,527 M	$1.6	US$2,840 M	$1.8	-11%
John W. Turk, Jr. Power Plant	America	600	1	600	US$1,695 M	$2.8	US$1,060 M	$1.8	60%
Huaibei Pingshan Power Plant	China	660	2	1,320	US$791 M	$0.6	US$1,630 M	$1.2	-51%
Eemshaven Power Plant	Netherlands	800	2	1,600	US$2,086 M	$1.3	US$2,800 M	$1.8	-26%
Safi Power Plant	Morocco	693	2	1,386	US$2,411 M	$1.7	US$2,000 M	$1.4	21%
Tanjung Bin Energy Power Plant	Malaysia	1,000	1	1,000	US$1,060 M	$1.1	US$1,510 M	$1.5	-30%
Chugoku Electric Power Plant	Malaysia	1,000	2	2,000	US$2,957 M	$1.5	US$2,860 M	$1.4	3%
Manjung Unit 4 Power Plant	Malaysia	1,000	1	1,000	US$938 M	$0.9	US$1,510 M	$1.5	-38%
Lunen Power Plant	Germany	820	1	820	US$1,468 M	$1.8	US$1,530 M	$1.9	-4%
Moorburg Power Plant	Germany	820	2	1,640	US$2,945 M	$1.8	US$2,900 M	$1.8	2%
Yuhuan Power Station	China	1,000	4	4,000	US$2,187 M	$0.5	US$4,400 M	$1.1	-50%
Kogan Creek Power Station (NOTE: SC plant only)	Australia	750	1	750	US$1,084 M	$1.4	US$1,330 M	$1.8	-18%
Tanjung Jati B Power Station *	Indonesia	1,000	2	2,000	US$4,600 M	$2.3	US$3,130 M	$1.6	47%

* Recently announced, not yet under construction

The following key results are identified:

- Three of the largest negative outliers are for projects that have been undertaken in China,
- Three of the four positive outliers are for three similar projects undertaken in Taiwan, and all present similar error percentages (approx. 40-60% higher than the cost predicted by PEACE,
- One of the two remaining positive outliers is for the first and only USC project carried out in the United States,
- 13 out of the 19 benchmark projects are within (or close to) ±40% accuracy,
- The most recent supercritical project delivered in Australia (Kogan Creek), based on a reported cost of AU$1.2 billion in 2007, is within 20% accuracy.

3.3 Benchmark against CO2CRC APGT report

Capital cost estimates for various new-build power plants were reported recently in CO2CRC's report[11], including a cost for a black coal-fired USC power plant of similar characteristics to the base case presented in this report.

A comparison against the cost reported by CO2CRC and that developed in this report is presented in Table 22.

The USC plant considered in the CO2CRC report is dry cooled, and the reported cost excludes Owner's Costs. As such, the 'Contractor's Cost' for the dry cooling comparison case presented in Section 2.2 has been used for this benchmarking exercise.

It is noted that the cost presented by CO2CRC is in June 2015 AU$, and has been converted to US$ in the table below using an exchange rate of 1AU$=0.75US$.

Table 22 Capital cost estimate benchmark against CO2CRC APGT report

Item	Unit	Value
CO2CRC reported total plant cost estimate	US$/kW sent-out	2,325
Dry cooling comparison case "Contractor's Cost" estimate from this report	US$/kW sent-out	2,134
Percent deviation of CO2CRC value from base case value	%	9%

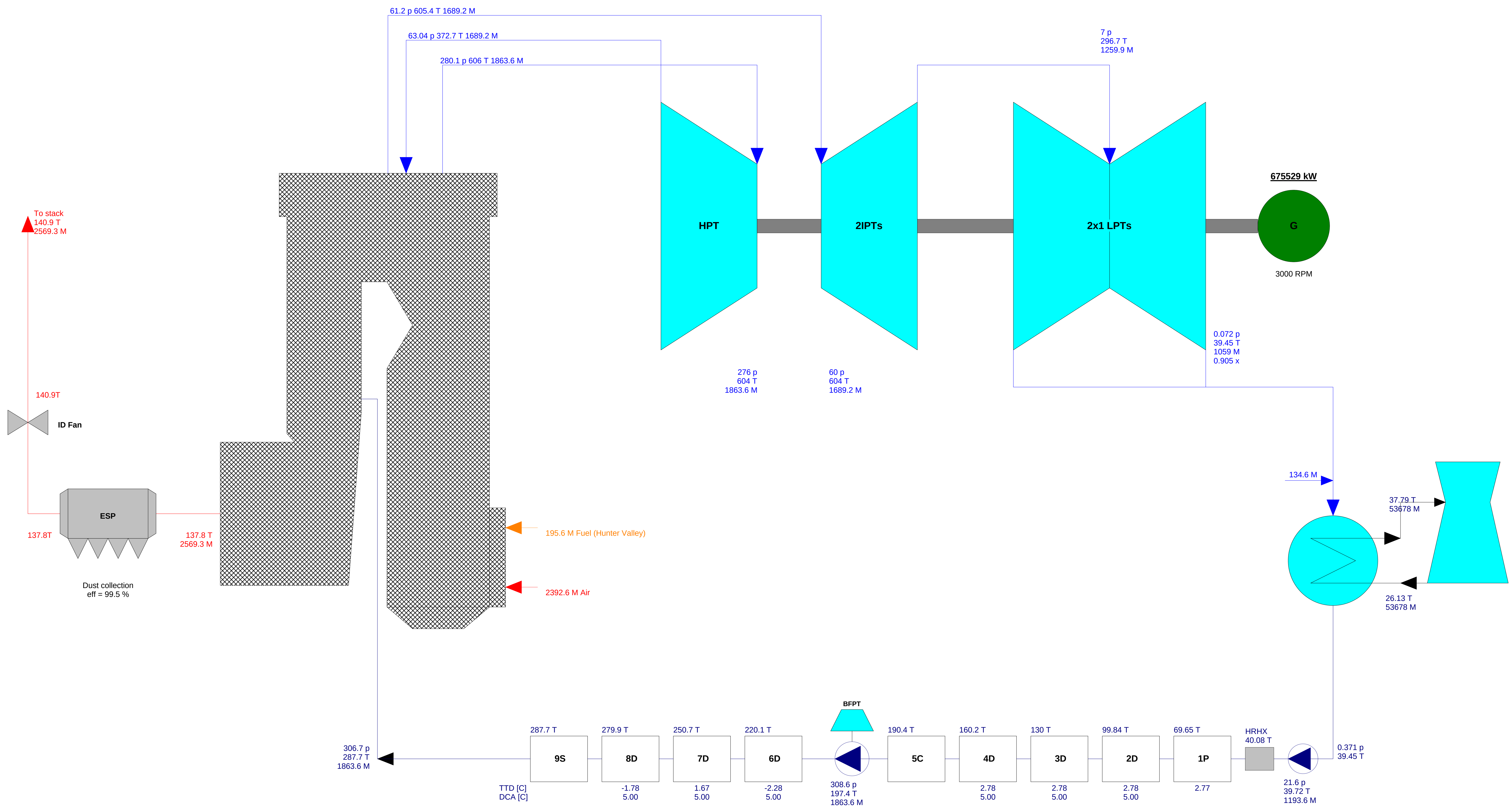
[11] CO2CRC (et. al) 2015, *Australian Power Generation Technology Report*, Table 96

Appendices

Appendix A – PEACE and STEAM PRO Results for the Base Case

Plant gross power	675529	kW
Plant net power	649989	kW
Number of units	1	
Plant net HR (HHV)	8704	kJ/kWh
Plant net HR (LHV)	8396	kJ/kWh
Plant net eff (HHV)	41.36	%
Plant net eff (LHV)	42.88	%
Aux. & losses	25539	kW
Fuel heat input (HHV)	5658	GJ/h
Fuel heat input (LHV)	5457	GJ/h
Fuel flow	4693	t/day

Ambient
1 p
25 T
60% RH
19.45 T wet bulb



Double HP Feed Water Heater Train & Single LP Feed Water Heater Train

p [bar] T [C] M [t/h] x [-]

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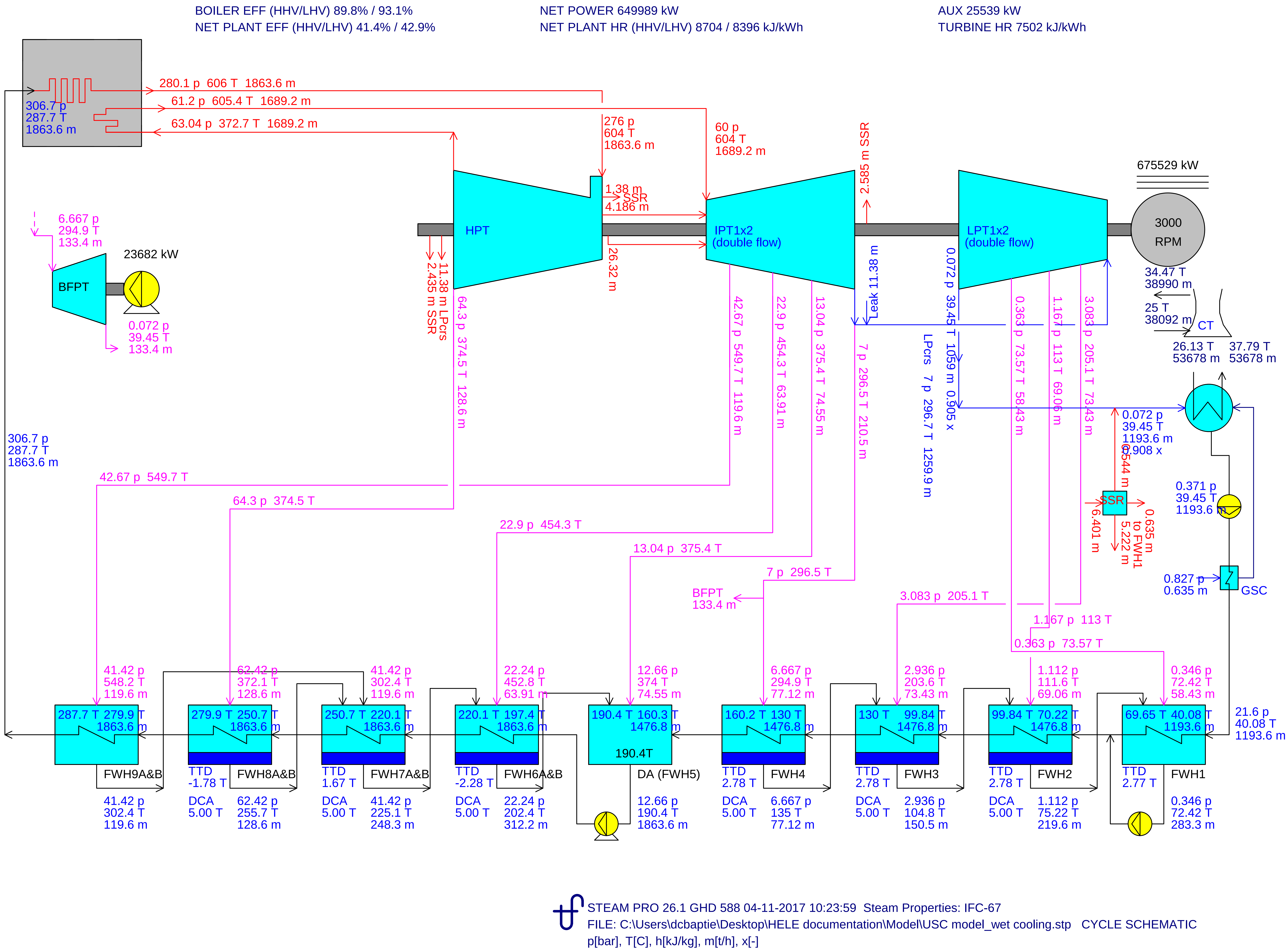
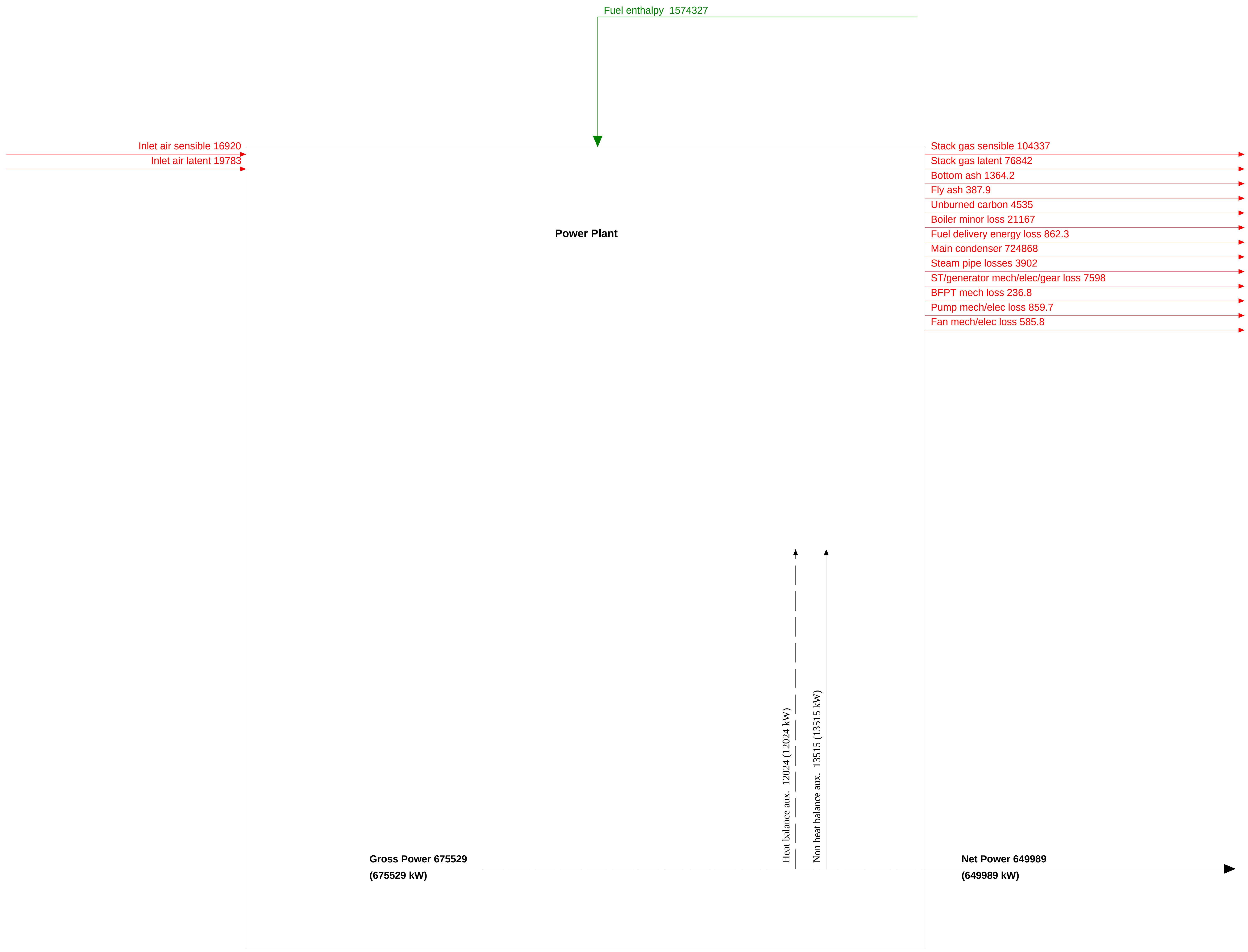


BOILER EFF (HHV/LHV) 89.8% / 93.1%
NET PLANT EFF (HHV/LHV) 41.4% / 42.9%
NET POWER 649989 kW
NET PLANT HR (HHV/LHV) 8704 / 8396 kJ/kWh
AUX 25539 kW
TURBINE HR 7502 kJ/kWh
280.1 p 606 T 1863.6 m
61.2 p 605.4 T 1689.2 m
63.04 p 372.7 T 1689.2 m
306.7 p
287.7 T
1863.6 m
276 p
604 T
1863.6 m
60 p
604 T
1689.2 m
2.585 m SSR
675529 kW
1.38 m
SSR
4.186 m
HPT
IPT1x2
(double flow)
LPT1x2
(double flow)
3000
RPM
6.667 p
294.9 T
133.4 m
23682 kW
BFPT
0.072 p
39.45 T
133.4 m
11.38 m LPcrs
2.435 m SSR
64.3 p 374.5 T 128.6 m
26.32 m
42.67 p 549.7 T 119.6 m
22.9 p 454.3 T 63.91 m
13.04 p 375.4 T 74.55 m
Leak 11.38 m
7 p 296.5 T 210.5 m
0.072 p 39.45 T 1059 m 0.905 x
LPcrs 7 p 296.7 T 1259.9 m
0.363 p 73.57 T 58.43 m
1.167 p 113 T 69.06 m
3.083 p 205.1 T 73.43 m
34.47 T
38990 m
25 T
38092 m
CT
26.13 T
53678 m
37.79 T
53678 m
0.072 p
39.45 T
1193.6 m
0.908 x
0.544 m
SSR
6.401 m
5.222 m
0.635 m
to FWH1
0.371 p
39.45 T
1193.6 m
0.827 p
0.635 m
GSC
306.7 p
287.7 T
1863.6 m
42.67 p 549.7 T
64.3 p 374.5 T
22.9 p 454.3 T
13.04 p 375.4 T
7 p 296.5 T
BFPT
133.4 m
3.083 p 205.1 T
1.167 p 113 T
0.363 p 73.57 T
41.42 p
548.2 T
119.6 m
62.42 p
372.1 T
128.6 m
41.42 p
302.4 T
119.6 m
22.24 p
452.8 T
63.91 m
12.66 p
374 T
74.55 m
6.667 p
294.9 T
77.12 m
2.936 p
203.6 T
73.43 m
1.112 p
111.6 T
69.06 m
0.346 p
72.42 T
58.43 m
287.7 T 279.9 T
1863.6 m
279.9 T 250.7 T
1863.6 m
250.7 T 220.1 T
1863.6 m
220.1 T 197.4 T
1863.6 m
190.4 T 160.3 T
1476.8 m
160.2 T 130 T
1476.8 m
130 T 99.84 T
1476.8 m
99.84 T 70.22 T
1476.8 m
69.65 T 40.08 T
1193.6 m
21.6 p
40.08 T
1193.6 m
190.4T
FWH9A&B
TTD
-1.78 T
FWH8A&B
TTD
1.67 T
FWH7A&B
TTD
-2.28 T
FWH6A&B
DA (FWH5)
TTD
2.78 T
FWH4
TTD
2.78 T
FWH3
TTD
2.78 T
FWH2
TTD
2.77 T
FWH1
41.42 p
302.4 T
119.6 m
DCA
5.00 T
62.42 p
255.7 T
128.6 m
DCA
5.00 T
41.42 p
225.1 T
248.3 m
DCA
5.00 T
22.24 p
202.4 T
312.2 m
12.66 p
190.4 T
1863.6 m
DCA
5.00 T
6.667 p
135 T
77.12 m
DCA
5.00 T
2.936 p
104.8 T
150.5 m
DCA
5.00 T
1.112 p
75.22 T
219.6 m
0.346 p
72.42 T
283.3 m
STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp CYCLE SCHEMATIC
p[bar], T[C], h[kJ/kg], m[t/h], x[-]

Fuel chemical LHV input = 1515877 kJ/s
Fuel chemical HHV input = 1571569 kJ/s

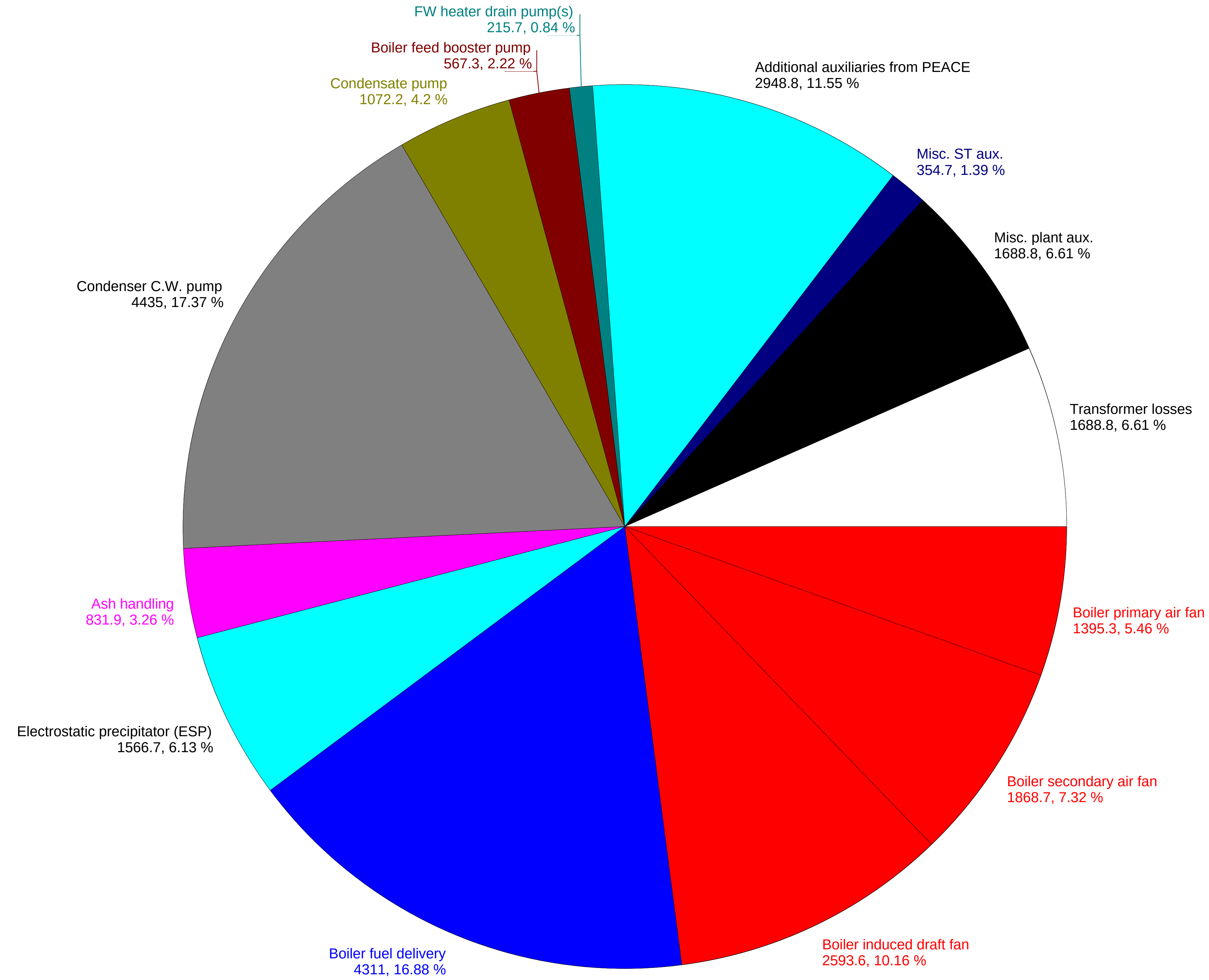
Plant Energy Flow Schematic [kJ/s]



Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

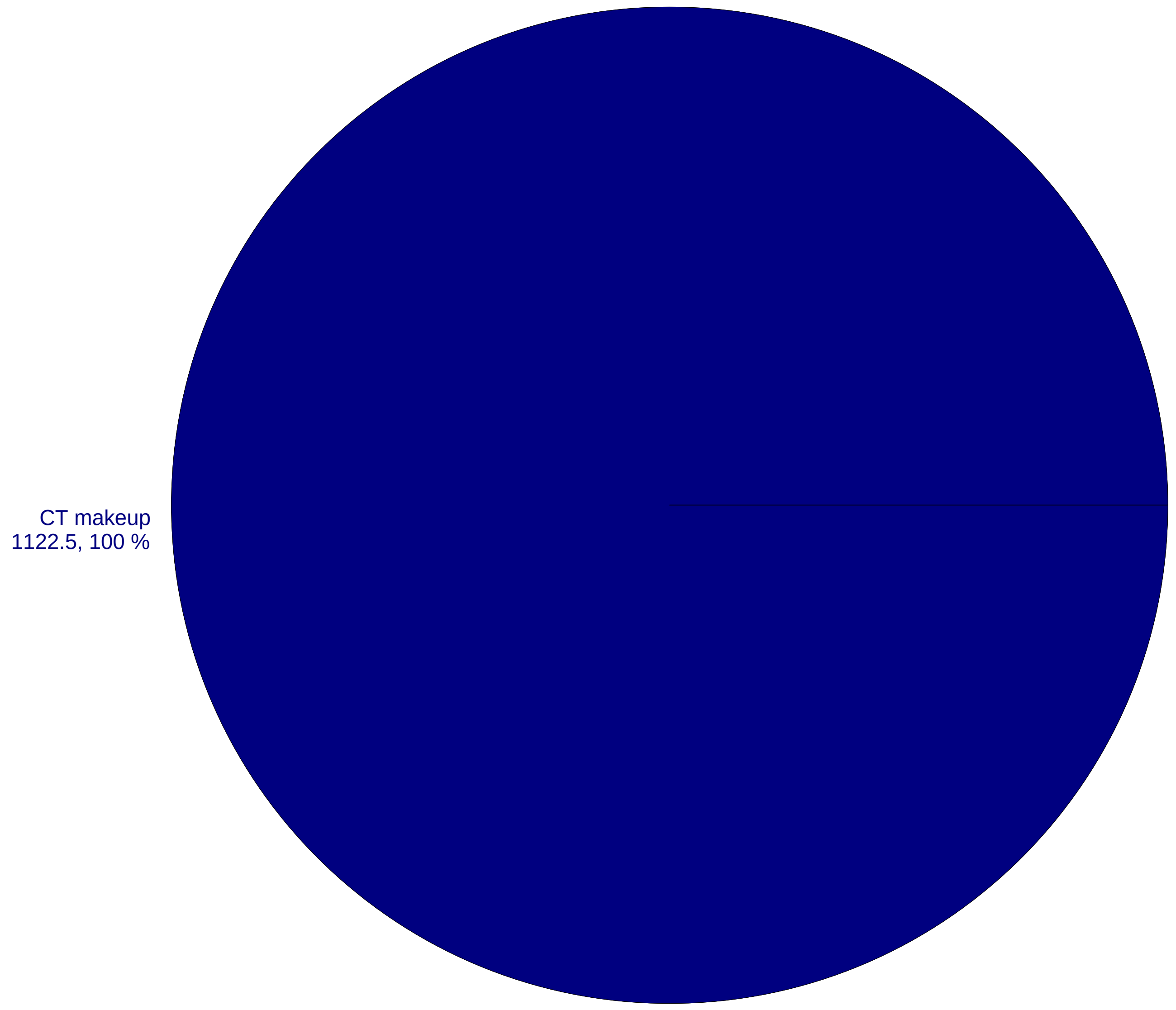
Auxiliaries & Losses [kW]

Total auxiliaries & transformer losses = 25539 kW



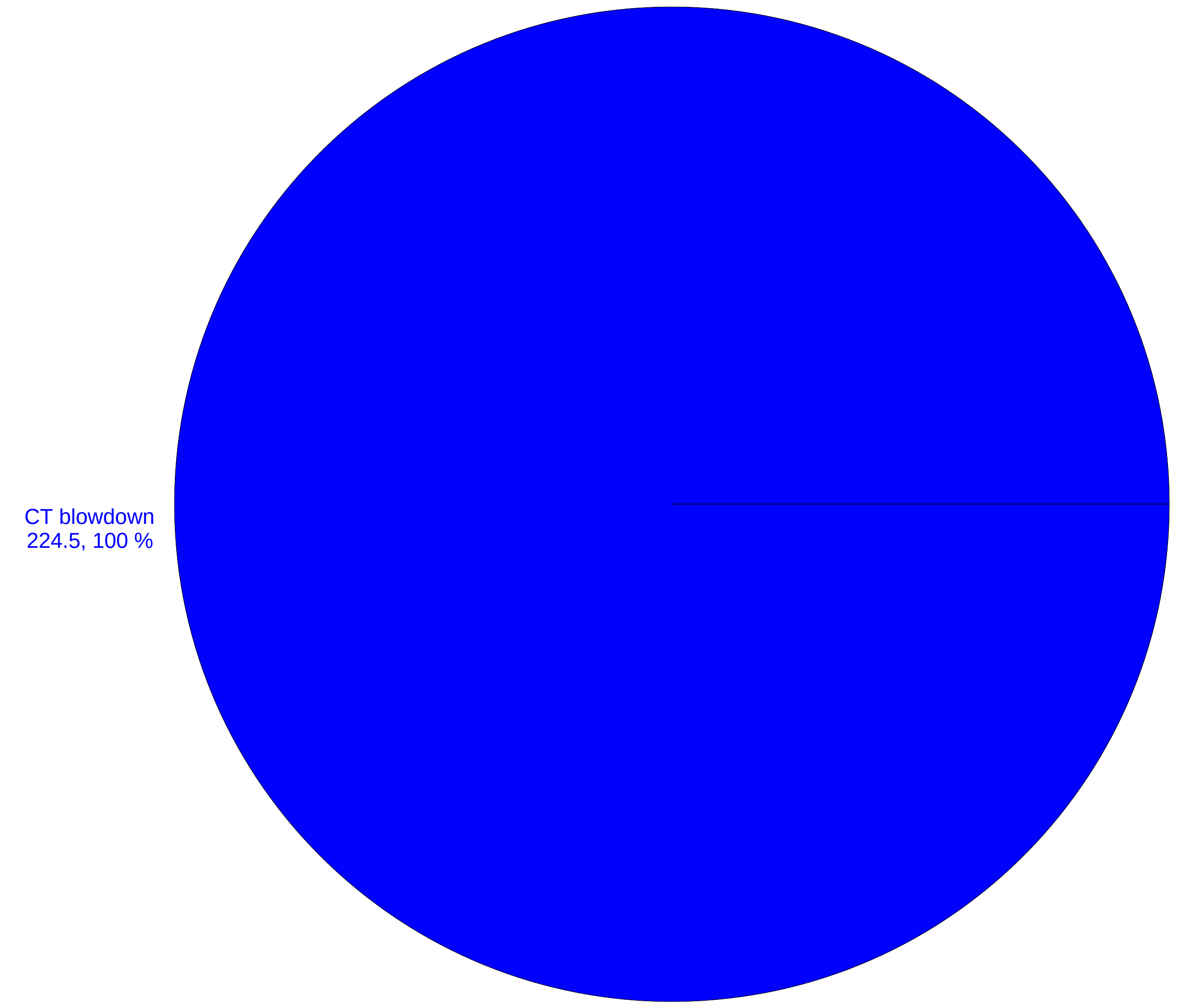
Plant Water Consumption [t/h]

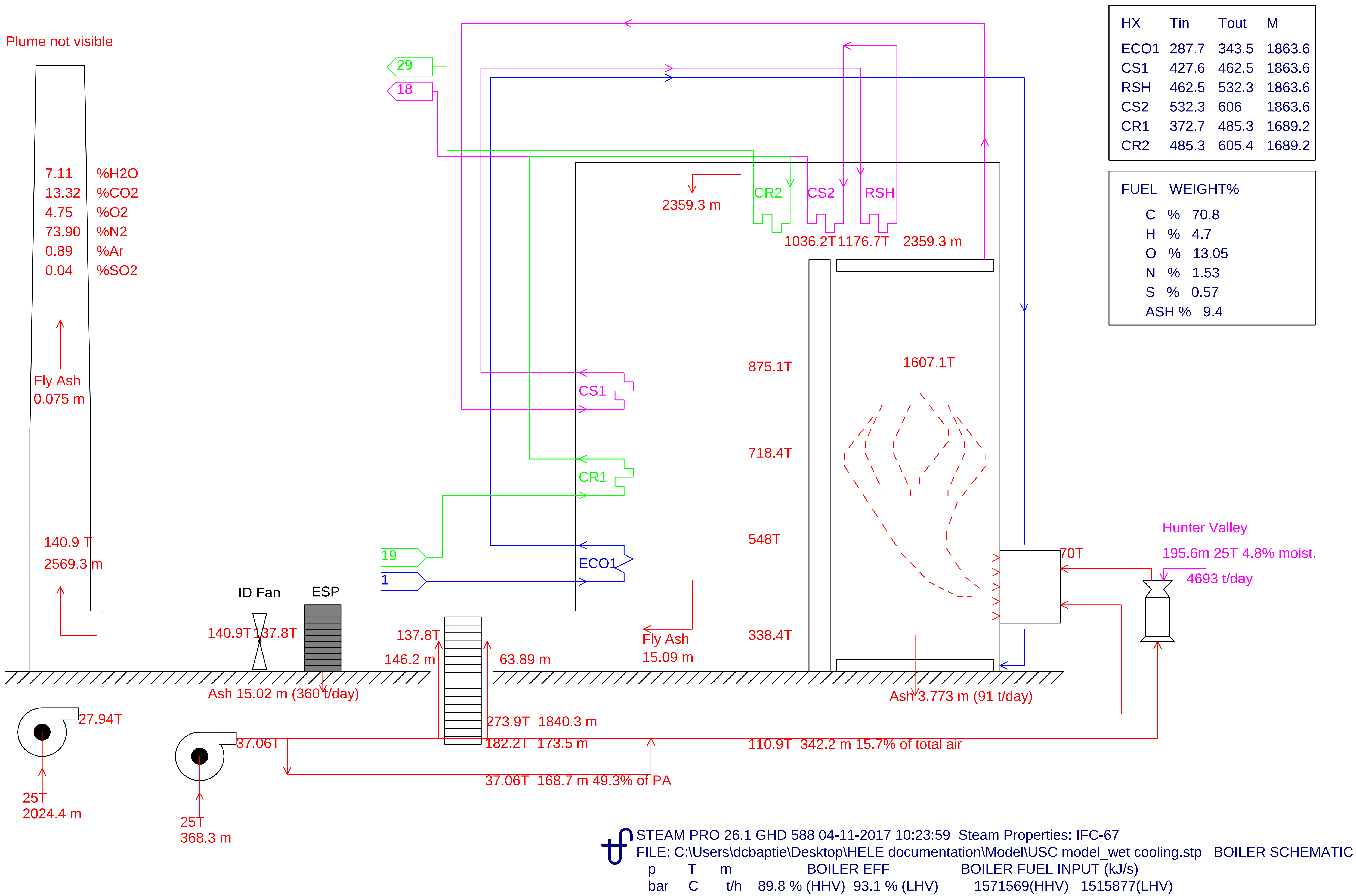
Plant water consumption = 1122.5 t/h



Plant Water Discharge [t/h]

Plant water discharge = 224.5 t/h

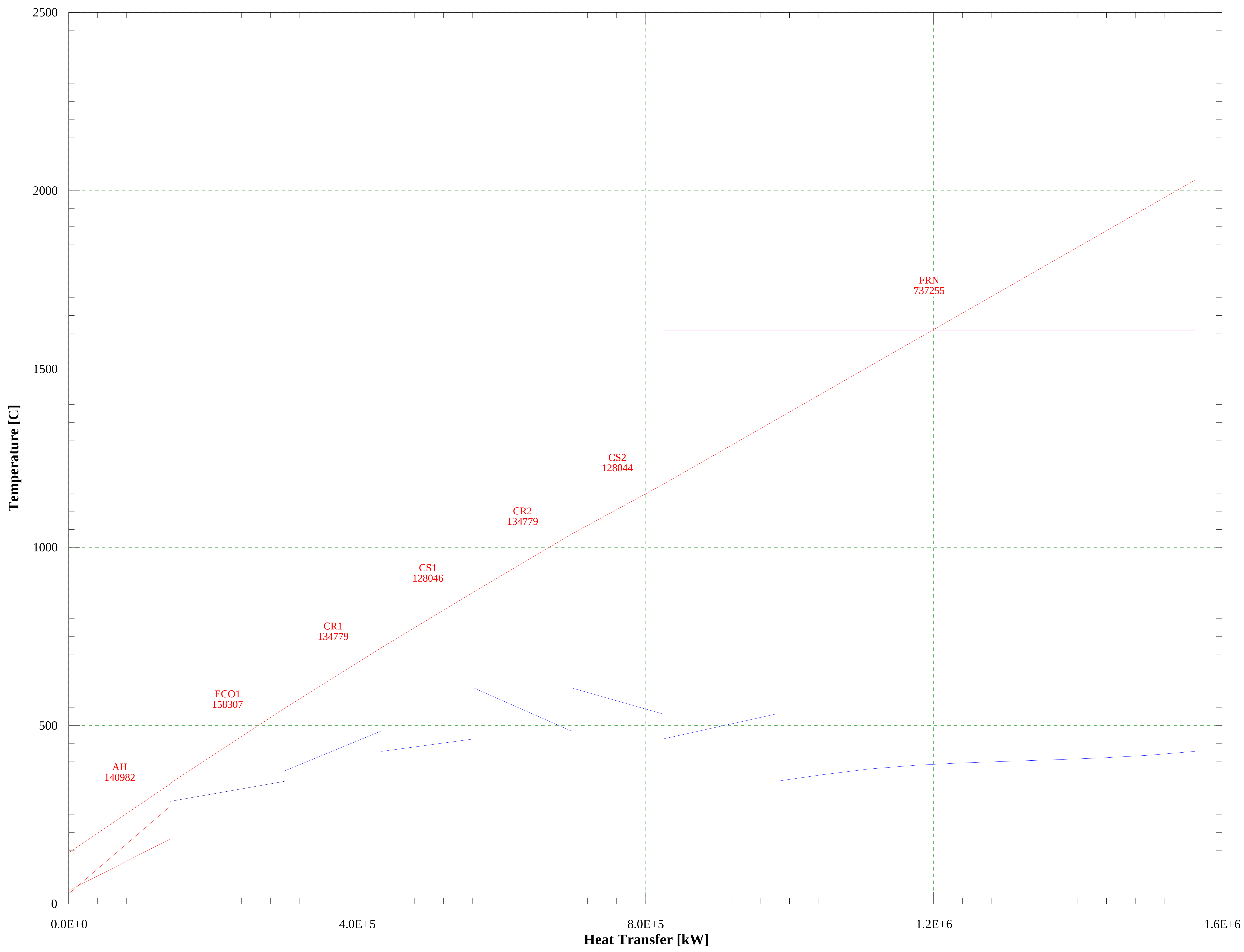




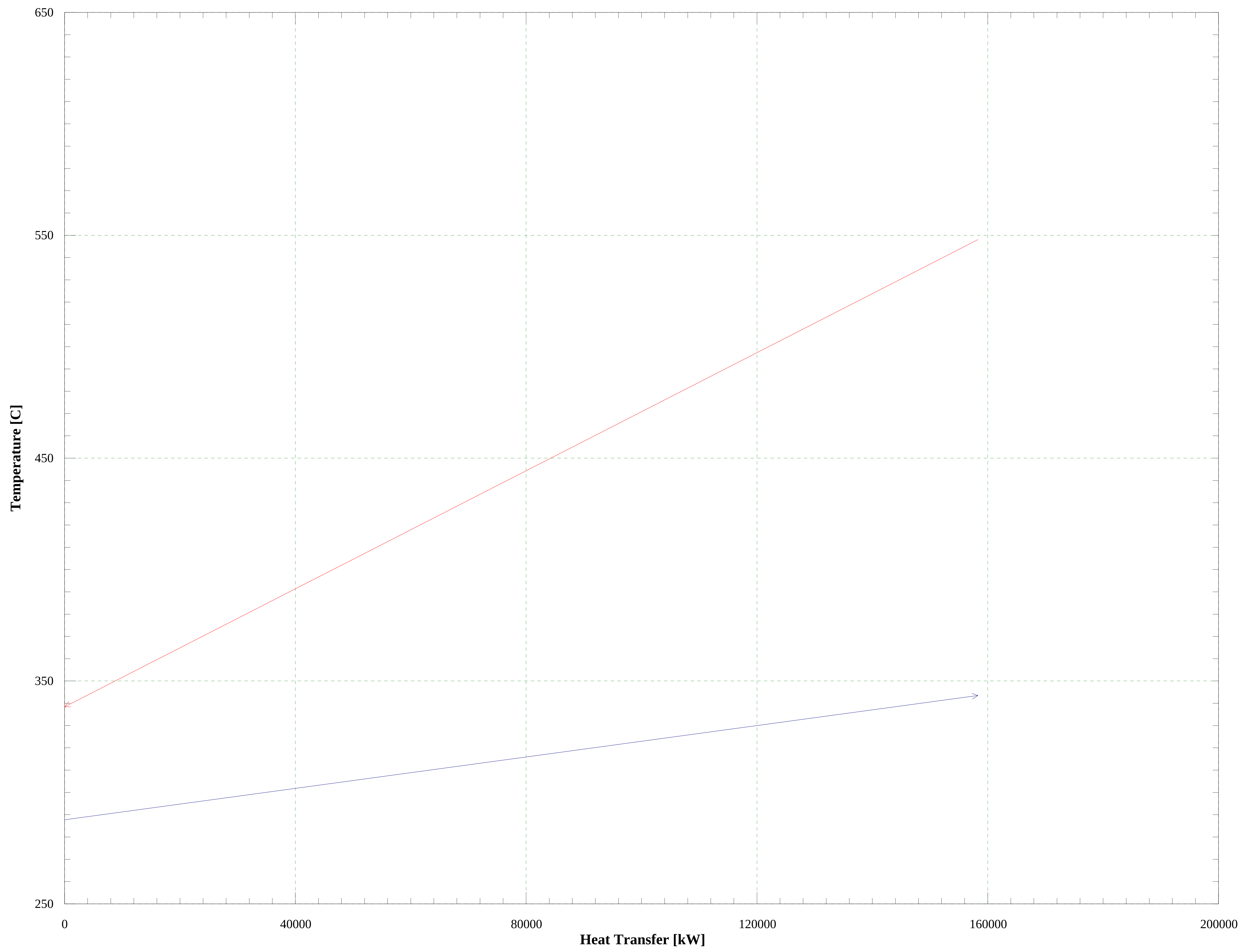
HX	Tin	Tout	M
ECO1	287.7	343.5	1863.6
CS1	427.6	462.5	1863.6
RSH	462.5	532.3	1863.6
CS2	532.3	606	1863.6
CR1	372.7	485.3	1689.2
CR2	485.3	605.4	1689.2

FUEL		WEIGHT%
C	%	70.8
H	%	4.7
O	%	13.05
N	%	1.53
S	%	0.57
ASH	%	9.4

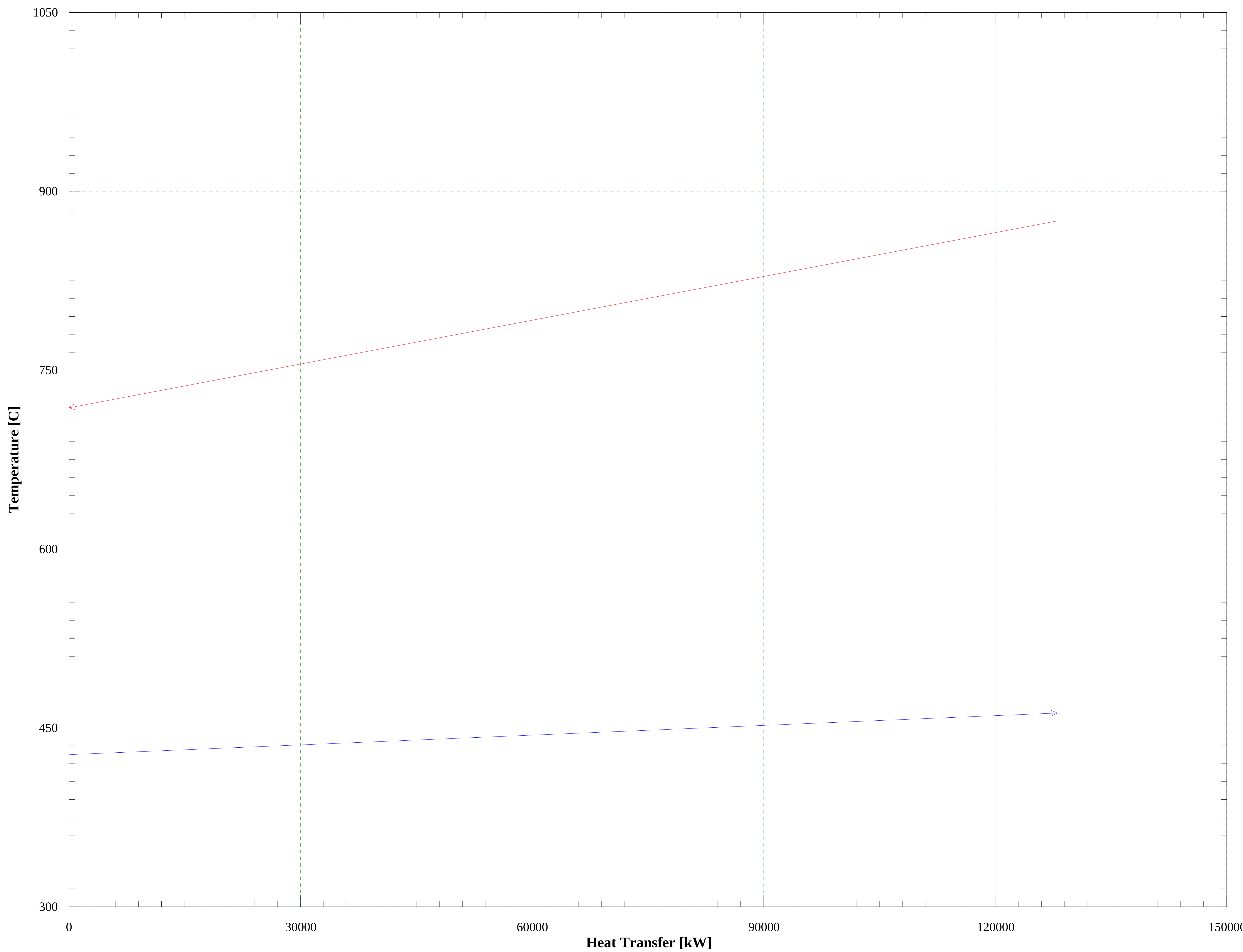
Boiler - TQ Diagram



ECO1 - TQ Diagram



CS1 - TQ Diagram



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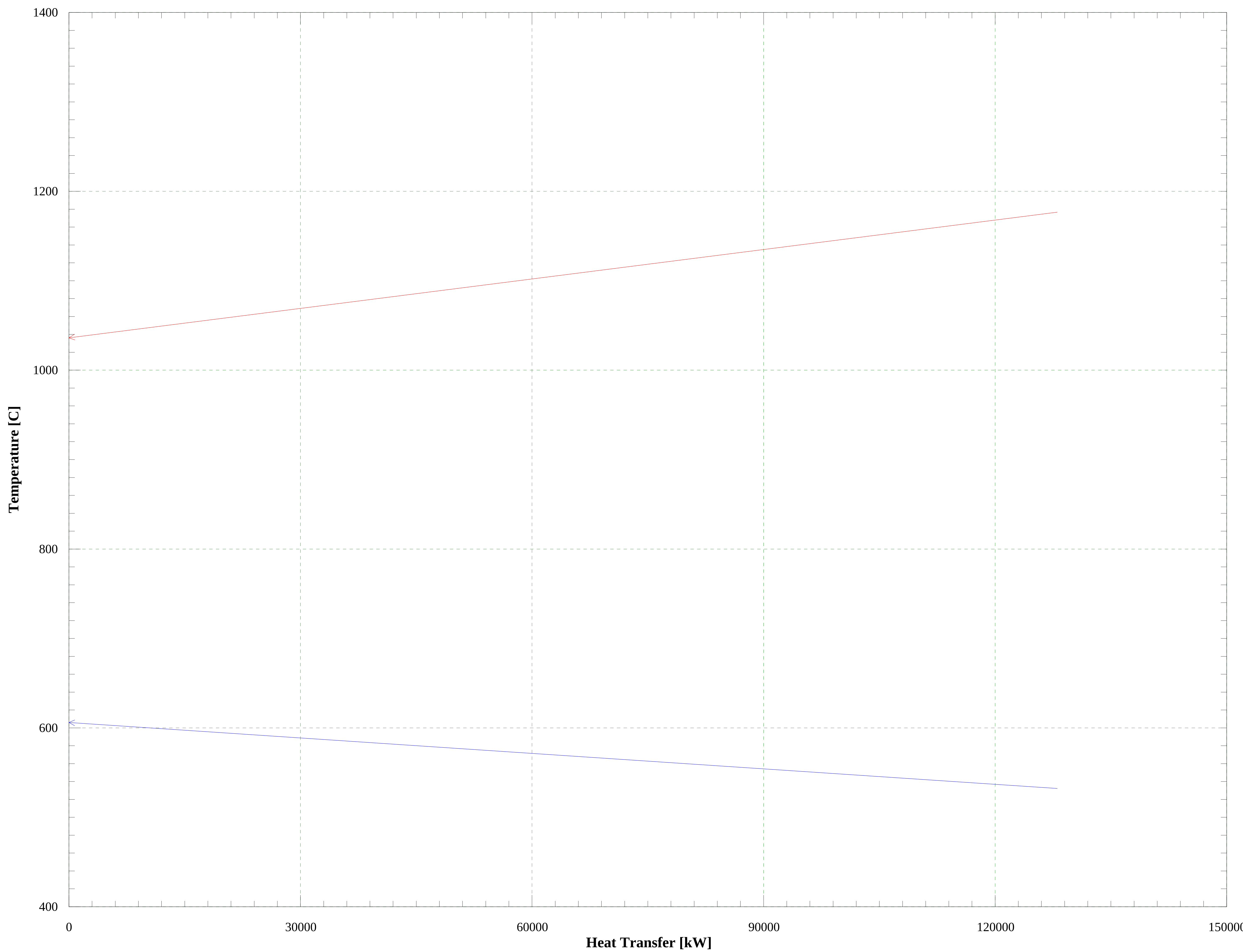
CS2 - TQ Diagram



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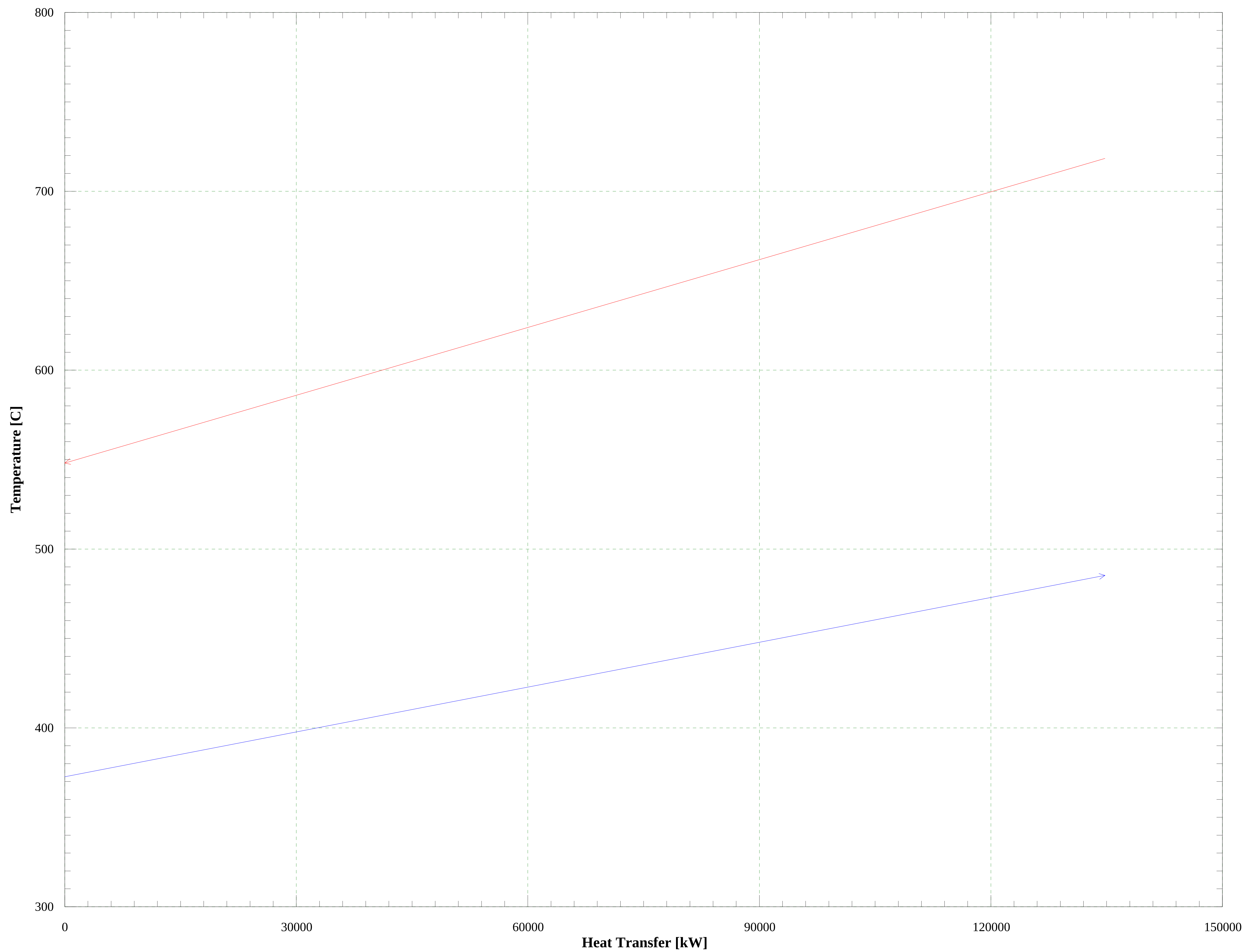
CR1 - TQ Diagram



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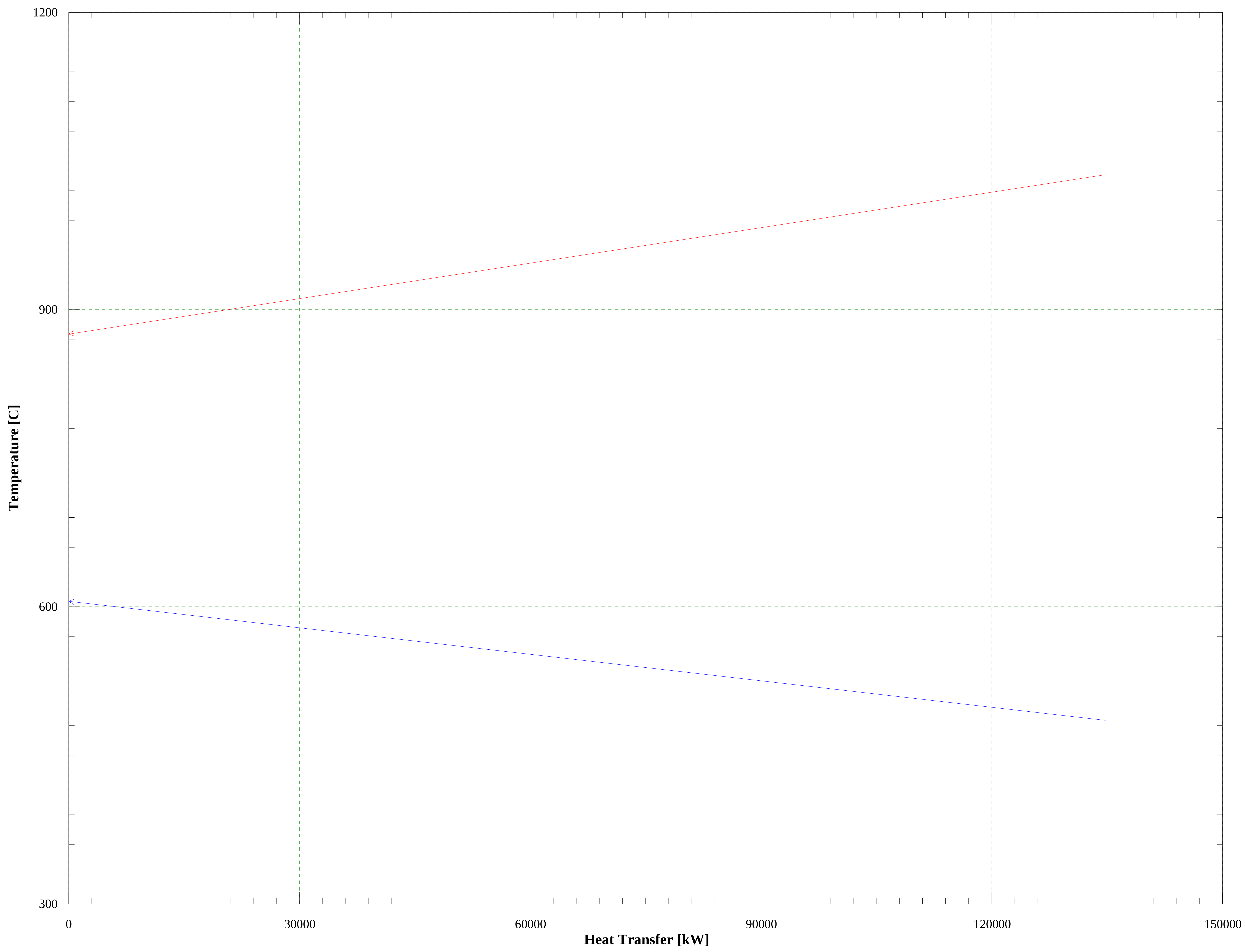
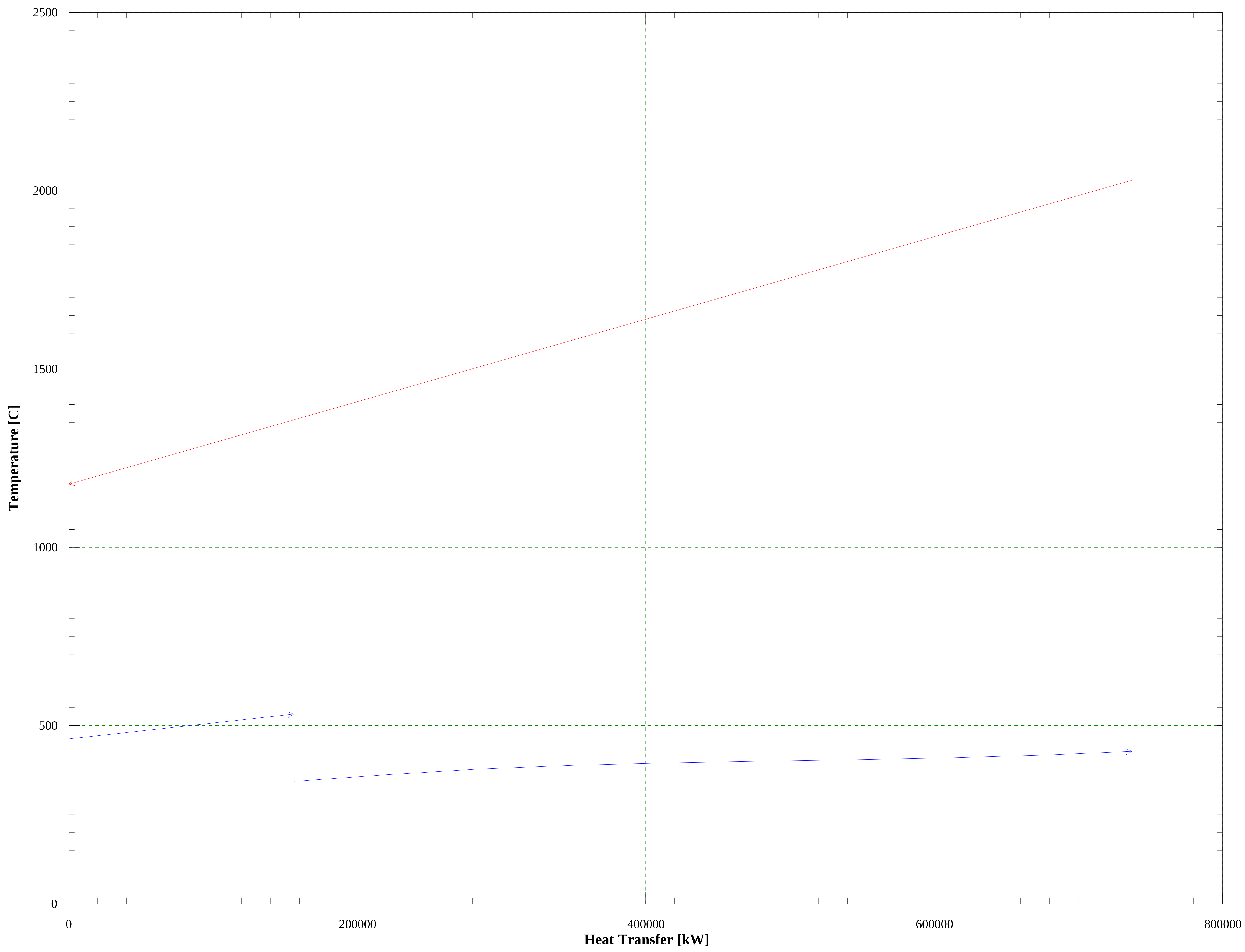
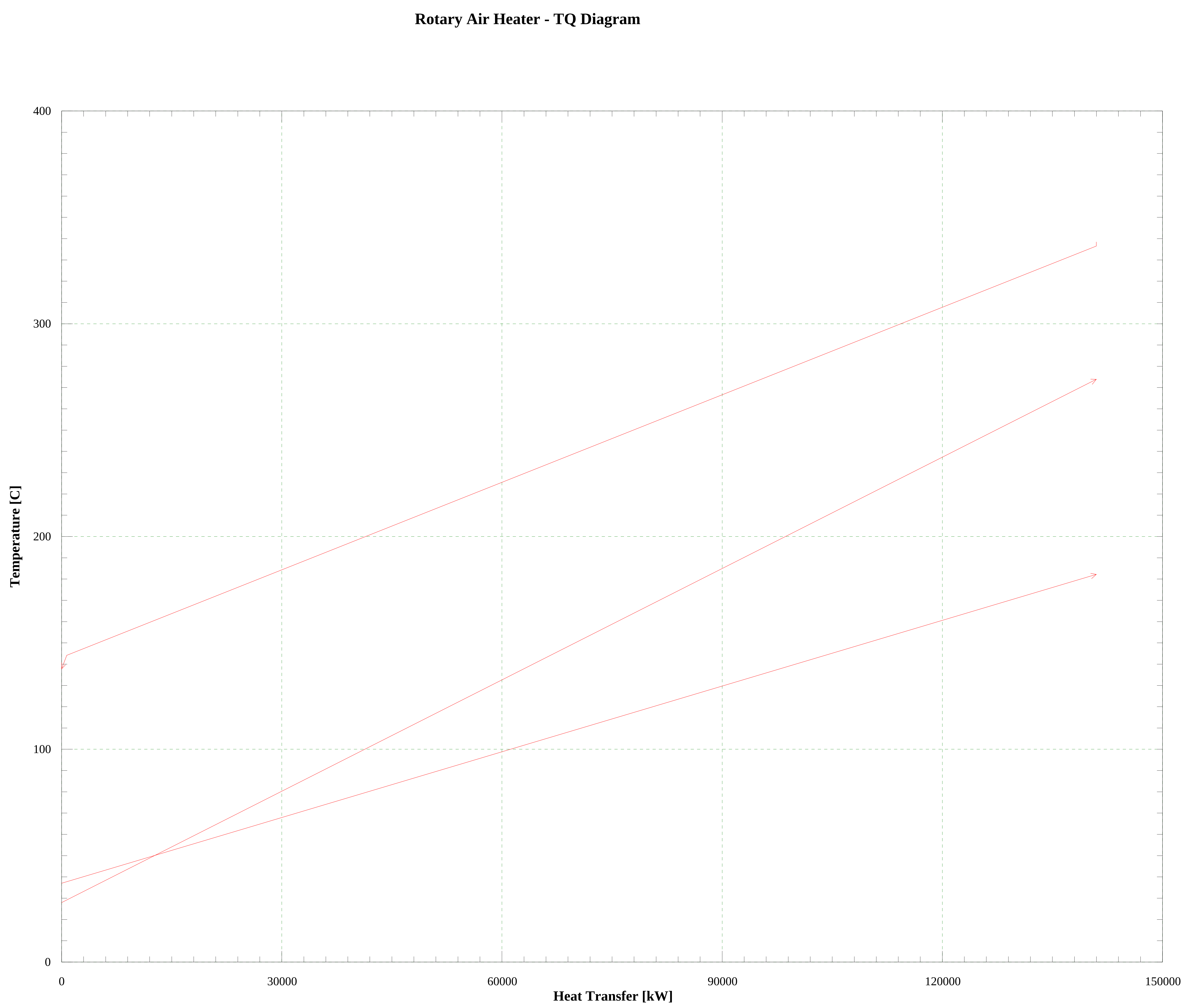
CR2 - TQ Diagram



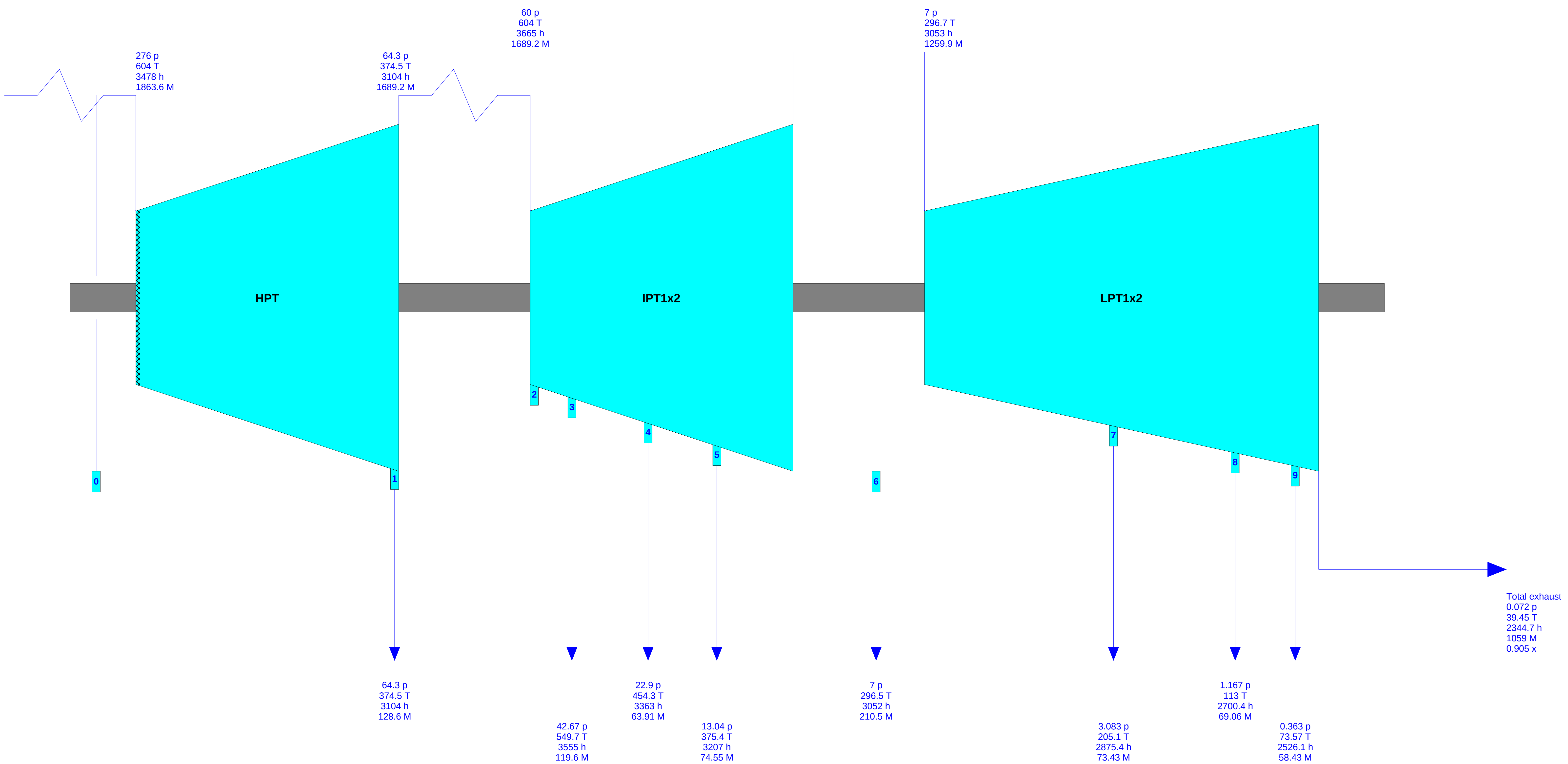
Furnace - TQ Diagram



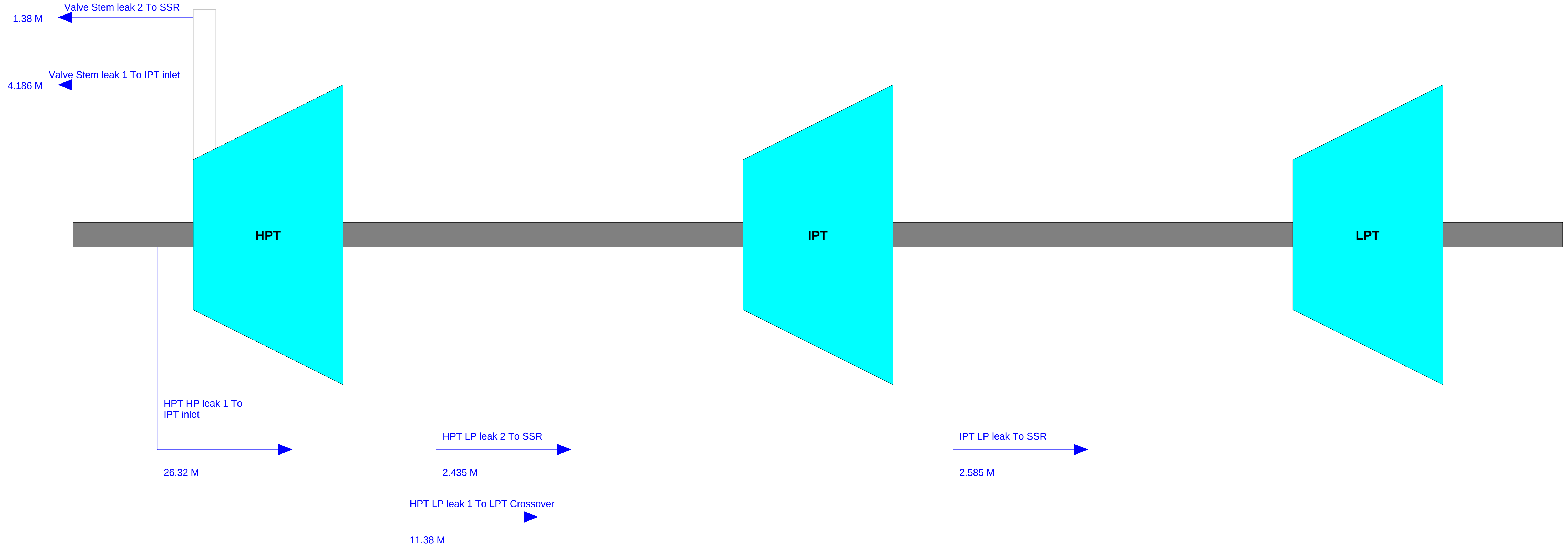


Rotary Air Heater - TQ Diagram
400
300
200
100
0
Temperature [C]
0
30000
60000
90000
120000
150000
Heat Transfer [kW]

Expansion power	683127	kW
Mechanical loss	1707.8	kW
Generator loss	5890	kW
Generator power	675529	kW

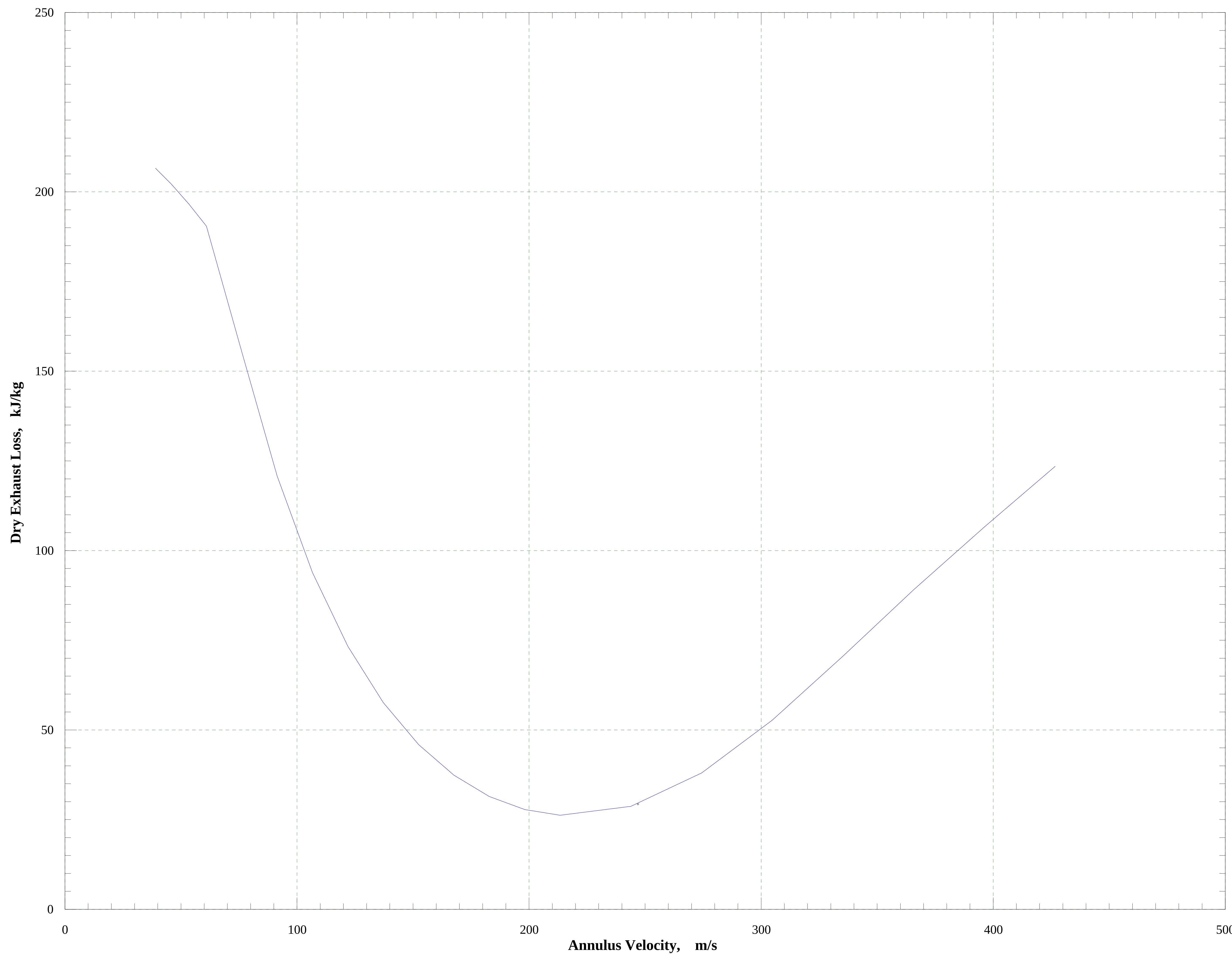


p [bar] T [C] h [kJ/kg] M [t/h] x [-]

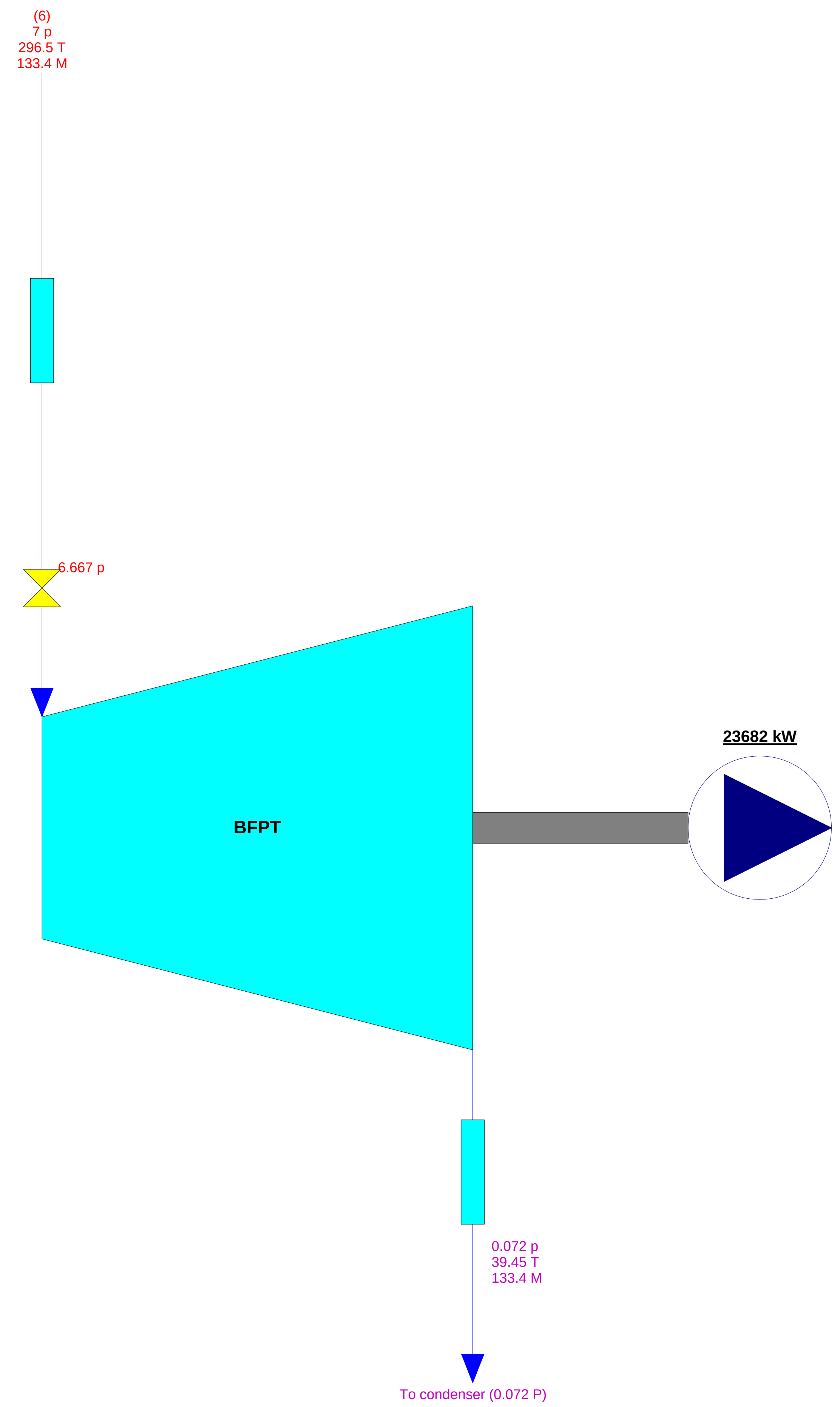


p [bar] T [C] h [kJ/kg] M [t/h] x [-]

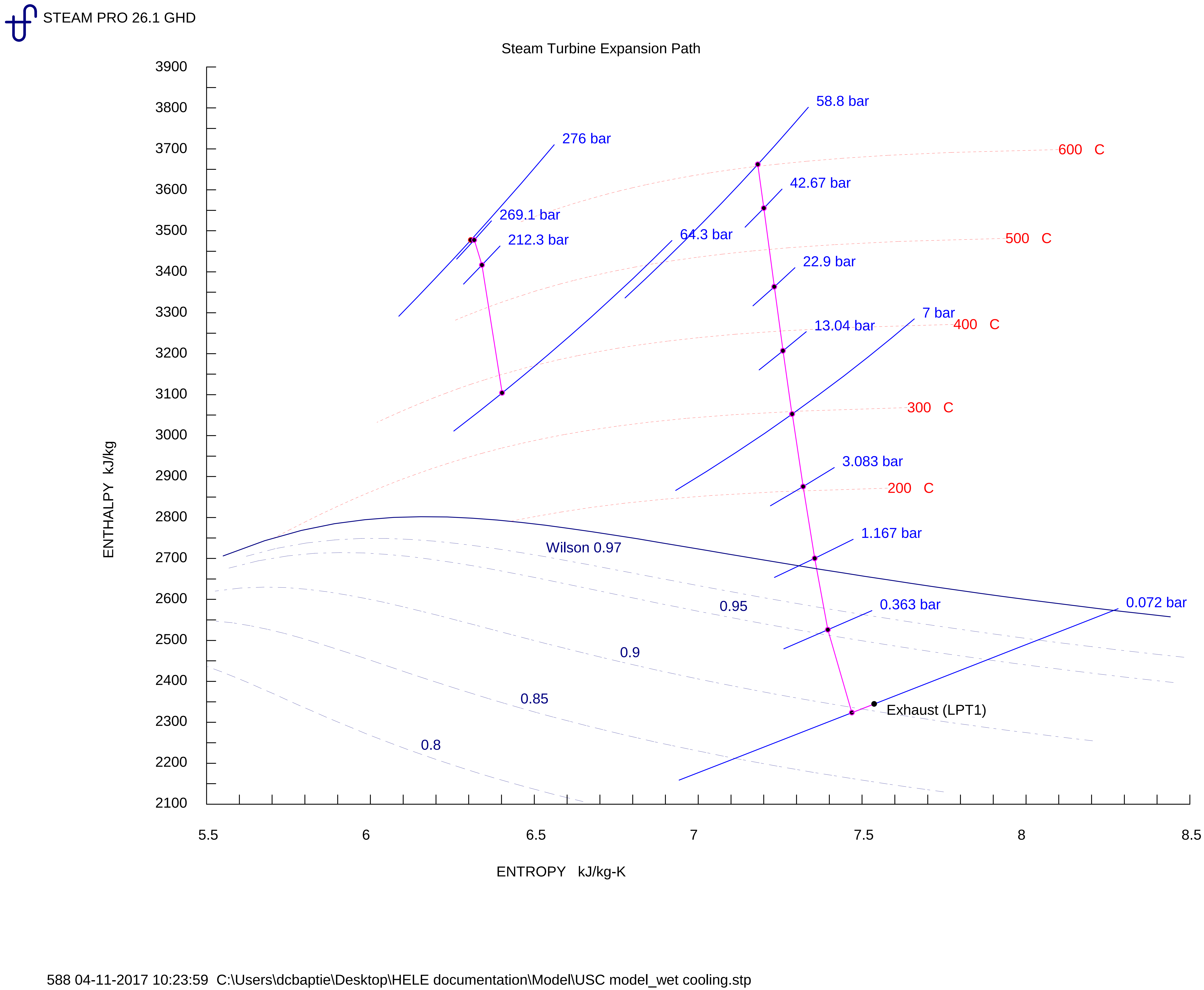
Steam Turbine Exhaust Loss



STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-11-2017 10:23:59 C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

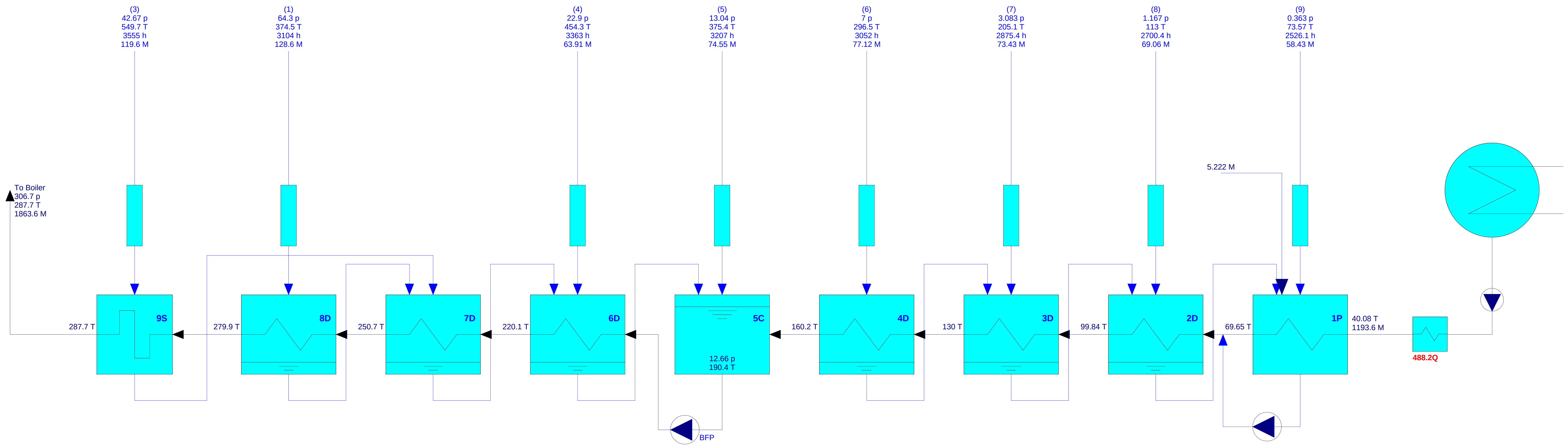

(6)
7 p
296.5 T
133.4 M
6.667 p
BFPT
23682 kW
0.072 p
39.45 T
133.4 M
To condenser (0.072 P)

p [bar] T [C] M [t/h] x [-]

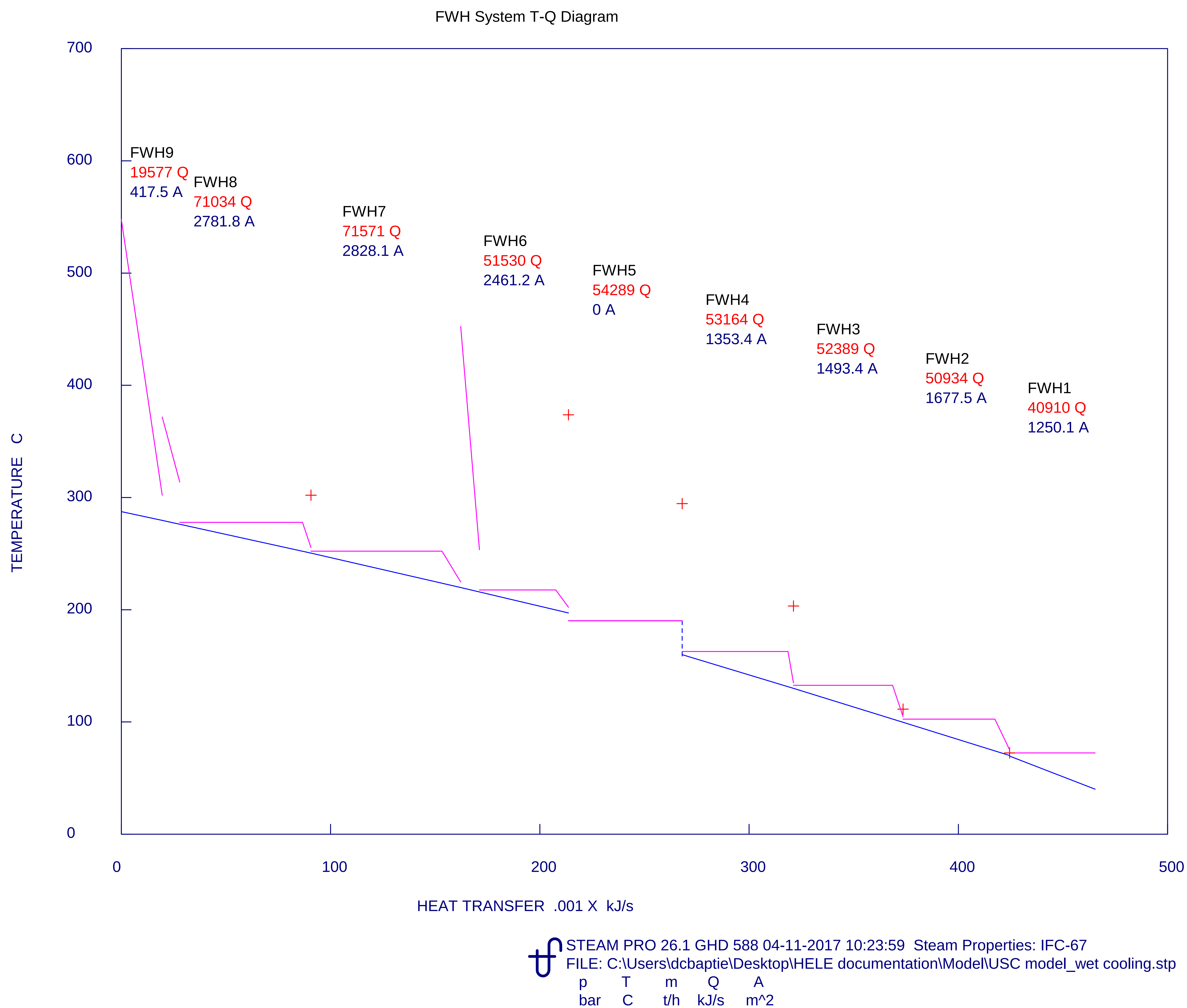


STEAM PRO 26.1 GHD
Steam Turbine Expansion Path
276 bar
269.1 bar
212.3 bar
64.3 bar
58.8 bar
42.67 bar
22.9 bar
13.04 bar
7 bar
3.083 bar
1.167 bar
0.363 bar
0.072 bar
600 C
500 C
400 C
300 C
200 C
Wilson 0.97
0.95
0.9
0.85
0.8
Exhaust (LPT1)
ENTHALPY kJ/kg
ENTROPY kJ/kg-K
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
5.5
6
6.5
7
7.5
8
8.5
588 04-11-2017 10:23:59 C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

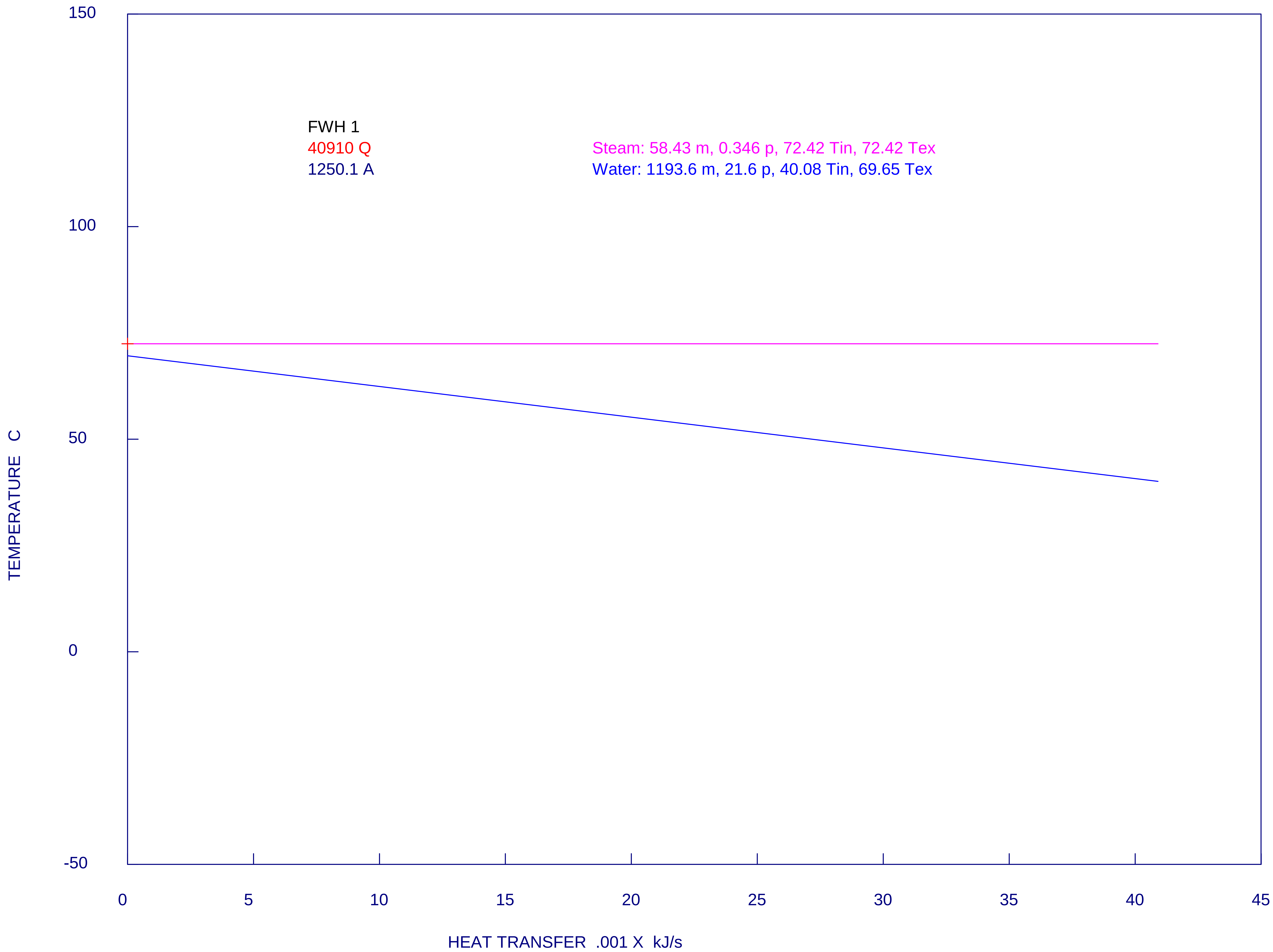
Double HP Feed Water Heater Train & Single LP Feed Water Heater Train



p [bar] T [C] h [kJ/kg] M [t/h] Q [kJ/s] x [-]


FWH System T-Q Diagram
TEMPERATURE C
HEAT TRANSFER .001 X kJ/s
0
100
200
300
400
500
600
700
0
100
200
300
400
500
FWH9
19577 Q
417.5 A
FWH8
71034 Q
2781.8 A
FWH7
71571 Q
2828.1 A
FWH6
51530 Q
2461.2 A
FWH5
54289 Q
0 A
FWH4
53164 Q
1353.4 A
FWH3
52389 Q
1493.4 A
FWH2
50934 Q
1677.5 A
FWH1
40910 Q
1250.1 A
STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp
p T m Q A
bar C t/h kJ/s m^2

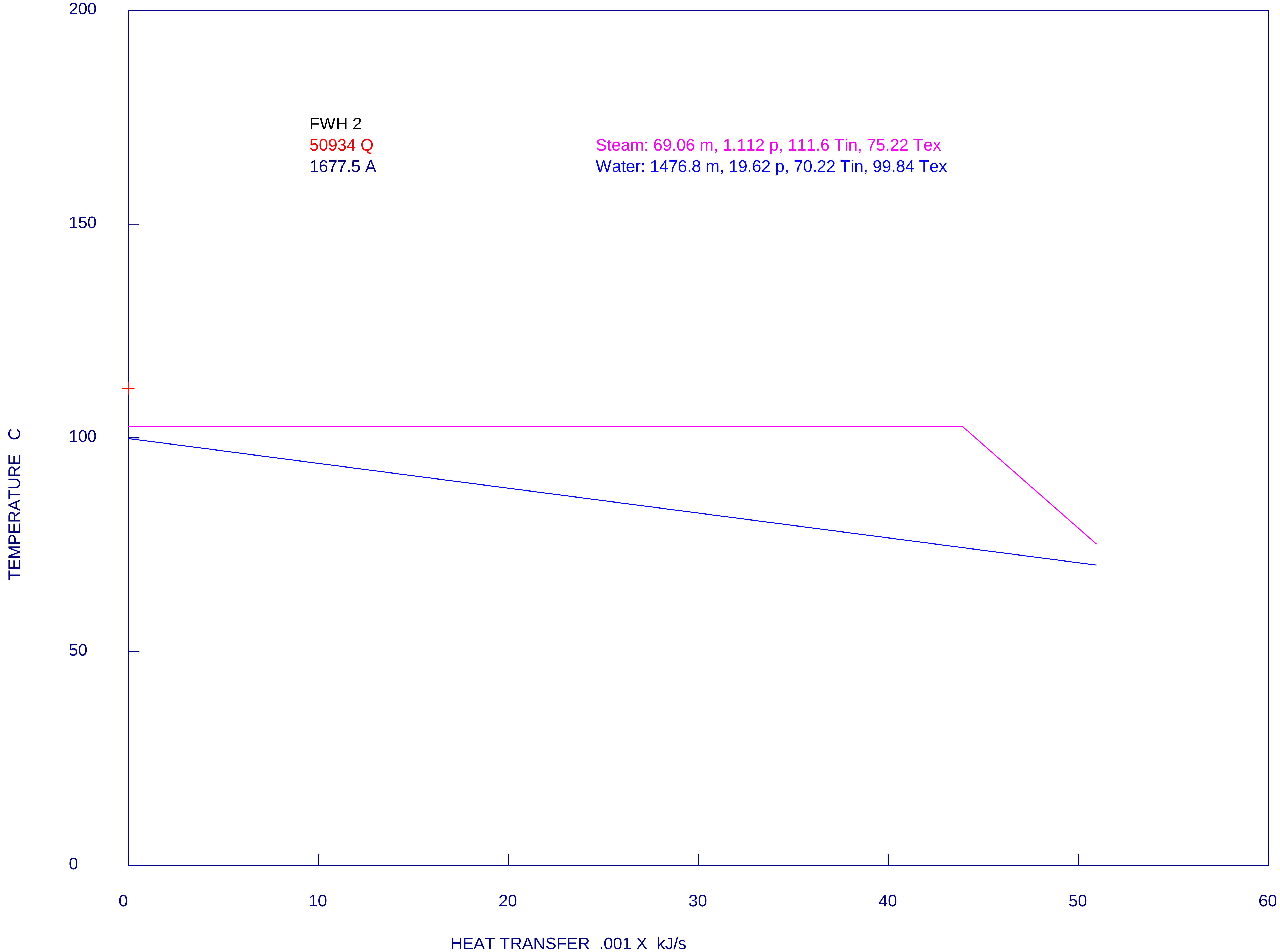
FWH 1 T-Q Diagram



STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

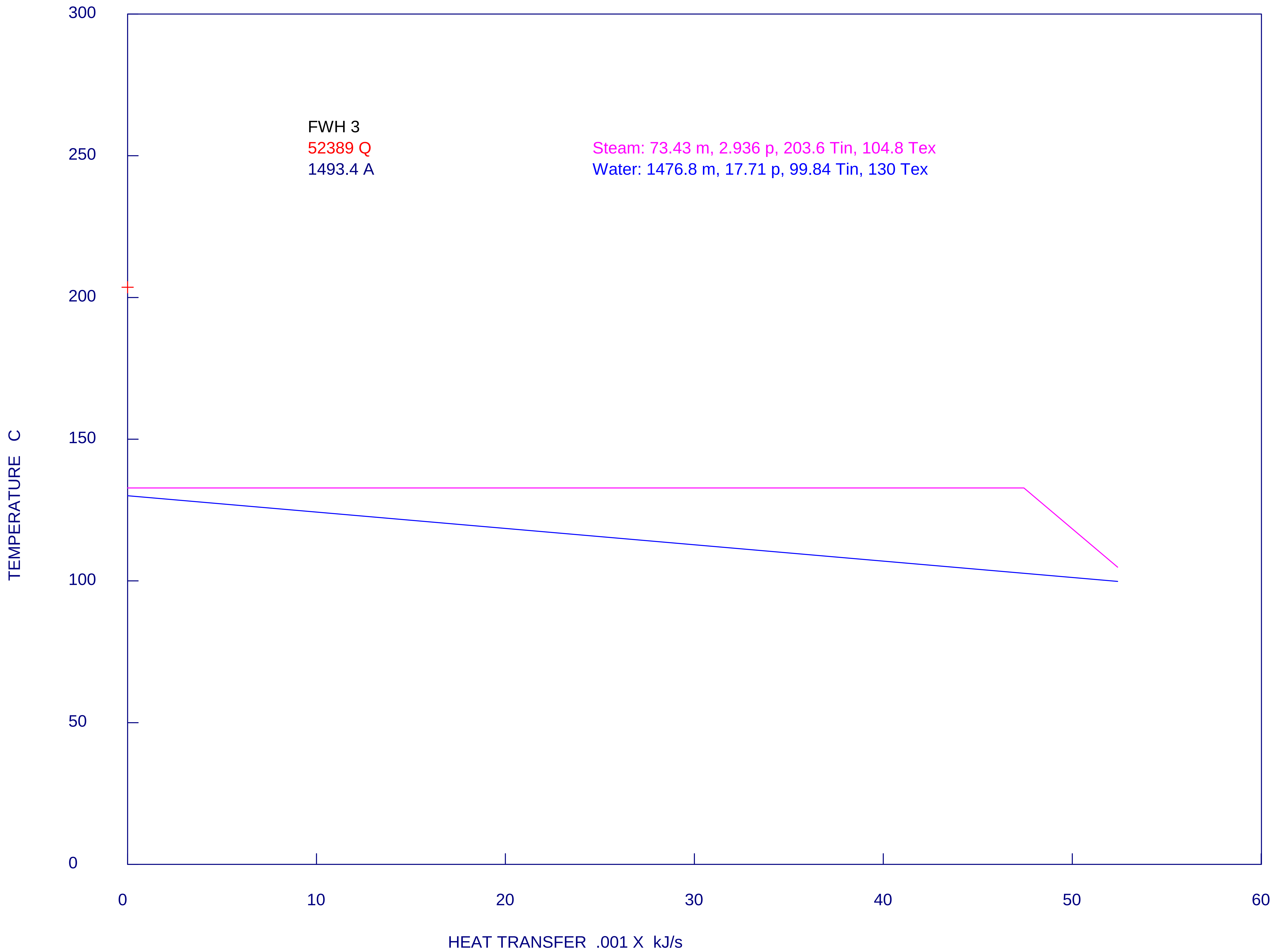
FWH 2 T-Q Diagram



STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

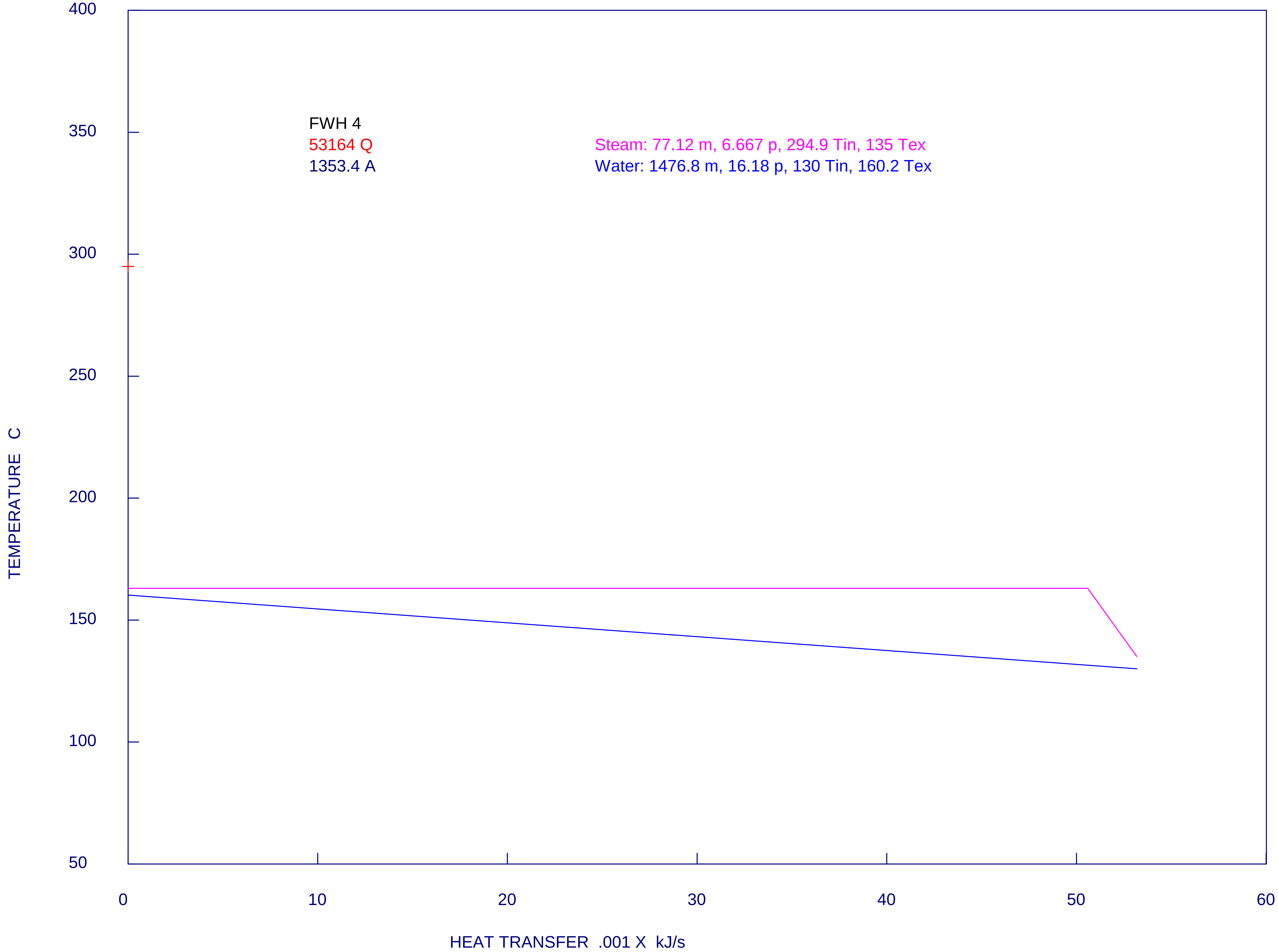
FWH 3 T-Q Diagram



STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

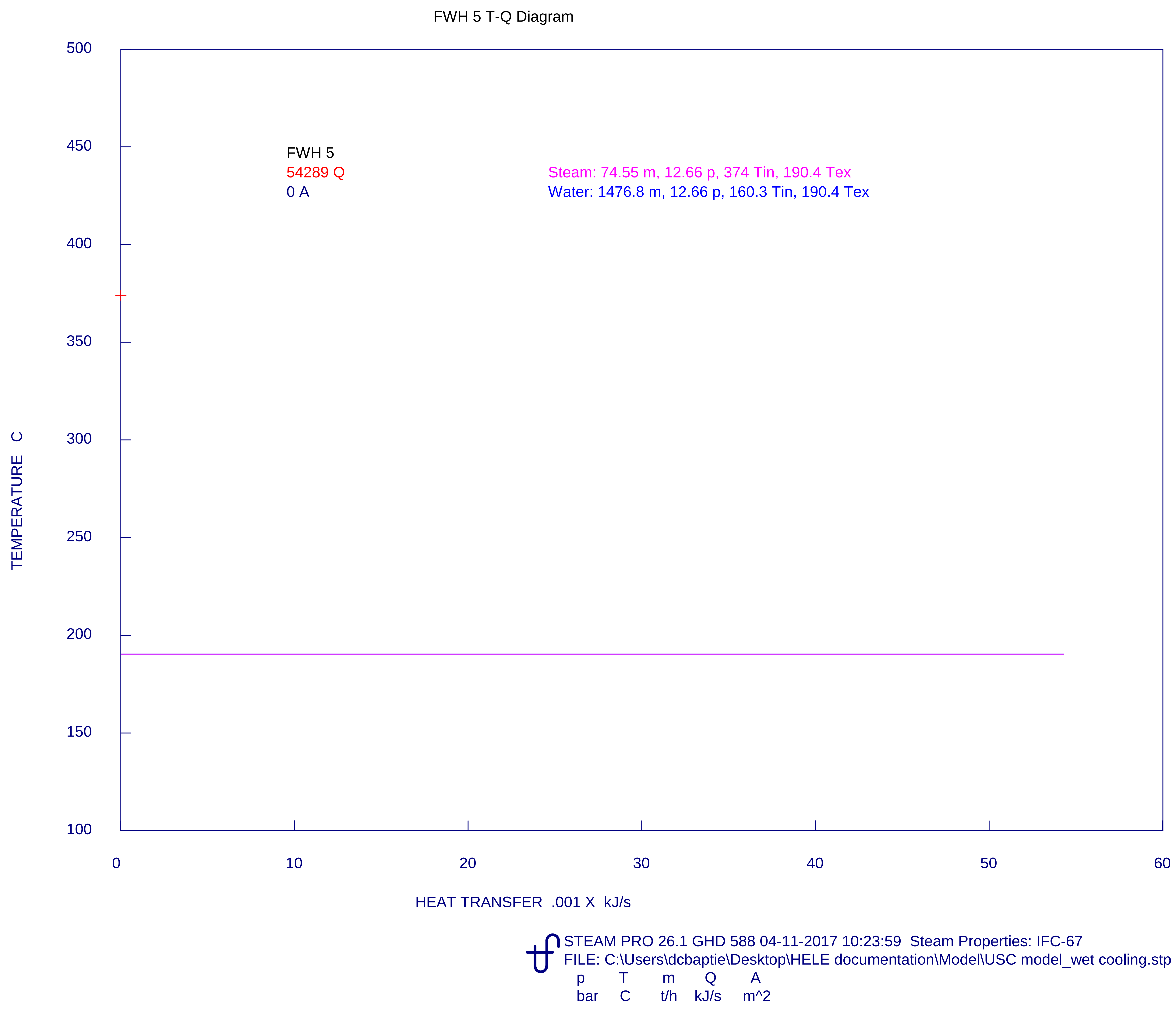
p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

FWH 4 T-Q Diagram

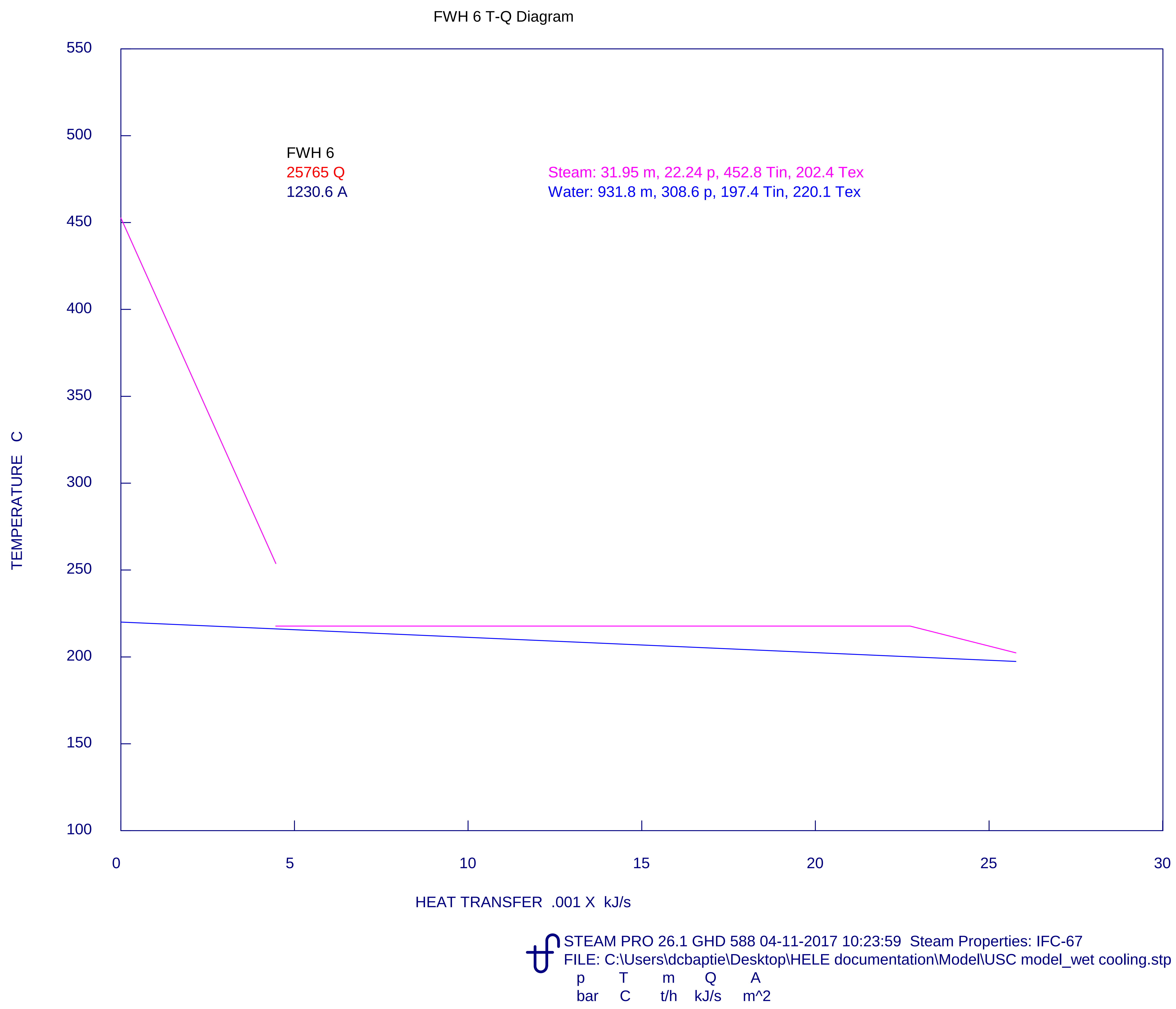


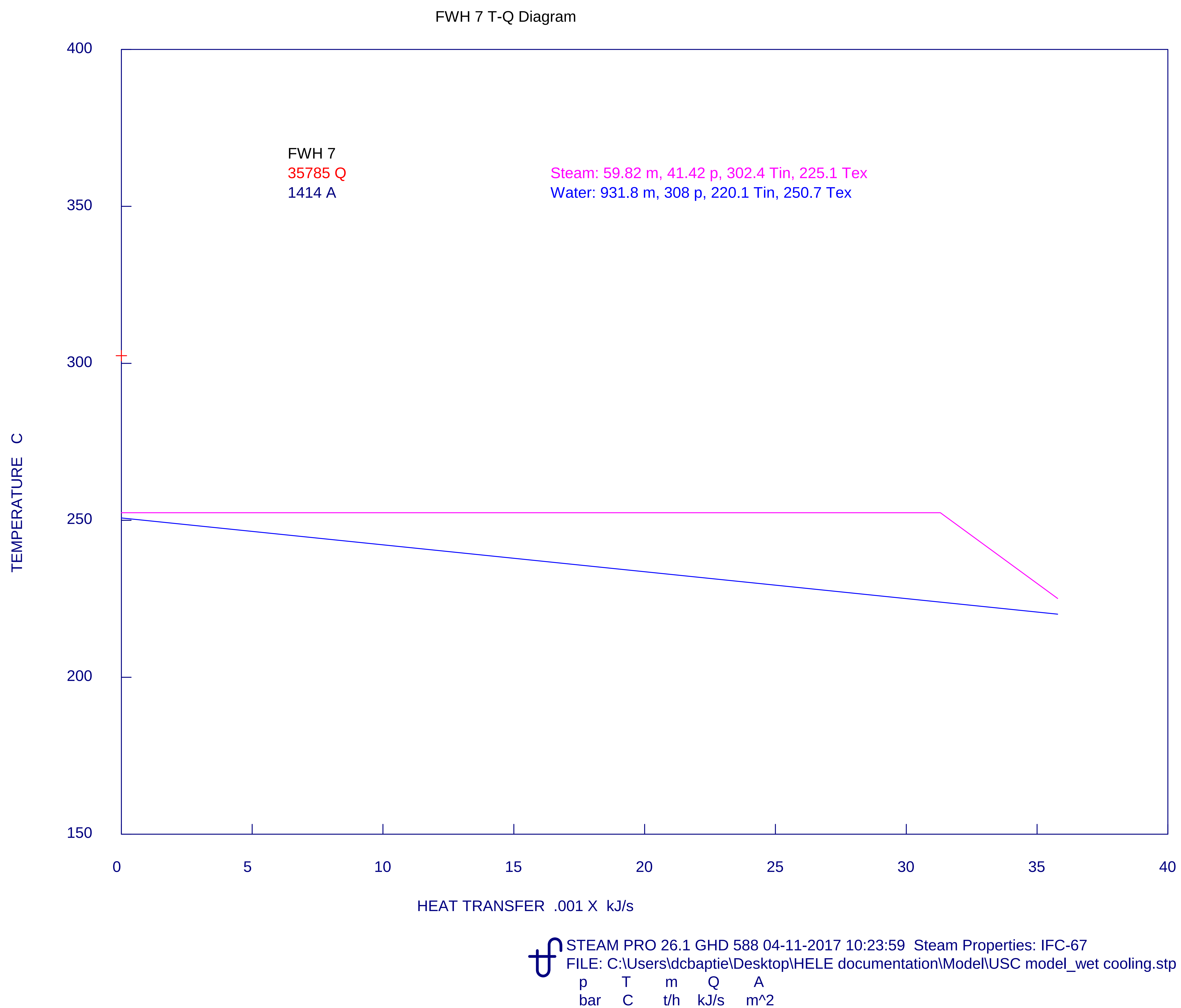
STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

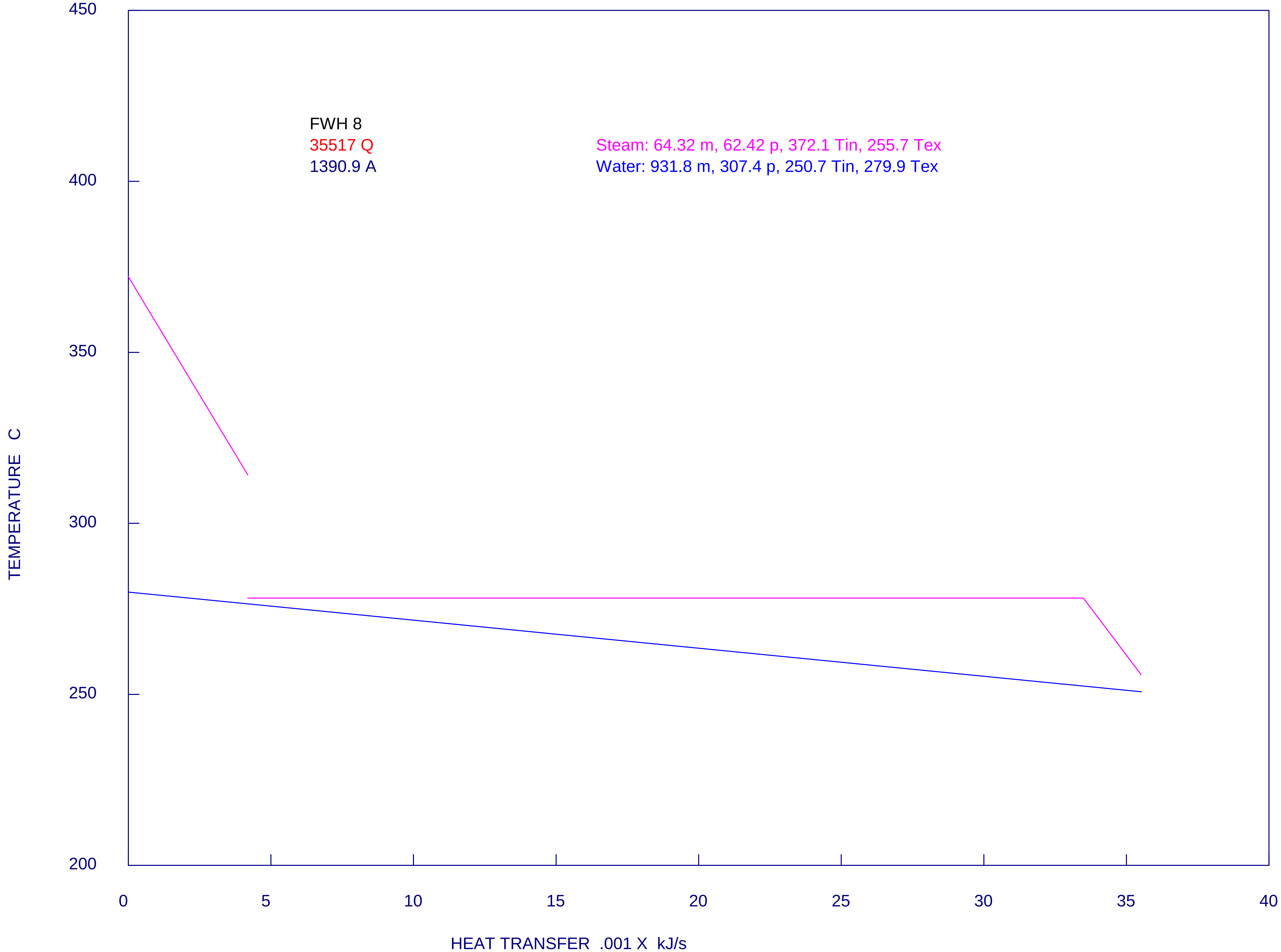


FWH 5 T-Q Diagram
FWH 5
54289 Q
0 A
Steam: 74.55 m, 12.66 p, 374 Tin, 190.4 Tex
Water: 1476.8 m, 12.66 p, 160.3 Tin, 190.4 Tex
TEMPERATURE C
500
450
400
350
300
250
200
150
100
0
10
20
30
40
50
60
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp
p T m Q A
bar C t/h kJ/s m^2


FWH 6 T-Q Diagram
FWH 6
25765 Q
1230.6 A
Steam: 31.95 m, 22.24 p, 452.8 Tin, 202.4 Tex
Water: 931.8 m, 308.6 p, 197.4 Tin, 220.1 Tex
550
500
450
400
350
300
250
200
150
100
TEMPERATURE C
0
5
10
15
20
25
30
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp
p T m Q A
bar C t/h kJ/s m^2


FWH 7 T-Q Diagram
FWH 7
35785 Q
1414 A
Steam: 59.82 m, 41.42 p, 302.4 Tin, 225.1 Tex
Water: 931.8 m, 308 p, 220.1 Tin, 250.7 Tex
TEMPERATURE C
400
350
300
250
200
150
0
5
10
15
20
25
30
35
40
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp
p T m Q A
bar C t/h kJ/s m^2

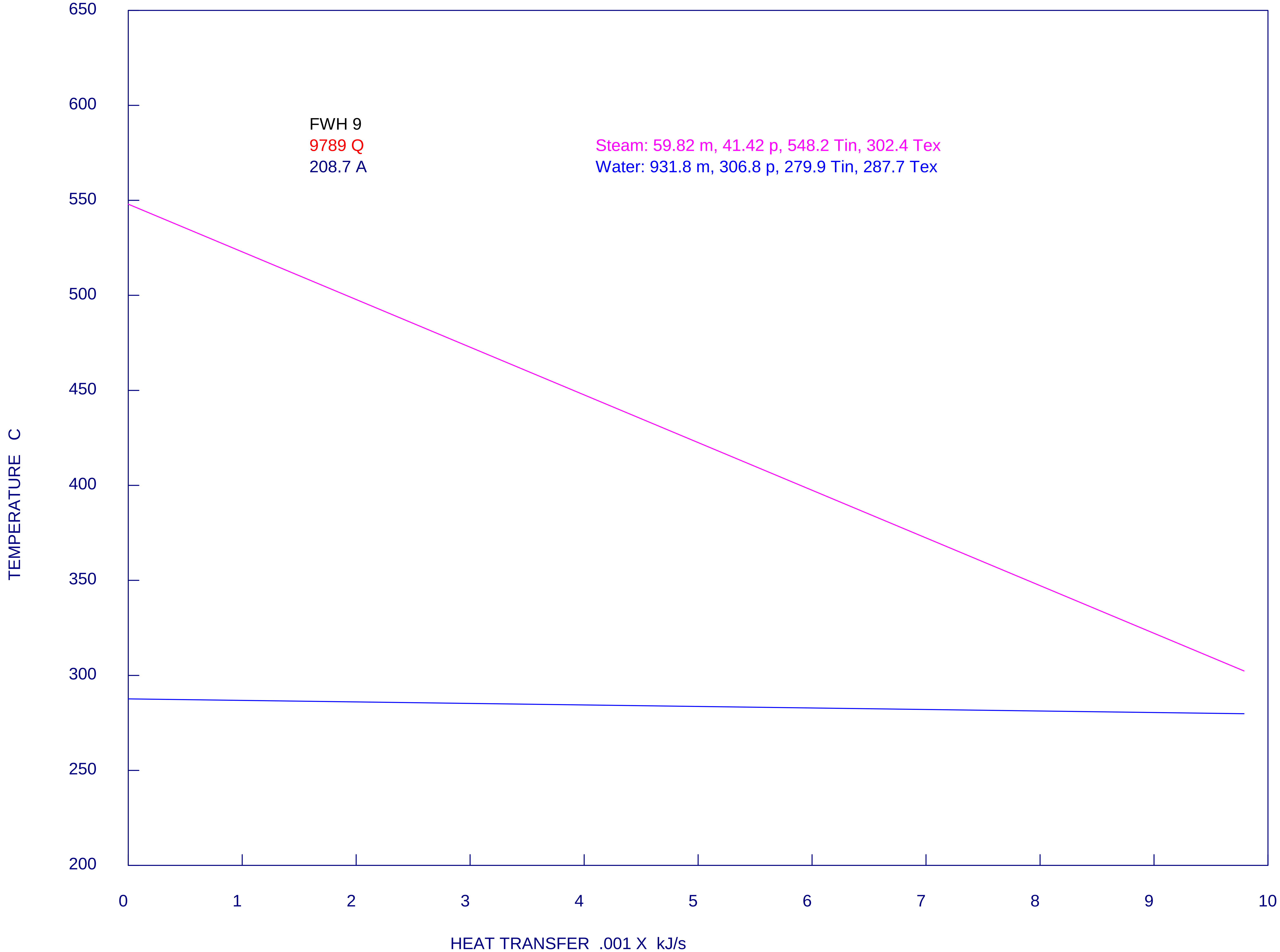
FWH 8 T-Q Diagram



STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

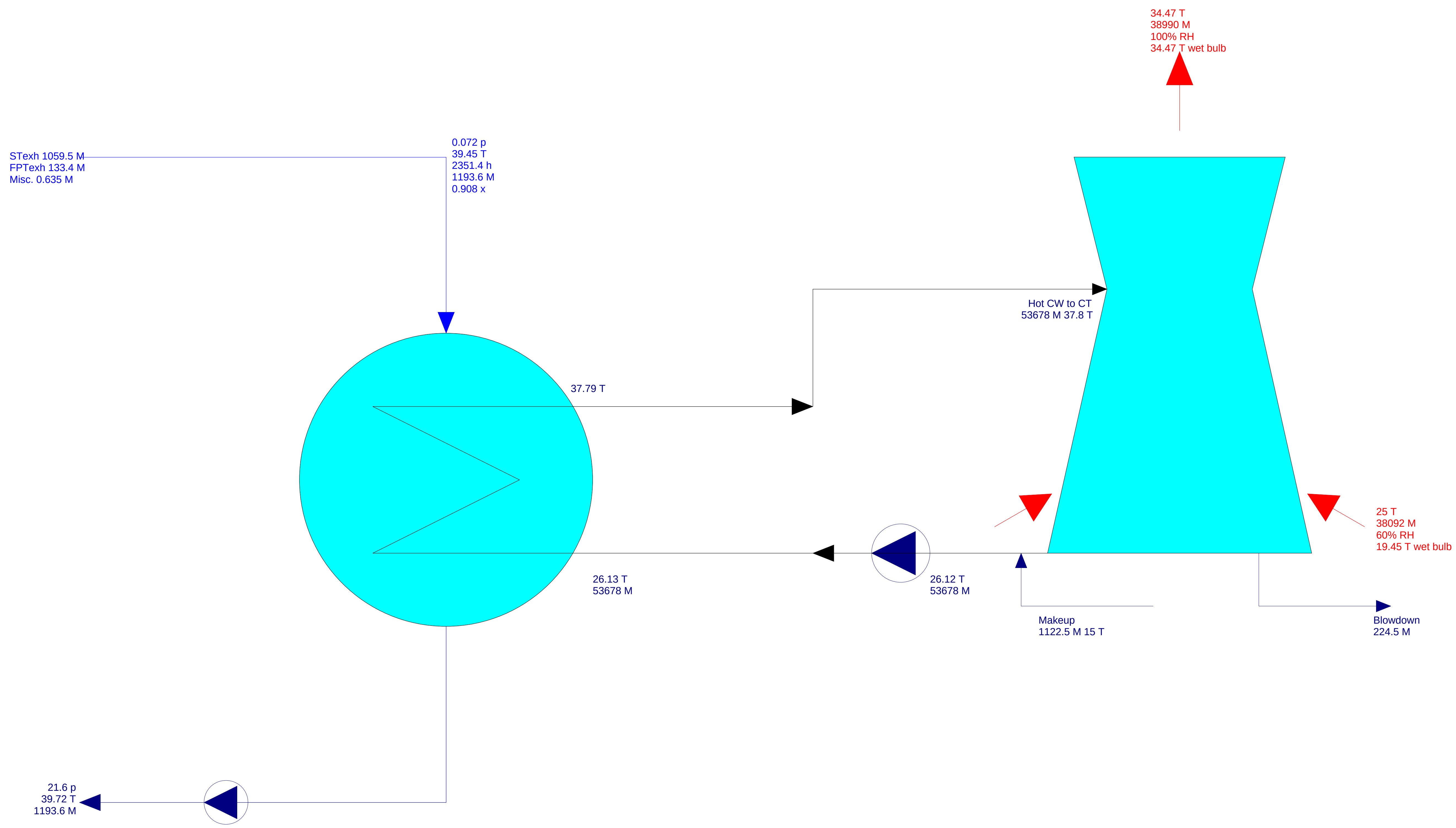
FWH 9 T-Q Diagram



STEAM PRO 26.1 GHD 588 04-11-2017 10:23:59 Steam Properties: IFC-67
FILE: C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

Condenser heat rejection	724868	kJ/s
Condensate pump power	1072.2	kW
Condenser CW pump power	4435	kW
Cooling tower heat rejection	728999	kJ/s
CW blowdown	224.5	t/h
CW makeup	1122.5	t/h

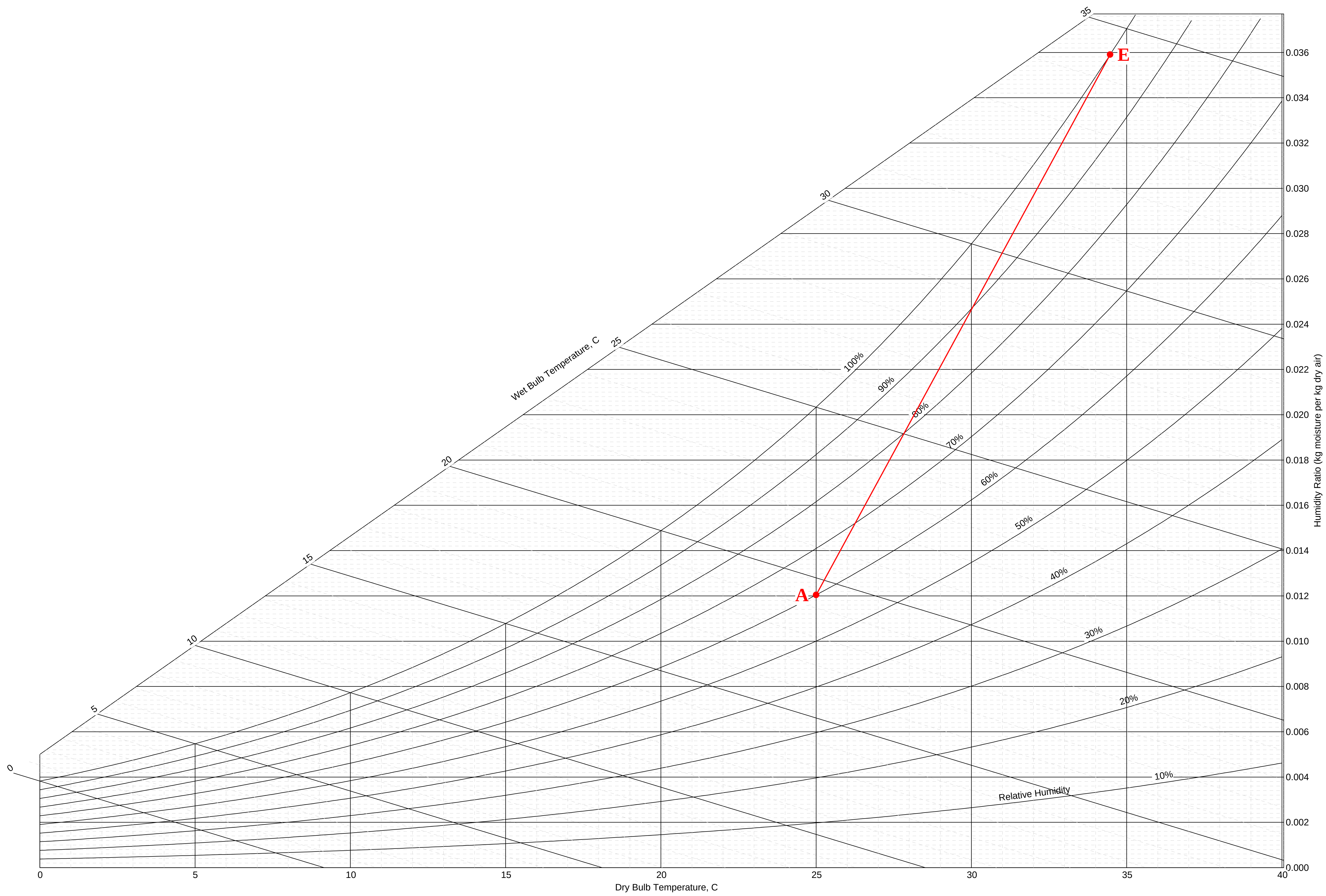


p [bar] T [C] h [kJ/kg] M [t/h] x [-]

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-11-2017 10:23:59 C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

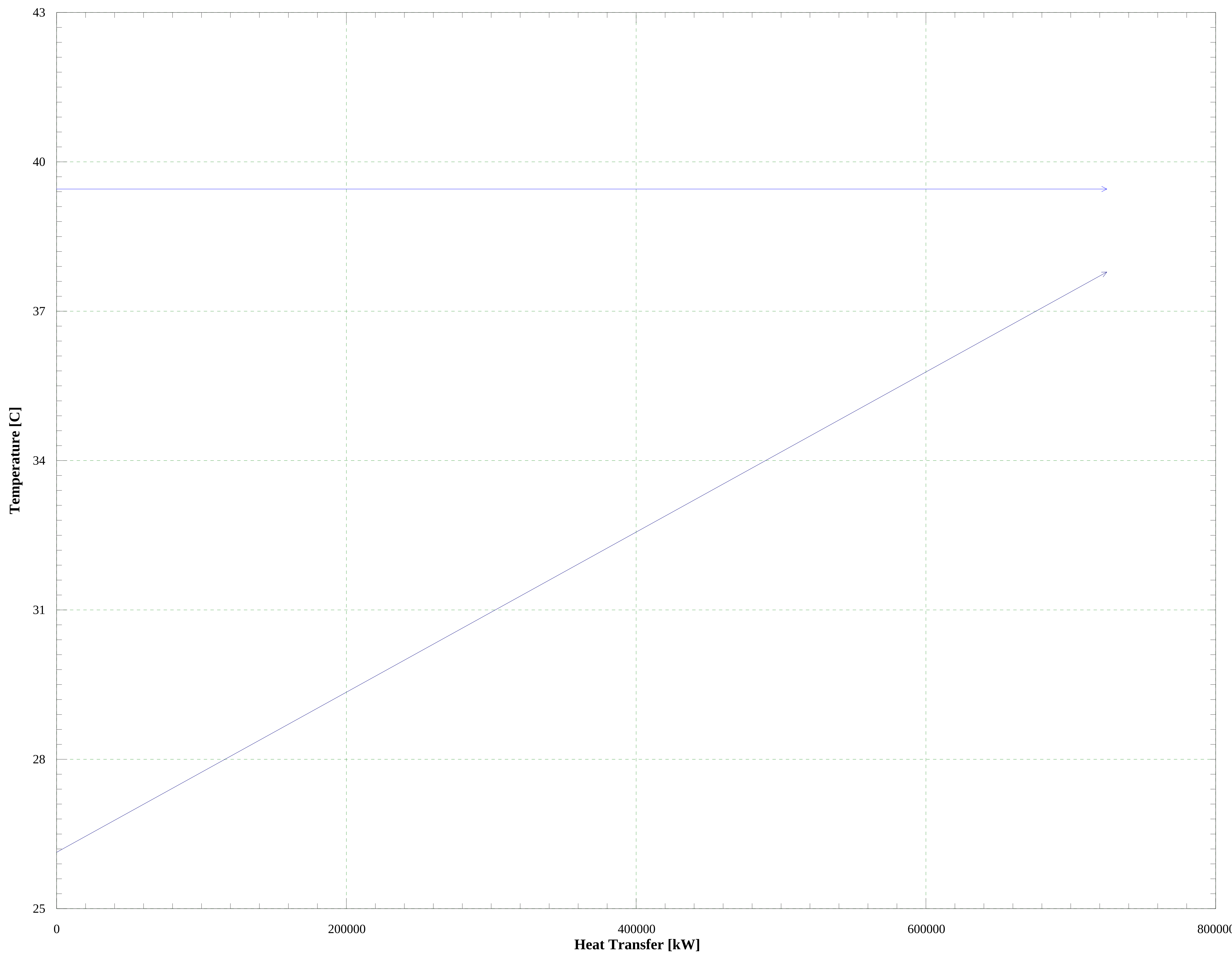
AIR STATES:
A) Ambient or Inlet:
Pressure = 1 bar
Dry bulb = 25 C
Wet bulb = 19.45 C
RH = 60 %
E) Air Exit:
Dry bulb = 34.47 C
Wet bulb = 34.47 C
RH = 100 %
Plume invisible
(Plume Visibility
index = 0.00)

Psychrometric Chart

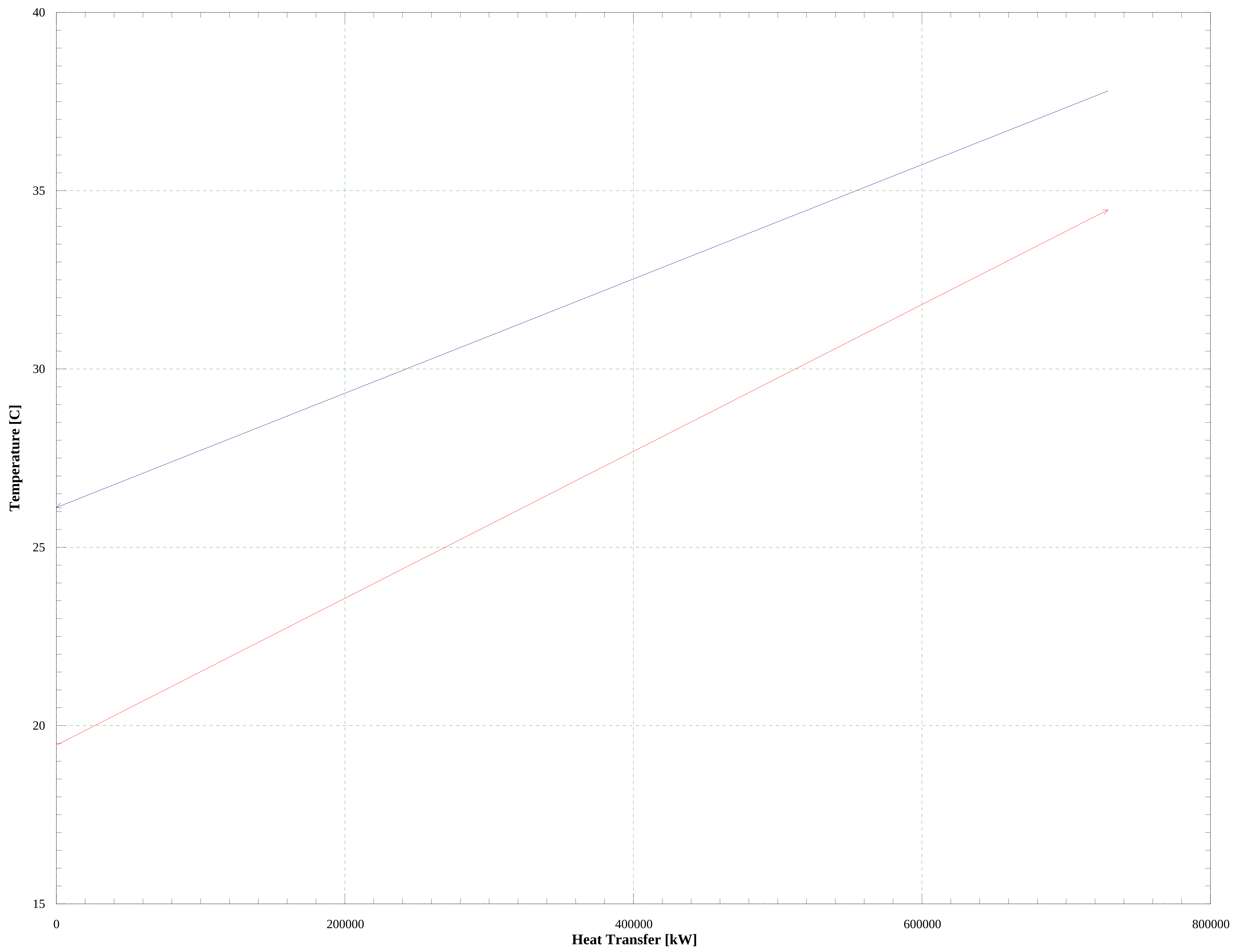


Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Natural Draft CT
Date: 04/11/17	
Drawing No:	

WCC - TQ Diagram

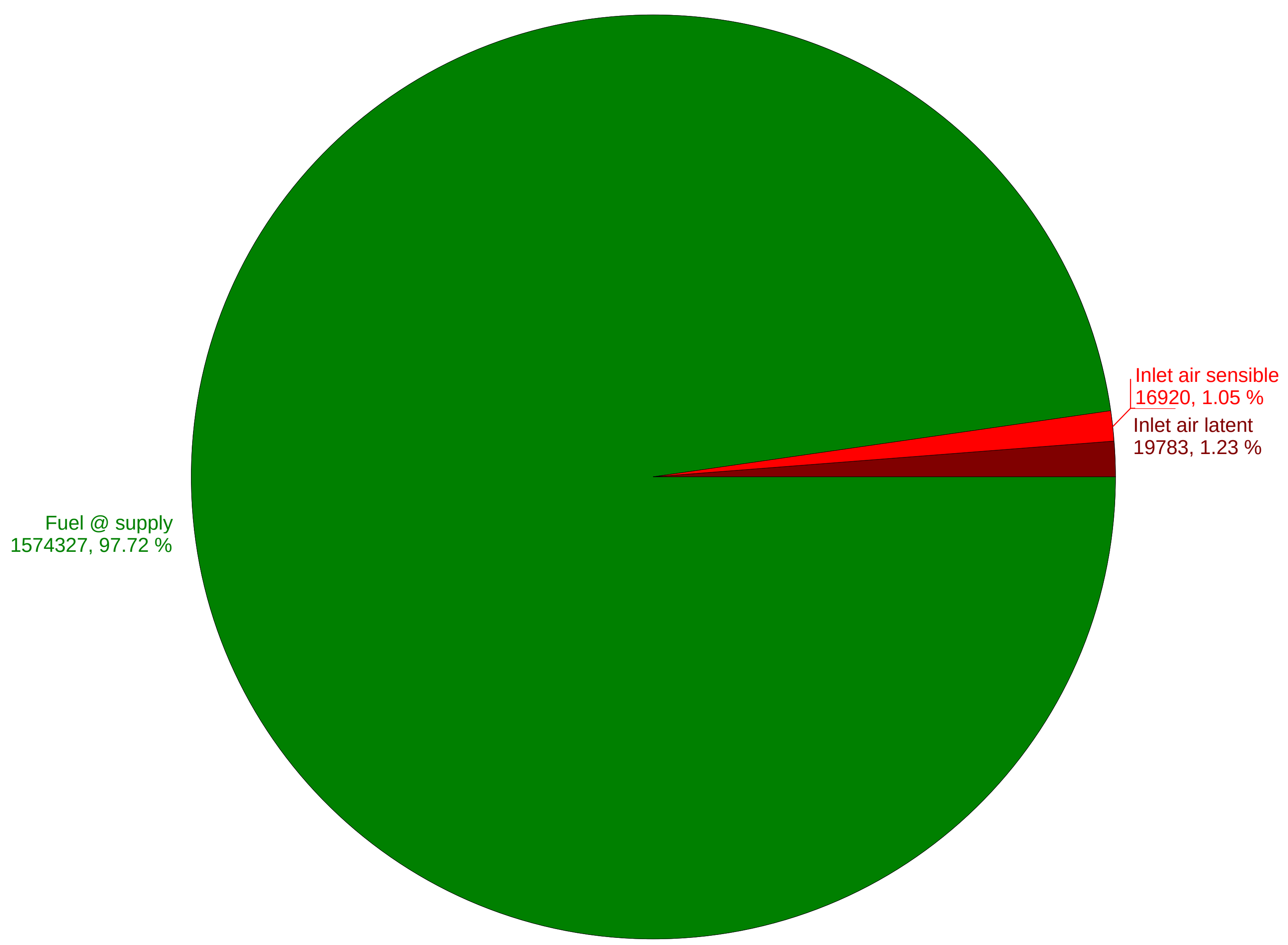


Natural Draft CT - TQ Diagram



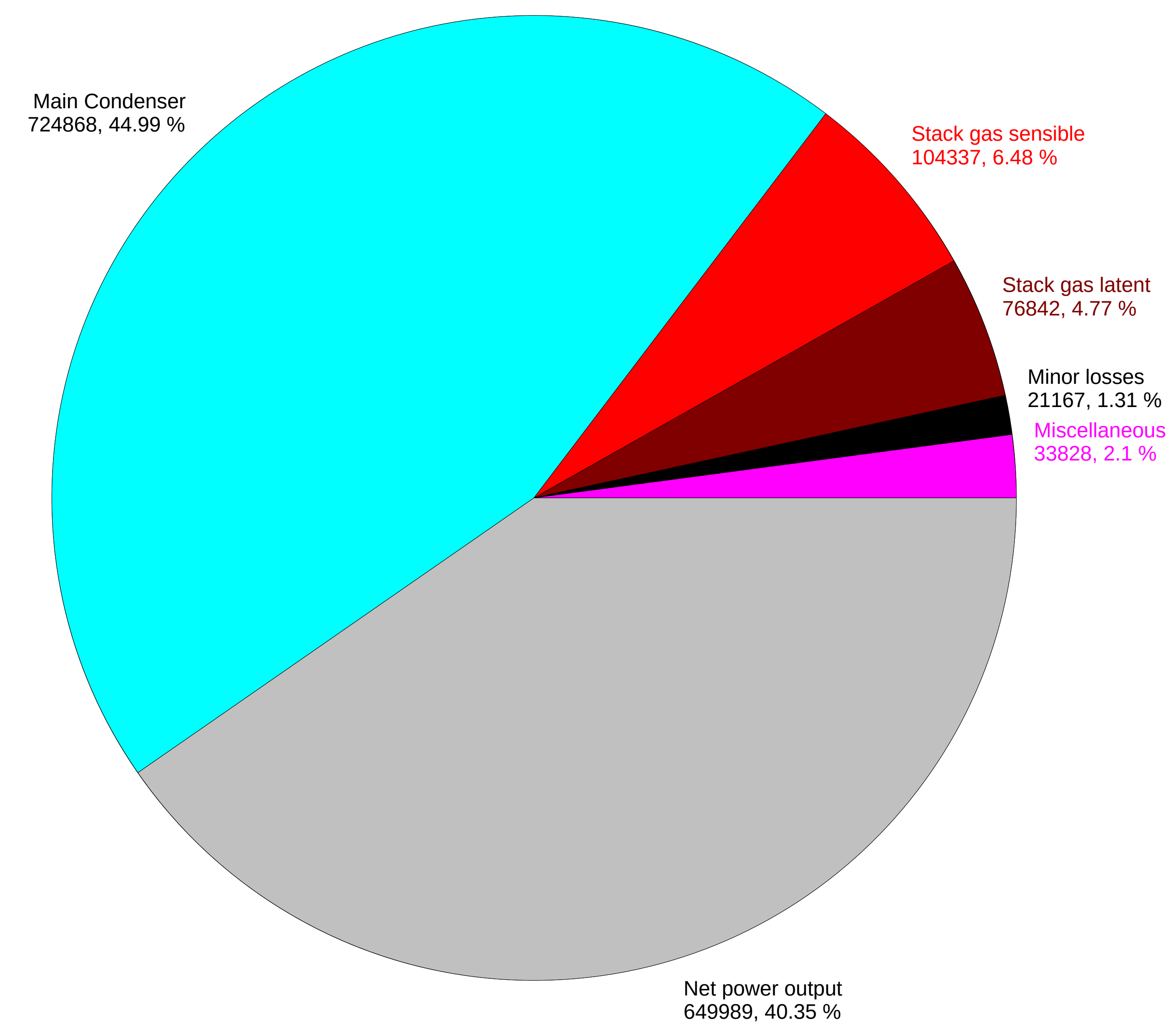
Plant Energy In [kJ/s]

Plant energy in = 1611030 kJ/s
Plant fuel chemical LHV input = 1515877 kJ/s, HHV = 1571569 kJ/s



Plant Energy Out [kJ/s]

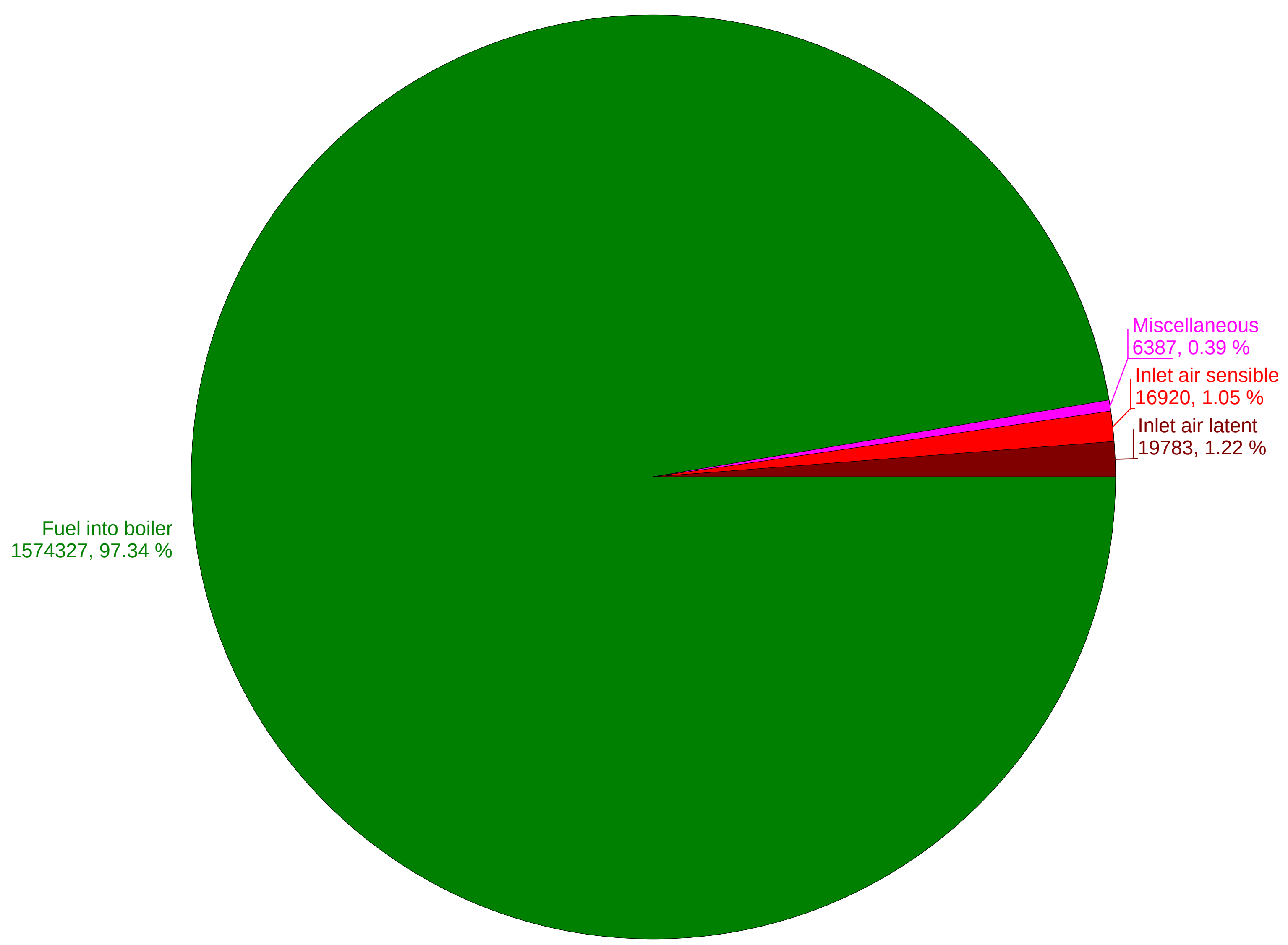
Plant energy out = 1611049 kJ/s



Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

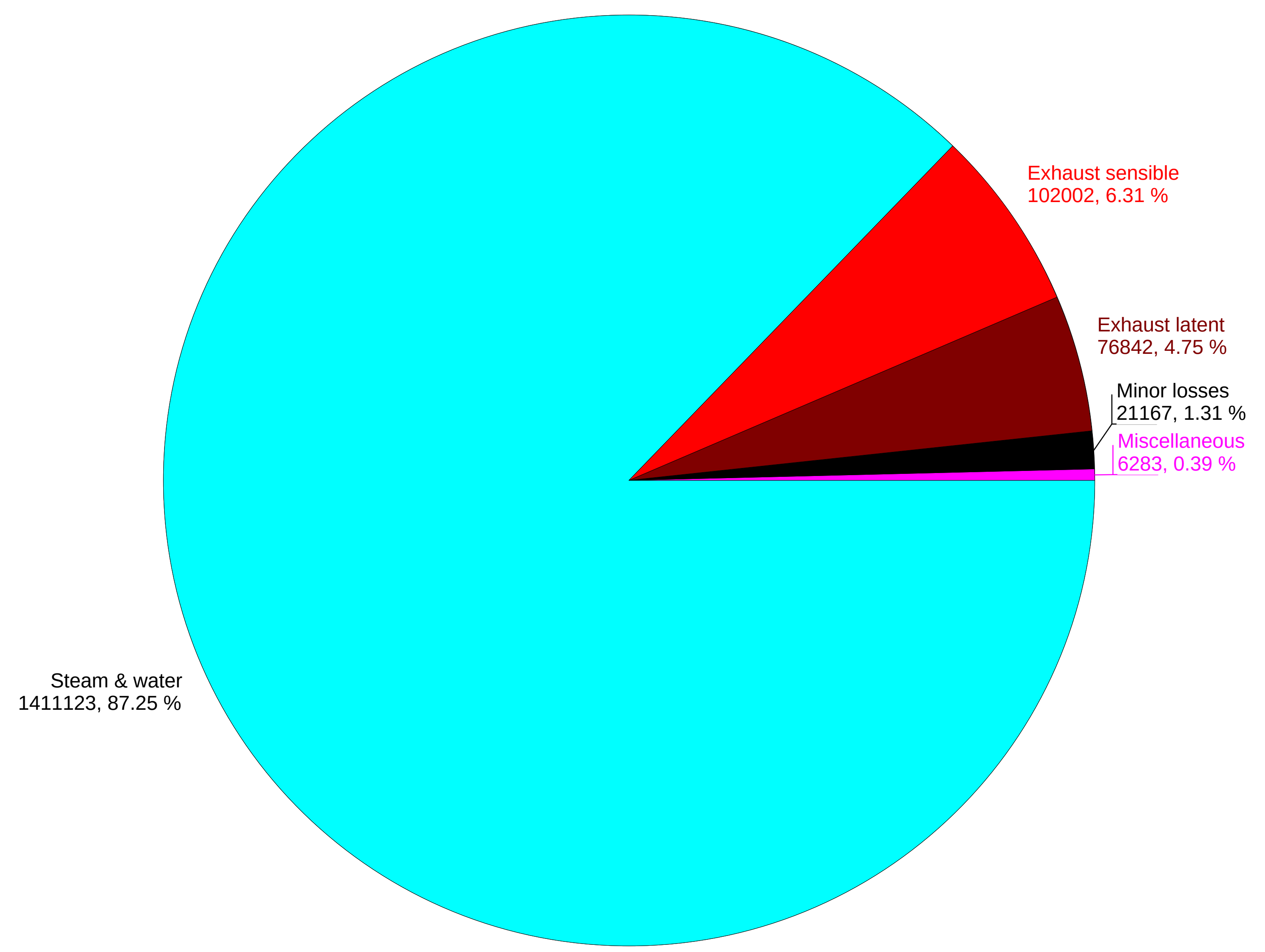
Boiler Energy In [kJ/s]

Boiler energy in = 1617417 kJ/s
Plant fuel chemical LHV input = 1515877 kJ/s, HHV = 1571569 kJ/s



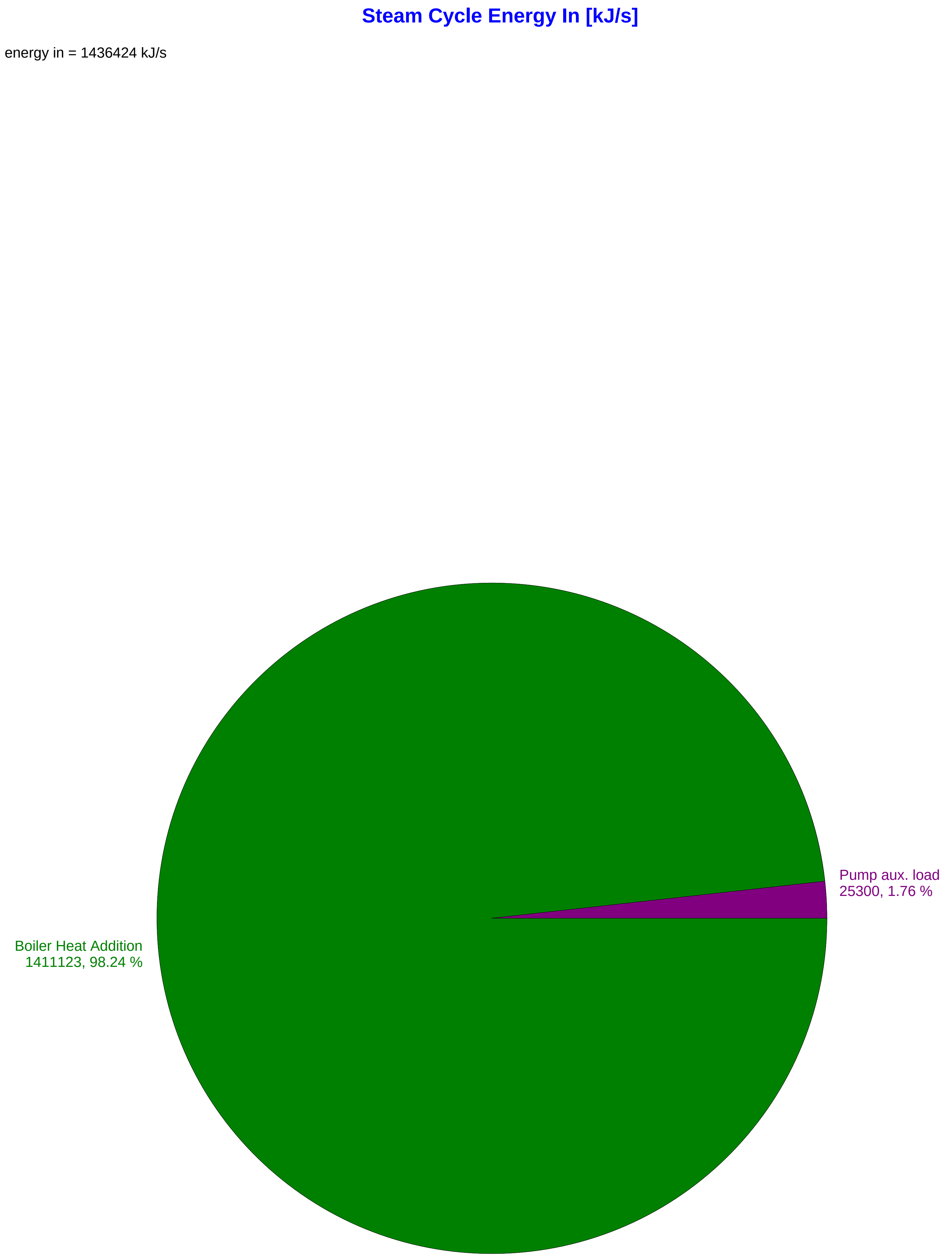
Boiler Energy Out [kJ/s]

Boiler energy out = 1617421 kJ/s

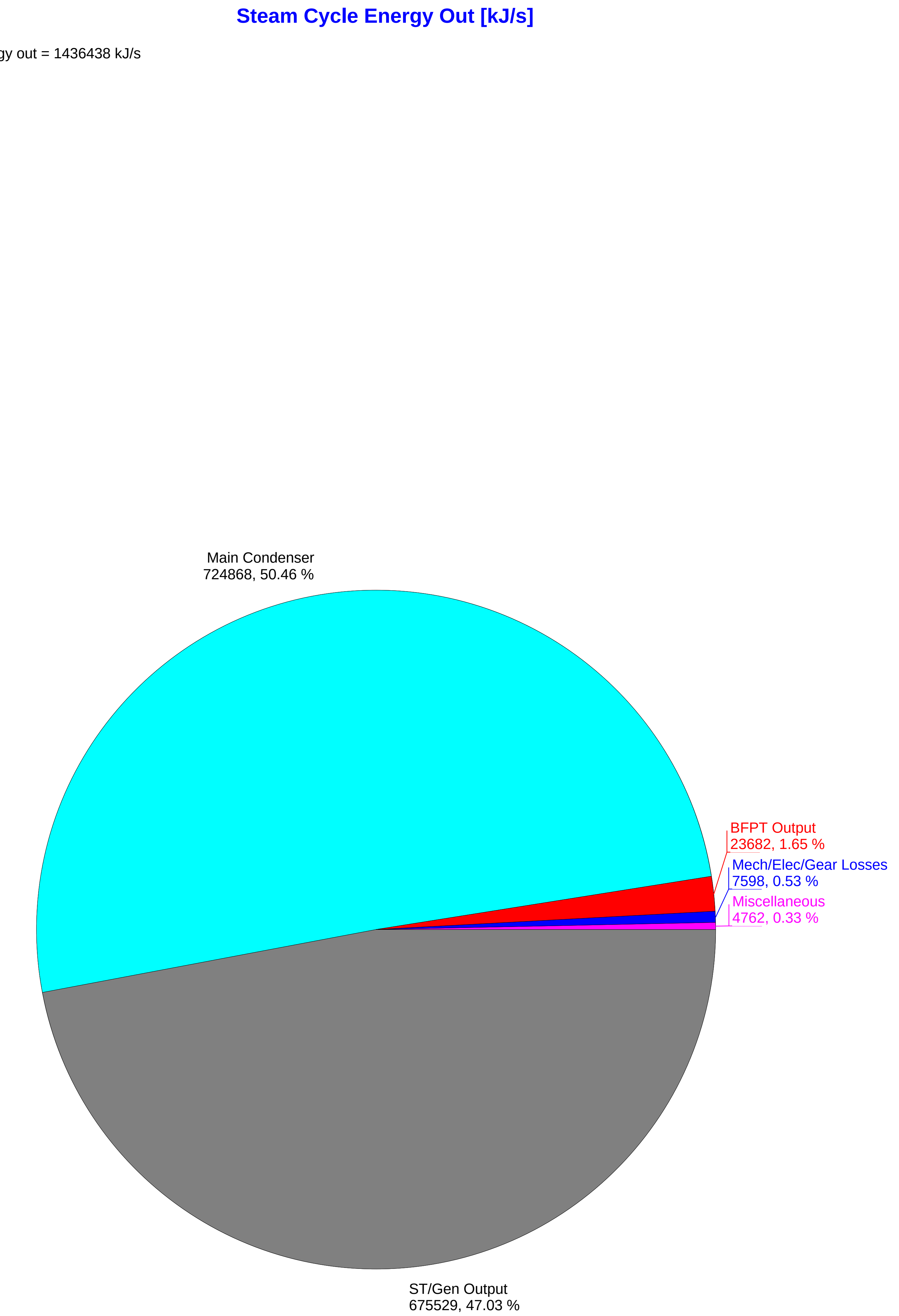


Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

Steam cycle energy in = 1436424 kJ/s

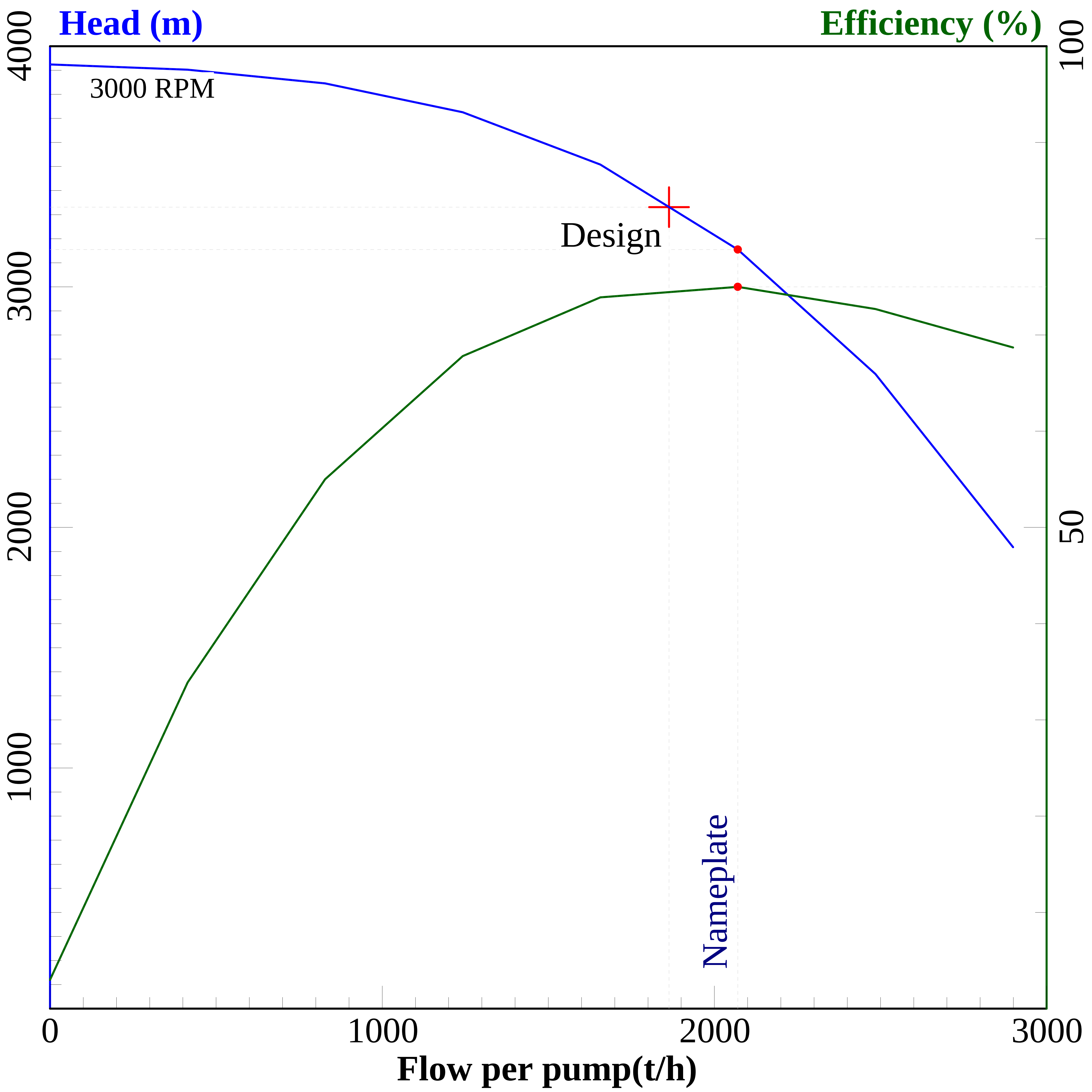


Steam cycle energy out = 1436438 kJ/s



Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

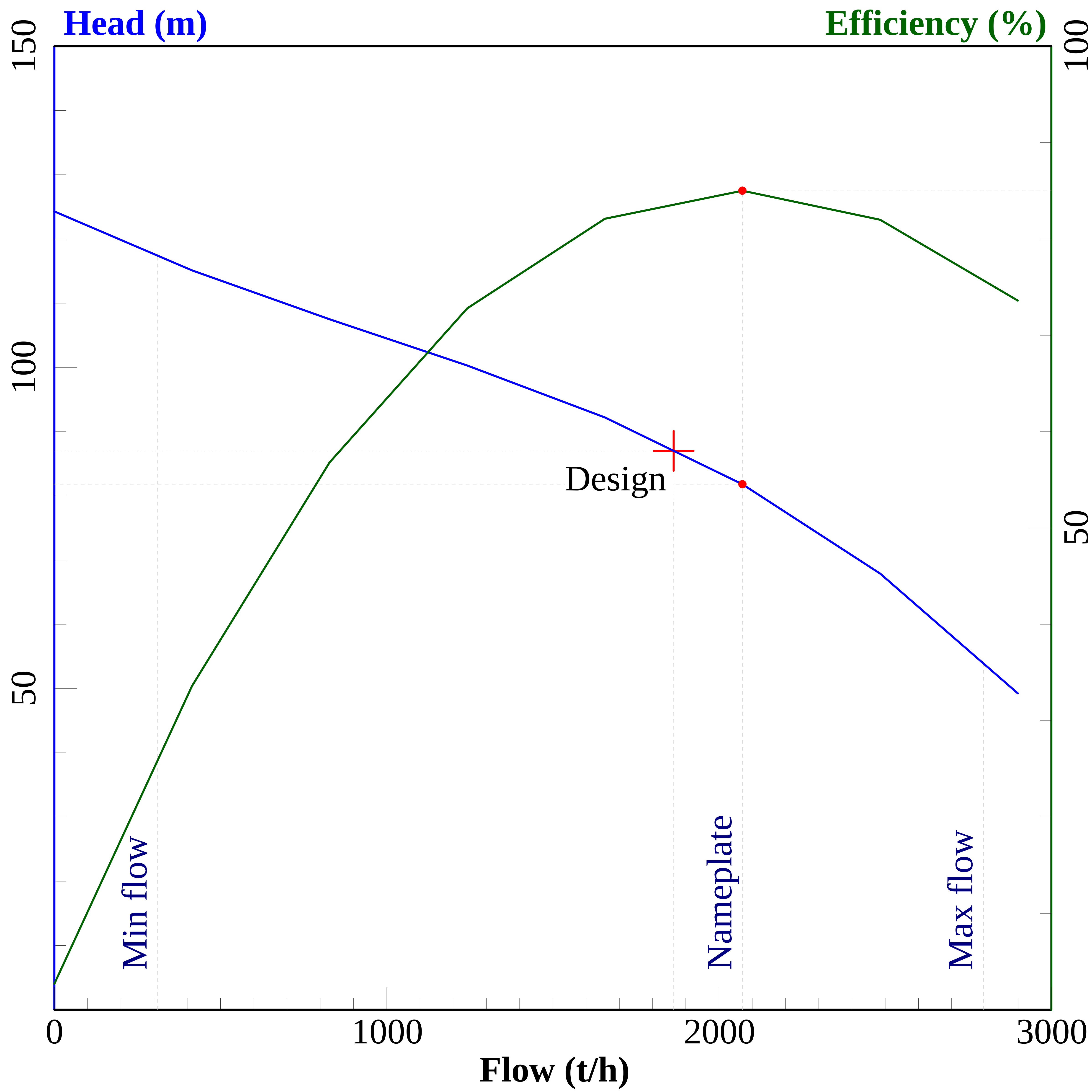
Boiler Feed Pump (P1)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2070.6 t/h
Nameplate head	3155 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	3170 m
Nameplate RPM	3000
Design flow	1863.6 t/h
Design head	3331 m
Design RPM	3000

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Pump (P1)
Date: 04/11/17	
Drawing No:	

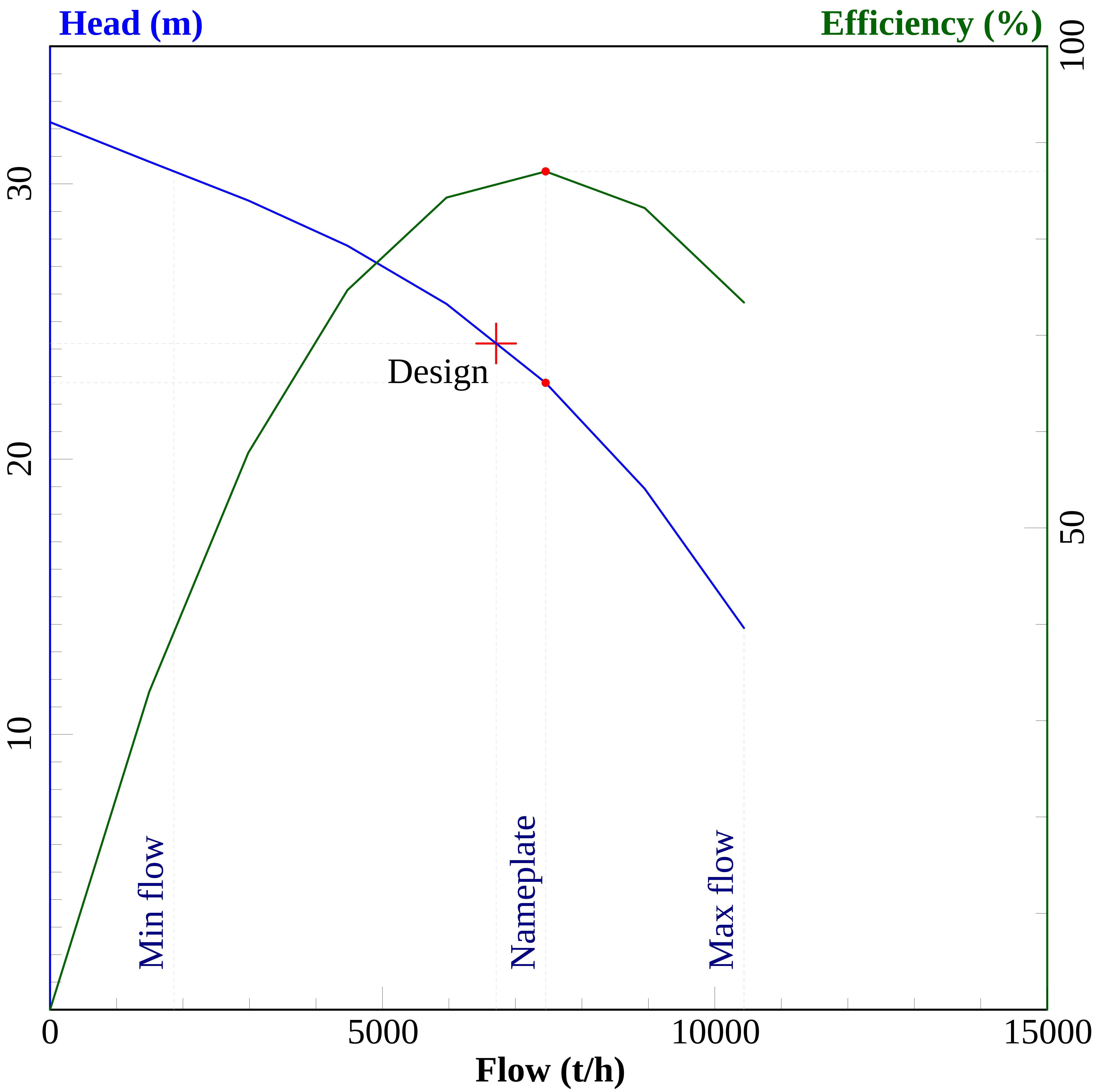
Boiler Feed Booster Pump (P3)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2070.6 t/h
Nameplate head	81.81 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	83.82 m
Nameplate RPM	600
Design flow	1863.6 t/h
Design head	87.01 m
Design RPM	600
Minimum continuous flow	310.6 t/h
Maximum continuous flow	2795.3 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Booster Pump (P3)
Date: 04/11/17	
Drawing No:	

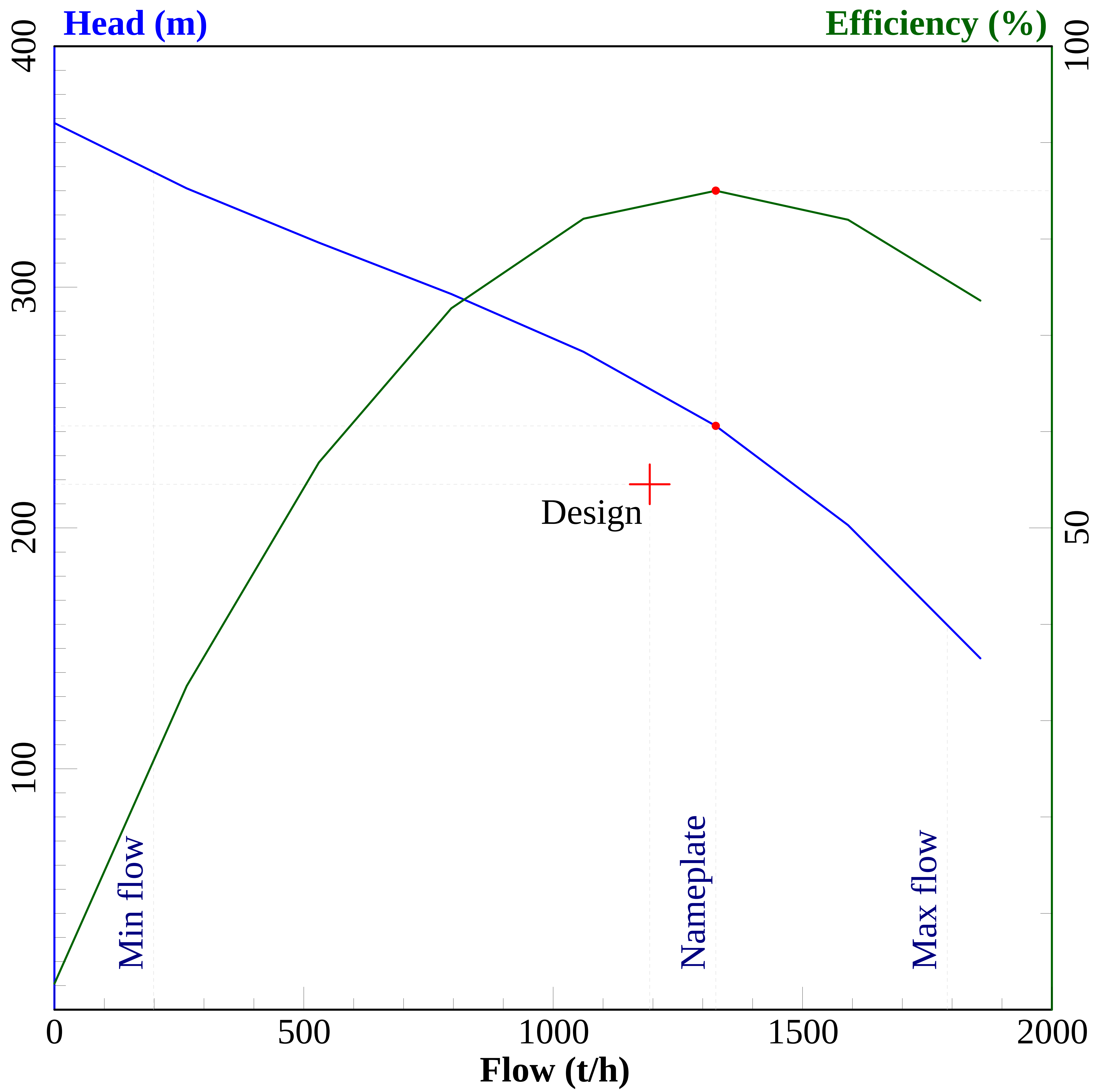
Condenser C.W. Pump (P4)



No. per ST	8
No. operating per ST	8
Nameplate flow	7455 t/h
Nameplate head	22.77 m
Nameplate flow (nominal)	124919 lpm
Nameplate head (nominal)	24.38 m
Nameplate RPM	500
Design flow	6710 t/h
Design head	24.2 m
Design RPM	500
Minimum continuous flow	1863.8 t/h
Maximum continuous flow	10437 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Condenser C.W. Pump (P4)
Date: 04/11/17	
Drawing No:	

Condensate Forwarding Pump (P6)



No. per ST	2
No. operating per ST	1
Nameplate flow	1326.2 t/h
Nameplate head	242.4 m
Nameplate flow (nominal)	22712 lpm
Nameplate head (nominal)	243.8 m
Nameplate RPM	1500
Design flow	1193.6 t/h
Design head	218.1 m
Design RPM	1500
Minimum continuous flow	198.9 t/h
Maximum continuous flow	1790.4 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Condensate Forwarding Pump (P6)
Date: 04/11/17	
Drawing No:	

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:13:26 G:\41\30763\Tech\HELE documentation\Model\USC model_wet cooling.stp
Program revision date: February 16, 2017
Steam source: Conventional boiler
Steam turbine: Single reheat condensing turbine 3000+3000/3000
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train
Cooling system: Water cooling with natural draft cooling tower
Steam Property Formulation: IFC-67

SYSTEM SUMMARY

	Power Output (kW)		Fuel Input (kJ/s)		Fuel Flows	
	Gross	**Net**	**LHV**	**HHV**	**t/h**	**t/day**
Plant Total	**675529**	**649989**	**1515877**	**1571569**	**195.6**	**4693**

Number of units =	1	
Net process heat output =	0	kJ/s
as % of total output (net elec. + net heat) =	0	%

PLANT EFFICIENCY AND HEAT RATE

	LHV*		HHV*		Boiler Heat Input**		
	Gross	**Net**	**Gross**	**Net**	**Gross**	**Net**	
Heat rate	**8078**	**8396**	**8375**	**8704**	**8078**	**8396**	**kJ/kWh**
Electric efficiency	**44.56**	**42.88**	**42.98**	**41.36**	**44.56**	**42.88**	**%**
CHP (Total) efficiency		**42.88**		**41.36**		**42.88**	**%**
U.S. PURPA efficiency		**42.88**		**41.36**		**42.88**	**%**

* Heat input is based on fuel chemical energy, LHV or HHV, at 77 F/25 C
** Boiler heat input includes fuel chemical LHV energy at 77 F/ 25 C, plus enthalpy of supply air (gas)
in excess of ambient temperature.

Total heat input (LHV adjusted) =	1515877	kJ/s
Fuel input to boiler (LHV adjusted) =	1515874	kJ/s.

STEAM CYCLE/BOILER PERFORMANCE

Steam cycle heat rate	**7520**	**kJ/kWh**
Steam cycle efficiency	**47.87**	**%**
Turbine heat rate	**7502**	**kJ/kWh**
Boiler LHV adjusted efficiency	**93.09**	**%**
Boiler HHV adjusted efficiency	**89.79**	**%**

ESTIMATED PLANT AUXILIARIES		
Boiler primary air fan*	1395.3	kW
Boiler secondary air fan*	1868.7	kW
Boiler induced draft fan*	2593.6	kW
Boiler fuel delivery*	4311.4	kW
Boiler forced circulation pump	0.0	kW
Electrostatic precipitator (ESP)	1566.7	kW
Ash handling	831.9	kW
Condenser cooling water pump	4435.4	kW
Cooling tower fan	0.0	kW
Condensate pump*	1072.2	kW
Contact heater feed forward pump(s)*	0.0	kW
Boiler feed pump*	0.0	kW
Boiler feed booster pump*	567.3	kW
FW heater drain pump(s)*	215.7	kW
Aux. from PEACE running motor/load list	2948.8	kW
Miscellaneous ST auxiliaries	354.7	kW
Miscellaneous plant auxiliaries	1688.8	kW
Constant plant auxiliary load	0.0	kW
Program estimated overall plant auxiliaries	23850.7	kW
Actual (user input) overall plant auxiliaries	23850.7	kW
Transformer losses	1688.8	kW
Total auxiliaries & transformer losses	**25539.5**	**kW**
* Heat balance related auxiliaries		

PLANT HEAT BALANCE				
Energy In	**1611030**	**kW**		
Ambient air sensible	16920	kW		
Ambient air latent	19783	kW		
Fuel enthalpy @ supply	1574327	kW		
External steam	0	kW		
External water	0	kW		
Makeup, process return, and blowdown recovery	0	kW		
FGD water	0	kW		
FGD oxidation air	0	kW		
CO2 capture makeup water	0	kW		
Condensate external heating or cooling	0	kW		
Energy Out	**1611049**	**kW**		
Net power output	649989	kW		
Stack gas sensible	104337	kW		
Stack gas latent	76842	kW		
Bottom ash	1364.2	kW		
Fly ash	387.9	kW		
Unburned carbon	4535	kW		
Boiler minor loss	21167	kW		
Fuel delivery energy loss	862.3	kW		
Main condenser	724868	kW		
BFPT condenser	0	kW		
Process steam	0	kW		
Process water	0	kW		
District heat	0	kW		
Discharged seal steam	0	kW		
Blowdown	0	kW		
Steam pipe losses	3902	kW		
ST/generator mech/elec/gear loss	7598	kW		
BFPT mech loss	236.8	kW		
Pumps mech/elec loss	859.7	kW		
Fans mech/elec loss	585.8	kW		
ESP heat loss	0	kW		
FGD energy loss	0	kW		
CO2 capture energy loss	0	kW		
Desal heat	0	kW		
Non-heat balance related auxiliaries	13515	kW		
Other	0	kW		
Energy In - Energy Out	**-19.12**	**kW**	**-0.0012**	**%**
Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)				

STEAM PRO Streams	P	T	h	M	s
	bar	C	kJ/kg	t/h	kJ/kg-C
Note: This is a fixed format table. Not all					H2O: ref @ 32F
streams are applicable to current heat balance.					
Zero enthalpy: steam & liquid water at 32 F (273.15 K).					
1 Feedwater into boiler	306.7	287.7	1266.98	1863.57	-
2 Feedwater leaving grate cooling HX	306.7	287.7	1266.98	1863.57	-
3 Water leaving 1st economiser	303.7	343.5	1568.27	1863.57	-
4 Water entering 2nd economiser	303.7	343.5	1568.27	1863.57	-
5 Water leaving 2nd economiser	303.7	343.5	1568.27	1863.57	-
6 Boiler blowdown	-	-	-	-	-
7 Steam leaving CEV	-	-	-	-	-
8 Steam leaving REV	288.5	427.6	2690.99	1863.57	-
9 Steam leaving CEV+REV	288.5	427.6	2690.99	1863.57	-
10 1st superheater inlet	288.5	427.6	2690.99	1863.57	-
11 1st superheater exit	285.9	462.5	2934.68	1863.57	-
12 2nd superheater inlet	285.9	462.5	2934.68	1863.57	-
13 2nd superheater exit	282.7	532.3	3236.20	1863.57	-
14 3rd superheater inlet	282.7	532.3	3236.20	1863.57	-
15 3rd superheater exit	280.1	606.0	3479.90	1863.57	-
16 4th superheater inlet	280.1	606.0	3479.90	1863.57	-
17 4th superheater exit	280.1	606.0	3479.90	1863.57	-
18 Steam leaving superheater	280.1	606.0	3479.89	1863.57	-
19 Cold reheat after pipe	63.04	372.7	3101.70	1689.24	-
20 Mixing cold reheat with steam add.	63.04	372.7	3101.70	1689.24	-
21 1st reheater inlet	63.04	372.7	3101.70	1689.24	-
22 1st reheater exit	62.12	485.3	3384.68	1689.24	-
23 2nd reheater inlet	62.12	485.3	3384.68	1689.24	-
24 2nd reheater exit	62.12	485.3	3384.68	1689.24	-
25 3rd reheater inlet	62.12	485.3	3384.68	1689.24	-
26 3rd reheater exit	61.2	605.4	3667.67	1689.24	-
27 4th reheater inlet	61.2	605.4	3667.67	1689.24	-
28 4th reheater exit	61.2	605.4	3667.67	1689.24	-
29 Steam leaving reheater	61.2	605.4	3667.67	1689.24	-
30 Cold LP reheat after pipe	-	-	-	-	-
31 Mixing cold LP reheat with steam add.	-	-	-	-	-
32 1st LP reheater inlet	-	-	-	-	-
33 1st LP reheater exit	-	-	-	-	-
34 2nd LP reheater inlet	-	-	-	-	-
35 2nd LP reheater exit	-	-	-	-	-
36 3rd LP reheater inlet	-	-	-	-	-
37 3rd LP reheater exit	-	-	-	-	-
38 4th LP reheater inlet	-	-	-	-	-
39 4th LP reheater exit	-	-	-	-	-
40 Steam leaving LP reheater	-	-	-	-	-
41 HPT inlet, before stop valves	276	604.0	3477.57	1863.57	6.306
42 HPT inlet, after stop valves	269.1	601.9	3477.57	1831.68	-
43 HPT exit	64.3	374.5	3104.00	1689.24	6.402
44 PIPT inlet, before intercept valve	-	-	-	-	-
45 PIPT exit	-	-	-	-	-
46 IPT inlet, before intercept valve	60	604.0	3665.34	1689.24	7.177
47 IPT bowl	58.8	602.2	3662.01	1719.74	7.182
48 LPT crossover	7	296.7	3052.62	1259.92	7.287
49 LPT exhaust	0.0716	39.5	2344.72	1058.99	7.537
50 ST group 1 inlet	269.1	601.9	3477.57	1831.68	6.317
51 ST group 1 blading exit	212.3	562.3	3416.49	1831.68	6.34
52 ST group 1 addition / extraction	-	-	-	-	-
53 ST group 2 inlet	212.3	562.3	3416.49	1831.68	6.34
54 ST group 2 blading exit	64.3	374.5	3104.00	1831.68	6.402
55 ST group 2 addition / extraction	64.3	374.5	3104.00	-128.63	6.402
56 ST group 3 inlet	58.8	602.2	3662.01	1719.74	7.182
57 ST group 3 blading exit	42.67	549.7	3555.23	1719.74	7.2
58 ST group 3 addition / extraction	42.67	549.7	3555.23	-119.65	7.2
59 ST group 4 inlet	42.67	549.7	3555.23	1600.10	7.2
60 ST group 4 blading exit	22.9	454.3	3363.28	1600.10	7.232
61 ST group 4 addition / extraction	22.9	454.3	3363.28	-63.91	7.232
62 ST group 5 inlet	22.9	454.3	3363.28	1536.19	7.232
63 ST group 5 blading exit	13.04	375.4	3206.91	1536.19	7.259
64 ST group 5 addition / extraction	13.04	375.4	3206.91	-74.55	7.259
65 ST group 6 inlet	13.04	375.4	3206.91	1461.64	7.259
66 ST group 6 blading exit	7	296.5	3052.15	1461.64	7.286
67 ST group 6 addition / extraction	7	296.5	3052.15	-210.51	7.286
68 ST group 7 inlet	7	296.7	3052.62	1259.92	7.287
69 ST group 7 blading exit	3.083	205.1	2875.37	1259.92	7.32
70 ST group 7 addition / extraction	3.083	205.1	2875.37	-73.43	7.32
71 ST group 8 inlet	3.083	205.1	2875.37	1186.48	7.32
72 ST group 8 blading exit	1.167	113.0	2700.39	1186.48	7.355
73 ST group 8 addition / extraction	1.167	113.0	2700.39	-69.06	7.355
74 ST group 9 inlet	1.167	113.0	2700.39	1117.42	7.355
75 ST group 9 blading exit	0.363	73.6	2526.06	1117.42	7.396
76 ST group 9 addition / extraction	0.363	73.6	2526.06	-58.43	7.396
77 ST group 10 inlet	0.363	73.6	2526.06	1058.99	7.396
78 ST group 10 blading exit	0.0716	39.5	2323.38	1058.99	7.469
79 ST group 10 addition / extraction	0.0716	39.5	2344.72	1058.99	7.537
80 ST group 11 inlet	-	-	-	-	-

STEAM PRO Streams	P	T	h	M	s
	bar	C	kJ/kg	t/h	kJ/kg-C
81 ST group 11 blading exit	-	-	-	-	-
82 ST group 11 addition / extraction	-	-	-	-	-
83 ST group 12 inlet	-	-	-	-	-
84 ST group 12 blading exit	-	-	-	-	-
85 ST group 12 addition / extraction	-	-	-	-	-
86 ST group 13 inlet	-	-	-	-	-
87 ST group 13 addition / extraction	-	-	-	-	-
88 ST group 13 blading exit	-	-	-	-	-
89 ST group 14 inlet	-	-	-	-	-
90 ST group 14 blading exit	-	-	-	-	-
91 ST group 14 addition / extraction	-	-	-	-	-
92 ST group 15 inlet	-	-	-	-	-
93 ST group 15 blading exit	-	-	-	-	-
94 ST group 15 addition / extraction	-	-	-	-	-
95 ST group 16 inlet	-	-	-	-	-
96 ST group 16 addition / extraction	-	-	-	-	-
97 ST group 16 blading exit	-	-	-	-	-
98 ST group 17 inlet	-	-	-	-	-
99 ST group 17 blading exit	-	-	-	-	-
100 ST group 17 addition / extraction	-	-	-	-	-
101 ST group 18 inlet	-	-	-	-	-
102 ST group 18 blading exit	-	-	-	-	-
103 ST group 18 addition / extraction	-	-	-	-	-
104 ST group 19 inlet	-	-	-	-	-
105 ST group 19 blading exit	-	-	-	-	-
106 ST group 19 addition / extraction	-	-	-	-	-
107 FW into condensate pump	0.3707	39.4	165.15	1193.57	-
108 FW after condensate pump	21.6	39.7	168.18	1193.57	-
109 FW after recovery HXs before 1st FWH	21.6	40.1	169.65	1193.57	-
110 FW before booster pump	14.9	190.4	809.24	1863.57	-
111 FW after booster pump	22.38	190.5	810.26	1863.57	-
112 FW into boiler feed pump	22.38	190.5	810.26	1863.57	-
113 FW after boiler feed pump	308.6	197.4	854.14	1863.57	-
114 FWH1 heating steam	0.3458	72.4	2523.74	58.43	-
115 FWH1 feedwater inlet	21.6	40.1	169.65	1193.57	-
116 FWH1 feedwater exit	19.62	69.6	293.04	1193.57	-
117 FWH1 drain	0.3458	72.4	303.11	283.26	-
118 FWH2 heating steam	1.112	111.6	2698.06	69.06	-
119 FWH2 feedwater inlet	19.62	70.2	295.45	1476.83	-
120 FWH2 feedwater exit	17.71	99.8	419.60	1476.83	-
121 FWH2 drain	1.112	75.2	314.91	219.61	-
122 FWH3 heating steam	2.936	203.6	2873.04	73.43	-
123 FWH3 feedwater inlet	17.71	99.8	419.60	1476.83	-
124 FWH3 feedwater exit	16.18	130.0	547.31	1476.83	-
125 FWH3 drain	2.936	104.8	439.59	150.55	-
126 FWH4 heating steam	6.667	294.9	3049.83	77.12	-
127 FWH4 feedwater inlet	16.18	130.0	547.31	1476.83	-
128 FWH4 feedwater exit	14.9	160.2	676.90	1476.83	-
129 FWH4 drain	6.667	135.0	568.00	77.12	-
130 FWH5 heating steam	12.66	374.0	3204.58	74.55	-
131 FWH5 feedwater inlet	12.66	160.3	676.90	1476.83	-
132 FWH5 feedwater exit	12.66	190.4	809.24	1476.83	-
133 FWH5 drain	12.66	190.4	809.24	386.73	-
134 FWH6 heating steam	22.24	452.8	3360.95	63.91	-
135 FWH6 feedwater inlet	308.6	197.4	854.14	1863.57	-
136 FWH6 feedwater exit	308	220.1	953.68	1863.57	-
137 FWH6 drain	22.24	202.4	863.26	312.18	-
138 FWH7 heating steam	41.42	302.4	2963.86	119.65	-
139 FWH7 feedwater inlet	308	220.1	953.68	1863.57	-
140 FWH7 feedwater exit	307.4	250.7	1091.94	1863.57	-
141 FWH7 drain	41.42	225.1	967.53	248.28	-
142 FWH8 heating steam	62.42	372.1	3101.67	128.63	-
143 FWH8 feedwater inlet	307.4	250.7	1091.94	1863.57	-
144 FWH8 feedwater exit	306.8	279.9	1229.16	1863.57	-
145 FWH8 drain	62.42	255.7	1113.67	128.63	-
146 FWH9 heating steam	41.42	548.2	3552.90	119.65	-
147 FWH9 feedwater inlet	306.8	279.9	1229.16	1863.57	-
148 FWH9 feedwater exit	306.7	287.7	1266.98	1863.57	-
149 FWH9 drain	41.42	302.4	2963.86	119.65	-
150 FWH10 heating steam	-	-	-	-	-
151 FWH10 feedwater inlet	-	-	-	-	-
152 FWH10 feedwater exit	-	-	-	-	-
153 FWH10 drain	-	-	-	-	-
154 FWH11 heating steam	-	-	-	-	-
155 FWH11 feedwater inlet	-	-	-	-	-
156 FWH11 feedwater exit	-	-	-	-	-
157 FWH11 drain	-	-	-	-	-
158 FWH12 heating steam	-	-	-	-	-
159 FWH12 feedwater inlet	-	-	-	-	-
160 FWH12 feedwater exit	-	-	-	-	-
161 FWH12 drain	-	-	-	-	-
162 Condenser inlet steam	0.0716	39.5	2351.44	1193.57	7.559
163 Condenser condensate exit	0.3707	39.4	165.15	1193.57	-
164 Condenser CW inlet	3.366	26.1	109.79	53678.23	-

STEAM PRO Streams	P	T	h	M	s
	bar	C	kJ/kg	t/h	kJ/kg-C
165 Condenser CW exit	2.495	37.8	158.41	53678.23	-
166 CW into cooling tower	1.897	37.8	158.41	53678.23	-
167 CW leaving cooling tower basin	1	26.1	109.52	53678.23	-
168 CW after circulation pump	3.366	26.1	109.79	53678.23	-
169 FPT inlet before valve	6.667	294.9	3049.83	133.40	7.304
170 FPT 1st group inlet	5.333	293.3	3049.83	133.40	7.406
171 FPT extraction 1	0.0716	39.5	2410.74	133.40	7.748
172 FPT 2nd group inlet	-	-	-	-	-
173 FPT extraction 2	-	-	-	-	-
174 FPT 3rd group inlet	-	-	-	-	-
175 FPT extraction 3	-	-	-	-	-
176 FPT condenser condensate exit	-	-	-	-	-
177 FPT condenser CW inlet	-	-	-	-	-
178 FPT condenser CW exit	-	-	-	-	-
179 External steam source 1	-	-	-	-	-
180 External steam source 2	-	-	-	-	-
181 Process stream 1	-	-	-	-	-
182 Process stream 2	-	-	-	-	-
183 Process stream 3	-	-	-	-	-
184 Process stream 4	-	-	-	-	-
185 Process stream 5	-	-	-	-	-
186 Steam addition 1	-	-	-	-	-
187 Steam addition 2	-	-	-	-	-
188 Steam addition 3	-	-	-	-	-
189 Water extraction 1	-	-	-	-	-
190 Water extraction 2	-	-	-	-	-
191 Water extraction 3	-	-	-	-	-
192 Water addition 1	-	-	-	-	-
193 Water addition 2	-	-	-	-	-
194 Water addition 3	-	-	-	-	-
195 DHW return	-	-	-	-	-
196 DHTR1 heating steam	-	-	-	-	-
197 DHTR1 DHW inlet	-	-	-	-	-
198 DHTR1 DHW exit	-	-	-	-	-
199 DHTR1 drain	-	-	-	-	-
200 DHTR2 heating steam	-	-	-	-	-
201 DHTR2 DHW inlet	-	-	-	-	-
202 DHTR2 DHW exit	-	-	-	-	-
203 DHTR2 drain	-	-	-	-	-
204 SSR inlet steam	1.241	344.4	3163.62	6.40	8.267
205 GSC inlet steam	0.8274	344.0	3163.62	0.63	-
206 SAH1 heating steam	-	-	-	-	-
207 SAH1 drain	-	-	-	-	-
208 SAH2 heating steam	-	-	-	-	-
209 SAH2 drain	-	-	-	-	-
210 Fuel heater heating stream	-	-	-	-	-
211 Fuel heater drain	-	-	-	-	-
212 CO2 capture first steam after pipe	-	-	-	-	-
213 CO2 capture first condensate after pump	-	-	-	-	-
214 CO2 capture second steam after pipe	-	-	-	-	-
215 CO2 capture second condensate after pump	-	-	-	-	-
216 CO2 capture CW inlet	-	-	-	-	-
217 CO2 capture CW exit	-	-	-	-	-
218 Total desalinated water from desalination plant	-	-	-	-	-
219 Desalinated water from MSF plant	-	-	-	-	-
220 MSF plant heating steam before pipe	-	-	-	-	-
221 MSF plant heating steam after pipe	-	-	-	-	-
222 MSF plant vacuum steam	-	-	-	-	-
223 MSF plant condensate return	-	-	-	-	-
224 Seawater supply to MSF plant	-	-	-	-	-
225 Seawater discharge from MSF plant	-	-	-	-	-
226 Brine discharge from MSF plant	-	-	-	-	-
227 Desalinated water from RO plant	-	-	-	-	-
228 Seawater supply to RO plant	-	-	-	-	-
229 Brine discharge from RO plant	-	-	-	-	-

Warning Messages	
	No warning messages
Advisory Messages	
1.	Natural Draft CT: CW flow may be too low for natural draft cooling tower. Mechanical draft tower may
	be better choice.
Remarks	
1.	FWH 6 exit water temperature has been cut-off at minimum pinch of 1.667 C.
	Desired = 220.6 C, Actual = 220.1 C
2.	FWH 8 exit water temperature has been cut-off at minimum pinch of 1.667 C.
	Desired = 280.9 C, Actual = 279.9 C
3.	CS2: The user-defined water-side pressure drop (0.9267 % or 2.596 bar) is much higher than the pressure
	drop determined by the HX hardware (0.0826 % or 0.2314 bar). The water-side pressure drop correction
	factor which will be used for off-design has been set to the maximum value (2.056). When converted to
	off-design, your computed pressure drop may be lower than the present value.

STEAM PRO 26.1 GHD GHD Pty Ltd						
588 04-21-2017 16:13:26 G:\41\30763\Tech\HELE documentation\Model\USC model_wet cooling.stp						
Program revision date: February 16, 2017						
Steam source: Conventional boiler						
Steam turbine: Single reheat condensing turbine 3000+3000/3000						
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train						
Cooling system: Water cooling with natural draft cooling tower						
Steam Property Formulation: IFC-67						
			BOILER HEAT BALANCE			
Energy in =	**1617417**	**kJ/s**				
Fuel enthalpy	**Heat from**	**Sorbent**	**Energy Gain**	**Inlet Air**	**Inlet Air**	**Other***
to boiler	**Steam/Water Air Heater**	**Sensible**	**from Sulfation**	**Sensible**	**Latent**	
1574341	**0**	**0**	**0**	**16920**	**19783**	**6387**
Energy out =	**1617421**	**kJ/s**				
Water	**Bottom Ash**	**Fly Ash**	**Calcination**	**Exhaust**	**Minor**	**Unburned**
& Steam	**Sensible**	**Sensible**	**of Sorbent**	**Gas**	**Losses**	**Carbon**
1411123	**1364**	**388**	**0**	**178844**	**21167**	**4535**
* 'Others' includes energy of fan (excluding ID fan) and fuel delivery power.						
Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)						
Heat Balance Error (In - Out) =		-3.8 kJ/s	=	-0.0002	%	

BOILER AIR/GAS ZONE SUMMARY

Zone	Name	T	Dp	Q	M	M.W.	Mole Composition [%]						Ash
		C	millibar	kJ/s	t/h		N2	O2	CO2	H2O	Ar	SO2	t/h
		25.0			2024.4	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
1	**FD Fan**		30.514	1682									
		27.9			2024.4	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
		25											
3	**PA Fan**		129.504	1255.8	368.3								
		37.06											
					-168.7	Pulverizer tempering air							
					-17.35	Cold end leakage							
		37.06											
3	**PA Heater**		4.873	7524									
		182.2			182.2	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
					-8.675	Hot end leakage							
					168.7	Pulverizer tempering air							
					-128.8	Cold end leakage							
		27.94											
3	**SA Heater**		6.212	133458									
		273.9			1895.5	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
					-55.21	Hot end leakage							
		248.6			2182.6	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
4	**Burner**		12.463	1515877									
		Adiabatic flame			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	18.87
		Adiabatic flame											
5	**Furnace**		0.000	756389									
		1176.7			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.09
		1176.7											
7	**CS2**		0.129	119972									
		1036.2			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.09
		1036.2											
8	**CR2**		0.175	134779									
		875.1			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.09
		875.1											
10	**CS1**		0.247	128044									
		718.4			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.09
		718.4											
11	**CR1**		0.571	134779									
		548.0			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.09
		548.0											
14	**ECO1**		0.698	158309									
		338.4			2359.3	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.09

					55.21	Secondary air hot leakage							
					8.675	Primary air hot leakage							
		336.5											
16	**Air Heater**		9.107	-140982									
	(gas side)	**144.1**			2423.1	29.81	73.73	3.76	14.15	7.43	0.89	0.04	15.09
					128.8	Secondary air cold leakage							
					17.35	Primary air cold leakage							
		137.8											
19	**ESP**		8.101	0									
		137.8			2569.3	29.74	73.90	4.75	13.32	7.11	0.89	0.04	0.08
		137.8											
20	**ID Fan**		24.318	2334									
		140.9			2569.3	29.74	73.90	4.75	13.32	7.11	0.89	0.04	0.08
		140.9											
30	**STK**		-2.812	0									
		140.9			2569.3	29.74	73.90	4.75	13.32	7.11	0.89	0.04	0.08
Excess Air =						20		%					
Adiabatic flame temperature is greater than						1093.3		C					
Miscellaneous & ducts air-side pressure drop =						12.45		millibar					
Miscellaneous & ducts gas-side pressure drop =						7.472		millibar					

BOILER HEAT EXCHANGER SUMMARY									
Zone	Tg	Tw	DT	Afrn	DP	Mg	Qg	Vg	Tube
/path	C	C	C	m^2	millibar	t/h	kJ/s	m/s	rows
5	1176.7	427.6	749.1						
	REV				0.0	2359.3	589907	10.0	
	1176.7	343.5	833.2						
6	1176.7	532.3	644.4						
	RSH				0.0	2359.3	158429	10.0	
	1176.7	462.5	714.2						
7	1176.7	532.3	644.4						
0	CS2			352.6	0.1	2374.3	119972	10.4	14.0
	1036.2	606.0	430.1						
8	1036.2	485.3	550.9						
0	CR2			352.6	0.2	2374.3	134779	9.6	20.0
	875.1	605.4	269.7						
10	875.1	462.5	412.7						
0	CS1			343.4	0.2	2374.3	128046	10.3	16.0
	718.4	427.6	290.8						
11	718.4	485.3	233.1						
0	CR1			343.4	0.6	2374.3	134779	10.5	24.0
	548.0	372.7	175.4						
14	548.0	343.5	204.5						
0	ECO1			343.4	0.7	2374.3	158308	7.5	20.0
	338.4	287.7	50.7						
Totals					1.8		1424220		94.0

Note: g = gas + ash

BOILER HEAT TRANSFER SURFACES							
	Economizers	Evaporators	Superheaters	HP Reheaters	LP Reheaters	TOTAL	
Q	155969	581189	408391	265574	0	1411123	kJ/s
A	46762	5121	13010	19116	0	84009	m^2

BOILER WATER/STEAM SUMMARY								
Stream	P	T	h	M	s	UA	Q	A
	bar	C	kJ/kg	t/h	kJ/kg-K	kJ/s-K	kJ/s	m^2
ECO1 inlet	306.75	287.7	1267.0	1863.6	3.0652			
ECO1 exit	303.71	343.5	1568.3	1863.6	3.5772	1414.1	155968	46763
REV exit	288.54	427.6	2691.0	1863.6	5.2705		581189	5121
CS1 inlet	288.54	427.6	2691.0	1863.6	5.2705			
CS1 exit	285.95	462.5	2934.7	1863.6	5.6132	362.3	126154	6971
RSH inlet	285.95	462.5	2934.7	1863.6	5.6132			
RSH exit	282.74	532.3	3236.2	1863.6	6.0097		156065	1829.8
CS2 inlet	282.74	532.3	3236.2	1863.6	6.0097			
CS2 exit	280.14	606.0	3479.9	1863.6	6.3032	237.8	126152	4210
HP steam	280.14	606.0	3479.9	1863.6	6.3032			
Cold RH steam	63.04	372.7	3101.7	1689.2	6.4065			
CR1 inlet	63.04	372.7	3101.7	1689.2	6.4065			
CR1 exit	62.12	485.3	3384.7	1689.2	6.8175	654.5	132787	12767
CR2 inlet	62.12	485.3	3384.7	1689.2	6.8175			
CR2 exit	61.20	605.4	3667.7	1689.2	7.1705	337.2	132787	6349
Hot RH steam	61.20	605.4	3667.7	1689.2	7.1705			

FUEL - 'Hunter Valley' (Solid)		
Fuel Name: Hunter Valley		
Thermoflow library fuel		
Coal, High-volatile B bituminous		
Fuel supply temp.	25.00	C
Heating Values		
LHV	27904.8	kJ/kg
HHV	28930.0	kJ/kg
Ultimate Analysis (weight %)		
Moisture	4.80	%
Ash	9.40	%
Carbon	70.72	%
Hydrogen	4.16	%
Nitrogen	1.53	%
Chlorine	0.04	%
Sulfur	0.57	%
Oxygen	8.78	%
Total	100.00	%
Proximate Analysis (weight %)		
Moisture	4.80	%
Ash	9.40	%
Volatile Matter	31.70	%
Fixed Carbon	54.10	%
Total	100.00	%
Ash Analysis (weight %)		
SiO_2	63.90	%
Al_2O_3	22.30	%
Fe_2O_3	7.40	%
CaO	0.80	%
MgO	0.70	%
Na_2O	0.20	%
K_2O	1.60	%
TiO_2	0.80	%
P_2O_5	0.70	%
SO_3	0.50	%
Other	1.10	%
Total	100.00	%
Ash Characteristics		
Fouling	Low/Medium	
Initial deformation temperature	1280.00	C
Softening temperature	1480.00	C
Bulk density	768.89	kg/m^3
Mercury content (dry basis)	0.00	ppmw

Pseudo molecular weight	7.8810	
Mole flow	6.2449	kg-mol/s
Mass flow (ash-free)	177.1778	t/h
Mass flow	195.5605	t/h
Mass flow	4693	t/day
LHV (ash-free) @ 25 C	30800.00	kJ/kg
LHV (adjusted)* @ 25 C	30800.00	kJ/kg
Enthalpy (ash-free) ref. to 0 C	31987.95	kJ/kg
Atomic percentage		
C	51.25	%
H	40.56	%
O	7.09	%
N	0.95	%
S	0.15	%
Ar	0.00	%

* Adjusted heating values include fuel sensible enthalpy
above 77 F/25 C and are on an ash-free basis

ASME Boiler Energy Balance			
Energy In	**HHV based**	**LHV based**	
Energy input from fuel*	1571570	1515877	kW
Credit due to entering dry air	2873.8	2873.8	kW
Credit due to moisture in entering air	63.94	63.94	kW
Credit due to sensible heat in fuel	0	0	kW
Credit due to sulfation	0	0	kW
Credit due to sensible heat in sorbent	0	0	kW
Credit due to auxiliary equipment power	3449	3449	kW
Total credits	6387	6387	kW
Total energy in	1577956	1522264	kW
Energy Out			
Energy output to steam and water	1411123	1411123	kW
Loss due to sensible heat in dry gas	77158	77158	kW
Loss due to moisture in fuel	6924	554.2	kW
Loss due to moisture from burning hydrogen	53625	4292	kW
Loss due to moisture in air	1680.8	1680.8	kW
Loss due to unburned carbon	4535	4535	kW
Loss due to calcination of sorbent	0	0	kW
Loss due to radiation and unmeasured losses	22919	22919	kW
Total losses	166842	111139	kW
Total energy out	1577966	1522262	kW
ASME fuel efficiency (Output/Input)	**89.79**	**93.09**	**%**
ASME gross efficiency (Output/(Input+Credits))	**89.43**	**92.7**	**%**
*Energy input from fuel is based upon fuel heating value at 77 F/25 C			
Zero enthalpy: dry gases & liquid water at 77 F/25 C			
The entering air enthalpy is calculated based on air temperature before air heater.			
The leaving gas enthalpy is calculated based on flue gas temperature after air heater.			

Solid Fuel		
Fuel Name: Hunter Valley		
Type: Coal, High-volatile B bituminous		
Fuel supply temperature	25	C
Total LHV + Sensible heat @ 25C	27905	kJ/kg
Total fuel enthalpy referenced to 0C	28981	kJ/kg
Heating Values (at 25C)		
LHV (moisture and ash included)	27905	kJ/kg
HHV (moisture and ash included)	28930	kJ/kg
Ultimate Analysis (weight %)		
Moisture	4.8	%
Ash	9.4	%
Carbon	70.72	%
Hydrogen	4.16	%
Nitrogen	1.53	%
Chlorine	0.04	%
Sulfur	0.57	%
Oxygen	8.78	%
Total	100	%
Proximate Analysis (weight %)		
Moisture	4.8	%
Ash	9.4	%
Volatile Matter	31.7	%
Fixed Carbon	54.1	%
Total	100	%
Other Properties		
Specific Heat @ 25C, dry	1.214	kJ/kg-C
Specific Heat @ 300C, dry	1.968	kJ/kg-C
Bulk density	768.9	kg/m^3
Hardgrove Grindability Index (HGI)	50	
Mercury content (dry basis)	0	ppmw
Ash Analysis (weight %)		
SiO_2	63.9	%
Al_2O_3	22.3	%
Fe_2O_3	7.4	%
CaO	0.8	%
MgO	0.7	%
Na_2O	0.2	%
K_2O	1.6	%
TiO_2	0.8	%
P_2O_5	0.7	%
SO_3	0.5	%
Other	1.1	%
Total	100	%
Ash Characteristics		
Fouling	Low/Medium	
Ash Initial Deformation Temperature (reducing atm.)	1280	C
Ash Softening Temperature (reducing atm.)	1480	C

Pulverizer		
Design Data		
Pulverizer type	Vertical air-swept mill	
Number per boiler	6	
Number operating	5	
Capacity margin	15	%
Nameplate capacity at standard condition* (each)	44.98	tonne/hr
Full load capacity at current condition** (each)	44.98	tonne/hr
Fineness correction factor	1	
HGI correction factor	1	
Moisture correction factor	1	
Total correction factor	1	
Nameplate specific power consumption	22.05	kWh/tonne
Specific power consumption at current condition	22.05	kWh/tonne
* Nameplate condition: Fineness = 70%, Moisture = 8%, HGI = 50		
** Current condition: Fineness = 70%, Moisture = 4.8%, HGI = 50		
Heat Balance (each)		
Desired pulverizer exit temperature	70	C
Desired fuel outlet moisture	1.734	%
Air/fuel mass ratio	1.75	
Total power consumption	862.3	kW
Fuel in		
Flow	39.11	t/h
Temperature	25	C
Moisture	4.8	%
LHV	27905	kJ/kg
HHV	28930	kJ/kg
Fuel out		
Flow	37.89	t/h
Temperature	70	C
Moisture	1.734	%
LHV	28882	kJ/kg
HHV	29862	kJ/kg
Hot gas inlet		
Hot gas flow	34.7	t/h
Hot gas pressure	1.125	bar
Hot gas temperature	182.2	C
Tempering air flow	33.75	t/h
Tempering air pressure	1.125	bar
Tempering air temperature	37.06	C
Drying air flow	68.45	t/h
Drying air temperature	110.9	C
Pressure	1.125	bar
Percentage of tempering air over drying air	49.3	%
Gas outlet		
Mass flow	69.67	t/h
Pressure	1.1	bar
Temperature	70	C
Gauge pressure	99.63	millibar
Dew point	33.16	C
Relative humidity	16.28	%
Volume flow	17.64	m^3/s
Pulverizer(integral) Performance		
Total moisture evaporated	6.101	t/h
Actual percentage of fuel moisture evaporated	65	%
Total power consumption	4311	kW
Pressure drop	24.91	millibar
Energy in		
Energy provided by drying fluid	793.1	kW
Grinding heat	689.8	kW
Total	1482.9	kW
Energy consumed		
Fuel heating	692	kW
Moisture evaporation	790.9	kW
Total	1482.9	kW

ECO1		
Heat Balance		
Inlet Water		
Mass flow	1863.6	t/h
Pressure	306.7	bar
Temperature	287.7	C
Enthalpy	1267	kJ/kg
Exit Water		
Mass flow	1863.6	t/h
Pressure	303.7	bar
Temperature	343.5	C
Enthalpy	1568.3	kJ/kg
Gas		
Mass flow	2359.3	t/h
Flyash mass flow	15.09	t/h
Inlet temperature	548	C
Exit temperature	338.4	C
Sulfur dew point temperature	119.8	C
Dew point temperature	40.5	C
Static pressure drop	0.6971	millibar
Heat Transfer		
Heat from gas	157273	kW
Heat from ash	1034.5	kW
Heat transfer to water/steam	155968	kW
Heat loss	2339.5	kW
Hardware		
Tubes		
Fin-tube type	Solid fins	
Tube arrangement	In line	
Tube material	T22	
Number of tube rows (longitudinal)	20	
Number of tubes per row (transverse)	134	
Number of rows per waterside flow pass	2	
Longitudinal row pitch	101.6	mm
Gas path transverse width	18.72	m
Tube length	18.34	m
Tube outer diameter	50.8	mm
Tube wall thickness	7.62	mm
Transverse tube pitch	139.7	mm
Tube metal conductivity @ 500F (260C)	36.86	W/m-C
Tube metal conductivity slope	-0.0109	W/m-C^2
Fins		
Fin material	T22	
Fin height	19.05	mm
Fin spacing	8.944	mm
Fin thickness	1.905	mm
Number of fins per meter	92.17	per meter
Fin metal conductivity @ 500F (260C)	36.86	W/m-C
Fin metal conductivity slope	-0.0109	W/m-C^2
Overall Data		
Gas path frontal area	343.4	m^2
Min. gas free flow cross section / frontal area	0.5884	
H.T. surface area / min. free flow cross section	11.57	
Primary tube surface / total heat transfer surf.	0.1383	
Water side flow cross section area	0.2662	m^2
Heat exchanger prime outside surface	6468	m^2
Heat exchanger total fin area	40295	m^2
Heat exchanger total outside area	46763	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	4.402	m/s
Face mass flux	6.915	t/h-m^2
Velocity at minimum flow area	7.482	m/s
Mass flux at minimum flow area	11.75	t/h-m^2
Reynolds number	5377	
Prandtl number	0.7196	
Convective Nusselt number	42.94	
Convective heat transfer coefficient	40.77	W/m^2-C
Radiative heat transfer coefficient	2.297	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	43.06	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1799	
Friction factor Re coefficient	3.222	
Radiation beam mean length	0.257	m
Pressure drop correction factor	0.9	
Pressure drop	0.6971	millibar

ECO1		
Water Side		
Mass flux	7001	t/h-m^2
Mean velocity	2.689	m/s
Reynolds number	786625	
Prandtl number	0.8345	
Nusselt number	1128.3	
Heat transfer coefficient	17818	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	1.402	
User-defined pressure drop	3.037	bar
Hardware determined pressure drop	2.166	bar
Overall Performance		
Fin effectiveness	0.794	
Effective / total external area	0.8225	
Overall heat transfer coefficient	30.24	W/m^2-C
Tube metal mean temperature	322.9	C
Fin metal mean temperature	340.2	C
Estimated minimum tube surface temperature	293.5	C
Estimated maximum tube wall temperature	366.8	C
Maximum allowable tube wall metal temperature	732.2	C
Estimated maximum fin tip temperature	415.1	C
Recommended maximum fin metal temperature	732.2	C
Estimated maximum allowable water side pressure	392.7	bar
Heat transfer rate from gas	157273	kW
Heat from fly ash	1034.5	kW
Heat transfer rate to water	155968	kW
Heat loss	2339.5	kW
Overall heat transfer coefficient X total outer area, (UA)	1414.1	kW/C
Heat exchanger effectiveness	0.8052	

CS1		
Heat Balance		
Inlet Steam		
Mass flow	1863.6	t/h
Pressure	288.5	bar
Temperature	427.6	C
Enthalpy	2691	kJ/kg
Exit Steam		
Mass flow	1863.6	t/h
Pressure	285.9	bar
Temperature	462.5	C
Enthalpy	2934.7	kJ/kg
Gas		
Mass flow	2359.3	t/h
Flyash mass flow	15.09	t/h
Inlet temperature	875.1	C
Exit temperature	718.4	C
Static pressure drop	0.2472	millibar
Heat Transfer		
Heat from gas	127232	kW
Heat from ash	814	kW
Heat transfer to water/steam	126154	kW
Heat loss	1892.3	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	T91	
Number of tube rows (longitudinal)	16	
Number of tubes per row (transverse)	120	
Number of rows per waterside flow pass	2	
Longitudinal row pitch	76.2	mm
Gas path transverse width	18.87	m
Tube length	18.2	m
Tube outer diameter	63.5	mm
Tube wall thickness	7.62	mm
Transverse tube pitch	157.2	mm
Tube metal conductivity @ 500F (260C)	27	W/m-C
Tube metal conductivity slope	0.0053	W/m-C^2
Overall Data		
Gas path frontal area	343.4	m^2
Min. gas free flow cross section / frontal area	0.5961	
H.T. surface area / min. free flow cross section	2.128	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	0.439	m^2
Heat exchanger prime outside surface	6971	m^2
Heat exchanger total outside area	6971	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	6.151	m/s
Face mass flux	6.915	t/h-m^2
Velocity at minimum flow area	10.32	m/s
Mass flux at minimum flow area	11.6	t/h-m^2
Reynolds number	5330	
Prandtl number	0.7172	
Convective Nusselt number	41.93	
Convective heat transfer coefficient	42.28	W/m^2-C
Radiative heat transfer coefficient	14.57	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	56.85	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1769	
Friction factor Re coefficient	0.1003	
Radiation beam mean length	0.1495	m
Pressure drop correction factor	0.9	
Pressure drop	0.2472	millibar
Water Side		
Mass flux	4245	t/h-m^2
Mean velocity	8.305	m/s
Reynolds number	1886004	
Prandtl number	1.556	
Nusselt number	2789.3	
Heat transfer coefficient	7373	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	2.056	
User-defined pressure drop	2.596	bar
Hardware determined pressure drop	2.294	bar

CS1		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	51.98	W/m^2-C
Tube metal mean temperature	452.1	C
Estimated minimum tube surface temperature	439.2	C
Estimated maximum tube wall temperature	478.9	C
Maximum allowable tube wall metal temperature	732.2	C
Estimated maximum allowable water side pressure	340.4	bar
Heat transfer rate from gas	127232	kW
Heat from fly ash	814	kW
Heat transfer rate to water	126154	kW
Heat loss	1892.3	kW
Overall heat transfer coefficient X total outer area, (UA)	362.3	kW/C
Heat exchanger effectiveness	0.3502	

CS2		
Heat Balance		
Inlet Steam		
Mass flow	1863.6	t/h
Pressure	282.7	bar
Temperature	532.3	C
Enthalpy	3236	kJ/kg
Exit Steam		
Mass flow	1863.6	t/h
Pressure	280.1	bar
Temperature	606	C
Enthalpy	3480	kJ/kg
Gas		
Mass flow	2359.3	t/h
Flyash mass flow	15.09	t/h
Inlet temperature	1176.7	C
Exit temperature	1036.2	C
Static pressure drop	0.1285	millibar
Heat Transfer		
Heat from gas	119282	kW
Radiant heat influx	8071	kW
Heat from ash	690.6	kW
Heat transfer to water/steam	126152	kW
Heat loss	1892.3	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	TP347 HFG	
Number of tube rows (longitudinal)	14	
Number of tubes per row (transverse)	80	
Number of rows per waterside flow pass	7	
Longitudinal row pitch	76.2	mm
Gas path transverse width	18.71	m
Tube length	18.84	m
Tube outer diameter	63.5	mm
Tube wall thickness	8.344	mm
Transverse tube pitch	233.9	mm
Tube metal conductivity @ 500F (260C)	18.34	W/m-C
Tube metal conductivity slope	0.015	W/m-C^2
Overall Data		
Gas path frontal area	352.6	m^2
Min. gas free flow cross section / frontal area	0.7285	
H.T. surface area / min. free flow cross section	1.171	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	0.9639	m^2
Heat exchanger prime outside surface	4210	m^2
Heat exchanger total outside area	4210	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	7.56	m/s
Face mass flux	6.734	t/h-m^2
Velocity at minimum flow area	10.38	m/s
Mass flux at minimum flow area	9.243	t/h-m^2
Reynolds number	3663	
Prandtl number	0.716	
Convective Nusselt number	28.9	
Convective heat transfer coefficient	35.29	W/m^2-C
Radiative heat transfer coefficient	28.9	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	64.19	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1557	
Friction factor Re coefficient	0.0688	
Radiation beam mean length	0.2479	m
Pressure drop correction factor	0.9	
Pressure drop	0.1285	millibar
Water Side		
Mass flux	1933.4	t/h-m^2
Mean velocity	6.193	m/s
Reynolds number	744838	
Prandtl number	1.043	
Nusselt number	1162.4	
Heat transfer coefficient	2608.1	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	2.056	
User-defined pressure drop	2.596	bar
Hardware determined pressure drop	0.2314	bar

CS2		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	56.48	W/m^2-C
Tube metal mean temperature	588	C
Estimated minimum tube surface temperature	577.6	C
Estimated maximum tube wall temperature	636.3	C
Maximum allowable tube wall metal temperature	1093.3	C
Estimated maximum allowable water side pressure	296.9	bar
Heat transfer rate from gas	119282	kW
Radiant heat influx	8071	kW
Heat from fly ash	690.6	kW
Heat transfer rate to water	126152	kW
Heat loss	1892.3	kW
Overall heat transfer coefficient X total outer area, (UA)	237.8	kW/C
Heat exchanger effectiveness	0.218	

CR1		
Heat Balance		
Inlet Steam		
Mass flow	1689.2	t/h
Pressure	63.04	bar
Temperature	372.7	C
Enthalpy	3102	kJ/kg
Exit Steam		
Mass flow	1689.2	t/h
Pressure	62.12	bar
Temperature	485.3	C
Enthalpy	3385	kJ/kg
Gas		
Mass flow	2359.3	t/h
Flyash mass flow	15.09	t/h
Inlet temperature	718.4	C
Exit temperature	548	C
Static pressure drop	0.5709	millibar
Heat Transfer		
Heat from gas	133889	kW
Heat from ash	890.2	kW
Heat transfer to water/steam	132787	kW
Heat loss	1991.8	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	T91	
Number of tube rows (longitudinal)	24	
Number of tubes per row (transverse)	146	
Number of rows per waterside flow pass	4	
Longitudinal row pitch	76.2	mm
Gas path transverse width	18.8	m
Tube length	18.26	m
Tube outer diameter	63.5	mm
Tube wall thickness	2.794	mm
Transverse tube pitch	128.8	mm
Tube metal conductivity @ 500F (260C)	27	W/m-C
Tube metal conductivity slope	0.0053	W/m-C^2
Overall Data		
Gas path frontal area	343.4	m^2
Min. gas free flow cross section / frontal area	0.5069	
H.T. surface area / min. free flow cross section	3.056	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	1.538	m^2
Heat exchanger prime outside surface	12767	m^2
Heat exchanger total outside area	12767	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	5.313	m/s
Face mass flux	6.915	t/h-m^2
Velocity at minimum flow area	10.48	m/s
Mass flux at minimum flow area	13.64	t/h-m^2
Reynolds number	6743	
Prandtl number	0.7177	
Convective Nusselt number	51.9	
Convective heat transfer coefficient	47.59	W/m^2-C
Radiative heat transfer coefficient	9.892	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	57.48	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1879	
Friction factor Re coefficient	0.1364	
Radiation beam mean length	0.1129	m
Pressure drop correction factor	0.9	
Pressure drop	0.5709	millibar
Water Side		
Mass flux	1098.1	t/h-m^2
Mean velocity	14.62	m/s
Reynolds number	688430	
Prandtl number	0.992	
Nusselt number	1073.7	
Heat transfer coefficient	1185.6	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	0.8917	
User-defined pressure drop	0.918	bar
Hardware determined pressure drop	0.7953	bar

CR1		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	51.27	W/m^2-C
Tube metal mean temperature	435.4	C
Estimated minimum tube surface temperature	383.7	C
Estimated maximum tube wall temperature	499.9	C
Maximum allowable tube wall metal temperature	732.2	C
Estimated maximum allowable water side pressure	105.1	bar
Heat transfer rate from gas	133889	kW
Heat from fly ash	890.2	kW
Heat transfer rate to water	132787	kW
Heat loss	1991.8	kW
Overall heat transfer coefficient X total outer area, (UA)	654.5	kW/C
Heat exchanger effectiveness	0.4928	

CR2		
Heat Balance		
Inlet Steam		
Mass flow	1689.2	t/h
Pressure	62.12	bar
Temperature	485.3	C
Enthalpy	3385	kJ/kg
Exit Steam		
Mass flow	1689.2	t/h
Pressure	61.2	bar
Temperature	605.4	C
Enthalpy	3668	kJ/kg
Gas		
Mass flow	2359.3	t/h
Flyash mass flow	15.09	t/h
Inlet temperature	1036.2	C
Exit temperature	875.1	C
Static pressure drop	0.1752	millibar
Heat Transfer		
Heat from gas	133989	kW
Heat from ash	790.3	kW
Heat transfer to water/steam	132787	kW
Heat loss	1991.8	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	TP347 HFG	
Number of tube rows (longitudinal)	20	
Number of tubes per row (transverse)	84	
Number of rows per waterside flow pass	5	
Longitudinal row pitch	76.2	mm
Gas path transverse width	18.61	m
Tube length	18.95	m
Tube outer diameter	63.5	mm
Tube wall thickness	2.794	mm
Transverse tube pitch	221.6	mm
Tube metal conductivity @ 500F (260C)	18.34	W/m-C
Tube metal conductivity slope	0.015	W/m-C^2
Overall Data		
Gas path frontal area	352.6	m^2
Min. gas free flow cross section / frontal area	0.7134	
H.T. surface area / min. free flow cross section	1.262	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	1.106	m^2
Heat exchanger prime outside surface	6349	m^2
Heat exchanger total outside area	6349	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	6.829	m/s
Face mass flux	6.734	t/h-m^2
Velocity at minimum flow area	9.572	m/s
Mass flux at minimum flow area	9.439	t/h-m^2
Reynolds number	3954	
Prandtl number	0.7165	
Convective Nusselt number	30.92	
Convective heat transfer coefficient	35.16	W/m^2-C
Radiative heat transfer coefficient	23.93	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	59.08	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1585	
Friction factor Re coefficient	0.0715	
Radiation beam mean length	0.2321	m
Pressure drop correction factor	0.9	
Pressure drop	0.1752	millibar
Water Side		
Mass flux	1526.9	t/h-m^2
Mean velocity	24.96	m/s
Reynolds number	802304	
Prandtl number	0.9309	
Nusselt number	1188.3	
Heat transfer coefficient	1580.9	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	0.8917	
User-defined pressure drop	0.918	bar
Hardware determined pressure drop	1.264	bar

CR2		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	53.11	W/m^2-C
Tube metal mean temperature	556.5	C
Estimated minimum tube surface temperature	515.2	C
Estimated maximum tube wall temperature	620	C
Maximum allowable tube wall metal temperature	1093.3	C
Estimated maximum allowable water side pressure	93.06	bar
Heat transfer rate from gas	133989	kW
Heat from fly ash	790.3	kW
Heat transfer rate to water	132787	kW
Heat loss	1991.8	kW
Overall heat transfer coefficient X total outer area, (UA)	337.2	kW/C
Heat exchanger effectiveness	0.2923	

Furnace		
Design Heat Balance: Once through - Coal fired		
Furnace gage pressure	-0.6226	millibar
Excess air	20	%
Secondary Air		
Temperature	273.9	C
Mass flow	1840.3	t/h
Primary Air into Pulverizer		
Temperature	182.2	C
Mass flow	173.5	t/h
Tempering Air into Pulverizer		
Temperature	37.06	C
Mass flow	168.7	t/h
Pulverizer inlet Dry Air		
Temperature	110.9	C
Mass flow	342.2	t/h
Pulverizer outlet Gas		
Temperature	70	C
Mass flow	348.3	t/h
Gage pressure	124.5	millibar
Flue Gas		
Temperature	1176.7	C
Mass flow	2359.2	t/h
Ash mass flow	15.09	t/h
Mole percent N2	73.65	%
Mole percent O2	3.287	%
Mole percent CO2	14.55	%
Mole percent H2O	7.587	%
Mole percent SO2	0.044	%
Mole percent Ar	0.8853	%
SO3 in flue gas	2.2	ppm
Emission		
Reference O2 content	6	%
Actual O2 content in exit gas	3.287	%
H2O content in exit gas	7.587	%
Hg from combustion	0	kg/hr
Hg in exit gas	0	kg/hr
HCl in exit gas	64.36	kg/hr
NOx production	0	kg/hr
NOx volume concentration in exit gas	0	ppmv
NOx mass concentration in exit gas	0	ppm
Exit Steam		
Steam produced by waterwall	1863.6	t/h
Pressure	288.5	bar
Temperature	427.6	C
Enthalpy	2691	kJ/kg
Inlet Water		
Mass flow	1863.6	t/h
Pressure	303.7	bar
Temperature	343.5	C
Enthalpy	1568.3	kJ/kg
Radiant Superheater Exit Steam		
Mass flow	1863.6	t/h
Pressure	282.7	bar
Temperature	532.3	C
Enthalpy	3236	kJ/kg
Radiant Superheater Inlet Steam		
Pressure	285.9	bar
Temperature	462.5	C
Enthalpy	2934.7	kJ/kg
Inlet Fuel : Solid		
Fuel mass flow	195.6	t/h
LHV @ 77 F (25 C)	27905	kJ/kg
HHV @ 77 F (25 C)	28930	kJ/kg
Fuel input (LHV)	1515.9	MW
Fuel input (HHV)	1571.6	MW
Weight percent ash	9.4	%
Fuel ash flow	18.38	t/h
Fuel inlet temperature	25	C
Exit Ash		
Bottom ash flow	3.773	t/h
Unburnt carbon flow in bottom ash	0.0968	t/h

Furnace		
Unburnt carbon in bottom ash	2.566	%
Fly ash flow	15.09	t/h
Unburnt carbon flow in fly ash	0.3872	t/h
Unburnt carbon in fly ash	2.566	%
Total unburnt carbon flow in ash	0.484	t/h
Combustion efficiency	99.7	%
Heat Transfer		
Heat transfer to waterwall	581189	kW
Heat transfer to radiant superheater	156065	kW
Unburnt carbon in ash	4535	kW
Heat losses	11058	kW
Radiant flux past screen	8071	kW
Bottom ash (bed drain) sensible heat	1364.2	kW
Fly ash sensible heat	5457	kW
Performance		
Fuel delivery power	4311	kW
Ash handling power	831.9	kW
Heat Transfer		
Furnace Ratings		
Heat absorption rate	107.2	kW/m^2
Heat release rate	235.4	kW/m^2
Volumetric heat release rate	75.1	kW/m^3
Heat Transfer and Heat Balance		
Energy In		
Fuel input	1515874	kW
Fuel delivery energy included in heat balance calculation	3449	kW
Air input	139433	kW
Total Energy In	1658755	kW
Energy Out		
Flue gas	890994	kW
Heat transfer to waterwall	581189	kW
Heat transfer to radiant superheater	156065	kW
Heat losses	11058	kW
Radiant flux past screen	8071	kW
Unburnt carbon in ash	4535	kW
Bottom ash (bed drain) sensible heat	1364.2	kW
Fly ash sensible heat	5457	kW
Total Energy Out	1658733	kW
Heat Balance Error	**0.0013**	**%**
Heat Transfer Characteristics		
Gas emissivity	0.8402	
Gas absorptivity	0.8606	
Radiating mean beam length	14.51	m
Adiabatic temperature	2029.4	C
Effective radiating temperature	1607.1	C
Waterwall surface temperature	1163.1	C
Furnace exit temperature	1176.7	C
Gas mass flux @ aperture	6.734	t/h-m^2
Gas velocity leaving aperture @ furnace exit temperature	7.561	m/s
Furnace velocity @ Effective radiating temperature	10	m/s
Radiant flux to waterwall effective projected heat transfer surface	112.7	kW/m^2
Mean flux to waterwall effective projected heat transfer surface	113.5	kW/m^2

Rotary Air Heater		
Heat Balance		
Number per station	3	
Number operating	3	
Primary Air Path (station)		
Primary air flow	173.5	t/h
Primary air temperature	182.2	C
Inlet air flow	199.5	t/h
Inlet pressure	1.13	bar
Inlet temperature	37.06	C
Cold side leakage	17.35	t/h
Hot side leakage	8.675	t/h
Pressure drop	4.869	millibar
Channel velocity	6.761	m/s
Reynolds number	3147	
Stanton number	0.005	
Heat transfer coefficient	49.73	W/m^2-C
Secondary Air Path (station)		
Secondary air flow	1840.3	t/h
Secondary air temperature	273.9	C
Inlet pressure	1.018	bar
Inlet temperature	27.94	C
Cold side leakage to flue gas	128.8	t/h
Hot side leakage to flue gas	55.21	t/h
Pressure drop	6.207	millibar
Channel velocity	8.317	m/s
Reynolds number	2914.5	
Stanton number	0.0051	
Heat transfer coefficient	50.78	W/m^2-C
Flue Gas Path (station)		
Flue gas flow	2359.3	t/h
Fly ash flow	15.09	t/h
Flue gas temperature	338.4	C
After mixing with hot side leakages	336.5	C
Exit temperature (uncorrected)	144.1	C
Exit temperature with leakage (corrected)	137.8	C
Exit flow	2569.3	t/h
Pressure @ heater inlet	0.9976	bar
Pressure drop	9.101	millibar
Channel velocity	11.58	m/s
Reynolds number	3137	
Stanton number	0.0051	
Heat transfer coefficient	60.73	W/m^2-C
Performance (station)		
Flue gas heat transfer to air paths	140132	kW
Fly ash heat transfer to air paths	850	kW
Secondary air heat transfer	133458	kW
Primary air heat transfer	7524	kW
Average cold end temperature (ACET)	86.04	C
Cold end minimum metal temperature	68.33	C
Flue gas exit water dew point temperature	39.09	C
Flue gas exit SO3	2.014	ppm
Flue gas exit sulfur dew point temperature	118.1	C
Flue gas sulfur dew point temperature within air heater	119.1	C
Heat transfer effectiveness	77.07	%
Modified number of transfer units (NTU0)	2.602	

Heat Balance Results			
Stack			
Inlet			
Pressure	0.9972	bar	
Temperature	140.9	C	
Mass flow	2569.3	t/h	
Exit to air			
Pressure	0.9823	bar	
Temperature	140.9	C	
Water dew point temperature	39.25	C	
Sulfur dew point temperature	138	C	
Mass flow	2569.3	t/h	
Mercury (Hg)	0	kg/hr	
Exit Velocity	18.29	m/s	
Miscellaneous			
Heat loss	0	kW	
Buoyancy (DPc-DPh)	5.473	millibar	
-- Pressure by cold air column outside stack (DPc)	17.67	millibar	
-- Pressure by hot air column inside stack (DPh)	12.2	millibar	
Pressure drop (inlet to ambient)	-2.81	millibar	
-- Entrance loss	0.8655	millibar	
-- Leaving loss	1.443	millibar	
-- Friction loss	0.3554	millibar	
-- Buoyancy gain	5.473	millibar	
Emissions	**ng/J25C HHV @**	**mg/Nm^3 @ 6% O2, dry**	**ppmv @ 6% O2, dry**
Dust load	13.34	39.59	
Sulfur Dioxide (SO2)	393.9	1169.2	409.1
Nitrogen Oxides (NOx)	0	0	0
Mercury (Hg)	0	0	0
Plume invisible			
Plume visibility index	0		

STEAM PRO 26.1 GHD GHD Pty Ltd											
588 04-21-2017 16:13:26 G:\41\30763\Tech\HELE documentation\Model\USC model_wet cooling.stp											
Program revision date: February 16, 2017											
Steam source: Conventional boiler											
Steam turbine: Single reheat condensing turbine 3000+3000/3000											
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train											
Cooling system: Water cooling with natural draft cooling tower											
Steam Property Formulation: IFC-67											
STEAM CYCLE HEAT BALANCE											
Energy in =		**1436424**	**kJ/s**								
Boiler Heat		**External**	**External**		**Makeup**		**Process**	**Pump**	**Blowdown**		
Addition		**Steam**	**Water**				**Return**	**Aux. Load**	**Recovery**		
1411123		**0**	**0**		**0**		**0**	**25300**	**0**		
Energy out =		**1436438**	**kJ/s**								
ST/Gen	**BFPT**	**Mech/Elec/**	**Main**	**BFPT**	**Process**		**Pipe**	**CO2**	**Desal**	**Others***	
Output	**Output**	**Gear Losses**	**Condenser**		**Steam**	**Water**	**Losses**	**Capture**			
675529	**23682**	**7598**	**724868**	**0**	**0**	**0**	**3902**	**0**	**0**	**860**	
* 'Others' includes pump losses, heat to air heater, fuel heater, district heating system,											
misc heat to/from condensate, discharged seal steam and blowdown.											
Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)											
Heat Balance Error (In - Out) =			-14.2	kJ/s	=	-0.0010	%				

STEAM TURBINE FLOWS										
	P	T	h	M	s	Super-	Quality	Exp Pwr	Eff	# of
	bar	C	kJ/kg	t/h	kJ/kg-K	heat, C		kW	%	Stages
HP steam	280.140	606.0	3479.9	1863.565						
HP pipe inlet	280.140	606.0	3479.9	1863.565						
HP pipe outlet	276.000	604.0	3477.6	1863.565						
ST inlet	276.000	604.0	3477.6	1863.565	6.3065	211.2				
After HPT stop valve	269.100	601.9	3477.6							
-Valve Stem leak 1			3477.6	-4.186						
-Valve Stem leak 2			3477.6	-1.380						
-HPT HP leak 1			3477.6	-26.321						
HPT Casing: Group 1										
GROUP IN	269.100	601.9	3477.6	1831.677	6.3166	211.2			68.47*	1
GROUP OUT	212.308	562.3	3416.5	1831.677	6.3403	191.6		31079	75.57**	
HPT Casing: Group 2										
GROUP IN	212.308	562.3	3416.5	1831.677	6.3403	191.6			88.79*	9
GROUP OUT	64.297	374.5	3104.0	1831.677	6.4019	94.4		158997	88.79**	
Port (1) extraction	64.297	374.5	3104.0	-128.630	6.4019	94.4				
-HPT LP leak 1			3104.0	-11.376						
-HPT LP leak 2			3104.0	-2.435						
Cold RH pipe inlet	64.297	374.5	3104.0	1689.237	6.4019	94.4				
Cold RH pipe outlet	63.036	372.7	3101.7	1689.237						
RH steam	61.200	605.4	3667.7	1689.237						
Hot RH pipe inlet	61.200	605.4	3667.7	1689.237						
Hot RH pipe outlet	60.000	604.0	3665.3	1689.237						
IPT inlet	60.000	604.0	3665.3	1689.237	7.1767	328.4				
+Valve Stem leak 1			3477.6	4.186						
+HPT HP leak 1			3477.6	26.321						
IP bowl	58.800	602.2	3662.0	1719.744	7.1819	327.9				
IPT1 Casing: Group 3										
GROUP IN	58.800	602.2	3662.0	1719.744	7.1819	327.9			82.61*	3
GROUP OUT	42.666	549.7	3555.2	1719.744	7.2001	295.6		51010	87.61**	
Port (3) extraction	42.666	549.7	3555.2	-119.647	7.2001	295.6				
IPT1 Casing: Group 4										
GROUP IN	42.666	549.7	3555.2	1600.098	7.2001	295.6			89.22*	4
GROUP OUT	22.902	454.3	3363.3	1600.098	7.2321	235.0		85319	89.22**	
Port (4) extraction	22.902	454.3	3363.3	-63.906	7.2321	235.0				

IPT1 Casing: Group 5										
GROUP IN	22.902	454.3	3363.3	1536.191	7.2321	235.0			90.06*	3
GROUP OUT	13.040	375.4	3206.9	1536.191	7.2589	183.7		66725	90.06**	
Port (5) extraction	13.040	375.4	3206.9	-74.550	7.2589	183.7				
IPT1 Casing: Group 6										
GROUP IN	13.040	375.4	3206.9	1461.641	7.2589	183.7			90.92*	3
GROUP OUT	7.000	296.5	3052.2	1461.641	7.2862	131.5		62834	90.92**	
Port (6) extraction	7.000	296.5	3052.2	-210.515	7.2862	131.5				
-IPT LP leak			3052.2	-2.585						
+HPT LP leak 1			3104.0	11.376						
LPT crossover	7.000	296.7	3052.6	1259.917	7.2870	131.7				
LPT1 Casing: Group 7										
GROUP IN	7.000	296.7	3052.6	1259.917	7.2870	131.7			91.8*	3
GROUP OUT	3.083	205.1	2875.4	1259.917	7.3202	70.6		62036	91.8**	
Port (7) extraction	3.083	205.1	2875.4	-73.433	7.3202	70.6				
LPT1 Casing: Group 8										
GROUP IN	3.083	205.1	2875.4	1186.484	7.3202	70.6			92.85*	2
GROUP OUT	1.167	113.0	2700.4	1186.484	7.3554	9.0		57670	92.85**	
Port (8) extraction	1.167	113.0	2700.4	-69.064	7.3554	9.0				
LPT1 Casing: Group 9										
GROUP IN	1.167	113.0	2700.4	1117.421	7.3554	9.0			92.57*	2
GROUP OUT	0.363	73.6	2526.1	1117.421	7.3957		0.954	54111	92.57**	
Port (9) extraction	0.363	73.6	2526.1	-58.428	7.3957		0.954			
LPT1 Casing: Group 10										
GROUP IN	0.363	73.6	2526.1	1058.993	7.3957		0.954		80.4*	3
GROUP OUT	0.072	39.5	2323.4	1058.993	7.4689		0.896		89.86**	
After LL	0.072	39.5	2344.7	1058.993	7.5371		0.905	53345		
To condenser	0.072	39.5	2344.7	1058.993	7.5371		0.905			

*There are 2 symmetric IPT paths, each same as IPT1

*The LPT mass flow rates are multiplied by 2

* : Group overall efficiency (including control valve and/or leaving losses)

**: Group blading efficiency (excluding control valve and/or leaving losses)

STEAM TURBINE DESIGN

Group	Adj Nozzle Area, m^2	No. of Steps	Dry Step Eff., %	Group Blading Eff., %	Group Overall Eff., %
1	0.027	1	75.57	75.57	68.47
2	0.022	9	87.34	88.79	88.79
3	0.111	3	86.77	87.61	82.61
4	0.112	4	88.56	89.22	89.22
5	0.194	3	89.64	90.06	90.06
6	0.299	3	90.51	90.92	90.92
7	0.424	3	91.11	91.80	91.80
8	0.806	2	92.41	92.85	92.85
9	1.755	2	93.17	92.57	92.57
10	4.817	3	95.00	89.86	80.40

No. of parallel paths at LPT	1 x 2	
Last stage rotor exit angle	62.22	degree
Last stage blade length	1144.48	mm
Last stage pitch diameter	2983.51	mm
Exhaust annulus area / end	10.73	m^2

DRY EXHAUST LOSS

Annulus Vel m/s	Exh Loss kJ/kg	Annulus Vel m/s	Exh Loss kJ/kg	Annulus Vel m/s	Exh Loss kJ/kg
39	206.59	122	73.29	244	28.71
46	202.27	137	57.65	274	38.01
53	196.68	152	45.92	305	52.71
61	190.46	168	37.37	335	70.57
76	155.45	183	31.44	366	89.08
91	120.74	198	27.80	396	106.60
107	93.89	213	26.21	427	123.49

EXHAUST END VELOCITIES AND LOSSES

	LPT1	
Annulus velocity	246.9	m/s
Dry exhaust loss	29.35	kJ/kg
Corrected exhaust loss	21.34	kJ/kg

STEAM TURBINE CASING POWER	
Casing	Expansion Power (kW)
HPT	190076
IPT1	265889
LPT1 x 2	227161

H2 COOLED GENERATOR 50 Hz		
Turbine Shaft Speed	3000 RPM	
Expansion power	683127	kW
ST mechanical loss	1707.8	kW
ST shaft power	681419	kW
Generator efficiency	99.14	%
Generator electrical & mechanical loss	5889.9	kW
- Generator electrical & windage loss	5141.4	kW
- Generator mechanical loss	748.5	kW
Generator power	675528.9	kW

STEAM TURBINE LEAKAGES						
Group	Leakage	Destination	Leakage Flow	C Factor	h	M
No.			Model	m^2	kJ/kg	t/h
1	Valve Stem leak 1	IPT inlet	Automatic	8.1	3477.6	4.186
2	Valve Stem leak 2	SSR	Automatic	9.3	3477.6	1.380
4	HPT HP leak 1	IPT inlet	Automatic	49.9	3477.6	26.321
7	HPT LP leak 1	LPT cROssover	Automatic	75.5	3104.0	11.376
8	HPT LP leak 2	SSR	Automatic	123.1	3104.0	2.435
16	IPT LP leak	SSR	Automatic	63.9	3052.2	2.585

SEALING STEAM REGULATOR & GLAND SEAL CONDENSER (IF ANY)				
Stream	P	T	h	M
	bar	C	kJ/kg	t/h
Valve Stem leak 2			3477.6	1.38
HPT LP leak 2			3104.0	2.435
IPT LP leak			3052.2	2.585
Steam at SSR inlet	1.241	344.4	3163.6	6.401
LPT SS to condenser			3163.6	0.5443
LPT SS packing exhaust to GSC			3163.6	0.6349
SS to FWH1 from SSR			3163.6	5.222
Steam at GSC inlet	0.8274	344.0	3163.6	0.6349
GSC drain to Condendser			395.5	0.6349

CONDENSER: Water cooling with natural draft cooling tower				
	P	T	h	M
	bar	C	kJ/kg	t/h
LPT exhaust	**0.0716**	**39.45**	**2344.7**	**1059**
LPT SS to condenser			**3163.6**	**0.5443**
FPT exhaust	**0.0716**	**39.45**	**2410.7**	**133.4**
Drain from GSC	**0.827**	**94.47**	**395.5**	**0.6349**
Condenser in	**0.0716**	**39.45**	**2351.4**	**1193.6**
Condensate	**0.3707**	**39.45**	**165.2**	**1193.6**
Cooling water in	**3.366**	**26.13**	**109.8**	**53678**
Cooling water out	**2.495**	**37.79**	**158.4**	**53678**
Cooled water from cooling tower	1	26.12	109.5	53678
Before cooling water pump	1	26.12		53678
After cooling water pump	3.366	26.13	109.8	53678
Hot cooling water mixed from all condensers	2.495	37.79	158.4	53678
Hot water to cooling tower	1.897	37.80	158.4	53678
Condenser cooling water pump power =	4435	kW		
Main condenser heat rejection =	724868	kJ/s		

COOLING TOWER (Natural Draft)					
	P	T	Twet bulb	M	RH
	bar	C	C	t/h	%
Air in	**1.00**	**25.00**	**19.45**	**38092**	**60.0**
Air out	**1.00**	**34.47**	**34.47**	**38990**	**100.0**
Hot water in	**1.90**	**37.80**		**53678**	
Cold water out	**1.00**	**26.12**		**53678**	
Makeup				**1122.5**	
Blowdown				**224.5**	
Cooling tower heat rejection =		728999	kJ/s		
Range =		11.68	C		
Approach =		6.667	C		
Cycles of concentration =		5			

CONDENSATE, MAKEUP WATER & FEEDWATER				
	P	T	h	M
	bar	C	kJ/kg	t/h
Condenser condensate	0.3707	39.45	165.2	1193.6
Condensate pump suction	0.3707	39.45	165.2	1193.6
Condensate pump exit	21.6	39.72	168.2	1193.6
To SJAE, GSC & recovery heat exchangers	21.6	39.72	168.2	1193.6
-Enthalpy change due to GSC			1.47	
Feedwater to 1st feedwater heater	21.6	40.08	169.7	1193.6

BOILER FEED PUMP TURBINE (Condensing)

The plant has 1 boiler feed pump turbine in operation

Stream	(Port)	P	T	h	M
		bar	C	kJ/kg	t/h
Turbine inlet from LPT cross	(6)	6.667	294.9	3049.8	133.4
1st group inlet		5.333	293.3	3049.8	133.4
Exhaust to main condenser		0.0716	39.5	2410.7	133.4

Boiler feed pump shaft power =	23445.0	kW
Feed pump turbine power =	23681.8	kW
Feed pump turbine efficiency =	82.16	%
Group 1 adjusted nozzle area =	0.053	m^2
Number of steps in Group 1 =	6	

HP casing - Group 1		
Number of governing stage rows	1	
Governing stage pitch diameter	1.165	m
Number of paths	1	
Number of stages	1	
Dry step efficiency	75.57	%
Group efficiency	68.47	%
Group inlet mass flow	1831.7	t/h
Shaft speed	3000	RPM
Before Valve		
Pressure	276	bar
Temperature	604	C
Enthalpy	3478	kJ/kg
Blading Inlet		
Pressure	269.1	bar
Temperature	601.9	C
Enthalpy	3478	kJ/kg
Volume flow	6.629	m^3/s
Nozzle area	0.0273	m^2
Blading Exit		
Pressure	212.3	bar
Temperature	562.3	C
Enthalpy	3416	kJ/kg
Volume flow	8.057	m^3/s

HP casing - Group 2		
Number of paths	1	
Number of stages	9	
Dry step efficiency	87.34	%
Group efficiency	88.79	%
Group inlet mass flow	1831.7	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	212.3	bar
Temperature	562.3	C
Enthalpy	3416	kJ/kg
Volume flow	8.057	m^3/s
Nozzle area	0.0218	m^2
Blading Exit		
Pressure	64.3	bar
Temperature	374.5	C
Enthalpy	3104	kJ/kg
Volume flow	21.09	m^3/s
Port at Group Exit		
Pressure	64.3	bar
Temperature	374.5	C
Enthalpy	3104	kJ/kg
Extraction mass flow	128.6	t/h

IP casing - Group 3		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	86.77	%
Group efficiency	82.61	%
Group inlet mass flow (per path)	859.9	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	58.8	bar
Temperature	602.2	C
Enthalpy	3662	kJ/kg
Volume flow (per path)	15.94	m^3/s
Nozzle area (per path)	0.0554	m^2
Blading Exit		
Pressure	42.67	bar
Temperature	549.7	C
Enthalpy	3555	kJ/kg
Volume flow (per path)	20.69	m^3/s
Port at Group Exit		
Pressure	42.67	bar
Temperature	549.7	C
Enthalpy	3555	kJ/kg
Extraction mass flow (per path)	59.82	t/h

IP casing - Group 4		
Number of paths	2	
Number of stages (per path)	4	
Dry step efficiency	88.56	%
Group efficiency	89.22	%
Group inlet mass flow (per path)	800	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	42.67	bar
Temperature	549.7	C
Enthalpy	3555	kJ/kg
Volume flow (per path)	19.25	m^3/s
Nozzle area (per path)	0.0562	m^2
Blading Exit		
Pressure	22.9	bar
Temperature	454.3	C
Enthalpy	3363	kJ/kg
Volume flow (per path)	31.82	m^3/s
Port at Group Exit		
Pressure	22.9	bar
Temperature	454.3	C
Enthalpy	3363	kJ/kg
Extraction mass flow (per path)	31.95	t/h

IP casing - Group 5		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	89.64	%
Group efficiency	90.06	%
Group inlet mass flow (per path)	768.1	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	22.9	bar
Temperature	454.3	C
Enthalpy	3363	kJ/kg
Volume flow (per path)	30.55	m^3/s
Nozzle area (per path)	0.0972	m^2
Blading Exit		
Pressure	13.04	bar
Temperature	375.4	C
Enthalpy	3207	kJ/kg
Volume flow (per path)	47.99	m^3/s
Port at Group Exit		
Pressure	13.04	bar
Temperature	375.4	C
Enthalpy	3207	kJ/kg
Extraction mass flow (per path)	37.27	t/h

IP casing - Group 6		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	90.51	%
Group efficiency	90.92	%
Group inlet mass flow (per path)	730.8	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	13.04	bar
Temperature	375.4	C
Enthalpy	3207	kJ/kg
Volume flow (per path)	45.66	m^3/s
Nozzle area (per path)	0.1496	m^2
Blading Exit		
Pressure	7	bar
Temperature	296.5	C
Enthalpy	3052	kJ/kg
Volume flow (per path)	74.9	m^3/s

LP casing - Group 7		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	91.11	%
Group efficiency	91.8	%
Group inlet mass flow (per path)	630	t/h
Shaft speed	3000	RPM
Port upstream of LP casing		
Pressure	7	bar
Temperature	296.5	C
Enthalpy	3052	kJ/kg
Extraction mass flow	210.5	t/h
Blading Inlet		
Pressure	7	bar
Temperature	296.7	C
Enthalpy	3053	kJ/kg
Volume flow (per path)	64.59	m^3/s
Nozzle area (per path)	0.2119	m^2
Blading Exit		
Pressure	3.083	bar
Temperature	205.1	C
Enthalpy	2875.4	kJ/kg
Volume flow (per path)	123.3	m^3/s
Port at Group Exit		
Pressure	3.083	bar
Temperature	205.1	C
Enthalpy	2875.4	kJ/kg
Extraction mass flow (per path)	36.72	t/h

LP casing - Group 8		
Number of paths	2	
Number of stages (per path)	2	
Dry step efficiency	92.41	%
Group efficiency	92.85	%
Group inlet mass flow (per path)	593.2	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	3.083	bar
Temperature	205.1	C
Enthalpy	2875.4	kJ/kg
Volume flow (per path)	116.1	m^3/s
Nozzle area (per path)	0.4031	m^2
Blading Exit		
Pressure	1.167	bar
Temperature	113	C
Enthalpy	2700.4	kJ/kg
Volume flow (per path)	247.8	m^3/s
Port at Group Exit		
Pressure	1.167	bar
Temperature	113	C
Enthalpy	2700.4	kJ/kg
Extraction mass flow (per path)	34.53	t/h

LP casing - Group 9		
Number of paths	2	
Number of stages (per path)	2	
Dry step efficiency	93.17	%
Group efficiency	92.57	%
Group inlet mass flow (per path)	558.7	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	1.167	bar
Temperature	113	C
Enthalpy	2700.4	kJ/kg
Volume flow (per path)	233.4	m^3/s
Nozzle area (per path)	0.8777	m^2
Blading Exit		
Pressure	0.363	bar
Temperature	73.57	C
Enthalpy	2526.1	kJ/kg
Volume flow (per path)	647.6	m^3/s
Port at Group Exit		
Pressure	0.363	bar
Temperature	73.57	C
Enthalpy	2526.1	kJ/kg
Extraction mass flow (per path)	29.21	t/h

LP casing - Group 10		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	95	%
Group efficiency	80.4	%
Group inlet mass flow (per path)	529.5	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	0.363	bar
Temperature	73.57	C
Enthalpy	2526.1	kJ/kg
Volume flow (per path)	613.7	m^3/s
Nozzle area (per path)	2.409	m^2
Blading Exit		
Pressure	0.0716	bar
Temperature	39.45	C
Enthalpy	2323.4	kJ/kg
Volume flow (per path)	2648.7	m^3/s
Annulus area (per path)	10.73	m^2
Annulus velocity	246.9	m/s
Pitch Diameter	2983.5	mm
Bucket Length	1144.5	mm
Pitch Speed	468.7	m/s
Tip Speed	648.4	m/s
After leaving loss		
Pressure	0.0716	bar
Temperature	39.45	C
Enthalpy	2344.7	kJ/kg

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:13:26 G:\41\30763\Tech\HELE documentation\Model\USC model_wet cooling.stp
Program revision date: February 16, 2017
Steam source: Conventional boiler
Steam turbine: Single reheat condensing turbine 3000+3000/3000
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train
Cooling system: Water cooling with natural draft cooling tower
Steam Property Formulation: IFC-67

THERMAL OUTPUT

FWH1: Pump Forward

Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					LPT1 port (9)	**0.363**	**73.6**	**2526.1**	**58.43**	
Feedwater in	**21.6**	**40.1**	**169.7**	**1193.6**	**Steam in**	**0.3458**	**72.4**	**2523.7**	**58.43**	**72.4**
					Flash back			**314.9**	**219.6**	
					SSR seal steam			**3163.6**	**5.222**	
Feedwater out	**19.62**	**69.6**	**293.0**	**1193.6**	**Drain before pump**	**0.3458**	**72.4**	**303.1**	**283.3**	
					Drain to FWH2	**19.62**		**305.6**	**283.3**	

Terminal temperature difference =	2.77	C

FWH2: Flash Back with Drain Cooler

Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					LPT1 port (8)	**1.167**	**113.0**	**2700.4**	**69.06**	
FWH1 drain			**305.6**	**283.3**						
Feedwater in	**19.62**	**70.2**	**295.4**	**1476.8**	**Steam in**	**1.112**	**111.6**	**2698.1**	**69.06**	**102.6**
					Flash back			**439.6**	**150.5**	
Feedwater out	**17.71**	**99.8**	**419.6**	**1476.8**	**Drain to FWH1**	**1.112**	**75.2**	**314.9**	**219.6**	

Terminal temperature difference =	2.78	C
Drain cooler approach =	5.00	C

FWH3: Flash Back with Drain Cooler

Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					LPT1 port (7)	**3.083**	**205.1**	**2875.4**	**73.43**	
Feedwater in	**17.71**	**99.8**	**419.6**	**1476.8**	**Steam in**	**2.936**	**203.6**	**2873.0**	**73.43**	**132.8**
					Flash back			**568.0**	**77.12**	
Feedwater out	**16.18**	**130.0**	**547.3**	**1476.8**	**Drain to FWH2**	**2.936**	**104.8**	**439.6**	**150.5**	

Terminal temperature difference =	2.78	C
Drain cooler approach =	5.00	C

FWH4: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					LPT cross port (6)	7	296.5	3052.2	77.12	
Feedwater in	16.18	130.0	547.3	1476.8	Steam in	6.667	294.9	3049.8	77.12	163.0
Feedwater out	14.9	160.2	676.9	1476.8	Drain to FWH3	6.667	135.0	568.0	77.12	

Terminal temperature difference =	2.78	C
Drain cooler approach =	5.00	C

FWH5: Deaerator										
Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					IPT1 port (5)	13.04	375.4	3206.9	74.55	
Feedwater in	12.66	160.3	676.9	1476.8	Steam in	12.66	374.0	3204.6	74.55	190.4
					Flash back			863.3	312.2	
Feedwater out	12.66	190.4	809.2	1863.6						
Booster pump in	14.9	190.4	809.2	1863.6						
FW pump in	22.38	190.5	810.3	1863.6						
FW pump out	308.6	197.4	854.1	1863.6						

FWH6: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					IPT1 port (4)	22.9	454.3	3363.3	63.91	
Feedwater in	308.6	197.4	854.1	1863.6	Steam in	22.24	452.8	3360.9	63.91	217.8
					Flash back			967.5	248.3	
Feedwater out	308	220.1	953.7	1863.6	Drain to FWH5	22.24	202.4	863.3	312.2	

Terminal temperature difference =	-2.28	C
Drain cooler approach =	5.00	C

FWH7: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					Sup. cooler exit	41.42	302.4	2963.9	119.6	
Feedwater in	308	220.1	953.7	1863.6	Steam in	41.42	302.4	2963.9	119.6	252.4
					Flash back			1113.7	128.6	
Feedwater out	307.4	250.7	1091.9	1863.6	Drain to FWH6	41.42	225.1	967.5	248.3	

Terminal temperature difference =	1.67	C
Drain cooler approach =	5.00	C

FWH8: Flash Back with Drain Cooler

Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					HPT exit port (1)	**64.3**	**374.5**	**3104.0**	**128.6**	
Feedwater in	**307.4**	**250.7**	**1091.9**	**1863.6**	**Steam in**	**62.42**	**372.1**	**3101.7**	**128.6**	**278.1**
Feedwater out	**306.8**	**279.9**	**1229.2**	**1863.6**	**Drain to FWH7**	**62.42**	**255.7**	**1113.7**	**128.6**	

Terminal temperature difference =	-1.78	C
Drain cooler approach =	5.00	C

FWH9: Superheat Cooler

Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					IPT1 port (3)	**42.67**	**549.7**	**3555.2**	**119.6**	
Feedwater in	**306.8**	**279.9**	**1229.2**	**1863.6**	**Steam in**	**41.42**	**548.2**	**3552.9**	**119.6**	**252.4**
Feedwater out	**306.7**	**287.7**	**1267.0**	**1863.6**	**Drain to FWH7**	**41.42**	**302.4**	**2963.9**	**119.6**	
To boiler	**306.7**	**287.7**	**1267.0**	**1863.6**						

Total bleed steam for FWH system =	664.8	t/h	572024	kJ/s

DESIGN PARAMETERS OF FEEDWATER HEATERS		
FWH1: Pump Forward		
1. Heat transfer rate Q	40910	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	2717	W/m^2-K
4. Overall h.t.c. in drain cooling section	0	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1250	m^2
7. Drain cooler heat transfer area	0	m^2
8. Total heat transfer area	1250	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	15.875	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	15.2	m
13. No. of passes	2	
14. No. of tubes	1648	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.774	C
17. Drain cooler approach (DCA)	N/A	
FWH2: Flash Back with Drain Cooler		
1. Heat transfer rate Q	50934	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3092	W/m^2-K
4. Overall h.t.c. in drain cooling section	1452	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1291	m^2
7. Drain cooler heat transfer area	386	m^2
8. Total heat transfer area	1677	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	15.875	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	16.2	m
13. No. of passes	2	
14. No. of tubes	2076	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.775	C
17. Drain cooler approach (DCA)	5	C

FWH3: Flash Back with Drain Cooler		
1. Heat transfer rate Q	52389	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3415	W/m^2-K
4. Overall h.t.c. in drain cooling section	1313	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1211	m^2
7. Drain cooler heat transfer area	283	m^2
8. Total heat transfer area	1493	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	18.0	m
13. No. of passes	2	
14. No. of tubes	1388	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.777	C
17. Drain cooler approach (DCA)	5	C

FWH4: Flash Back with Drain Cooler		
1. Heat transfer rate Q	53164	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3644	W/m^2-K
4. Overall h.t.c. in drain cooling section	1017	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1173	m^2
7. Drain cooler heat transfer area	180	m^2
8. Total heat transfer area	1353	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	15.9	m
13. No. of passes	2	
14. No. of tubes	1426	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.778	C
17. Drain cooler approach (DCA)	5	C

FWH5: Deaerator		
1. Heat transfer rate Q	54289	kJ/s

FWH6: Flash Back with Drain Cooler (Each of FWH6A, FWH6B)		
1. Heat transfer rate Q	25765	kJ/s
2. Overall h.t.c. in desuperheating section	511	W/m^2-K
3. Overall h.t.c. in condensing section	3025	W/m^2-K
4. Overall h.t.c. in drain cooling section	1306	W/m^2-K
5. Desuperheater heat transfer area	99	m^2
6. Condensing section heat transfer area	891	m^2
7. Drain cooler heat transfer area	241	m^2
8. Total heat transfer area	1231	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	3.404	mm
12. Tube length per pass	9.1	m
13. No. of passes	2	
14. No. of tubes	2270	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	-2.277	C
17. Drain cooler approach (DCA)	5	C

FWH7: Flash Back with Drain Cooler (Each of FWH7A, FWH7B)		
1. Heat transfer rate Q	35785	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3021	W/m^2-K
4. Overall h.t.c. in drain cooling section	1115	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1096	m^2
7. Drain cooler heat transfer area	318	m^2
8. Total heat transfer area	1414	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	3.404	mm
12. Tube length per pass	10.0	m
13. No. of passes	2	
14. No. of tubes	2354	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	1.667	C
17. Drain cooler approach (DCA)	5	C

FWH8: Flash Back with Drain Cooler (Each of FWH8A, FWH8B)		
1. Heat transfer rate Q	35517	kJ/s
2. Overall h.t.c. in desuperheating section	911	W/m^2-K
3. Overall h.t.c. in condensing section	3008	W/m^2-K
4. Overall h.t.c. in drain cooling section	877	W/m^2-K
5. Desuperheater heat transfer area	95	m^2
6. Condensing section heat transfer area	1109	m^2
7. Drain cooler heat transfer area	187	m^2
8. Total heat transfer area	1391	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	3.404	mm
12. Tube length per pass	9.4	m
13. No. of passes	2	
14. No. of tubes	2468	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	-1.781	C
17. Drain cooler approach (DCA)	5	C

FWH9: Superheat Cooler (Each of FWH9A, FWH9B)		
1. Heat transfer rate Q	9789	kJ/s
2. Overall h.t.c. in desuperheating section	490	W/m^2-K
3. Overall h.t.c. in condensing section	0	W/m^2-K
4. Overall h.t.c. in drain cooling section	0	W/m^2-K
5. Desuperheater heat transfer area	209	m^2
6. Condensing section heat transfer area	0	m^2
7. Drain cooler heat transfer area	0	m^2
8. Total heat transfer area	209	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	22.225	mm
11. Tube wall thickness	4.191	mm
12. Tube length per pass	3.0	m
13. No. of passes	1	
14. No. of tubes	999	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	N/A	
17. Drain cooler approach (DCA)	N/A	

FWH Hardware	FWH 1	FWH 2	FWH 3	FWH 4	FWH 5	FWH 6	FWH 7	FWH 8	FWH 9
1. Type	P	D	D	D	C	D	D	D	S
2. Tube material	TP 304	TP 304	TP 304	TP 304		Carbon steel	Carbon steel	Carbon steel	Carbon steel
3. Tube outer diameter [mm]	15.88	15.88	19.05	19.05		19.05	19.05	19.05	22.23
4. Tube length (per pass) [m]	15.21	16.2	17.98	15.86		9.058	10.04	9.417	2.993
5. Number of tubes	1648	2076	1388	1426		2270	2354	2468	999
6. Total heat transfer area [m^2]	1250.1	1677.5	1493.5	1353.4		1230.6	1414.1	1390.9	208.7
7. Number of passes	2	2	2	2		2	2	2	1
8. Tube wall thickness [mm]	1.245	1.245	1.245	1.245		3.404	3.404	3.404	4.191
9. Tube pitch [mm]	23.02	23.02	27.62	27.62		23.81	25.72	23.81	30
10. Tube thermal cond. @ 300 F [W/m-C]	16.61	16.61	16.61	16.61		49.5	49.5	49.5	49.5
11. Tube thermal conductivity slope [W/m-C^2]	0.0125	0.0125	0.0125	0.0125		-0.0249	-0.0249	-0.0249	-0.0249
12. Fouling resistance [m^2-C/W]	0	0	0	0		0	0	0	0
13. Desuperheater heat transfer area [m^2]	0	0	0	0		98.93	0	95.03	208.7
14. Condensing heat transfer area [m^2]	1250.1	1291.2	1210.9	1173.5		890.6	1096.5	1109	0
15. Drain cooler heat transfer area [m^2]	0	386.3	282.5	179.9		241	317.6	186.9	0

FWH 1 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Pump Forward Heater				
Saturation temperature		72.42		
Inlet Steam & Flash In Streams				
Heating steam from LPT1 - Port 9	0.36	73.6	2526.1	58.430
Heating steam into heater (after piping)	0.35	72.4	2523.7	58.430
Flash in			314.9	219.600
Steam from Sealing Steam Regulator			3164.0	5.222
Exit Drain				
FWH 1 drain to FWH 2	0.35	72.4	303.1	283.300
Feedwater				
Feedwater into heater	21.60	40.1	169.7	1193.600
Feedwater leaving heater	19.62	69.7	293.0	1193.600

FWH 2 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Flash Back with Drain Cooler				
Saturation temperature		102.6		
Inlet Steam & Flash In Streams				
Heating steam from LPT1 - Port 8	1.17	113.0	2700.4	69.060
Heating steam into heater (after piping)	1.11	111.6	2698.1	69.060
Flash in			439.6	150.500
Exit Drain				
FWH 2 drain to FWH 1	1.11	75.2	314.9	219.600
Feedwater				
Drain from FWH1			305.6	283.300
Feedwater into heater	19.62	70.2	295.4	1476.800
Feedwater leaving heater	17.71	99.8	419.6	1476.800

FWH 3 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Flash Back with Drain Cooler				
Saturation temperature		132.8		
Inlet Steam & Flash In Streams				
Heating steam from LPT1 - Port 7	3.08	205.1	2875.4	73.430
Heating steam into heater (after piping)	2.94	203.6	2873.0	73.430
Flash in			568.0	77.120
Exit Drain				
FWH 3 drain to FWH 2	2.94	104.8	439.6	150.500
Feedwater				
Feedwater into heater	17.71	99.8	419.6	1476.800
Feedwater leaving heater	16.18	130.0	547.3	1476.800

FWH 4 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Flash Back with Drain Cooler				
Saturation temperature		163		
Inlet Steam & Flash In Streams				
Heating steam from LPT cross - Port 6	7.00	296.5	3052.0	77.120
Heating steam into heater (after piping)	6.67	294.9	3050.0	77.120
Exit Drain				
FWH 4 drain to FWH 3	6.67	135.0	568.0	77.120
Feedwater				
Feedwater into heater	16.18	130.0	547.3	1476.800
Feedwater leaving heater	14.90	160.2	676.9	1476.800

FWH 5 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Contact Heater				
Saturation temperature		190.4		
Inlet Steam & Flash In Streams				
Heating steam from IPT1 - Port 5	13.04	375.4	3207.0	74.550
Heating steam into heater (after piping)	12.66	374.0	3205.0	74.550
Flash in			863.3	312.200
Feedwater				
Feedwater into heater	12.66	160.3	676.9	1476.800
Feedwater leaving heater	12.66	190.4	809.2	1863.600
Boiler feedpump delivery	308.60	197.4	854.1	1863.600

FWH 6 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 6A & 6B)				
Type: Flash Back with Drain Cooler				
Saturation temperature		217.8		
Inlet Steam & Flash In Streams				
Heating steam from IPT1 - Port 4	22.90	454.3	3363.0	63.910
Heating steam into heater (after piping)	22.24	452.8	3361.0	63.910
Flash in			967.5	248.300
Exit Drain				
FWH 6 drain to FWH 5	22.24	202.4	863.3	312.200
Feedwater				
Feedwater into heater	308.60	197.4	854.1	1863.600
Feedwater leaving heater	308.00	220.1	953.7	1863.600

FWH 7 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 7A & 7B)				
Type: Flash Back with Drain Cooler				
Saturation temperature		252.4		
Inlet Steam & Flash In Streams				
Steam from superheat cooler exit	41.42	302.4	2963.9	119.600
Heating steam into heater (after piping)	41.42	302.4	2963.9	119.600
Flash in			1113.7	128.600
Exit Drain				
FWH 7 drain to FWH 6	41.42	225.1	967.5	248.300
Feedwater				
Feedwater into heater	308.00	220.1	953.7	1863.600
Feedwater leaving heater	307.40	250.7	1091.9	1863.600

FWH 8 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 8A & 8B)				
Type: Flash Back with Drain Cooler				
Saturation temperature		278.1		
Inlet Steam & Flash In Streams				
Heating steam from HPT exit - Port 1	64.30	374.5	3104.0	128.600
Heating steam into heater (after piping)	62.42	372.1	3102.0	128.600
Exit Drain				
FWH 8 drain to FWH 7	62.42	255.7	1113.7	128.600
Feedwater				
Feedwater into heater	307.40	250.7	1091.9	1863.600
Feedwater leaving heater	306.80	279.9	1229.2	1863.600

FWH 9 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 9A & 9B)				
Type: External Desuperheater				
Saturation temperature		252.4		
Inlet Steam & Flash In Streams				
Heating steam from IPT1 - Port 3	42.67	549.7	3555.0	119.600
Heating steam into heater (after piping)	41.42	548.2	3553.0	119.600
Exit Drain				
FWH 9 drain to FWH 7	41.42	302.4	2963.9	119.600
Feedwater				
Feedwater into heater	306.80	279.9	1229.2	1863.600
Feedwater leaving heater	306.70	287.7	1267.0	1863.600
Feedwater to boiler	306.70	287.7	1267.0	1863.600

CONDENSER: Water cooling with natural draft cooling tower				
	P	T	h	M
	bar	C	kJ/kg	t/h
LPT exhaust	**0.0716**	**39.45**	**2344.7**	**1059**
LPT SS to condenser			**3163.6**	**0.5443**
FPT exhaust	**0.0716**	**39.45**	**2410.7**	**133.4**
Drain from GSC	**0.827**	**94.47**	**395.5**	**0.6349**
Condenser in	**0.0716**	**39.45**	**2351.4**	**1193.6**
Condensate	**0.3707**	**39.45**	**165.2**	**1193.6**
Cooling water in	**3.366**	**26.13**	**109.8**	**53678**
Cooling water out	**2.495**	**37.79**	**158.4**	**53678**
Cooled water from cooling tower	1	26.12	109.5	53678
Before cooling water pump	1	26.12		53678
After cooling water pump	3.366	26.13	109.8	53678
Hot cooling water mixed from all condensers	2.495	37.79	158.4	53678
Hot water to cooling tower	1.897	37.80	158.4	53678
Condenser cooling water pump power =	4435	kW		
Main condenser heat rejection =	724868	kJ/s		

COOLING TOWER (Natural Draft)					
	P	T	Twet bulb	M	RH
	bar	C	C	t/h	%
Air in	**1.00**	**25.00**	**19.45**	**38092**	**60.0**
Air out	**1.00**	**34.47**	**34.47**	**38990**	**100.0**
Hot water in	**1.90**	**37.80**		**53678**	
Cold water out	**1.00**	**26.12**		**53678**	
Makeup				**1122.5**	
Blowdown				**224.5**	
Cooling tower heat rejection =		728999	kJ/s		
Range =		11.68	C		
Approach =		6.667	C		
Cycles of concentration =		5			

WCC		
Heat Balance		
Condenser pressure	0.0716	bar
Condenser saturation temperature	39.45	C
Heat rejection	724868	kW
Number of units	1	
Inlet Steam		
Pressure	0.0716	bar
Temperature	39.45	C
Mass flow	1193.6	t/h
Enthalpy	2351.4	kJ/kg
Condensate @ bottom of hotwell		
Pressure	0.3707	bar
Temperature	39.45	C
Mass flow	1193.6	t/h
Enthalpy	165.2	kJ/kg
Inlet Cooling Water		
Pressure	3.366	bar
Temperature	26.13	C
Mass flow	53678	t/h
Enthalpy	109.8	kJ/kg
Exit Cooling Water		
Pressure	2.495	bar
Temperature	37.79	C
Mass flow	53678	t/h
Enthalpy	158.4	kJ/kg
Flash-in Stream		
Temperature	15	C
Mass flow	0	t/h
Enthalpy	62.8	kJ/kg
Heat Transfer Data		
Fouling factor	0.026 * 10^-3	m^2-C/W
Cleanliness factor	90	%
Water velocity	1.999	m/s
Water Reynolds number	54033	
Water Prandtl number	5.173	
Water Nusselt number	271.2	
Condensing heat transfer coefficient	14200	W/m^2-C
Water-side heat transfer coefficient	8063	W/m^2-C
Sinlge tube overall heat transfer coefficient from hardware	3604	W/m^2-C
Tube bundle h.t.c. / Single tube h.t.c.	0.875	
Tube bundle overall heat transfer coefficient from hardware	3154	W/m^2-C
Condenser heat transfer calculation	Hardware model	
Tube bundle overall heat transfer coefficient from HEI method	N/A	
Overall UA	129390	kW/C
Water pressure drop in tubes/water box	0.8707	bar
Hardware		
Condenser type	Shell & tube	
Number of units	1	
1. Condenser Tube Description		
Effective surface area	41031	m^2
Number of condenser passes	2	
Tube material	Stainless steel (304)	
Number of tubes in condenser	44113	
Tube length	13.3	m
Tube outside diameter (O.D.)	22.23	mm
Tube inside diameter (I.D.)	20.8	mm
Tube wall thickness	0.7112	mm
Tube weight, dry	226,800	kg
Tube pitch	35.56	mm
2. Condenser Shell Description		
Shell material	Carbon steel	
Nominal shell thickness	15.88	mm
Number tube support plates	23	
Tube support plate spacing	0.55	m
Hotwell depth	0.87	m
Total dry weight	695,200	kg
Overall footprint area	168.7	m^2
Overall length	19.4	m
Overall width	8.7	m
Overall height	13.9	m

Design Point Heat Balance Results		
Water temperature range	11.68	C
Cold water approach to inlet wet bulb	6.667	C
Hot water approach to exit wet bulb	3.333	C
Air wet bulb temperature rise	15.02	C
Heat rejection	728999	kW
Inlet Water		
Pressure	1.897	bar
Temperature	37.8	C
Mass flow	53678	t/h
Enthalpy	158.4	kJ/kg
Exit Water		
Pressure	1	bar
Temperature	26.12	C
Mass flow	53678	t/h
Enthalpy	109.5	kJ/kg
Inlet Air		
Pressure	1	bar
Dry bulb temperature	25	C
Relative humidity	60	%
Wet bulb temperature	19.45	C
Mass flow	38092	t/h
Exit Air		
Pressure	1	bar
Dry bulb temperature	34.47	C
Relative humidity	100	%
Wet bulb temperature	34.47	C
Mass flow	38990	t/h
Plume visibility index (Plume invisible)	0	
Makeup & Blowdown		
Water evaporated	898	t/h
Blowdown	224.5	t/h
Blowdown temperature	26.35	C
Makeup water flow	1122.5	t/h
Makeup water temperature	15	C
Cycles of concentration	5	
Water flow in / Air flow in (L/G ratio)	1.409	
Hardware		
1. Estimated Major Dimensions		
Height		
Overall - ground to top	208.8	m
Throat - ground to throat	148.2	m
Above fill - top of fill to exit	199.6	m
Below fill - ground to top of fill	9.144	m
Diameter		
Base	93.85	m
Throat	52.14	m
Exit	61.11	m
Basin area	6918	m^2
Average shell thickness	457.2	mm
Tower includes flue gas connection		
2. Concrete		
Shell	23,770	m^3
Basin	2,180	m^3
Ring foundation	1,040	m^3
Total	26,990	m^3

Emissions	kg/hr	metric ton/year	kg/MWhr (gross)
Furnace Emissions			
NOx as NO2	0	0	0
SOx as SO2	2228.6	18051	3.299
CO2 (net)	505287	4092822	748
Particulate	15093	122256	22.34
Mercury as Hg	0	0	0
Electrostatic Precipitator Exit			
NOx as NO2	0	0	0
SOx as SO2	2228.6	18051	3.299
CO2 (net)	505287	4092822	748
Particulate	75.47	611.3	0.1117
Mercury as Hg	0	0	0
Plant Total Emissions			
NOx as NO2	0	0	0
SOx as SO2	2228.6	18051	3.299
CO2 (net)	505287	4092822	748
Particulate	75.47	611.3	0.1117
Mercury as Hg	0	0	0
Stack Levels	**ng/J HHV @25C**	**mg/Nm³**	**ppmv**
NOx as NO2	0	0 @ 6% O2, dry	0 @ 6% O2, dry
SOx as SO2	393.9	1169.3 @ 6% O2, dry	409.1 @ 6% O2, dry
Particulate	13.34	39.59 @ 6% O2, dry	
Mercury as Hg	0	0 @ 6% O2, dry	0 @ 6% O2, dry
Nm3 at 0 C, 101.325 kPa (32 F, 14.696 psia)			
Note:			
Boiler NOx emission is computed from the user-specified			
generation rate input on the Environment topic.			
The program DOES NOT predict NOx emissions.			
Therefore, it is incumbent on the user to input OEM-provided data			
consistent with equipment operation at this specific running condition.			

Plant Water/Steam Mass Flow Balance	Mass flow	
Mass Flow In	**1233.1**	**t/h**
Steam cycle makeup	0	t/h
Cooling tower makeup	1122.5	t/h
Wet air-cooled condenser makeup	0	t/h
Auxiliary cooling tower makeup	0	t/h
Total boiler desuperheating water from makeup	0	t/h
Total process steam desuperheating water from makeup	0	t/h
Total steam addition	0	t/h
Total water addition	0	t/h
Total external steam	0	t/h
Total process return	0	t/h
FGD makeup/cake wash	0	t/h
FGD water from reagent	0	t/h
FGD water from oxidation air	0	t/h
CO2 capture makeup	0	t/h
Water in combustion air	28.47	t/h
Water in fuel	9.387	t/h
Water from combustion of hydrogen in fuel	72.74	t/h
Seawater FGD evaporation	0	t/h
Mass Flow Out	**1233.1**	**t/h**
Cooling tower blowdown	224.5	t/h
Cooling tower water evaporation	898	t/h
Wet air-cooled condenser blowdown	0	t/h
Wet air-cooled condenser water evaporation	0	t/h
Auxiliary cooling tower blowdown	0	t/h
Auxiliary cooling tower water evaporation	0	t/h
Boiler blowdown to external sink	0	t/h
Total process steam	0	t/h
Total water extraction	0	t/h
FGD blowdown/stacking water	0	t/h
FGD water in byproduct	0	t/h
CO2 capture drain	0	t/h
CO2 capture water evaporation	0	t/h
CO2 capture water removed with CO2 stream	0	t/h
ST leakage to external sink	0	t/h
Water in flue gas at stack exit	110.6	t/h
Seawater FGD condensation	0	t/h

Plant Water Accounting	Current flow	% included		
Total Water Consumption			**1122.5**	**t/h**
Steam cycle makeup	0	100	0	t/h
Cooling tower makeup	1122.5	100	1122.5	t/h
Wet air-cooled condenser makeup	0	100	0	t/h
Auxiliary cooling tower makeup	0	100	0	t/h
FGD makeup/cake wash	0	100	0	t/h
CO2 capture makeup	0	100	0	t/h
Water addition 1	0	0	0	t/h
Water addition 2	0	0	0	t/h
Water addition 3	0	0	0	t/h
Process steam desuperheating water from makeup	0	100	0	t/h
Superheater desuperheating water from makeup	0	100	0	t/h
Reheater desuperheating water from makeup	0	100	0	t/h
LP reheater desuperheating water from makeup	0	100	0	t/h
Seawater FGD evaporation	0	0	0	t/h
Total Water Discharge			**224.5**	**t/h**
Cooling tower blowdown	224.5	100	224.5	t/h
Wet air-cooled condenser blowdown	0	100	0	t/h
Auxiliary cooling tower blowdown	0	100	0	t/h
Boiler blowdown to external sink	0	100	0	t/h
FGD blowdown/stacking water	0	100	0	t/h
CO2 capture drain	0	100	0	t/h
Water extraction 1	0	0	0	t/h
Water extraction 2	0	0	0	t/h
Water extraction 3	0	0	0	t/h
Seawater FGD condensation	0	0	0	t/h

ESP		
Heat Balance		
Flue Gas		
Flue gas inlet temperature	137.8	C
Flue gas outlet temperature	137.8	C
Flue gas mass flow (excluding particulate flow)	2,570	t/h
Flue gas volume flow	3,009,000	m^3/hr
Flue gas velocity	1.365	m/s
Performance		
Particulate collection efficiency	99.5	%
Inlet particulate load per energy input	2667.8	ng/J
Inlet particulate load per gas flow	7919	mg/Nm^3 @ 6% O2, dry
Outlet particulate load per energy input	13.34	ng/J
Outlet particulate load per gas flow	39.59	mg/Nm^3 @ 6% O2, dry
Inlet particulate flow	15.09	t/h
Particulate removal	15.02	t/h
Outlet particulate flow	0.0755	t/h
Pressure drop (including ductwork)	8.095	millibar
Electricity consumption	1566.7	kW
Flue gas SO2	402.7	ppm
Flue gas SO3 at inlet	2.014	ppm
Injected sulfur trioxide (SO3) for flue gas conditioning	0.1244	t/h
Flue gas SO3 after conditioning	20	ppm
Flue gas SO3 at exit	15	ppm
Heat loss	0	kW
Modified Deutsch-Anderson Equation		
Specific collecting area (SCA)	89.78	m^2 / m^3/s
Particulate resistivity	1.739188E+08	ohm-cm
Effective migration velocity	0.3062	m/s
Dimensionless K	0.5032	
Hardware		
Design collection efficiency	99.5	%
Design inlet temperature	137.8	C
Design flue gas mass flow	2,570	t/h
Design flue gas volume flow	3,009,000	m^3/hr
Design flue gas velocity	1.372	m/s
Overall Dimensions		
Number of chambers	3	
Number of fields	4	
Total length	30.8	m
Total width	68.67	m
Total height	20.58	m
Total weight	1,905,000	kg
Collecting Plates		
Design specific collecting area (SCA)	89.78	m^2 / m^3/s
Total collection surface area	75,050	m^2
Number of plates per chamber	62	
Collecting plates height	10.97	m
Collecting plates spacing	304.8	mm
Collecting plates bundle width per chamber	18.59	m
Collecting plates depth per field	4.671	m
Collecting length	18.68	m
Aspect ratio (Collecting length / Plate height)	1.703	

Heat Balance Results		
Boiler Feed Pump		
Type	Variable RPM	
Number per Boiler	1	
Number operating	1	
Suction Side (each)		
Pressure	22.38	bar
Temperature	190.5	C
Mass flow	1863.6	t/h
Enthalpy	810.3	kJ/kg
Density	876.2	kg/m^3
Delivery Side (each)		
Pressure	308.6	bar
Temperature	197.4	C
Mass flow	1863.6	t/h
Enthalpy	854.1	kJ/kg
Performance Data (each)		
Pump pressure rise	286.2 (3331)	bar (m)
Pressure rise after valve pressure drop	286.2 (3331)	bar (m)
Pump shaft speed	3000	RPM
Pump isentropic efficiency	74.45	%
Pump apparent isentropic efficiency	74.45	%
Pump hydraulic work	22715	kW
Pump mechanical efficiency	96.89	%
Pump shaft work	23445	kW
Boiler Feed Booster Pump		
Type	Fixed RPM	
Number per Boiler	1	
Number operating	1	
Suction Side (each)		
Pressure	14.9	bar
Temperature	190.4	C
Mass flow	1863.6	t/h
Enthalpy	809.2	kJ/kg
Density	875.8	kg/m^3
Delivery Side (each)		
Pressure	22.38	bar
Temperature	190.5	C
Mass flow	1863.6	t/h
Enthalpy	810.3	kJ/kg
Performance Data (each)		
Pump pressure rise	7.473 (87.01)	bar (m)
Pressure rise after valve pressure drop	7.473 (87.01)	bar (m)
Pump shaft speed	600	RPM
Pump isentropic efficiency	83.55	%
Pump apparent isentropic efficiency	83.55	%
Pump hydraulic work	528.6	kW
Pump mechanical efficiency	96.93	%
Pump shaft work	545.3	kW
Recirculation ratio	0	
Recirculation cooling load	0	kW
Motor efficiency	96.12	%
Electricity consumption	567.3	kW
Condenser C.W. Pump		
Type	Fixed RPM	
Number per ST	8	
Number operating	8	
Suction Side (each)		
Pressure	1	bar
Temperature	26.12	C
Mass flow	6710	t/h
Enthalpy	109.5	kJ/kg
Density	996.9	kg/m^3
Delivery Side (each)		
Pressure	3.366	bar
Temperature	26.13	C
Mass flow	6710	t/h
Enthalpy	109.8	kJ/kg
Performance Data (each)		
Pump pressure rise	2.366 (24.2)	bar (m)
Pressure rise after valve pressure drop	2.366 (24.2)	bar (m)
Pump shaft speed	500	RPM
Pump isentropic efficiency	85.65	%
Pump apparent isentropic efficiency	85.65	%

Heat Balance Results		
Pump hydraulic work	516.5	kW
Pump mechanical efficiency	96.93	%
Pump shaft work	532.9	kW
Recirculation ratio	0	
Recirculation cooling load	0	kW
Motor efficiency	96.11	%
Electricity consumption	554.4	kW
Condensate Forwarding Pump		
Type	Fixed RPM	
Number per ST	2	
Number operating	1	
Suction Side (each)		
Pressure	0.3707	bar
Temperature	39.45	C
Mass flow	1193.6	t/h
Enthalpy	165.2	kJ/kg
Density	992.5	kg/m^3
Delivery Side (each)		
Pressure	21.6	bar
Temperature	39.72	C
Mass flow	1193.6	t/h
Enthalpy	168.2	kJ/kg
Performance Data (each)		
Pump pressure rise	25.09 (257.7)	bar (m)
Pressure rise after valve pressure drop	21.23 (218.1)	bar (m)
Pump shaft speed	1500	RPM
Pump isentropic efficiency	83.55	%
Pump apparent isentropic efficiency	70.71	%
Pump hydraulic work	1003	kW
Pump mechanical efficiency	96.93	%
Pump shaft work	1034.7	kW
Recirculation ratio	0	
Recirculation cooling load	0	kW
Motor efficiency	96.5	%
Electricity consumption	1072.2	kW
District Heating Pump	**None**	

PIPES	
Pipe name	Pressure loss
	bar
BLR to HPT	4.14
Cold Reheat	1.26
Hot Reheat	1.20
Main Circulating Water	0.60
FWH 1 Heating	0.02
FWH 2 Heating	0.06
FWH 3 Heating	0.15
FWH 4 Heating	0.33
Deaerator (FWH 5) Heating	0.38
FWH 6 Heating	0.67
FWH 8 Heating	1.87
FWH 9 Heating	1.24
FPT Main Steam	0.33
FPT Exhaust (to condenser)	0.00
* Non-heat balance pipes are shown in PEACE output	

Project Cost Summary	Reference Cost	Estimated Cost	
Power Plant:			
I Specialized Equipment	341,908,000	444,481,000	USD
II Other Equipment	110,414,000	143,538,000	USD
III Civil	63,370,000	102,339,000	USD
IV Mechanical	183,610,000	321,495,000	USD
V Electrical Assembly & Wiring	12,894,000	24,219,000	USD
VI Buildings & Structures	18,708,000	31,103,000	USD
VII Engineering & Plant Startup	53,757,000	54,590,000	USD
CO2 Capture Plant	NA	NA	
Desalination Plant	NA	NA	
Subtotal - Contractor's Internal Cost	784,661,000	1,121,765,000	USD
VIII Contractor's Soft & Miscellaneous Costs	129,622,000	211,664,000	USD
Contractor's Price	914,283,000	1,333,429,000	USD
IX Owner's Soft & Miscellaneous Costs	182,857,000	266,686,000	USD
Total - Owner's Cost (1 USD per US Dollar)	1,097,140,000	1,600,115,000	USD
Nameplate Net Plant Output	650	650	MW
Cost per kW - Contractor's	1406.6	2051.5	USD per kW
Cost per kW - Owner's	1687.9	2461.8	USD per kW
* Cost estimates as of August 2016.			
** Land cost, utility connection cost, and spare parts costs are zero.			
The user may want to edit those inputs for better cost estimates.			

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
I Specialized Equipment (USD)				341,908,000	444,481,000
1. Boiler		179,784,000	1	179,784,000	233,719,000
Furnace (incl. radiant platens)	62,750,000				
Convective Elements (incl. interconnecting piping)	66,902,000				
Additional Waterwall	5,513,000				
Soot Blowers	5,129,000				
Desuperheaters and Controls	7,458,000				
Air and Flue Gas Ducts	5,633,000				
Coal Pulverisers and Feeders	17,145,000				
FD Fan, PA Fan, ID Fan	1,671,000				
Structural Steel, Ladders, Walkways	3,235,000				
Steam Air Heater					
Rotary Air Heaters	4,349,000				
Approximate shipping to typical US site	incl.				
2. Steam Turbine Package		94,021,000	1	94,021,000	122,227,000
Turbine	incl.				
Generator	incl.				
Exhaust System	incl.				
Electrical/Control/Instrumentation Package	incl.				
Lube Oil Package w/ main, auxiliary & emergency pump	incl.				
High Voltage Generator					
Approximate shipping to typical US site	incl.				
3. Feedwater Heaters			13	9,230,000	11,999,000
Feedwater Heater 1-P	701,700		1		
Feedwater Heater 2	647,700		1		
Feedwater Heater 3	586,100		1		
Feedwater Heater 4	536,500		1		
Feedwater Heater 5-DA	960,600		1		
Feedwater Heater 6 (6A, 6B)	687,400		2		
Feedwater Heater 7 (7A, 7B)	811,900		2		
Feedwater Heater 8 (8A, 8B)	822,600		2		
Feedwater Heater 9-S (9A, 9B)	576,800		2		
Feedwater Heater 10					
Feedwater Heater 11					
Feedwater Heater 12					
4. Water-cooled Condensers			1	8,679,000	11,283,000
Water-cooled Condenser 1	8,679,000		1		
Water-cooled Condenser 2					
Water-cooled Condenser 3					
Water-cooled Condenser 4					
Water-cooled Condenser 5					
Water-cooled Condenser 6					
Feed Pump Turbine Water-cooled Condenser					
5. Air-cooled Condenser					
Tube Bundles					
Fans, Gears, and Motors					
Steam Duct & Condenser					
Turbine Exhaust Transition					
Steam Jet Air Ejector					
Condensate Receiver Tank					
Support Structures					
Approximate shipping to typical US site					
6. Particulate and Mercury Control		18,158,000	1	18,158,000	23,605,000
Electrostatic Precipitator (ESP)	incl.				
Active Carbon Injection Equipment					
Ductwork	incl.				
Instruments & Controls	incl.				
Approximate shipping to typical US site	incl.				
7. Flue Gas Desulfurization					
Reagent Feed System					
Absorber Tower & Ancillaries					
Active Carbon Injection Equipment					
Slurry Pumps					
Flue Gas Handling System					
Flue Gas Reheater					
Waste/Byproduct Handling System					
Support Equipment					
8. Nitrogen Oxide Control (SCR)					
9. Stack		10,997,000	1	10,997,000	14,296,000
10. Continuous Emissions Monitoring System		373,300	1	373,300	485,300
Enclosures	incl.				
Electronics, Display Units, Printers & Sensors	incl.				
11. Distributed Control System		1,442,000	1	1,442,000	1,875,000
Enclosures	incl.				
Electronics, Display Units, Printers & Sensors	incl.				
Approximate shipping to typical US site					
12. Transmission Voltage Equipment		11,316,000	1	11,316,000	14,710,000
Transformers	9,816,000				
Circuit Breakers	961,000				
Miscellaneous Equipment	538,800				
Approximate shipping to typical US site	incl.				
13. Generating Voltage Equipment		7,908,000	1	7,908,000	10,280,000
Generator Buswork	4,452,000				
Circuit Breakers	3,079,000				

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
Current Limiting Reactors					
Miscellaneous Equipment	376,550				
Approximate shipping to typical US site	incl.				
14. User-defined				**0**	**0**

	Unit Cost	Quantity	Ref. Cost	Est. Cost
II Other Equipment (USD)			**110,414,000**	**143,538,000**
1. Pumps			**11,478,000**	**14,922,000**
Boiler Feed Pump (turbine included)	7,330,000	1	7,330,000	9,529,000
Boiler Feed Booster Pump	125,450	1	125,450	163,100
Condenser C.W. Pump	290,350	8	2,323,000	3,020,000
Condensate Forwarding Pump	219,950	2	439,900	571,800
Condenser Vacuum Pump	164,600	2	329,200	427,950
Fuel Oil Unloading Pump	8,490	1	8,490	11,030
Fuel Oil Forwarding Pump	5,670	2	11,340	14,740
Aux Cooling Water Pump (closed loop)	18,970	2	37,950	49,330
Treated Water Pump	5,900	1	5,900	7,660
Diesel Fire Pump	72,800	3	218,450	284,000
Electric Fire Pump				
Jockey Fire Pump	4,220	1	4,220	5,490
ST+Generator Lube Oil Coolant Pump				
ST Generator Coolant Pump				
Demin Water Pump	5,840	2	11,670	15,170
Raw Water Pump 1	5,600	1	5,600	7,280
Raw Water Pump 2	5,600	1	5,600	7,280
Raw Water Pump 3				
District Heating Pump				
Aux Cooling Water Pump (open loop)	18,970	2	37,950	49,330
FGD Slurry Pump	elsewhere			
Startup Boiler Feed Pump	584,300	1	584,300	759,500
2. Tanks		**7**	**523,700**	**680,800**
Fuel Oil	183,000	1	183,000	237,900
Hydrous Ammonia				
Demineralized Water	49,570	1	49,570	64,450
Raw Water	49,570	1	49,570	64,450
Neutralized Water	34,280	1	34,280	44,570
Acid Storage	7,150	1	7,150	9,290
Caustic Storage	7,150	1	7,150	9,290
Waste Water				
Dedicated Fire Protection Water Storage	193,000	1	193,000	250,900
3. Cooling Tower	**41,948,000**	**1**	**41,948,000**	**54,533,000**
4. Auxiliary Heat Exchangers			**129,800**	**168,750**
Auxiliary Cooling Water Heat Exchanger	129,800	1	129,800	168,750
Auxiliary Cooling Tower				
Primary Air Fan Fin Fan Cooler				
Induced Draft Fan Fin Fan Cooler				
Miscellaneous Heat Exchangers				
5. District Heaters				
District Heater 1				
District Heater 2				
6. Auxiliary Boiler				
7. Makeup Water Treatment System	**1,299,000**	**1**	**1,299,000**	**1,688,000**
8. Waste Water Treatment System	**165,800**	**1**	**165,800**	**215,550**
9. Bridge Crane(s)	**1,838,000**	**1**	**1,838,000**	**2,390,000**
Steam Turbine Crane				
10. Station/Instrument Air Compressors	**156,400**	**5**	**782,100**	**1,017,000**
11. Reciprocating Engine Genset(s)		**6**	**13,551,000**	**17,616,000**
Emergency Generator	810,700	1	810,700	1,054,000
Black Start Generator	2,548,000	5	12,740,000	16,562,000
12. General Plant Instrumentation	**370,650**	**1**	**370,650**	**481,850**
13. Medium Voltage Equipment	**4,462,000**	**1**	**4,462,000**	**5,801,000**
Transformers	584,300			
Circuit Breakers	132,850			
Switchgear	1,393,000			
Motor Control Centers	2,139,000			
Miscellaneous	212,450			
14. Low Voltage Equipment	**719,100**	**1**	**719,100**	**934,800**
Transformers	246,250			
Circuit Breakers	240,450			
Switchgear				
Motor Control Centers	198,200			
Miscellaneous	34,240			
15. Coal Handling Equipment	**23,590,000**	**1**	**23,590,000**	**30,666,000**
16. Ash Handling Equipment	**4,299,000**	**1**	**4,299,000**	**5,588,000**
17. Miscellaneous Equipment	**5,258,000**		**5,258,000**	**6,835,000**
18. User-defined			**0**	**0**

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
III Civil (USD)						63,370,000	102,339,000
1. Site Work	8,479,000	145,250	36			13,708,000	21,611,000
Site Clearing	incl.	incl.					
Demolition	incl.	incl.					
Culverts & Drainage	incl.	incl.					
Erosion Control	incl.	incl.					
Fencing, Controlled Access Gates	incl.	incl.					
Finish Grading	incl.	incl.					
Finish Landscaping	incl.	incl.					
Material (Dirt, Sand, Stone)	incl.	incl.					
Waste Material Removal	incl.	incl.					
Obstacles R&R	incl.	incl.					
Miscellaneous	incl.	incl.					
2. Excavation & Backfill	1,706,000	36,960	36	67.73	44,840 m^3	3,037,000	4,913,000
Steam Turbine	162,250	3,550	36	67.36	4,310 m^3	290,050	469,750
Boiler	852,900	18,770	36	68.98	22,160 m^3	1,529,000	2,477,000
Stack	elsewhere	elsewhere					
Water Cooled Condenser(s)	138,200	2,980	36	63.63	3,860 m^3	245,650	397,200
Cooling Tower							
Air Cooled Condenser							
Particulate and Mercury Control	76,050	1,690	36	71.42	1,910 m^3	136,750	221,750
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Feedwater Heaters	23,100	663	36	64.5	728 m^3	46,950	78,350
District Heater(s)							
Underground Piping	261,250	4,890	36	67.33	6,490 m^3	437,250	696,000
Switchyard	5,130	113	36	90.63	102 m^3	9,220	14,950
Miscellaneous	187,350	4,300	36	64.98	5,270 m^3	342,350	557,400
3. Concrete	24,909,000	580,100	36	1,370	33,420 m^3	45,793,000	74,671,000
Steam Turbine	2,781,000	57,400	36	2,090	2,310 m^3	4,848,000	7,801,000
Laydown pads:	55,050	1,570	36		77.86 m^3	111,650	186,250
Steam Turbine	55,050	1,570	36	1,430	77.86 m^3	111,650	186,250
Boiler	10,939,000	250,600	36	1,380	14,430 m^3	19,962,000	32,491,000
Stack	elsewhere	elsewhere					
Water Cooled Condenser(s)	1,090,000	27,550	36	1,440	1,440 m^3	2,082,000	3,425,000
Cooling Tower							
Air Cooled Condenser							
Particulate and Mercury Control	490,300	11,440	36	1,150	788 m^3	902,100	1,471,000
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Underground Piping:	197,800	6,520	36		246 m^3	432,550	732,500
Circulating Water	197,800	6,520	36	1,760	246 m^3	432,550	732,500
Miscellaneous							
Makeup Water Treatment System	18,580	574	36	1,780	22.02 m^3	39,230	65,950
Auxiliary Boiler							
Electrical Power Equipment	1,074,000	27,170	36	1,390	1,470 m^3	2,052,000	3,377,000
Feedwater Heaters	186,000	7,140	36	901	492 m^3	442,950	762,100
Pumps	658,100	19,260	36	1,740	778 m^3	1,352,000	2,260,000
Auxiliary Heat Exchangers							
District Heater(s)							
Station/Instrument Air Compressors	87,400	2,250	36	2,800	60.13 m^3	168,400	277,700
Bridge Crane(s)							elsewhere
Reciprocating Engine Genset(s)	498,600	13,350	36	1,470	664 m^3	979,400	1,622,000
Tanks:	340,250	10,310	36		558 m^3	711,300	1,194,000
Fuel Oil	139,400	4,020	36	1,100	258 m^3	284,050	474,150
Hydrous Ammonia							
Demineralized Water	29,270	930	36	1,620	38.65 m^3	62,750	105,850
Raw Water	29,270	930	36	1,620	38.65 m^3	62,750	105,850
Neutralized Water	19,810	652	36	2,200	19.65 m^3	43,270	73,250
Acid Storage	4,360	146	36	2,460	3.921 m^3	9,630	16,330
Caustic Storage	4,360	146	36	2,460	3.921 m^3	9,630	16,330
Waste Water							
Dedicated Fire Protection Water Storage	113,800	3,480	36	1,220	196 m^3	239,250	401,950
Switchyard	52,350	1,560	36	1,350	80.41 m^3	108,400	181,600
Fuel Handling System	4,177,000	90,650	36	1,070	6,960 m^3	7,440,000	12,037,000
Miscellaneous	2,264,000	52,750	36	1,370	3,040 m^3	4,163,000	6,788,000
4. Roads, Parking, Walkways	747,500	2,270	37.65			832,800	1,144,000
Pavement, Curbing, Striping	612,900	1,640	36	4.2	14854	672,000	916,400
Lighting	134,650	623	42	5,740	28	160,800	228,000
5. User-defined						0	0

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
IV Mechanical (USD)						**183,610,000**	**321,495,000**
1. On-Site Transportation & Rigging	**9,856,000**					**9,856,000**	**16,386,000**
2. Equipment Erection & Assembly	**16,486,000**	**2,236,000**	**41**			**108,150,000**	**207,052,000**
Steam Turbine Package	469,200	64,050	41	3,095,000	1	3,095,000	5,927,000
Boiler	10,324,000	1,409,000	41	68,094,000	1	68,094,000	130,406,000
Feedwater Heaters	70,100	9,570	41			462,400	885,500
Condenser(s)	92,000	12,560	41			606,900	1,162,000
Cooling Tower	elsewhere	elsewhere					
Particulate and Mercury Control	2,147,000	293,100	41	14,164,000	1	14,164,000	27,125,000
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Coal Handling System	914,400	124,800	41	6,032,000	1	6,032,000	11,551,000
Ash Handling System	868,600	118,550	41	5,729,000	1	5,729,000	10,972,000
Makeup Water Treatment System	145,050	6,340	41			404,800	714,600
Auxiliary Boiler							
Electrical Power Equipment	174,200	23,780	41			1,149,000	2,201,000
Pumps	67,850	9,260	41			447,600	857,200
Tanks + Auxiliary Heat Exchangers	42,270	5,770	41			278,800	533,900
District Heater(s)							
Station/Instrument Air Compressors	5,900	805	41			38,900	74,500
Bridge Crane(s)	9,620	1,310	41			63,450	121,450
Reciprocating Engine Genset(s)	6,000	819	41			39,580	75,800
Miscellaneous	1,150,000	156,000	41			7,545,000	14,445,000
3. Piping	**46,586,000**	**413,450**	**41**	**2,860**	**22,210 m**	**63,537,000**	**94,889,000**
High Pressure Steam	8,336,000	22,820	41	43,330	214 m	9,272,000	12,732,000
Cold Reheat Steam	2,111,000	19,580	41	16,340	178 m	2,914,000	4,370,000
Hot Reheat Steam	5,272,000	33,030	41	28,610	232 m	6,626,000	9,596,000
FWH Heating Steam	1,873,000	20,420	41	5,090	532 m	2,710,000	4,131,000
Other Steam & Heating	3,329,000	18,500	41	34,210	119 m	4,088,000	5,864,000
Feedwater	8,906,000	40,740	41	18,160	582 m	10,576,000	14,960,000
Circulating Water	3,563,000	19,790	41	3,630	1,200 m	4,374,000	6,275,000
Auxiliary Cooling Water	439,950	11,950	41	967	961 m	929,900	1,564,000
Other Water	21,360	1,370	41	217	358 m	77,550	141,550
Raw Water	138,150	5,590	41	518	710 m	367,300	643,600
Service Water	267,700	10,240	41	566	1,210 m	687,700	1,199,000
Fuel Gas							
Fuel Oil							
Service Air	169,650	5,190	41	420	910 m	382,250	651,100
Vacuum Air	111,700	2,310	41	1,980	104 m	206,300	336,750
Ammonia							
Boiler & Equipment Drain	4,954,000	126,350	41	908	11,160 m	10,134,000	16,929,000
Boiler Blowdown							
Steam Blowoff	243,500	2,600	41	7,000	49.99 m	349,950	532,100
Fire Protection	3,599,000	44,150	41	2,550	2,120 m	5,409,000	8,344,000
Miscellaneous	3,250,000	28,850	41	2,860	1,550 m	4,433,000	6,620,000
4. Steel	**1,398,000**	**16,270**	**41**	**4,950**	**417**	**2,065,000**	**3,169,000**
Racks, Supports, Ladders, Walkways, Platforms	1,398,000	16,270	41	4,950	417	2,065,000	3,169,000
5. User-defined						**0**	**0**

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
V Electrical Assembly & Wiring (USD)						**12,894,000**	**24,219,000**
1. Controls	**568,200**	**194,400**	**42**			**8,732,000**	**17,271,000**
Steam Turbine Package	77,250	27,450	42	1,230,000	1	1,230,000	2,435,000
Boiler	344,850	122,550	42	5,491,000	1	5,491,000	10,869,000
Feedwater Heaters	2,180	776	42			34,770	68,800
Condenser(s)	6,240	2,220	42			99,300	196,600
Cooling Tower	elsewhere	elsewhere					
Particulate and Mercury Control	43,410	15,430	42	691,300	1	691,300	1,368,000
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Coal Handling System	28,480	10,120	42	453,500	1	453,500	897,700
Ash Handling System	27,050	9,610	42	430,800	1	430,800	852,700
Makeup Water Treatment System	3,570	1,270	42			56,800	112,400
Auxiliary Boiler							
Electrical Power Equipment							
Pumps	11,170	3,970	42			177,900	352,100
Tanks + Auxiliary Heat Exchangers							
District Heater(s)							
Station/Instrument Air Compressors	8,090	345	42			22,580	39,860
Bridge Crane(s)	7,700	328	42			21,480	37,910
Reciprocating Engine Genset(s)	8,230	351	42			22,970	40,550
2. Assembly & Wiring	**2,041,000**	**50,500**	**42**			**4,162,000**	**6,948,000**
Switchgear	37,330	2,680	42	25,000	6	150,000	276,700
Motor Control Centers	62,650	2,780	42	3,990	45	179,500	318,050
Feeders	395,150	11,020	42	8,940	96	857,800	1,451,000
Medium/Low Voltage Cable Bus	813,300	13,420	42	25,980	53	1,377,000	2,198,000
Cable Tray	201,800	4,260	42	380,550	1	380,550	624,300
General Plant Instrumentation	178,300	3,190	42	1,380	227	312,400	503,400
Generator to Step-up Transformer Bus	40,650	722	42	71,000	1	71,000	114,250
Transformers	134,650	7,180	42	87,200	5	436,100	785,500
Circuit Breakers	76,450	2,720	42	27,230	7	190,600	330,500
Miscellaneous	100,850	2,530	42	207,250	1	207,250	346,600
3. User-defined						**0**	**0**

	Area	Cost/Unit Area	Ref. Cost	Est. Cost
VI Buildings (USD)			18,708,000	31,103,000
1. Boiler House and Turbine Hall	9357	1811.29	16,948,000	28,176,000
2. Administration, Control Room, Machine Shop / Warehouse	1486.5	1150.46	1,710,000	2,843,000
3. Water Treatment System	23.21	1200.49	27,860	46,320
4. Guard House	18.58	1200.48	22,310	37,080
5. Fuel Barn				
6. User-defined			0	0

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
VII Engineering & Plant Startup (USD)						53,757,000	54,590,000
1. Engineering						44,037,000	44,037,000
2. Start-Up	2,778,000	76,200	91.07	9,720,000		9,720,000	10,553,000
3. User-defined						0	0

	Ref. Cost	Est. Cost
VIII Soft & Miscellaneous Costs (USD)		
1. Contractor's Soft Costs	**129,622,000**	**211,664,000**
Contingency:	39,034,000	67,496,000
Labor	23,106,000	46,789,000
Specialized Equipment	6,838,000	8,890,000
Other Equipment	3,312,000	4,306,000
Commodity	5,778,000	7,511,000
Profit:	59,201,000	99,297,000
Labor	30,807,000	62,385,000
Specialized Equipment	17,095,000	22,224,000
Other Equipment	5,521,000	7,177,000
Commodity	5,778,000	7,511,000
Permits, Licenses, Fees, Miscellaneous	0	0
Bonds and Insurance	7,847,000	11,218,000
Spare Parts & Materials	0	0
Contractor's Fee	23,540,000	33,653,000
2. Owner's Soft Costs	**182,857,000**	**266,686,000**
Permits, Licenses, Fees, Miscellaneous	18,286,000	26,669,000
Land Cost	0	0
Utility Connection Cost	0	0
Legal & Financial Costs	18,286,000	26,669,000
Escalation and Interest During Construction	137,142,000	200,014,000
Spare Parts & Materials	0	0
Project Administration & Developer's Fee	9,143,000	13,334,000
3. Total of all user-defined costs displayed on each account	**0**	**0**

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
CO2 Capture Plant (USD)				**0**	**0**
1. CO2 Capture					
Absorbers					
Strippers					
CO2 compressors and dehydrators					
Heat exchangers					
Pumps					
Piping					
Electrical & Controls					
Engineering & Design					
Miscellaneous					
Approximate shipping to typical US site					
2. User-defined				**0**	**0**

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
Desalination Plant (USD)				**0**	**0**
1. Desalination					
MSF System					
- Evaporators					
- Brine Heater					
- Deaerator					
- Pumps					
- Piping					
- Electrical & Controls					
- Intake System & Distillate Delivery					
- Engineering & Design					
- Platform/ladder/walkway					
- Miscellaneous					
RO System					
- Intake & Outfall					
- Pre-treatment System					
- Pumps					
- Energy Recovery Device					
- RO Membrane Assembly					
- Post-treatment System					
- Miscellaneous					
Approximate shipping to typical US site					
2. User-defined				**0**	**0**

Estimated Site Plan Data		
1. Site Plot Plan		
Length	428	m
Width	392	m
Area	16.79	hectare
2. Boiler House and Turbine Hall		
Area	9,360	m^2
3. Switchyard		
Length	117	m
Width	74.9	m
Area	8,760	m^2
4. Water Treatment Facility		
Length	6.8	m
Width	3.4	m
Area	23.21	m^2
5. Administration, Shop & Warehouse Building		
Length	35.2	m
Width	14.1	m
Area	1,490	m^2
Number of Floors	3	
6. Road		
Length	847	m
Width	7.6	m
Area	6,460	m^2
7. Parking Lot		
Number of Parking Spaces	16	
Total Width	48.8	m
Depth of Parking Space	6.1	m
Total Area	297	m^2
8. Walkways		
Area	8,400	m^2
9. Guard House		
Area	18.58	m^2

Estimated Piping Data	ID x No.	Nom. D [mm]	Length [m]	Schedule	Material	Fittings	M [t/h]	Design Flow	Design Vel. [m/s]
1. High Pressure Steam Piping									
BLR to HPT	HP0 x 1	450.9	169.5	Custom	TP347HFG	8	1863.6	6.491 m^3/s	41.22 m/s
HP Bypass	HPBP x 1	450.9	44.5	Custom	TP347HFG	3	1863.6	6.491 m^3/s	41.22 m/s
2. Cold Reheat Steam Piping									
Cold Reheat	CRH0 x 1	717.6	178.3	Custom	P-22	8	1689.2	19.45 m^3/s	48.99 m/s
3. Hot Reheat Steam Piping									
Hot Reheat	HRH0 x 1	800.1	187.1	Custom	TP347HFG	8	1689.2	30.18 m^3/s	61.17 m/s
IP Bypass	IPBP x 1	800.1	44.5	Custom	TP347HFG	3	1689.2	30.18 m^3/s	61.17 m/s
4. FWH Heating Steam Piping									
FWH 1 Heating	FWHHS1 x 1	914.4	12.19	10	A-106	4	58.43	71.7 m^3/s	117.3 m/s
FWH 2 Heating	FWHHS2 x 1	762	24.08	10	A-106	6	69.06	28.85 m^3/s	67.16 m/s
FWH 3 Heating	FWHHS3 x 1	508	35.97	40	A-106	8	73.43	14.38 m^3/s	83.44 m/s
FWH 4 Heating	FWHHS4 x 1	406.4	47.85	40	A-106	10	77.12	7.903 m^3/s	71.93 m/s
Deaerator (FWH 5) Heating	FWHHS5 x 1	406.4	101.8	40	A-106	19	74.55	4.657 m^3/s	41.77 m/s
FWH 6 Heating	FWHHS6 x 2	203.2	41.76	40	P-11	9	31.95	1.271 m^3/s	39.84 m/s
FWH 8 Heating	FWHHS8 x 2	203.2	53.65	60	P-22	11	64.32	0.7407 m^3/s	24.08 m/s
FWH 9 Heating	FWHHS9 x 2	203.2	59.74	60	P-91	12	59.82	1.44 m^3/s	47.56 m/s
5. Other Steam & Heating Piping									
FPT Main Steam	FPTMS1 x 1	508	72.85	40	A-106	9	133.4	13.67 m^3/s	79.75 m/s
FPT Exhaust (to condenser)	FPTX1 x 1	3658	46.63	20	A-106	5	133.4	752.1 m^3/s	75.22 m/s
6. Feedwater Piping									
FWH 1 Exit Feedwater	FWFW1 x 1	457.2	19.81	20	A-106	2	1193.6	20325 lpm	2.214 m/s
FWH 2 Exit Feedwater	FWFW2 x 1	508	21.34	20	A-106	2	1476.8	25665 lpm	2.278 m/s
FWH 3 Exit Feedwater	FWFW3 x 1	609.6	23.17	20	A-106	2	1476.8	26318 lpm	1.601 m/s
FWH 4 Exit Feedwater	FWFW4 x 1	609.6	101.8	20	A-106	11	1476.8	27121 lpm	1.65 m/s
Deaerator (FWH 5) Exit Feedwater	FWFW5 x 1	609.6	101.8	20	A-106	11	1863.6	35377 lpm	2.151 m/s
FWH 6 Exit Feedwater	FWFW6 x 2	406.4	13.72	Custom	A-106	2	931.8	17988 lpm	2.311 m/s
FWH 7 Exit Feedwater	FWFW7 x 2	419.1	14.94	Custom	A-106	2	931.8	18809 lpm	2.272 m/s
FWH 8 Exit Feedwater	FWFW8 x 2	431.8	14.33	Custom	A-106	2	931.8	19797 lpm	2.253 m/s
FWH 9 Exit Feedwater	FWFW9 x 2	431.8	7.62	Custom	A-106	2	931.8	20107 lpm	2.289 m/s
Feedwater to Boiler	FW3 x 1	609.6	173.4	Custom	A-106	14	1863.6	40215 lpm	2.297 m/s
Condensate	FW1 x 1	457.2	39.93	20	A-106	14	1193.6	20030 lpm	2.182 m/s
7. Circulating Water Piping									
Main Circulating Water	CW0 x 3	1524	401.4	150psi	Ductile iron	12	18050	302888 lpm	2.72 m/s
8. Auxiliary Cooling Water Piping									
CW for ST+Generator Lube Oil	CW7 x 1	152.4	177.1	40	A-106	20	152.1	2541.1 lpm	2.272 m/s
CW for ST Generator	CW8 x 1	254	177.1	40	A-106	20	318.3	5319 lpm	1.743 m/s
Main Auxiliary CW	CW1 x 1	304.8	607.2	40	A-106	5	470.4	7860 lpm	1.814 m/s
9. Other Water Piping									
Makeup from Water Treatment System	FW2 x 1	63.5	358.1	40	A-106	14	22.26	371.3 lpm	2.003 m/s
10. Raw Water Piping									
Raw Water	RW0 x 1	88.9	709.6	40	A-106	118	22.26	371.6 lpm	0.971 m/s
11. Service Water Piping									
Service Water	SW0 x 1	76.2	1214	40	A-106	300	NA	NA	0.9541 m/s
12. Fuel Gas Piping									
13. Fuel Oil Piping									
14. Service Air Piping									
Service Air	SERVA x 1	50.8	910.4	40	A-106	225	NA	NA	31.1 m/s
15. Vacuum Air Piping									
Condenser Air Removal	CAR0 x 1	203.2	103.9	80	A-106	28	NA	NA	25.73 m/s
16. Ammonia Piping									
17. Boiler & Equipment Drain Piping									
FWH 1 Drain	FWDW1 x 1	254	27.43	40	A-106	4	283.3	4833 lpm	1.572 m/s
FWH 2 Drain	FWDW2 x 1	203.2	27.43	40	A-106	4	219.6	3756 lpm	1.939 m/s
FWH 3 Drain	FWDW3 x 1	203.2	29.57	40	A-106	4	150.5	2628.3 lpm	1.357 m/s
FWH 4 Drain	FWDW4 x 1	127	29.26	40	A-106	4	77.12	1381.4 lpm	1.784 m/s
FWH 6 Drain	FWDW6 x 2	203.2	88.09	40	A-106	4	156.1	3017 lpm	1.558 m/s
FWH 7 Drain	FWDW7 x 2	152.4	18.9	40	A-106	4	124.1	2476.9 lpm	2.215 m/s
FWH 8 Drain	FWDW8 x 2	127	19.2	80	A-106	4	64.32	1352 lpm	1.92 m/s
Small Drains	BEDR1 x 36	101.6	150	40	A-106	17	NA	NA	0.3452 m/s
Medium Drains	BEDR2 x 22	152.4	150	40	A-106	17	NA	NA	0.1521 m/s
Large Drains	BEDR3 x 14	254	150	40	A-106	17	NA	NA	0.0557 m/s
18. Boiler Blowdown Piping									
19. Steam Blowoff Piping									
Steam Blowoff Piping	STBL x 2	457.2	24.99	40	A-106	9	NA	NA	2.248 m/s

Estimated Piping Data	ID x No.	Nom. D [mm]	Length [m]	Schedule	Material	Fittings	M [t/h]	Design Flow	Design Vel. [m/s]
20. Fire Protection Piping									
Main Fire Protection	FP0 x 1	508	1062.2	20	A-106	88	1362	22712 lpm	2.016 m/s
Miscellaneous Fire Protection	FP1 x 1	406.4	1062.2	20	A-106	88	681	11356 lpm	1.58 m/s

Estimated Pump Data		
Number of Units	**1**	
Boiler Feed Pump		
Pump type	Multistage centrifugal	
Drive type	Variable RPM	
Number per Boiler	1 - 100%	
Nameplate (unrounded) mass flow	2070.6	t/h
Nameplate (unrounded) head	3155	m
Nameplate volume flow	41640	lpm
Nameplate head	3170	m H2O
Pump shaft speed	3000	RPM
Shaft power	33000	hp
Pump isentropic efficiency	75	%
Pump mechanical efficiency	97	%
Baseplate length (each)	12.72	m
Baseplate width (each)	4.096	m
Pump weight (each)	89266	kg
Turbine weight (each)	85444	kg
Boiler Feed Booster Pump		
Pump type	Vertical canned	
Drive type	Fixed RPM	
Number per Boiler	1 - 100%	
Nameplate (unrounded) mass flow	2070.6	t/h
Nameplate (unrounded) head	81.81	m
Nameplate volume flow	41640	lpm
Nameplate head	83.82	m H2O
Pump shaft speed	600	RPM
Shaft power	800	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.792	m
Baseplate width (each)	1.792	m
Pump weight (each)	2042.6	kg
Motor weight (each)	2022.5	kg
Condenser C.W. Pump		
Pump type	Vertical turbine	
Drive type	Fixed RPM	
Number per ST	8 - 12.5%	
Nameplate (unrounded) mass flow	7455	t/h
Nameplate (unrounded) head	22.77	m
Nameplate volume flow	124919	lpm
Nameplate head	24.38	m H2O
Pump shaft speed	500	RPM
Shaft power	800	hp
Pump isentropic efficiency	87	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.784	m
Baseplate width (each)	1.784	m
Pump weight (each)	1999.8	kg
Motor weight (each)	2004.9	kg
Condensate Forwarding Pump		
Pump type	Vertical canned	
Drive type	Fixed RPM	
Number per ST	2 - 100%	
Nameplate (unrounded) mass flow	1326.2	t/h
Nameplate (unrounded) head	242.4	m
Nameplate volume flow	22712	lpm
Nameplate head	243.8	m H2O
Pump shaft speed	1500	RPM
Shaft power	1500	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	2.066	m
Baseplate width (each)	2.066	m
Pump weight (each)	3875	kg
Motor weight (each)	3334	kg
Condenser Vacuum Pump		
Drive type	Fixed RPM	
Number per ST	2 - 50%	
Nameplate Suction Pressure	53.72	mmHg
Pump shaft speed	500	RPM
Shaft power	90	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	3.052	m
Baseplate width (each)	2.18	m
Pump weight (each)	5749	kg
Fuel Oil Unloading Pump		
Pump type	Single stage centrifugal	

Estimated Pump Data		
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	111.5	t/h
Nameplate (unrounded) head	45.81	m
Nameplate volume flow	2271.2	lpm
Nameplate head	53.34	m H2O
Pump shaft speed	3000	RPM
Shaft power	23	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.389	m
Baseplate width (each)	0.4881	m
Pump weight (each)	247	kg
Motor weight (each)	122.5	kg
Fuel Oil Forwarding Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	2 - 100%	
Nameplate (unrounded) mass flow	40.29	t/h
Nameplate (unrounded) head	38.17	m
Nameplate volume flow	851.7	lpm
Nameplate head	45.72	m H2O
Pump shaft speed	3000	RPM
Shaft power	7	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.067	m
Baseplate width (each)	0.3725	m
Pump weight (each)	127.1	kg
Motor weight (each)	48.44	kg
Aux Cooling Water Pump (closed loop)		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	2 - 100%	
Nameplate (unrounded) mass flow	470.4	t/h
Nameplate (unrounded) head	24.43	m
Nameplate volume flow	8517	lpm
Nameplate head	27.43	m H2O
Pump shaft speed	1500	RPM
Shaft power	55	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.659	m
Baseplate width (each)	0.5858	m
Pump weight (each)	386.8	kg
Motor weight (each)	246.4	kg
Treated Water Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	22.26	t/h
Nameplate (unrounded) head	57.55	m
Nameplate volume flow	378.5	lpm
Nameplate head	60.96	m H2O
Pump shaft speed	3000	RPM
Shaft power	6	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.025	m
Baseplate width (each)	0.3575	m
Pump weight (each)	114.9	kg
Motor weight (each)	40.3	kg
Diesel Fire Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	3 - 100%	
Nameplate (unrounded) mass flow	449.1	t/h
Nameplate (unrounded) head	70.44	m
Nameplate volume flow	7571	lpm
Nameplate head	76.2	m H2O
Pump shaft speed	3000	RPM
Shaft power	140	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	2.071	m
Baseplate width (each)	0.7358	m
Pump weight (each)	1692.9	kg
Electric Fire Pump (P13)		
Number of Pumps per Plant	None	

Estimated Pump Data		
Jockey Fire Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	10.25	t/h
Nameplate (unrounded) head	30.54	m
Nameplate volume flow	170.3	lpm
Nameplate head	38.1	m H2O
Pump shaft speed	3000	RPM
Shaft power	1.5	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	0.753	m
Baseplate width (each)	0.2604	m
Pump weight (each)	52.71	kg
Motor weight (each)	15.19	kg
ST+Generator Lube Oil Coolant Pump (P21)		
Number of Pumps per ST+Generator Lube Oil	None	
ST Generator Coolant Pump (P22)		
Number of Pumps per ST Generator	None	
Demin Water Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	2 - 100%	
Nameplate (unrounded) mass flow	22.26	t/h
Nameplate (unrounded) head	55.24	m
Nameplate volume flow	378.5	lpm
Nameplate head	60.96	m H2O
Pump shaft speed	3000	RPM
Shaft power	5.5	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.016	m
Baseplate width (each)	0.3542	m
Pump weight (each)	112.3	kg
Motor weight (each)	39.04	kg
Raw Water Pump 1		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	22.26	t/h
Nameplate (unrounded) head	46.04	m
Nameplate volume flow	378.5	lpm
Nameplate head	53.34	m H2O
Pump shaft speed	3000	RPM
Shaft power	4.75	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	0.9764	m
Baseplate width (each)	0.34	m
Pump weight (each)	101.6	kg
Motor weight (each)	33.91	kg
Raw Water Pump 2		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	22.26	t/h
Nameplate (unrounded) head	46.04	m
Nameplate volume flow	378.5	lpm
Nameplate head	53.34	m H2O
Pump shaft speed	3000	RPM
Shaft power	4.75	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	0.9764	m
Baseplate width (each)	0.34	m
Pump weight (each)	101.6	kg
Motor weight (each)	33.91	kg
Raw Water Pump 3 (P28)		
Number of Pumps per Plant	None	
District Heating Pump (P29)		
Number of Pumps per DHC	None	
Aux Cooling Water Pump (open loop)		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	2 - 100%	
Nameplate (unrounded) mass flow	470.4	t/h

Estimated Pump Data		
Nameplate (unrounded) head	24.43	m
Nameplate volume flow	8517	lpm
Nameplate head	27.43	m H2O
Pump shaft speed	1500	RPM
Shaft power	55	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.659	m
Baseplate width (each)	0.5858	m
Pump weight (each)	386.8	kg
Motor weight (each)	246.4	kg
FGD Slurry Pump (P31)		
Number of Pumps per FGD	None	
Startup Boiler Feed Pump		
Pump type	Multistage centrifugal	
Drive type	Fixed RPM	
Number per Boiler	1 - 100%	
Nameplate (unrounded) mass flow	517.7	t/h
Nameplate (unrounded) head	3334	m
Nameplate volume flow	10410	lpm
Nameplate head	3353	m H2O
Pump shaft speed	3000	RPM
Shaft power	9000	hp
Pump isentropic efficiency	75	%
Pump mechanical efficiency	97	%
Baseplate length (each)	5.114	m
Baseplate width (each)	1.862	m
Pump weight (each)	23585	kg
Motor weight (each)	19654	kg

Estimated Electric Load Data	Number in plant	Nameplate kW (each)	Nominal kW Operating	Nominal kW Standby	Nominal kWe Operating	Nominal kWe Standby	Voltage	Heat Balance Aux. kWe
1. Pump Motors								
Boiler Feed Booster Pump	1	597	597	0	600	0	6600 V	567.3
Condenser C.W. Pump	8	597	4,770	0	4,800	0	6600 V	4435
Condensate Forwarding Pump	2	1,120	1,120	1,120	1,100	1,100	6600 V	1072.2
Condenser Vacuum Pump	2	67.11	134	0	140	0	415 V	140
Fuel Oil Unloading Pump	1	15.66	0	15.66	0	19	415 V	0
Fuel Oil Forwarding Pump	2	4.847	4.847	4.847	6	6	415 V	6
Aux Cooling Water Pump (closed loop)	2	41.01	41.01	41.01	45	45	415 V	45
Treated Water Pump	1	3.729	3.729	0	5	0	415 V	5
Jockey Fire Pump	1	1.119	1.119	0	1.25	0	415 V	1.25
Demin Water Pump	2	3.542	3.542	3.542	4.75	4.75	415 V	4.75
Raw Water Pump 1	1	2.983	2.983	0	4	0	415 V	4
Raw Water Pump 2	1	2.983	2.983	0	4	0	415 V	4
Aux Cooling Water Pump (open loop)	2	41.01	41.01	41.01	45	45	415 V	45
Startup Boiler Feed Pump	1	6,710	0	6,710	0	7,000	6600 V	0
FWH 1 Drain Water Pump	3	130	261	130	260	130	415 V	215.7
2. Auxiliary Cooling Fan Motors								
3. Cooling Tower Fan Motors								
Main Cooling Tower Fan	1	0	0	0	0	0	415 V	0
4. Air Compressor Motors								
Station Air Compressor	5	205	1,030	0	1,120	0	6600 V	1025.3
5. Water Treatment System Motors								
Misc. Water Treatment Auxiliary Loads	18	52.2	313	626	330	660	415 V	270.2
6. Bridge Crane Motors								
ST bridge crane hoist motor	1	104	0	104	0	110	415 V	0
ST bridge crane bridge motor	2	7.457	0	14.91	0	17	415 V	0
ST bridge crane trolley motor	2	7.084	0	14.17	0	16	415 V	0
7. Boiler Fans								
Boiler Forced Draft Fan	3	746	2,240	0	2,400	0	6600 V	1868.7
Boiler Induced Draft Fan	3	1,040	3,130	0	3,300	0	6600 V	2593.6
Primary Air Fan	3	597	1,790	0	2,100	0	6600 V	1395.3
8. Pollution Control								
Electrostatic Precipitator	1	1,860	1,860	0	2,000	0	6600 V	1566.7
Ash Handling	3	522	1,040	522	1,000	500	6600 V	831.9
9. Fuel Delivery Motors								
Fuel Handling	6	895	5,370	0	5,400	0	6600 V	4311
10. ST Auxiliary Loads								
ST Lube Oil Pumps	2	1,300	1,300	1,300	1,300	1,300	6600 V	1013.3
Misc. ST Aux Loads	18	18.64	336	0	360	0	415 V	354.7
11. Miscellaneous Plant Loads								
HVAC Loads	1	104	104	0	110	0	415 V	110
Lighting Loads	1	298	298	0	275	0	415 V	275
Misc. Plant Aux Loads 1	8	205	1,230	410	1,200	400	6600 V	1182.2
Misc. Plant Aux Loads 2	9	55.93	503	0	540	0	415 V	506.6
Total Plant Motors & Loads	**117**		**36,930**	**14,840**	**28,460**	**11,350**		**23850.7**
Total 6600 V Motors & Loads					26,320	10,300		
Total 415 V Motors & Loads					2,130	1,050		

Estimated Main Electrical Data		
1. Steam Turbine Step-up Transformer		
Count	1	
Nominal Rating	788	MVA
Cooling	OA/FA/FA	
Configuration	Circuit Breaker Connected	
High-side Voltage	500	kV
Low-side Voltage	20	kV
Length	27.86	m
Width	9.285	m
Weight	625,000	kg
Unit Mechanical Installation hours	6,270	hours
Unit Electrical Installation hours	6,270	hours
Unit Reference Cost	9,816,000	USD
2. Medium Voltage Step-down Transformer		
Count	2	
Nominal Rating	20.35	MVA
High-side Voltage	20	kV
Low-side Voltage	6.6	kV
Length	2.418	m
Width	1.934	m
Weight	12,350	kg
Unit Mechanical Installation hours	310	hours
Unit Electrical Installation hours	310	hours
Unit Reference Cost	292,150	USD
3. Low Voltage Step-down Transformer		
Count	2	
Nominal Rating	1.768	MVA
High-side Voltage	20	kV
Low-side Voltage	0.415	kV
Length	2.198	m
Width	1.758	m
Weight	5,730	kg
Unit Mechanical Installation hours	144	hours
Unit Electrical Installation hours	144	hours
Unit Reference Cost	123,100	USD
4. Steam Turbine Generator Circuit Breaker		
Count	1	
Voltage	20	kV
Amperage	22,750	Amps
Unit Mechanical Installation hours	319	hours
Unit Electrical Installation hours	637	hours
Unit Reference Cost	3,079,000	USD
5. Utility Interconnect Circuit Breaker		
Count	1	
Voltage	500	kV
Amperage	859	Amps
Unit Mechanical Installation hours	182	hours
Unit Electrical Installation hours	364	hours
Unit Reference Cost	961,000	USD
6. Auxiliary Bus Feeder Circuit Breaker		
Count	1	
Voltage	20	kV
Amperage	1,280	Amps
Unit Mechanical Installation hours	155	hours
Unit Electrical Installation hours	310	hours
Unit Reference Cost	35,070	USD
7. Medium Voltage Circuit Breaker		
Count	2	
Voltage	6.6	kV
Amperage	1,780	Amps
Unit Mechanical Installation hours	169	hours
Unit Electrical Installation hours	337	hours
Unit Reference Cost	48,890	USD
8. Low Voltage Circuit Breaker		
Count	2	
Voltage	0.415	kV
Amperage	2,460	Amps
Unit Mechanical Installation hours	183	hours
Unit Electrical Installation hours	366	hours
Unit Reference Cost	120,200	USD
9. Generator to Step-up Transformer Bus		
Steam Turbine Generator Bus Type	Isolated phase bus	
Number generators	1	
Length (per generator)	73.41	m
Mechanical installation hours (per generator)	1,440	hours
Electrical installation hours (per generator)	722	hours

Estimated Main Electrical Data		
Reference Cost (per generator)	4,452,000	USD
10. Plant Buswork		
Low Voltage		
Total length (all runs)	4,720	m
Total Electrical Installation hours	7,380	hours
Total Reference Equipment Cost	463,800	USD
Medium Voltage		
Total length (all runs)	6,650	m
Total Electrical Installation hours	6,040	hours
Total Reference Equipment Cost	294,850	USD
11. Switch Gear		
Low Voltage		
Number sections in plant	0	
Medium Voltage		
Number sections in plant	6	
Total weight	10,400	kg
Total Mechanical Installation hours	805	hours
Total Electrical Installation hours	2,680	hours
Total Reference Equipment Cost	1,393,000	USD
12. Motor Control Centers		
Low Voltage		
Number sections in plant	21	
Total number of starters	53	
Total load on all starters	2,710	kW
Total weight	9,530	kg
Total Mechanical Installation hours	289	hours
Total Electrical Installation hours	964	hours
Total Reference Equipment cost	198,200	USD
Medium Voltage		
Number sections in plant	24	
Total number of starters	44	
Total load on all starters	32,940	kW
Total weight	33,680	kg
Total Mechanical Installation hours	545	hours
Total Electrical Installation hours	1,820	hours
Total Reference Equipment cost	2,139,000	USD
13. Motor & Load Feeders		
Low Voltage		
Number runs in plant	52	
Total length (all runs)	3,720	m
Total Electrical Installation hours	5,490	hours
Total Reference Equipment Cost	160,800	USD
Medium Voltage		
Number runs in plant	44	
Total length (all runs)	3,140	m
Total Electrical Installation hours	5,520	hours
Total Reference Equipment Cost	207,800	USD
14. Cable Tray		
Total length (all runs)	2,270	m
Total Mechanical Installation hours	12,160	hours
Total Electrical Installation hours	4,260	hours
Total Reference Equipment Cost	201,800	USD
15. General Plant Instrumentation		
Instrument Count	69.19	
Total Electrical Installation hours	3,190	hours
Total Reference Equipment Cost	370,650	USD

Estimated Tank Data	Number	Volume [l]	Diameter [m]	Height [m]
Fuel Oil	1	2,701,000	17.7	11.0
Demineralized Water	1	383,850	8.1	7.5
Raw Water	1	383,850	8.1	7.5
Neutralized Water	1	191,950	5.7	7.5
Acid Storage	1	23,030	2.4	5.1
Caustic Storage	1	23,030	2.4	5.1
Fire Protection	1	2,725,000	17.8	11

Estimated Water Treatment System Data		
1. Clarifier-Reactivator	**None**	
2. Pressure Filter	**None**	
3. Softener	**1 Twin Unit**	
Design Flow (8 hr continuous operation running one unit)	261	lpm
Exchange Capacity (each)	72,000	ppm per min.
Weight (twin unit)	32,860	kg
Cost (twin unit), Reference Basis	403,950	USD
4. Reverse Osmosis System	**None**	
5. Two-Bed Demineralizer	**1 Train**	
Design Flow (each)	261	lpm
Weight (each)	2,360	kg
Cost (each), Reference Basis	894,800	USD

Estimated Boiler Data		
Number of Units	1	
Displayed quantities in this table are on a per unit basis		
1. Boiler System Summary		
Boiler Type	Conventional, Two Pass	
Overall Length	40.28	m
Overall Width	18.72	m
Overall Height	66.45	m
Total Weight (wet)	13,768,000	kg
Total Weight (dry)	13,581,000	kg
Includes:		
- Furnace incl. burners & waterwall		
- Pulverizers & feeders		
- Boiler casing & refractory		
- Convective HX incl. waterwall		
- Desuperheaters and controls		
- Air & flue gas ducts		
- Burner piping & fittings		
- Soot blowers		
- Structural steel incl. walkways & ladders		
- Rotary air heater		
- Fans		
- Miscellaneous		
Overall Heat Transfer Surface Area	84,000	m^2
- Water Wall effective projected surface	5,120	m^2
- Economiser	46,760	m^2
- Superheater (convective & radiant)	13,010	m^2
- Reheater (convective & radiant)	19,120	m^2
Total Number of Tubes (in convective elements)	10,900	
Total Boiler Cost, Reference Basis	179,784,000	USD
Includes:		
- Furnace (incl. radiant platens)		
- Convective Elements (incl. interconnecting piping)		
- Additional Waterwall		
- Soot Blowers		
- Desuperheaters and Controls		
- Air and Flue Gas Ducts		
- Coal Pulverisers and Feeders		
- FD Fan, PA Fan, ID Fan		
- Supporting Steel Structure, Ladders, Walkways		
- Rotary Air Heater		
2. Furnace		
Furnace height (including hopper height if it exists)	66.45	m
Furnace width	18.72	m
Furnace depth	18.34	m
Aperture height	18.72	m
Hopper height	11.01	m
Furnace volume	20,930	m^3
Furnace effective projected radiant surface	6,950	m^2
Water wall effective projected surface	5,120	m^2
Radiant superheater	1,830	m^2
3. Horizontal Pass		
Height (tube length)	18.72	m
Width (boiler width)	18.72	m
Depth (duct length)	3.368	m
Gas flow frontal area	350	m^2
4. Second Vertical Downward Pass		
Height (duct length)	6.604	m
Width (boiler width)	18.72	m
Depth (tube length)	18.27	m
Gas flow frontal area	342	m^2
5. Rotary Air Heater		
Matrix heat transfer surface	45,420	m^2
Total flow cross section area	55.88	m^2
Total frontal surface	94.44	m^2
- Gas surface	50	%
- Secondary air surface	45.62	%
- Primary air surface	4.384	%
Unit height	5.975	m
Unit side dimension	12.56	m
Unit foot area	158	m^2

Estimated Steam Turbine Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
1. Steam Turbine Description		
Nameplate Capacity	788.1	MVA
Power Factor	0.9	
Steam Turbine Type	Condensing, Reheat	
Nameplate Throttle Pressure	289.8	bar
Nameplate Throttle Temperature	604	C
Nameplate Throttle Massflow	1863.6	t/h
Exhaust End Type	Down Draft	
Number of LPT Exhaust Annuli	2	
Last Stage Bucket Length	1144.5	mm
Last Stage Pitch Diameter	2983.5	mm
Number of Ports	12	
Number of Auto-Extraction Ports	0	
2. Estimated Weights, Dimensions & Cost		
Steam Turbine Length	38.2	m
Steam Turbine Width	6.605	m
Steam Turbine Weight	977,900	kg
Generator Length (Including Exciter)	15.93	m
Generator Width	4.39	m
Generator Weight	618,200	kg
Overall ST and Generator Length	54.12	m
Overall ST and Generator Width	6.605	m
Overall ST and Generator Weight	1,596,000	kg
Equipment Cost per Unit, Reference Basis	94,021,000	USD
Foundation Length	58.94	m
Foundation Width	7.926	m
Foundation Concrete per Unit	2315	m^3

Estimated Feedwater Heater Data		
Number of Units	1	
Displayed quantities in this table are on a per unit basis		
FWH 1-P		
Feedwater heater configuration: Includes condensing section only		
Nameplate steam pressure	0.3458	bar
Shell material	Carbon Steel	
Shell length	15.21	m
Shell inner diameter	1.424	m
Shell wall thickness	7.938	mm
Tube sheet thickness	60.33	mm
Nameplate water pressure	21.6	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	824	
Number of passes	2	
Number of tubes in heater	1648	
Tube length per pass	15.21	m
Tube outer diameter (O.D.)	15.88	mm
Tube wall thickness	1.245	mm
Tube pitch	23.02	mm
Total heat transfer area (outside tubes)	1,250	m^2
Tube weight, dry	11,600	kg
Overall length	17.5	m
Overall outer diameter	1.4	m
Heater total dry weight	20,820	kg
Heater total operating (wet) weight	26,650	kg
FWH 2-D		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	1.112	bar
Shell material	Carbon Steel	
Shell length	16.2	m
Shell inner diameter	1.598	m
Shell wall thickness	9.525	mm
Tube sheet thickness	63.5	mm
Nameplate water pressure	19.62	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	1038	
Number of passes	2	
Number of tubes in heater	2076	
Tube length per pass	16.2	m
Tube outer diameter (O.D.)	15.88	mm
Tube wall thickness	1.245	mm
Tube pitch	23.02	mm
Total heat transfer area (outside tubes)	1,680	m^2
Tube weight, dry	15,570	kg
Overall length	18.7	m
Overall outer diameter	1.6	m
Heater total dry weight	29,350	kg
Heater total operating (wet) weight	37,140	kg
FWH 3-D		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	2.936	bar
Shell material	Carbon Steel	
Shell length	17.98	m
Shell inner diameter	1.568	m
Shell wall thickness	7.938	mm
Tube sheet thickness	57.15	mm
Nameplate water pressure	17.71	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	694	
Number of passes	2	
Number of tubes in heater	1388	
Tube length per pass	17.98	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	1.245	mm
Tube pitch	27.62	mm
Total heat transfer area (outside tubes)	1,490	m^2
Tube weight, dry	14,040	kg
Overall length	20.5	m
Overall outer diameter	1.6	m
Heater total dry weight	26,580	kg
Heater total operating (wet) weight	34,880	kg

Estimated Feedwater Heater Data		
FWH 4-D		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	6.667	bar
Shell material	Carbon Steel	
Shell length	15.86	m
Shell inner diameter	1.589	m
Shell wall thickness	9.525	mm
Tube sheet thickness	44.45	mm
Nameplate water pressure	16.18	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	713	
Number of passes	2	
Number of tubes in heater	1426	
Tube length per pass	15.86	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	1.245	mm
Tube pitch	27.62	mm
Total heat transfer area (outside tubes)	1,350	m^2
Tube weight, dry	12,710	kg
Overall length	18.4	m
Overall outer diameter	1.6	m
Heater total dry weight	24,920	kg
Heater total operating (wet) weight	32,470	kg
FWH 5-DA		
DA type	HH	
Nameplate feedwater exit flow	1863563	kg/hr
Total storage volume	248306	l
Total storage capacity	7	Min
Number of units	1	
Overall height	7.955	m
Overall length	18.24	m
Storage tank		
-Thickness	25.4	mm
-Outside diameter	4.572	m
-Total length	18.24	m
Heater		
-Thickness	15.88	mm
-Outside diameter	2.773	m
-Total length	16.59	m
Dry weight	83017	kg
Operating weight	322174	kg
Flooded weight	407794	kg
Structure weight	90837	kg
FWH 6-D (6A, 6B)		
Feedwater heater configuration: Includes desuperheating section, condensing section, drain cooler		
Nameplate steam pressure	22.24	bar
Shell material	Carbon Steel	
Shell length	9.058	m
Shell inner diameter	1.728	m
Shell wall thickness	22.22	mm
Tube sheet thickness	460	mm
Nameplate water pressure	309	bar
Tube material	Carbon Steel	
Number of tubes per pass	1135	
Number of passes	2	
Number of tubes in heater	2270	
Tube length per pass	9.058	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	3.404	mm
Tube pitch	23.81	mm
Total heat transfer area (outside tubes)	1,230	m^2
Tube weight, dry	29,720	kg
Overall length	12.0	m
Overall outer diameter	1.8	m
Heater total dry weight	69,750	kg
Heater total operating (wet) weight	73,500	kg
FWH 7-D (7A, 7B)		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	41.42	bar
Shell material	Carbon Steel	
Shell length	10.04	m
Shell inner diameter	1.901	m
Shell wall thickness	50.8	mm

Estimated Feedwater Heater Data		
Tube sheet thickness	362	mm
Nameplate water pressure	308	bar
Tube material	Carbon Steel	
Number of tubes per pass	1177	
Number of passes	2	
Number of tubes in heater	2354	
Tube length per pass	10.04	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	3.404	mm
Tube pitch	25.72	mm
Total heat transfer area (outside tubes)	1,410	m^2
Tube weight, dry	33,230	kg
Overall length	13.1	m
Overall outer diameter	2	m
Heater total dry weight	99,050	kg
Heater total operating (wet) weight	103,450	kg
FWH 8-D (8A, 8B)		
Feedwater heater configuration: Includes desuperheating section, condensing section, drain cooler		
Nameplate steam pressure	62.42	bar
Shell material	Carbon Steel	
Shell length	9.417	m
Shell inner diameter	1.802	m
Shell wall thickness	69.85	mm
Tube sheet thickness	410	mm
Nameplate water pressure	307	bar
Tube material	Carbon Steel	
Number of tubes per pass	1234	
Number of passes	2	
Number of tubes in heater	2468	
Tube length per pass	9.417	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	3.404	mm
Tube pitch	23.81	mm
Total heat transfer area (outside tubes)	1,390	m^2
Tube weight, dry	33,140	kg
Overall length	12.5	m
Overall outer diameter	1.9	m
Heater total dry weight	102,300	kg
Heater total operating (wet) weight	106,300	kg
FWH 9-S (9A, 9B)		
Feedwater heater configuration: Shell heating with vapor only fluid		
Please Note:		
Design based on condensing FWH methods - may be less accurate for single-phase fluid in shell		
Nameplate steam pressure	41.42	bar
Shell material	Carbon Steel	
Shell length	2.993	m
Shell inner diameter	1.445	m
Shell wall thickness	38.1	mm
Tube sheet thickness	276	mm
Nameplate water pressure	307	bar
Tube material	Carbon Steel	
Number of tubes per pass	999	
Number of passes	1	
Number of tubes in heater	999	
Tube length per pass	2.993	m
Tube outer diameter (O.D.)	22.22	mm
Tube wall thickness	4.191	mm
Tube pitch	30	mm
Total heat transfer area (outside tubes)	209	m^2
Tube weight, dry	6,590	kg
Overall length	6.6	m
Overall outer diameter	1.5	m
Heater total dry weight	39,200	kg
Heater total operating (wet) weight	40,710	kg

Estimated Water Cooled Condenser Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
WCC		
Condenser type	Shell & tube	
Number of units	1	
1. Condenser Tube Description		
Effective surface area	41031	m^2
Number of condenser passes	2	
Tube material	Stainless steel (304)	
Number of tubes in condenser	44113	
Tube length	13.3	m
Tube outside diameter (O.D.)	22.23	mm
Tube inside diameter (I.D.)	20.8	mm
Tube wall thickness	0.7112	mm
Tube weight, dry	226,800	kg
Tube pitch	35.56	mm
2. Condenser Shell Description		
Shell material	Carbon steel	
Nominal shell thickness	15.88	mm
Number tube support plates	23	
Tube support plate spacing	0.55	m
Hotwell depth	0.87	m
Total dry weight	695,200	kg
Overall footprint area	168.7	m^2
Overall length	19.4	m
Overall width	8.7	m
Overall height	13.9	m

Estimated Cooling Tower Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
Natural Draft CT		
1. Estimated Major Dimensions		
Height		
Overall - ground to top	208.8	m
Throat - ground to throat	148.2	m
Above fill - top of fill to exit	199.6	m
Below fill - ground to top of fill	9.144	m
Diameter		
Base	93.85	m
Throat	52.14	m
Exit	61.11	m
Basin area	6918	m^2
Average shell thickness	457.2	mm
Tower includes flue gas connection		
2. Concrete		
Shell	23,770	m^3
Basin	2,180	m^3
Ring foundation	1,040	m^3
Total	26,990	m^3

Estimated Flue Gas Treatment Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
ESP		
Design collection efficiency	99.5	%
Design inlet temperature	137.8	C
Design flue gas mass flow	2,570	t/h
Design flue gas volume flow	3,009,000	m^3/hr
Design flue gas velocity	1.372	m/s
Overall Dimensions		
Number of chambers	3	
Number of fields	4	
Total length	30.8	m
Total width	68.67	m
Total height	20.58	m
Total weight	1,905,000	kg
Collecting Plates		
Design specific collecting area (SCA)	89.78	m^2 / m^3/s
Total collection surface area	75,050	m^2
Number of plates per chamber	62	
Collecting plates height	10.97	m
Collecting plates spacing	304.8	mm
Collecting plates bundle width per chamber	18.59	m
Collecting plates depth per field	4.671	m
Collecting length	18.68	m
Aspect ratio (Collecting length / Plate height)	1.703	
2. Stack		
Type	Concrete	
Concrete Shell Diameter at Base Level	17.63	m
Concrete Shell Diameter at Top Level	14.03	m
Steel Liner Diameter	7.603	m
Height	155.4	m
Total Reference Cost (Installation included)	10,997,000	USD

Estimated Desalination Plant Data: MSF System		
Multi-Stage Flash Desalination		
1. General		
Number of units	1	
Number of stages per unit	21	
Number of stages in heat recovery section (HGS)	0	
Number of stages in heat rejection section (HRS)	0	
Nominal desalinated water flow per unit	0	t/h
Nominal desalinated water flow per unit (MIGD)	0	MIGD
Nominal desalinated water flow per unit (m^3/day)	0	m^3/day
2. Overall dimensions and total weight (per unit, excluding seawater supply circuit)		
Length	0	m
Width	0	m
Height	0	m
Dry weight	0	tonne
3. Brine heater (per unit)		
Tube material	CuNi 70-30	
Heat transfer area	3,747	m^2
Tube outside diameter	38.1	mm
Tube wall thickness	1	mm
Tube length	15.24	m
Number of tubes	2054	
4. Evaporator (per unit)		
Length	0	m
Width	0	m
Height	0	m
Dry weight	0	tonne
HGS Stage Condensers		
- Tube material	CuNi 90-10	
- Heat transfer area per stage	3747	m^2
- HGS total heat transfer area	0	m^2
- Tube outside diameter	38.1	mm
- Tube wall thickness	1	mm
- Tube length	15.24	m
- Number of tubes per stage	2054	
HRS Stage Condensers		
- Tube material	Titanium	
- Heat transfer area per stage	3122	m^2
- HRS total heat transfer area	0	m^2
- Tube outside diameter	31.75	mm
- Tube wall thickness	0.7	mm
- Tube length	15.24	m
- Number of tubes per stage	2054	

Estimated Desalination Plant Data: MED System		
Multi-Effect Distillation		
1. General		
Number of units	0	
Number of effects per unit	8	
System configuration	MED only	
First effect heating steam saturation temperature	-17.78	C
Top brine temperature	-17.78	C
Final effect temperature	-17.78	C
Nameplate capacity	0	t/h
Nameplate capacity (MIGD)	0	MIGD
Nameplate capacity (m^3/day)	0	m^3/day
2. Evaporator island (per unit, incl. main condenser)		
Total heat transfer area	0	m^2
Length	0	m
Width	0	m
Height	0	m
Dry weight	0	tonne
Operating weight	0	tonne
3. Evaporators (per unit)		
Total heat transfer area	0	m^2
Number of effects	8	
Heat transfer area per effect	0	m^2
Number of tubes per effect	0	
Tube outside diameter	0	mm
Tube wall thickness	0	mm
Tube length	0	m
Tube material	Titanium	
Tube dry weight per effect	0	tonne
Total shell length of all effects	0	m
Shell outside diameter	0	m
Shell wall thickness	0	mm
Total tube dry weight	0	tonne
Total dry weight	0	tonne
Total operating weight	0	tonne
Total flooding weight	0	tonne
4. Main condenser (per unit)		
Overall length	0	m
Overall width	0	m
Overall height	0	m
Heat transfer area	0	m^2
Number of tubes	0	
Number of passes	0	
Tube outside diameter	0	mm
Tube wall thickness	0	mm
Tube length	0	m
Tube material	Titanium	
Tube dry weight	0	tonne
Total dry weight	0	tonne
Total operating weight	0	tonne

Estimated Desalination Plant Data: RO System		
Reverse Osmosis Desalination		
1. Nameplate Data		
Total number of RO trains in plant	0	
Desalinated water flow	0	t/h
Desalinated water flow (MIGD)	0	MIGD
Desalinated water flow (m^3/day)	0	m^3/day
Inlet water flow	0	t/h
Inlet water salinity	0	%
Water recovery ratio	40	%
Membrane feed pressure	0	bar
Total power consumption	0	kW

Estimated Miscellaneous Equipment Data		
1. Air Compressor		
Number of Air Compressors in plant	5 - 100%	
Capacity (each)	1529.1	m³/h
Motor Power (each)	205	kW
Weight (each)	7,070	kg
Installation Labor (each)	230	Labor Hours
Equipment Cost, Reference Basis, (each)	156,400	USD
Foundation Concrete (each)	12.03	m^3
Foundation Labor (each)	450	Labor Hours
2. Auxiliary Boiler	**None**	
3. Emergency Generator		
Number of Generators	1	
Generator Set Type	Medium Speed	
Capacity (each)	1,750	kW
Length	9.9	m
Width	2.4	m
Height	3.3	m
Weight	34,750	kg
Installation Labor (each)	195	Labor Hours
Equipment Cost, Reference Basis, (each)	810,700	USD
Foundation Concrete (each)	57.84	m^3
Foundation Labor (each)	1,340	Labor Hours
4. Black Start Generator		
Number of Generators	5	
Generator Set Type	Medium Speed	
Capacity (each)	5,500	kW
Length	12.5	m
Width	2.5	m
Height	3.9	m
Weight	73,050	kg
Installation Labor (each)	195	Labor Hours
Equipment Cost, Reference Basis, (each)	2,548,000	USD
Foundation Concrete (each)	121	m^3
Foundation Labor (each)	2,400	Labor Hours
5. Auxiliary Heat Exchanger		
Number of Cells (per plant)	1	
Capacity (each)	7,600	kW
Installation Labor (each)	125	Labor Hours
Equipment Cost, Reference Basis, (each)	129,800	USD
6. Bridge Crane (for ST)		
Number of Cranes in Plant	1	
Span	39.6	m
Capacity	156	Ton
Crane Weight	349,200	kg
Hoist Motor Power	104	kW
Bridge Motors	2 - 7.457	kW
Trolley Motor Power	7.084	kW
Installation Labor	1,640	Labor Hours
Crane & Support Cost, Reference Basis, (each)	1,838,000	USD

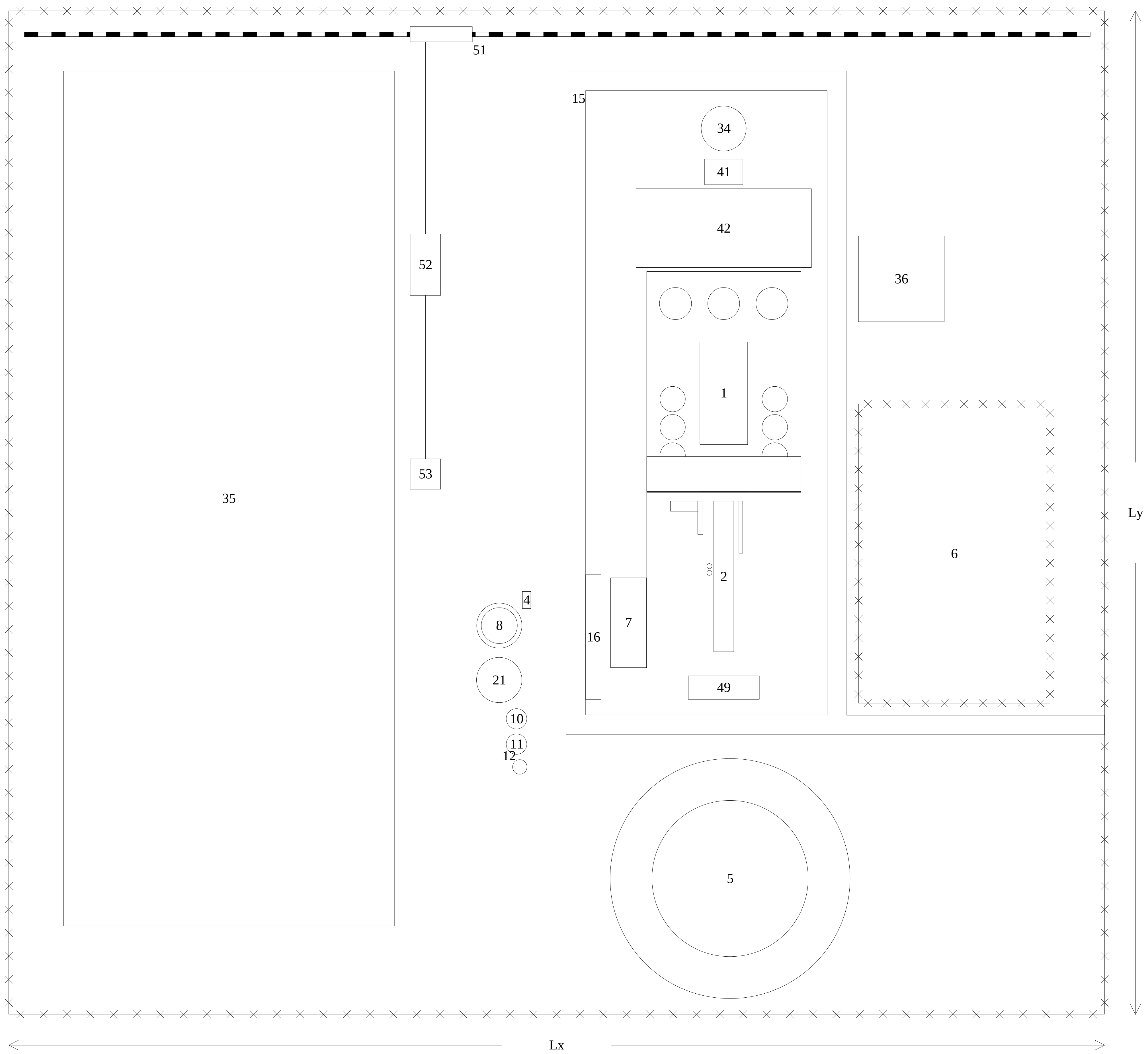
Caution! These results are based on a single set of nameplate plant		
performance data applied for user-input number of operating hours per year.		
Annual Electricity Exported	**5,260**	**10^6 kWh**
Annual Heat Exported	**0**	**TJ**
Annual Fuel Imported	**44,200**	**TJ LHV**
Annual Water Imported	**9,200**	**10^6 l**
Annual CO2 Emission	**4,090**	**ktonne**
Annual Desal Water Exported	**0**	**MM imperial gal.**
Annual Hydrogen Exported	**0**	**TJ LHV**
Annual Syngas Exported	**0**	**TJ LHV**
Annual CO2 Captured	**0**	**ktonne**
Annual Limestone Consumed	**0**	**ktonne**
Annual Lime Consumed	**0**	**ktonne**
Annual CO2 Capture Solvent Consumed	**0**	**ktonne**
Annual Combustion Waste Production	**152**	**ktonne**
Annual FGD Waste/Byproducts Production	**0**	**ktonne**
Annual Activated Carbon Consumed	**0**	**ktonne**
Total Investment	**1,600,115,000**	**USD**
Specific Investment	**2461.8**	**USD per kW**
Initial Equity	**480,035,000**	**USD**
Cumulative Net Cash Flow	**7,702,139,000**	**USD**
Internal Rate of Return on Investment (ROI)	**14.088**	**%**
Internal Rate of Return on Equity (ROE)	**23.528**	**%**
Years for Payback of Equity	**5.119**	**years**
Net Present Value	**1,048,186,000**	**USD**
Break-even Electricity Price @ Input Fuel Price (i.e. Levelised Cost of Electricity)	**0.0436**	**USD/kWhr**
Break-even Fuel LHV Price @ Input Electricity Price	**3.925**	**USD/GJ**
Other		
First Year Combustion Waste Disposal Cost	0	USD/tonne
First Year FGD Waste/Byproducts Disposal Cost	0	USD/tonne
First Year Combustion Waste Disposal Expense	0	USD
First Year FGD Waste/Byproducts Disposal Expense	0	USD
First Year Total Other Expense	0	USD

Cash Flow USD	2020 (1)	2021 (2)	2022 (3)	2023 (4)	2024 (5)	2025 (6)	2026 (7)	2027 (8)	2028 (9)	2029 (10)	2030 (11)	2031 (12)	2032 (13)	2033 (14)	2034 (15)	2035 (16)	2036 (17)	2037 (18)	2038 (19)	2039 (20)
Escalators																				
Inflation	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Fuel	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Steam	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Electricity	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Imported Water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desal water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
H2 from syngas	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Reagent	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Activated carbon	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Prices																				
Electricity, USD per kWh	0.065	0.0679	0.071	0.0742	0.0775	0.081	0.0846	0.0885	0.0924	0.0966	0.1009	0.1055	0.1102	0.1152	0.1204	0.1258	0.1315	0.1374	0.1436	0.15
Fuel, USD/GJ	1.37	1.432	1.496	1.563	1.634	1.707	1.784	1.864	1.948	2.036	2.128	2.223	2.323	2.428	2.537	2.651	2.771	2.895	3.026	3.162
Steam, USD/GJ	4.739	4.953	5.175	5.408	5.652	5.906	6.172	6.45	6.74	7.043	7.36	7.691	8.037	8.399	8.777	9.172	9.585	10.02	10.47	10.94
Imported Water, USD/m^3	0.2642	0.2761	0.2885	0.3015	0.315	0.3292	0.344	0.3595	0.3757	0.3926	0.4103	0.4287	0.448	0.4682	0.4892	0.5112	0.5343	0.5583	0.5834	0.6097
CO2 Emission Penalty, USD/tonne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desal water, USD per 1000 imperial gallons	4	4.18	4.368	4.565	4.77	4.985	5.209	5.443	5.688	5.944	6.212	6.491	6.784	7.089	7.408	7.741	8.089	8.454	8.834	9.231
H2 from syngas, USD/GJ	7.583	7.924	8.281	8.653	9.043	9.45	9.875	10.32	10.78	11.27	11.78	12.31	12.86	13.44	14.04	14.68	15.34	16.03	16.75	17.5
Syngas, USD/GJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limestone, USD/tonne	22.05	23.04	24.08	25.16	26.29	27.47	28.71	30	31.35	32.76	34.24	35.78	37.39	39.07	40.83	42.67	44.59	46.59	48.69	50.88
Lime, USD/tonne	88.18	92.15	96.3	100.6	105.2	109.9	114.8	120	125.4	131.1	136.9	143.1	149.6	156.3	163.3	170.7	178.3	186.4	194.8	203.5
Captured CO2, USD/tonne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent, USD/tonne	2204.6	2303.8	2407.5	2515.8	2629.1	2747.4	2871	3000	3135	3276	3424	3578	3739	3907	4083	4267	4459	4659	4869	5088
Activated carbon, USD/tonne	2204.6	2303.8	2407.5	2515.8	2629.1	2747.4	2871	3000	3135	3276	3424	3578	3739	3907	4083	4267	4459	4659	4869	5088
Revenues																				
Electricity	342,219,000	357,619,000	373,712,000	390,529,000	408,103,000	426,468,000	445,659,000	465,713,000	486,670,000	508,571,000	531,456,000	555,372,000	580,364,000	606,480,000	633,772,000	662,291,000	692,095,000	723,239,000	755,785,000	789,795,000
Capacity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Steam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desal water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2 from syngas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syngas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Captured CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	342,219,000	357,619,000	373,712,000	390,529,000	408,103,000	426,468,000	445,659,000	465,713,000	486,670,000	508,571,000	531,456,000	555,372,000	580,364,000	606,480,000	633,772,000	662,291,000	692,095,000	723,239,000	755,785,000	789,795,000
Operating Expenses																				
Fuel	60,558,000	63,283,000	66,130,000	69,106,000	72,216,000	75,466,000	78,862,000	82,410,000	86,119,000	89,994,000	94,044,000	98,276,000	102,698,000	107,320,000	112,149,000	117,196,000	122,470,000	127,981,000	133,740,000	139,758,000
Limestone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imported Water	2,430,000	2,539,000	2,653,000	2,773,000	2,897,000	3,028,000	3,164,000	3,306,000	3,455,000	3,611,000	3,773,000	3,943,000	4,120,000	4,306,000	4,500,000	4,702,000	4,914,000	5,135,000	5,366,000	5,607,000
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Activated carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inflating O&M	57,589,000	60,181,000	62,889,000	65,719,000	68,676,000	71,766,000	74,996,000	78,371,000	81,897,000	85,583,000	89,434,000	93,459,000	97,664,000	102,059,000	106,652,000	111,451,000	116,466,000	121,707,000	127,184,000	132,908,000
Book Value O&M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Constant O&M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	120,576,000	126,002,000	131,672,000	137,598,000	143,789,000	150,260,000	157,022,000	164,088,000	171,472,000	179,188,000	187,251,000	195,678,000	204,483,000	213,685,000	223,301,000	233,349,000	243,850,000	254,823,000	266,290,000	278,273,000
Operating Income	**221,643,000**	**231,617,000**	**242,040,000**	**252,932,000**	**264,314,000**	**276,208,000**	**288,637,000**	**301,626,000**	**315,199,000**	**329,383,000**	**344,205,000**	**359,694,000**	**375,881,000**	**392,795,000**	**410,471,000**	**428,942,000**	**448,245,000**	**468,416,000**	**489,494,000**	**511,522,000**
-Depreciation	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	96,007,000	0	0	0	0	0
-Deductible Interest Exp	78,406,000	75,286,000	71,947,000	68,375,000	64,552,000	60,463,000	56,086,000	51,404,000	46,394,000	41,033,000	35,297,000	29,159,000	22,591,000	15,564,000	8,045,000	0	0	0	0	0
Pre-Tax Income	**47,231,000**	**60,325,000**	**74,086,000**	**88,550,000**	**103,754,000**	**119,738,000**	**136,544,000**	**154,215,000**	**172,798,000**	**192,343,000**	**212,902,000**	**234,529,000**	**257,282,000**	**281,224,000**	**306,419,000**	**428,942,000**	**448,245,000**	**468,416,000**	**489,494,000**	**511,522,000**
-Tax	16,531,000	21,114,000	25,930,000	30,993,000	36,314,000	41,908,000	47,790,000	53,975,000	60,479,000	67,320,000	74,516,000	82,085,000	90,049,000	98,428,000	107,247,000	150,130,000	156,886,000	163,946,000	171,323,000	179,033,000
-Non-Deductible Interest Exp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Income	**30,700,000**	**39,211,000**	**48,156,000**	**57,558,000**	**67,440,000**	**77,830,000**	**88,753,000**	**100,240,000**	**112,319,000**	**125,023,000**	**138,386,000**	**152,444,000**	**167,233,000**	**182,796,000**	**199,172,000**	**278,813,000**	**291,359,000**	**304,470,000**	**318,171,000**	**332,489,000**
Debt Principal Payment	44,573,000	47,693,000	51,032,000	54,604,000	58,426,000	62,516,000	66,892,000	71,575,000	76,585,000	81,946,000	87,682,000	93,820,000	100,387,000	107,414,000	114,933,000	0	0	0	0	0
Debt Coverage	1.8	1.88	1.97	2.06	2.15	2.25	2.35	2.45	2.56	2.68	2.8	2.92	3.06	3.19	3.34	0.0	0.0	0.0	0.0	0.0
Net Cash Flow	82,134,000	87,525,000	93,131,000	98,960,000	105,021,000	111,321,000	117,868,000	124,672,000	131,741,000	139,084,000	146,711,000	154,631,000	162,853,000	171,388,000	180,246,000	278,813,000	291,359,000	304,470,000	318,171,000	332,489,000
Cumulative Net Cash Flow	**82,134,000**	**169,658,000**	**262,789,000**	**361,750,000**	**466,771,000**	**578,091,000**	**695,959,000**	**820,631,000**	**952,372,000**	**1,091,456,000**	**1,238,167,000**	**1,392,797,000**	**1,555,650,000**	**1,727,038,000**	**1,907,284,000**	**2,186,097,000**	**2,477,456,000**	**2,781,926,000**	**3,100,097,000**	**3,432,586,000**

Cash Flow USD	2040 (21)	2041 (22)	2042 (23)	2043 (24)	2044 (25)	2045 (26)	2046 (27)	2047 (28)	2048 (29)	2049 (30)
Escalators										
Inflation	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Fuel	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Steam	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Electricity	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Imported Water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0
Desal water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
H2 from syngas	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Reagent	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Activated carbon	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Prices										
Electricity, USD per kWh	0.1568	0.1638	0.1712	0.1789	0.1869	0.1954	0.2041	0.2133	0.2229	0.233
Fuel, USD/GJ	3.304	3.453	3.608	3.77	3.94	4.117	4.303	4.496	4.699	4.91
Steam, USD/GJ	11.43	11.94	12.48	13.04	13.63	14.24	14.88	15.55	16.25	16.99
Imported Water, USD/m^3	0.6371	0.6658	0.6957	0.727	0.7598	0.794	0.8297	0.867	0.906	0.9468
CO2 Emission Penalty, USD/tonne	0	0	0	0	0	0	0	0	0	0
Desal water, USD per 1000 imperial gallons	9.647	10.08	10.53	11.01	11.5	12.02	12.56	13.13	13.72	14.34
H2 from syngas, USD/GJ	18.29	19.11	19.97	20.87	21.81	22.79	23.82	24.89	26.01	27.18
Syngas, USD/GJ	0	0	0	0	0	0	0	0	0	0
Limestone, USD/tonne	53.17	55.56	58.06	60.67	63.41	66.26	69.24	72.36	75.61	79.01
Lime, USD/tonne	212.7	222.2	232.2	242.7	253.6	265	277	289.4	302.4	316.1
Captured CO2, USD/tonne	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent, USD/tonne	5317	5556	5806	6067	6341	6626	6924	7236	7561	7901
Activated carbon, USD/tonne	5317	5556	5806	6067	6341	6626	6924	7236	7561	7901
Revenues										
Electricity	825,336,000	862,476,000	901,287,000	941,845,000	984,228,000	1,028,518,000	1,074,802,000	1,123,168,000	1,173,710,000	1,226,527,000
Capacity	0	0	0	0	0	0	0	0	0	0
Steam	0	0	0	0	0	0	0	0	0	0
Desal water	0	0	0	0	0	0	0	0	0	0
H2 from syngas	0	0	0	0	0	0	0	0	0	0
Syngas	0	0	0	0	0	0	0	0	0	0
Captured CO2	0	0	0	0	0	0	0	0	0	0
TOTAL	825,336,000	862,476,000	901,287,000	941,845,000	984,228,000	1,028,518,000	1,074,802,000	1,123,168,000	1,173,710,000	1,226,527,000
Operating Expenses										
Fuel	146,048,000	152,620,000	159,488,000	166,664,000	174,164,000	182,002,000	190,192,000	198,750,000	207,694,000	217,040,000
Limestone	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent	0	0	0	0	0	0	0	0	0	0
Imported Water	5,860,000	6,123,000	6,399,000	6,687,000	6,988,000	7,302,000	7,631,000	7,974,000	8,333,000	8,708,000
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0
Activated carbon	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Inflating O&M	138,888,000	145,138,000	151,670,000	158,495,000	165,627,000	173,080,000	180,869,000	189,008,000	197,513,000	206,401,000
Book Value O&M	0	0	0	0	0	0	0	0	0	0
Constant O&M	0	0	0	0	0	0	0	0	0	0
TOTAL	290,795,000	303,881,000	317,556,000	331,846,000	346,779,000	362,384,000	378,691,000	395,732,000	413,540,000	432,150,000
Operating Income	**534,540,000**	**558,595,000**	**583,731,000**	**609,999,000**	**637,449,000**	**666,134,000**	**696,110,000**	**727,435,000**	**760,170,000**	**794,378,000**
-Depreciation	0	0	0	0	0	0	0	0	0	0
-Deductible Interest Exp	0	0	0	0	0	0	0	0	0	0
Pre-Tax Income	**534,540,000**	**558,595,000**	**583,731,000**	**609,999,000**	**637,449,000**	**666,134,000**	**696,110,000**	**727,435,000**	**760,170,000**	**794,378,000**
-Tax	187,089,000	195,508,000	204,306,000	213,500,000	223,107,000	233,147,000	243,639,000	254,602,000	266,059,000	278,032,000
-Non-Deductible Interest Exp	0	0	0	0	0	0	0	0	0	0
Net Income	**347,451,000**	**363,086,000**	**379,425,000**	**396,499,000**	**414,342,000**	**432,987,000**	**452,472,000**	**472,833,000**	**494,110,000**	**516,345,000**
Debt Principal Payment	0	0	0	0	0	0	0	0	0	0
Debt Coverage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net Cash Flow	347,451,000	363,086,000	379,425,000	396,499,000	414,342,000	432,987,000	452,472,000	472,833,000	494,110,000	516,345,000
Cumulative Net Cash Flow	**3,780,037,000**	**4,143,124,000**	**4,522,549,000**	**4,919,049,000**	**5,333,391,000**	**5,766,378,000**	**6,218,850,000**	**6,691,683,000**	**7,185,794,000**	**7,702,139,000**

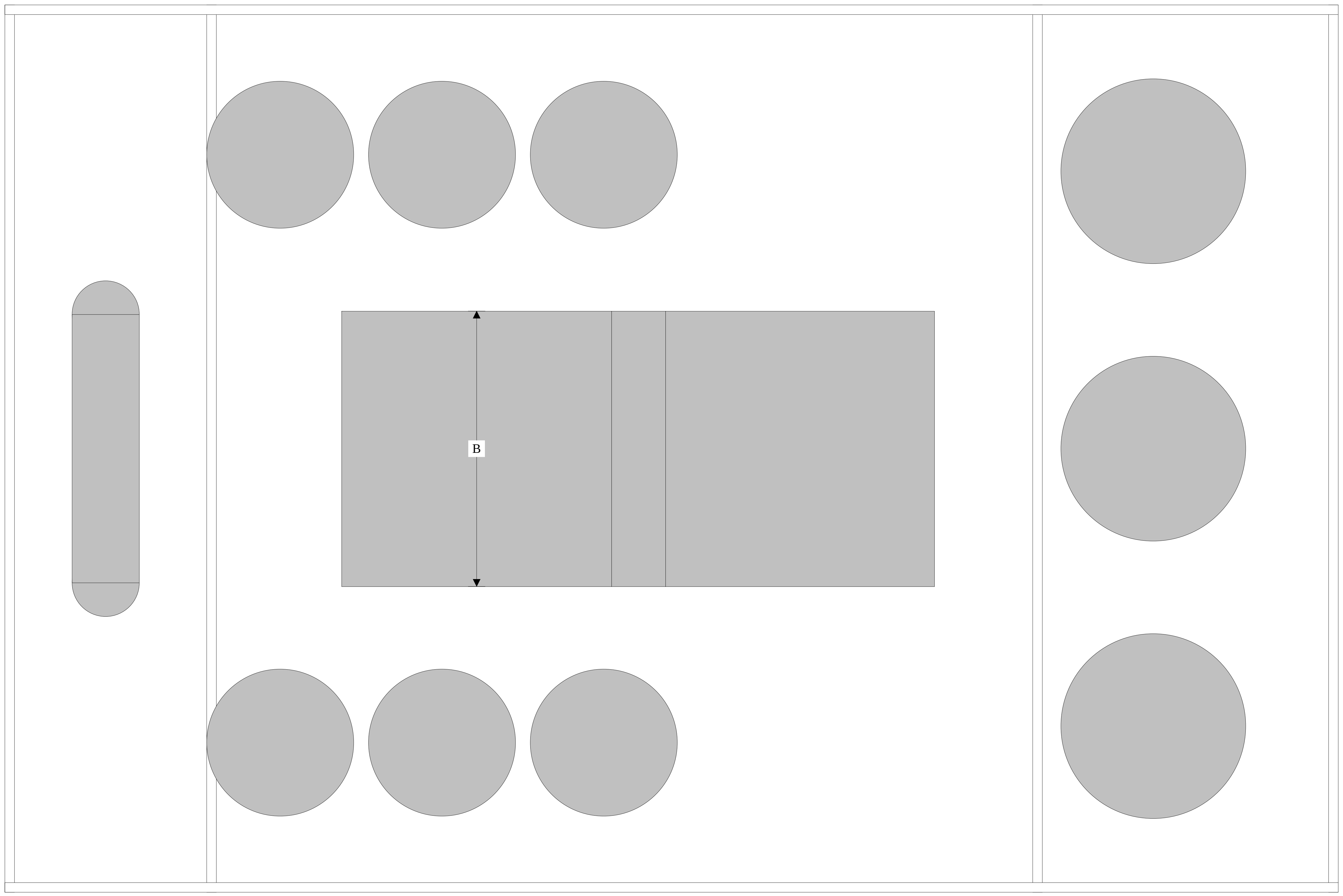
FOR QUALITATIVE INDICATION ONLY

Area 16.79 hectare
Lx 428 m
Ly 392 m
1 - Boiler
2 - Steam Turbine
4 - Water Treatment
5 - Cooling Tower
6 - Switchyard
7 - Administration, Shop & Warehouse
8 - Fuel Oil Tank
10 - Demineralized Water Tank
11 - Raw Water Tank
12 - Neutralized Water Tank
15 - Road
16 - Parking
21 - Fire Protection Tank
34 - Stack
35 - Coal Storage Area (lx=129, ly=334)
36 - Combustion Waste Storage Area (lx=34, ly=34)
41 - ID Fan
42 - Electrostatic Precipitators
49 - Transformer
51 - Car Dumper
52 - Reclaiming Hopper
53 - Crusher Building



Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Site Plan
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

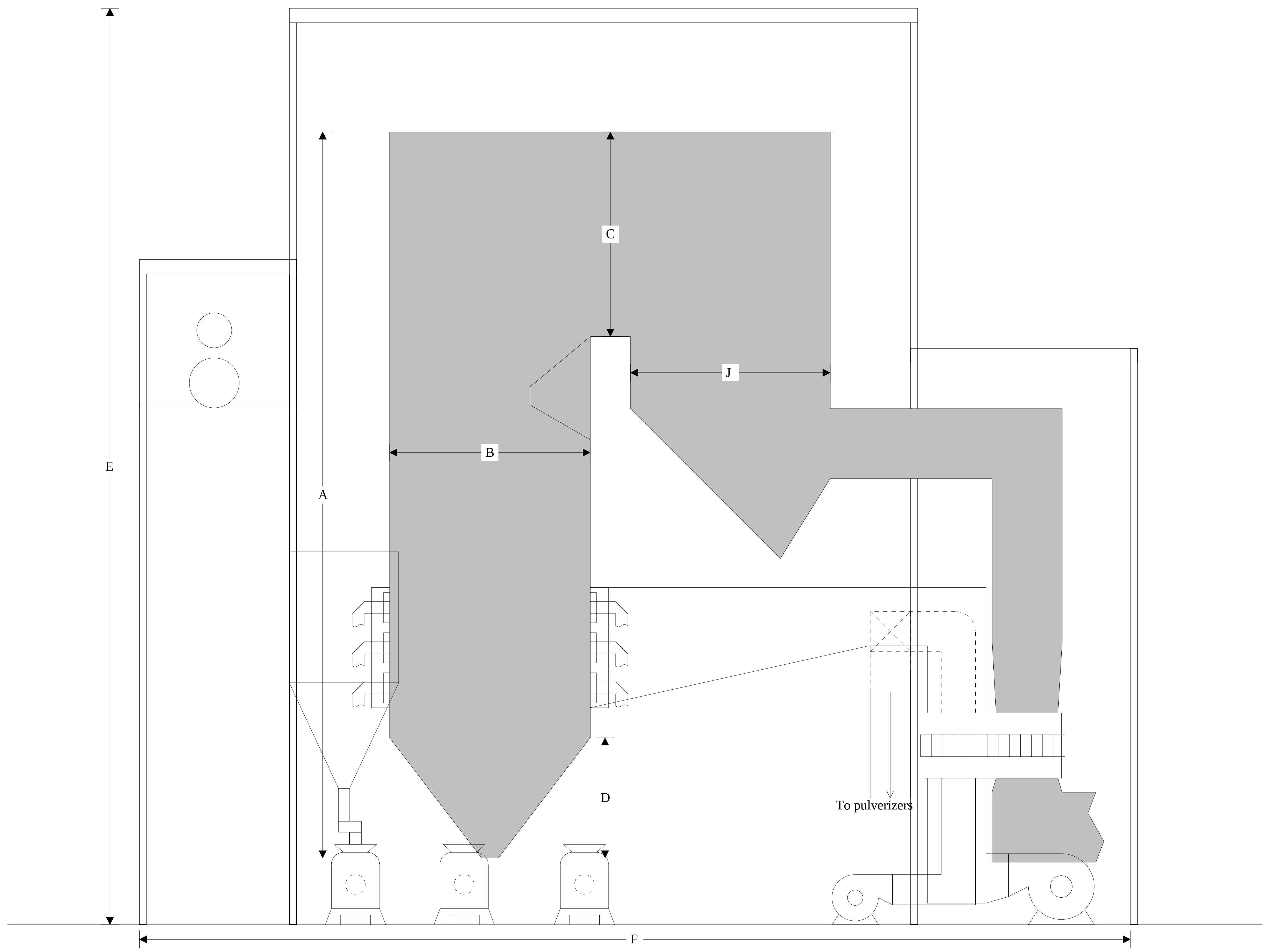


A	B	C	D	E	F	G	H	I	J
-	18.72 m	-	-	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	BOILER PLAN VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

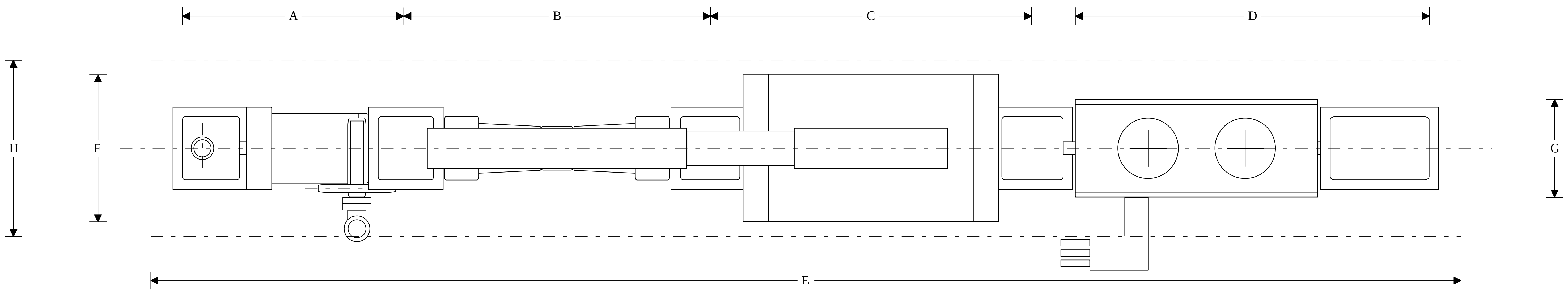


A	B	C	D	E	F	G	H	I	J
66.45 m	18.34 m	18.72 m	11.01 m	83.84 m	90.61 m	-	-	-	18.27 m

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	BOILER
	ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY



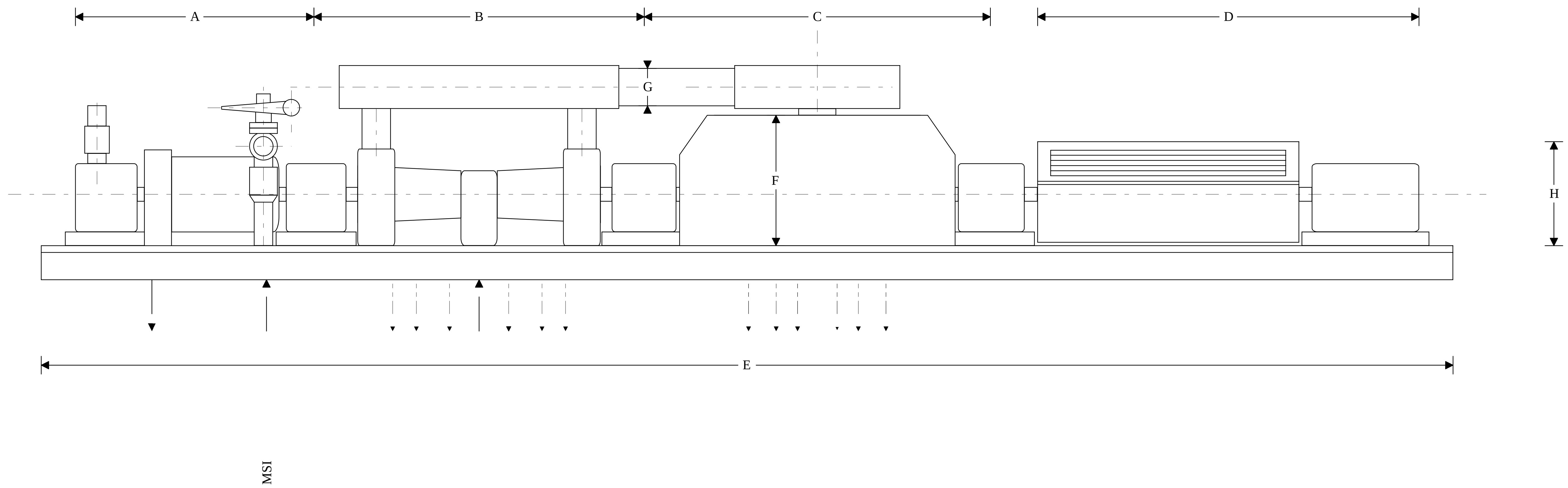
SHAPE, DIMENSIONS & SCALE ARE APPROXIMATE

A	B	C	D	E	F	G	H	I	J
9.959 m	13.79 m	14.45 m	15.93 m	58.94 m	6.605 m	4.39 m	7.926 m	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM TURBINE PACKAGE PLAN
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

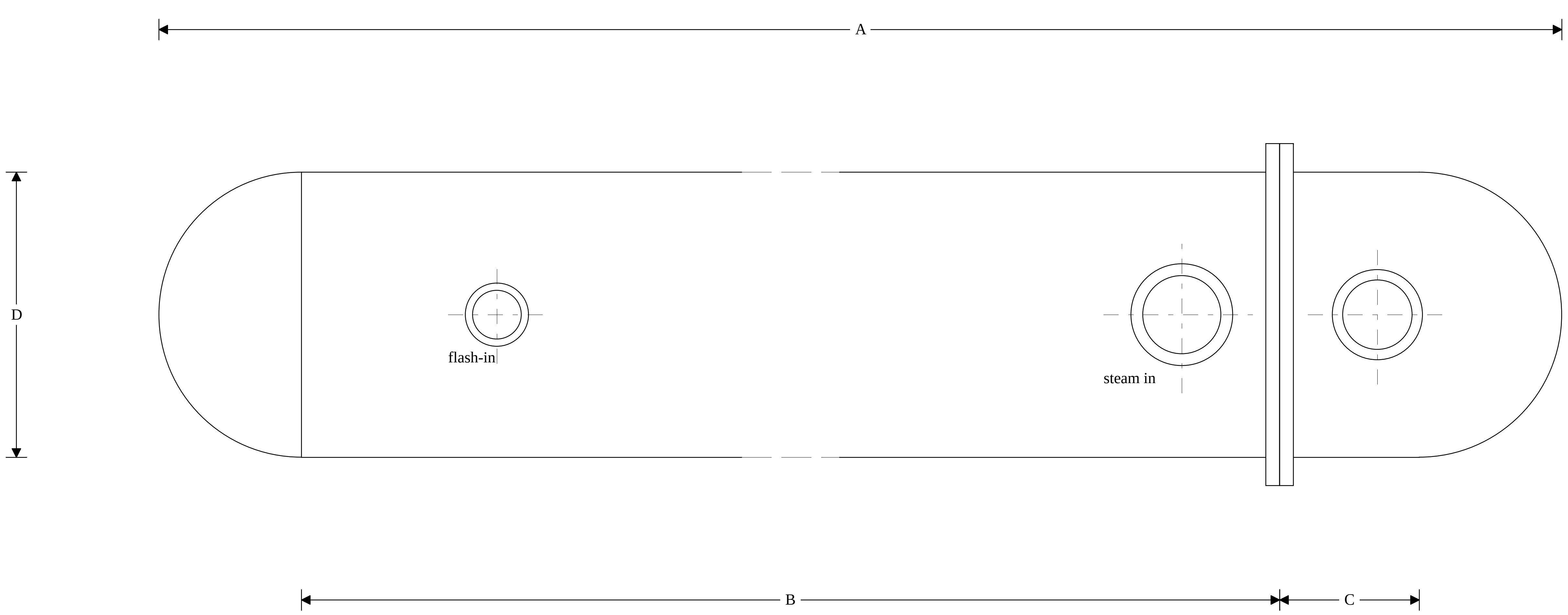


SHAPE, DIMENSIONS & SCALE ARE APPROXIMATE

A	B	C	D	E	F	G	H	I	J
9.959 m	13.79 m	14.45 m	15.93 m	58.94 m	5.44 m	1.566 m	4.332 m	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM TURBINE PACKAGE
	ELEV
Date: 04/11/17	
Drawing No:	

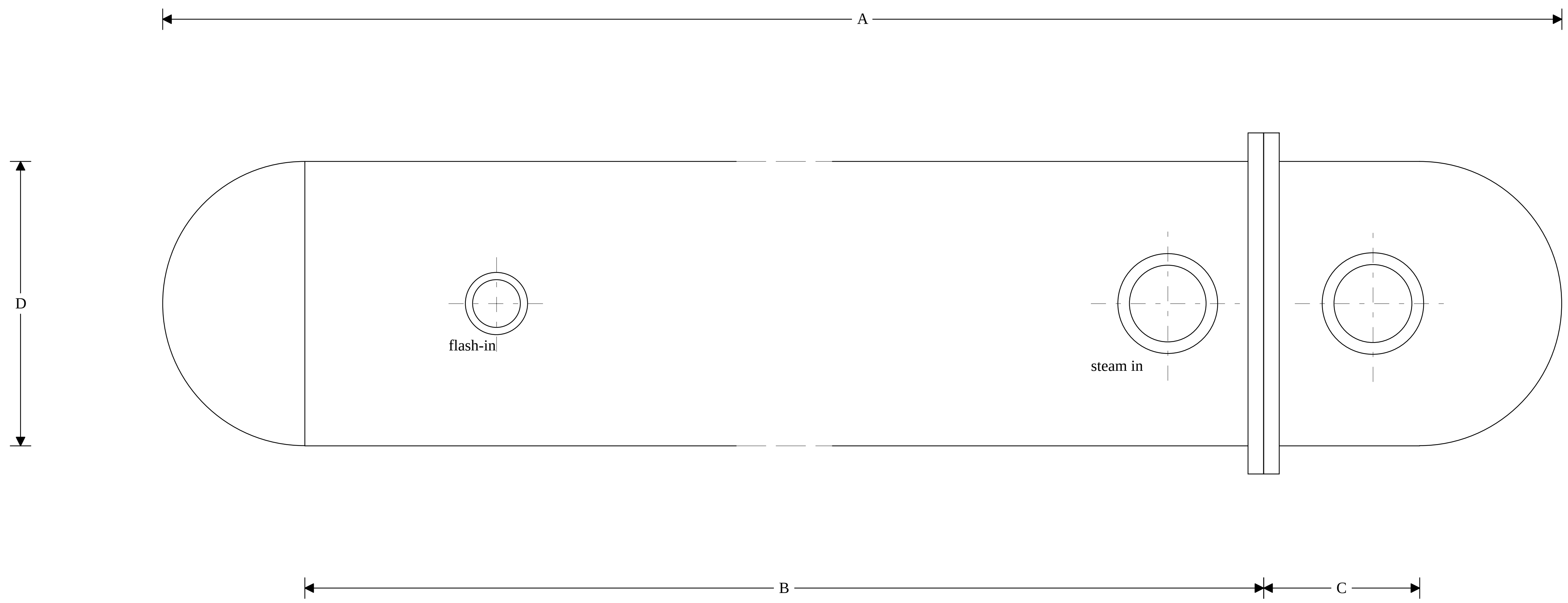
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
17.46 m	15.21 m	0.7469 m	1.439 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 1-P PLAN VIEW
Date: 04/11/17	
Drawing No:	

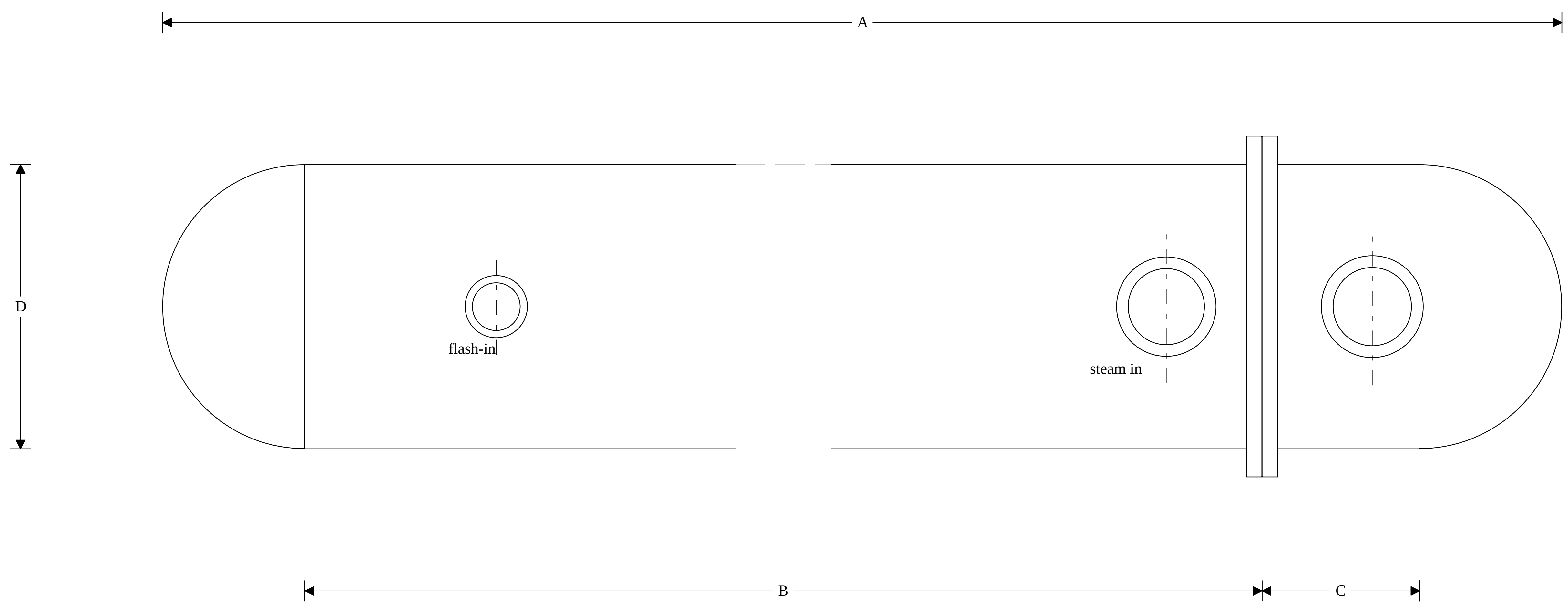
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
18.72 m	16.2 m	0.837 m	1.617 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 2-D PLAN VIEW
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

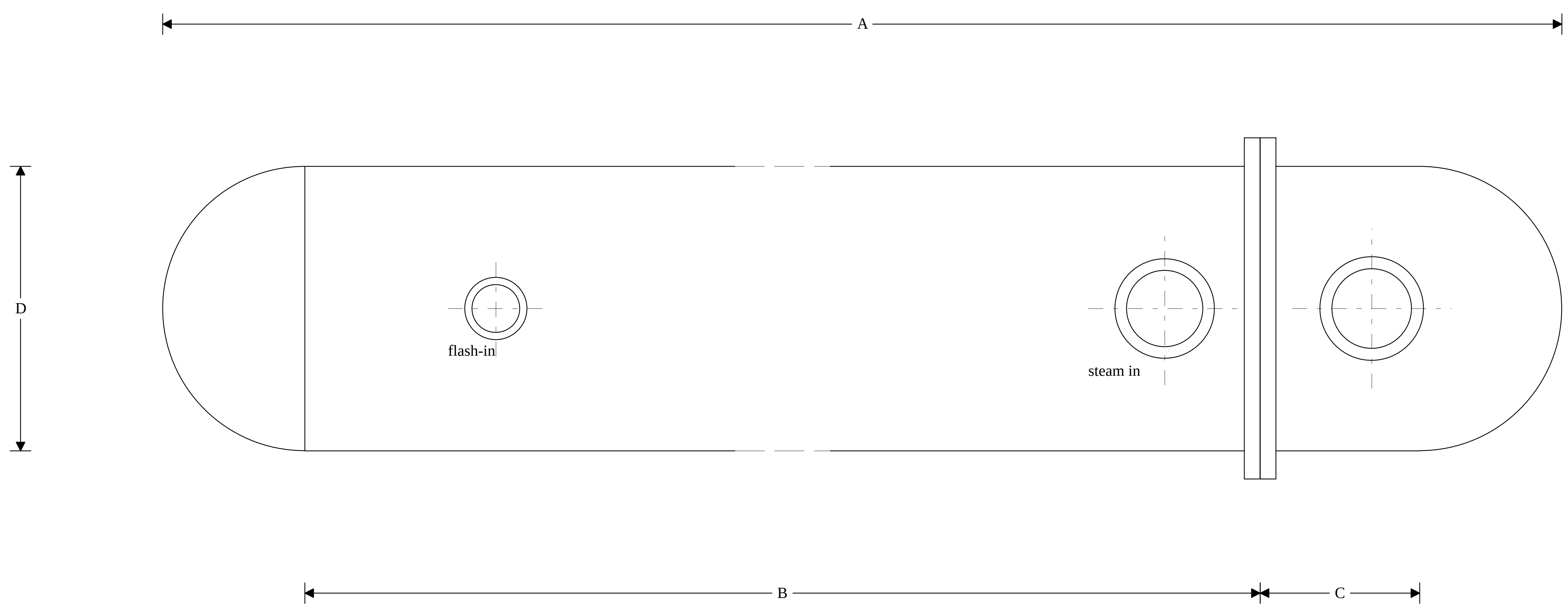


A	B	C	D	E	F	G	H	I	J
20.46 m	17.98 m	0.8454 m	1.584 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 3-D PLAN VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

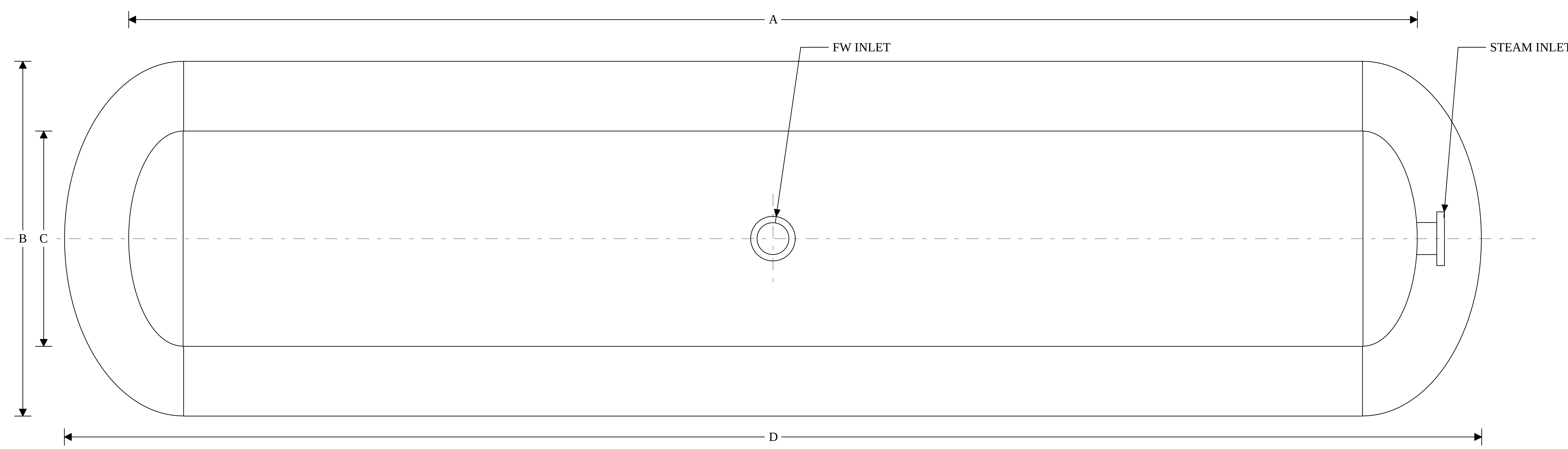
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
18.37 m	15.86 m	0.8561 m	1.608 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 4-D PLAN VIEW
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

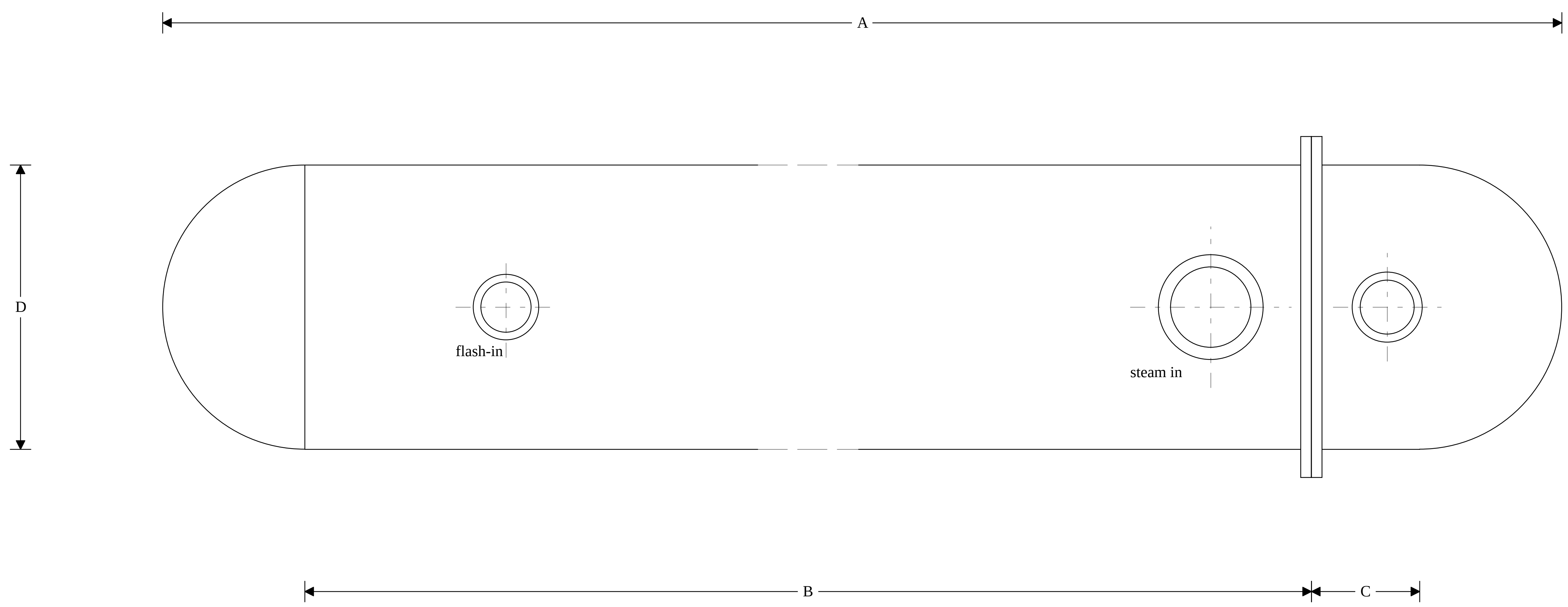


A	B	C	D	E	F	G	H	I	J
16.59 m	4.572 m	2.773 m	18.24 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM HEATED DEAERATOR PLAN VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

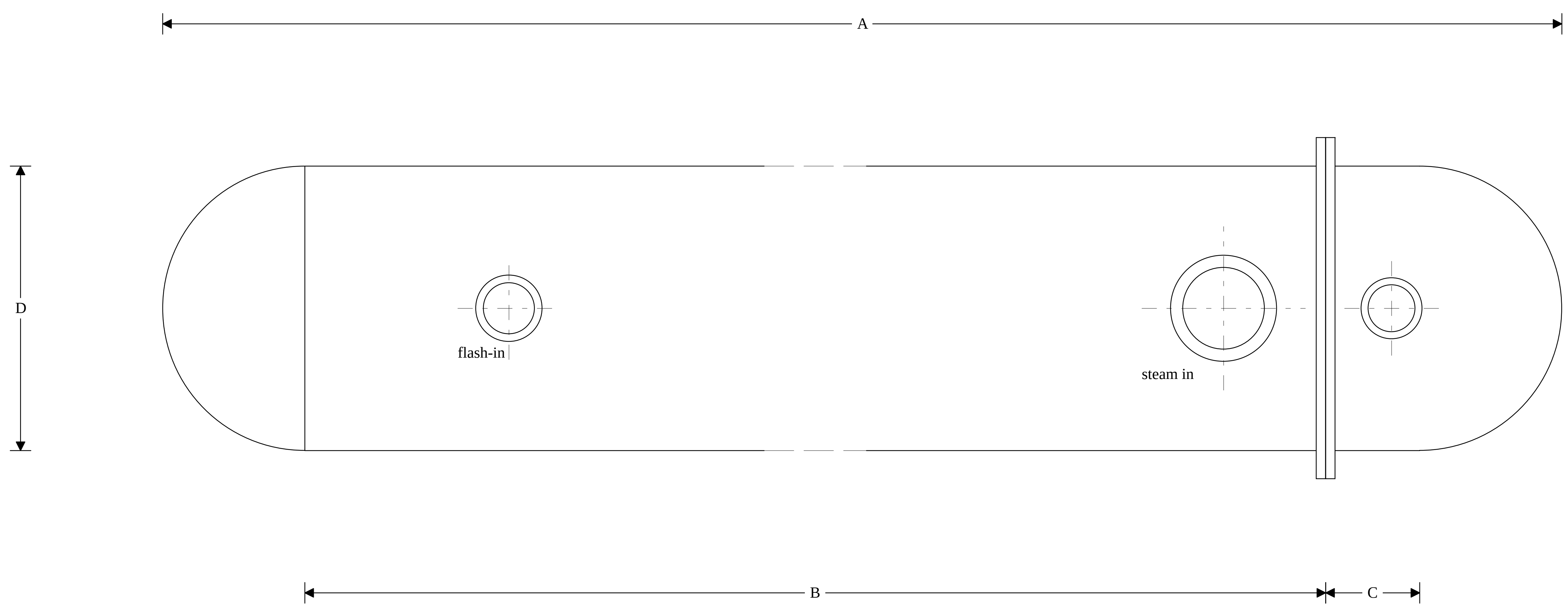
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
11.99 m	9.058 m	0.6978 m	1.773 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 6-D (6A, 6B) PLAN VIEW
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

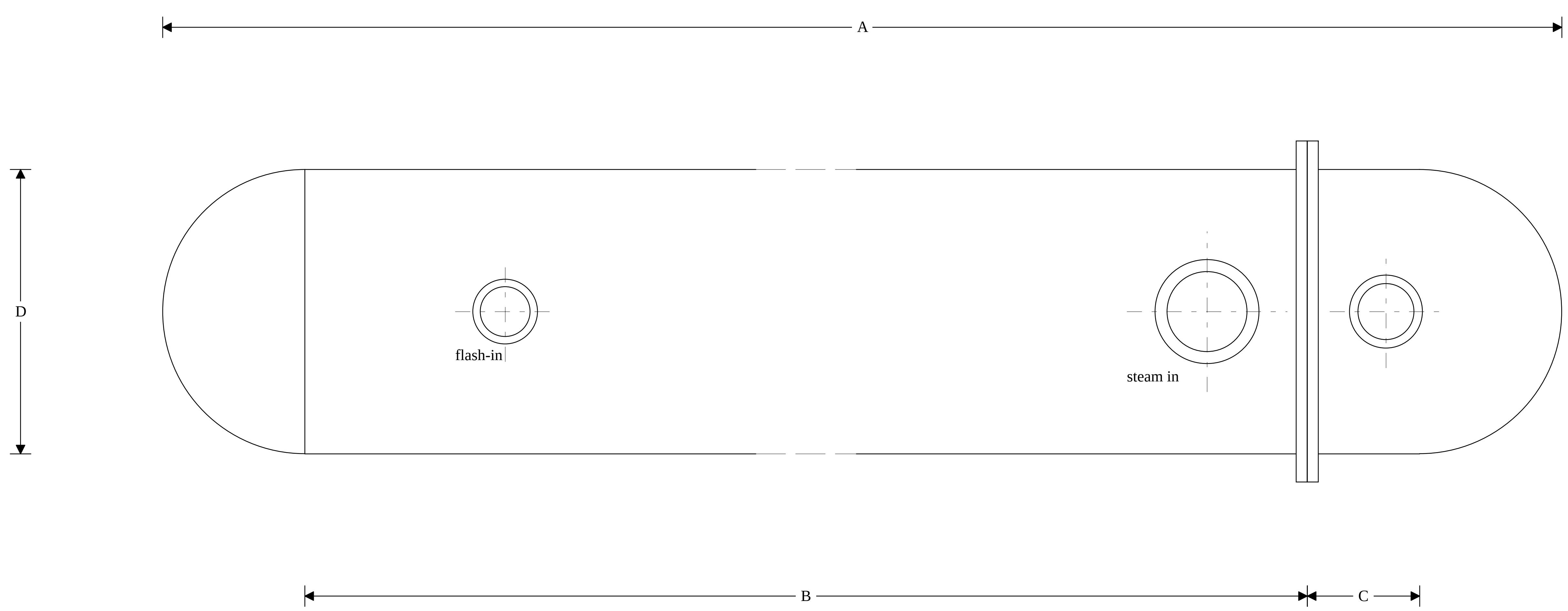


A	B	C	D	E	F	G	H	I	J
13.11 m	10.04 m	0.7078 m	2.002 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 7-D (7A, 7B)
	PLAN VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

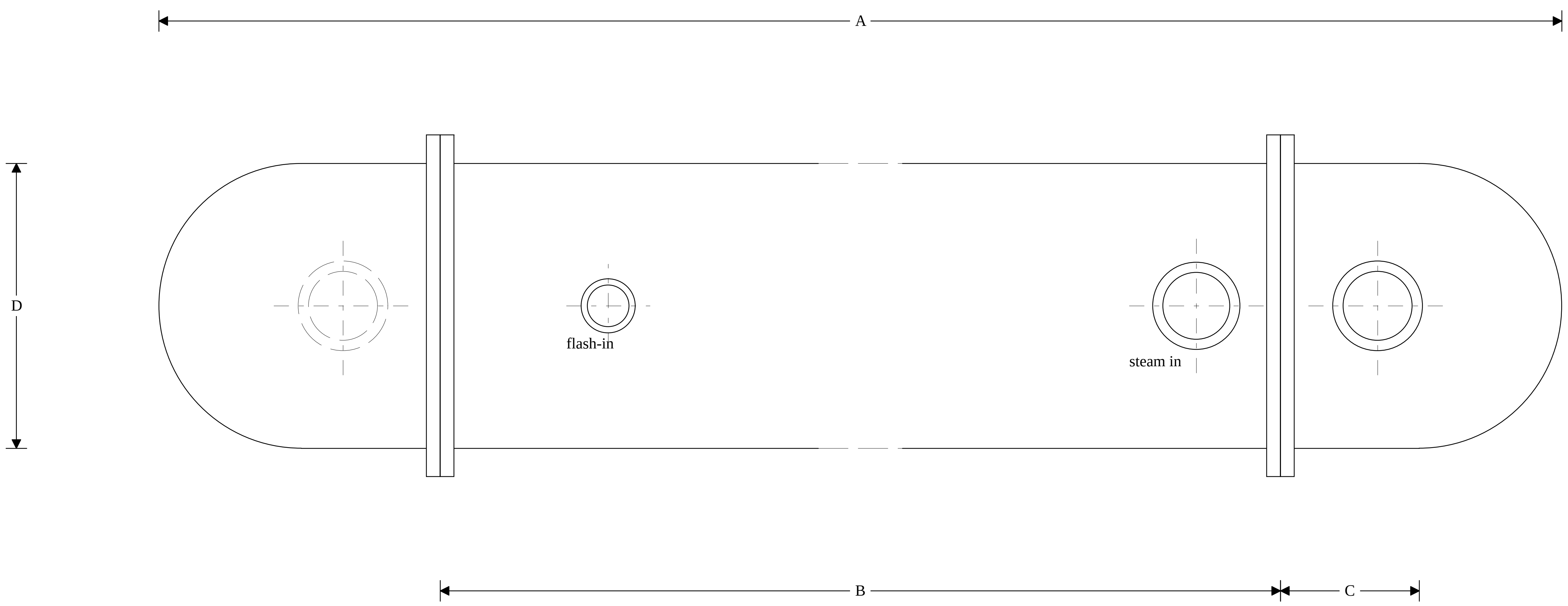


A	B	C	D	E	F	G	H	I	J
12.49 m	9.417 m	0.7237 m	1.942 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 8-D (8A, 8B) PLAN VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

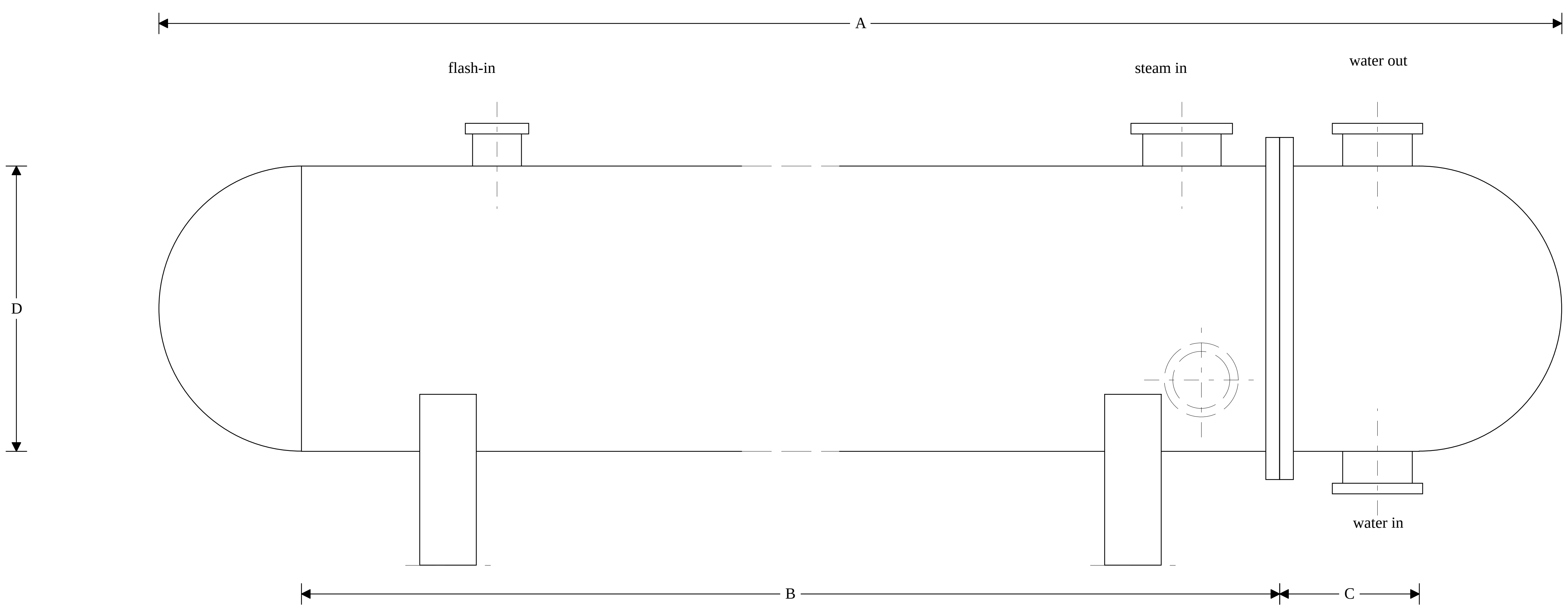
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
6.551 m	2.993 m	0.7425 m	1.521 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 9-S (9A, 9B) PLAN VIEW
Date: 04/11/17	
Drawing No:	

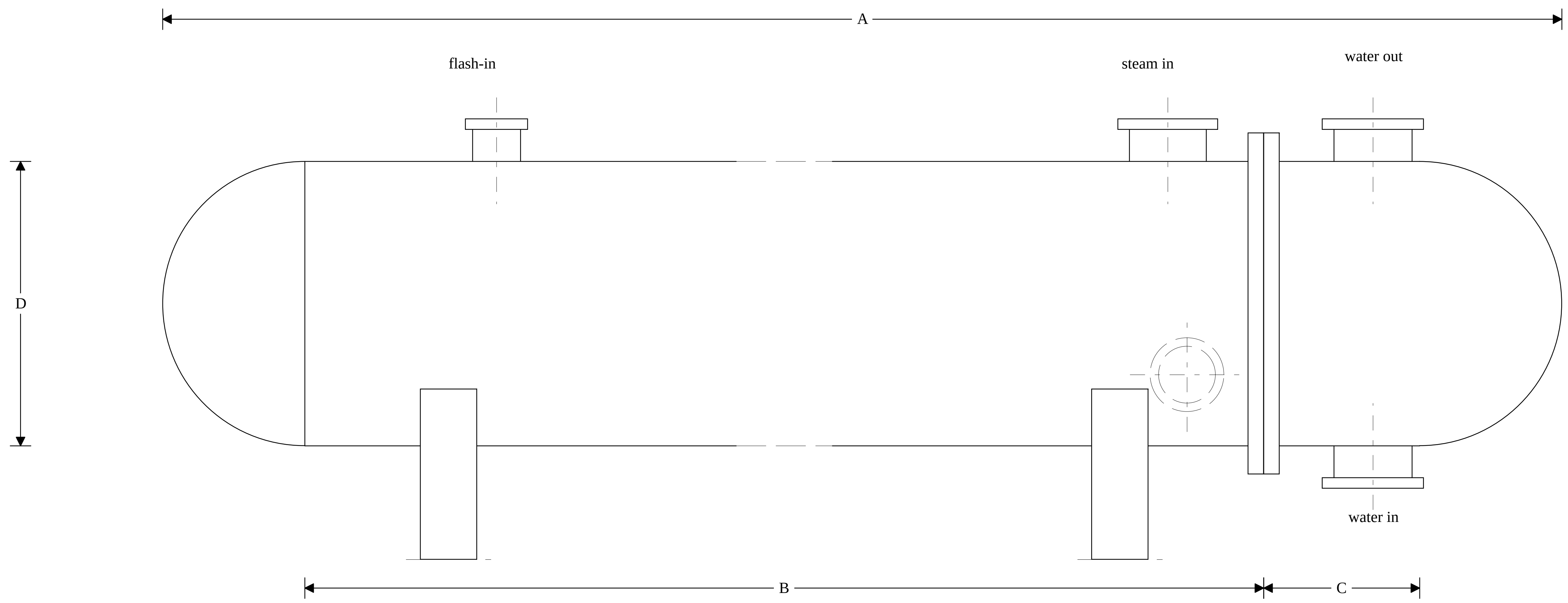
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
17.46 m	15.21 m	0.7469 m	1.439 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 1-P SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

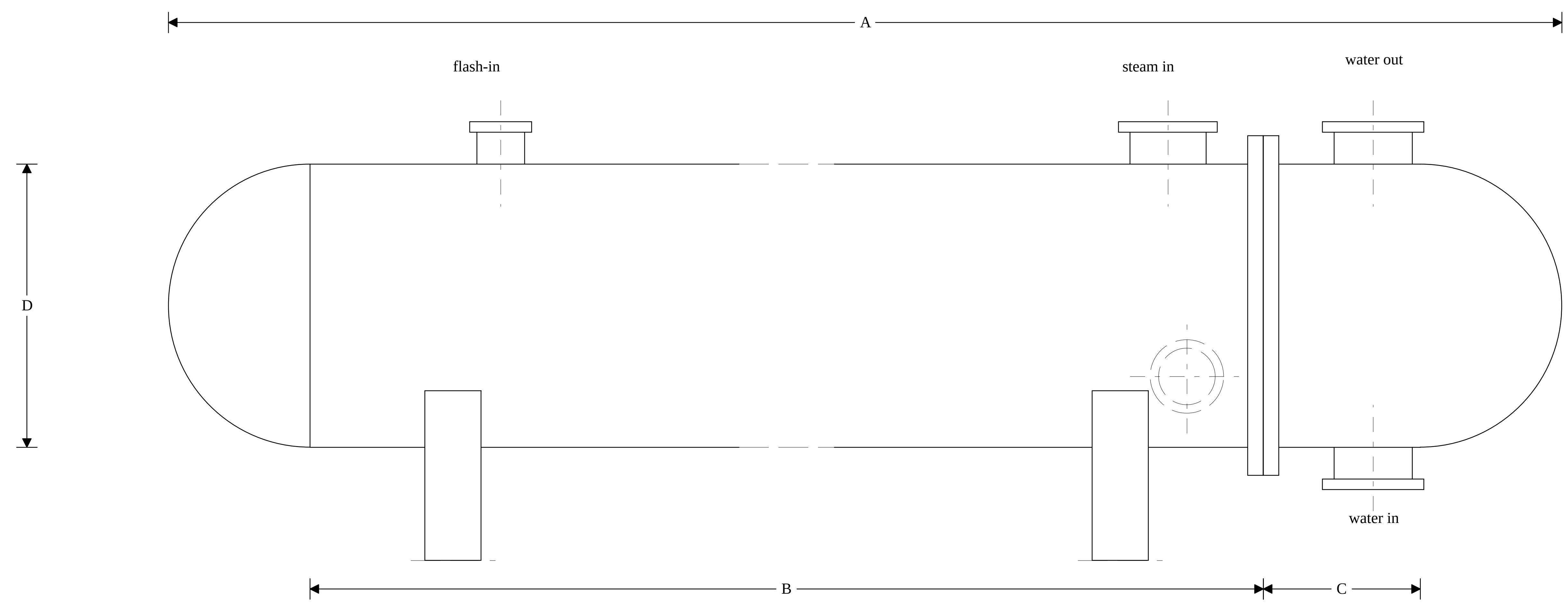
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
18.72 m	16.2 m	0.837 m	1.617 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 2-D SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

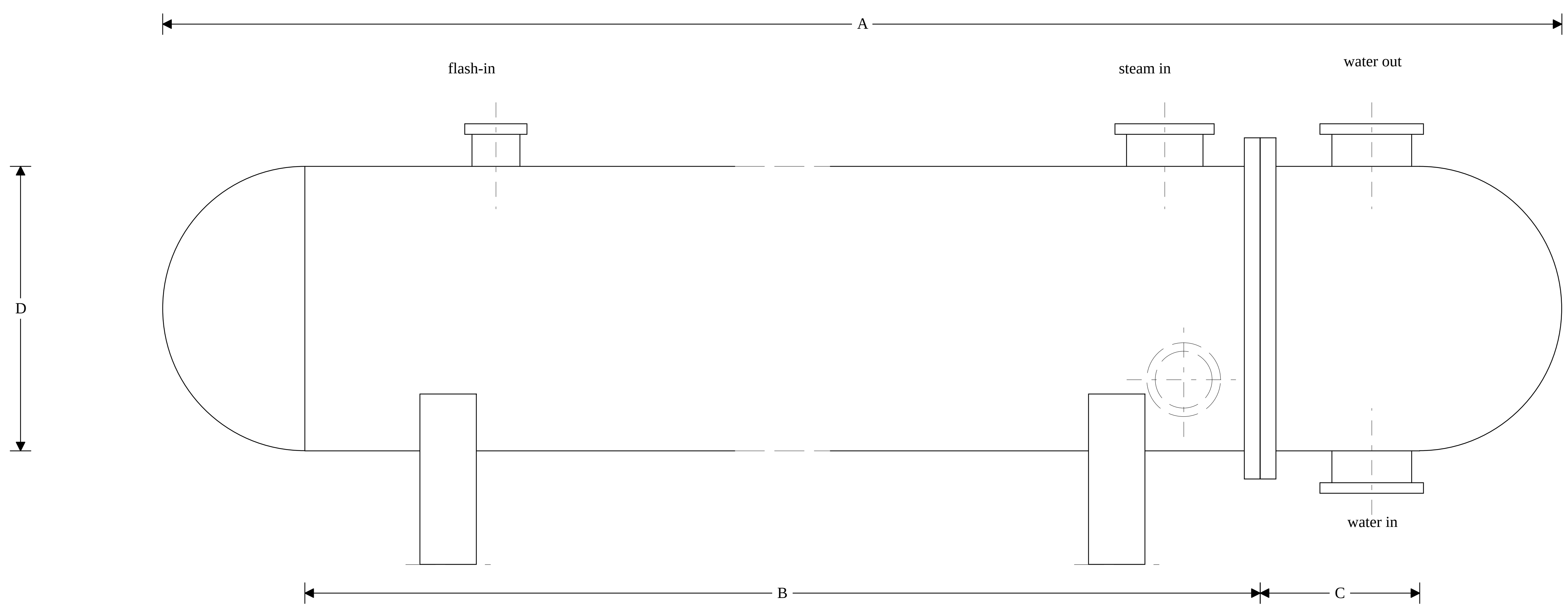
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
20.46 m	17.98 m	0.8454 m	1.584 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 3-D
	SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

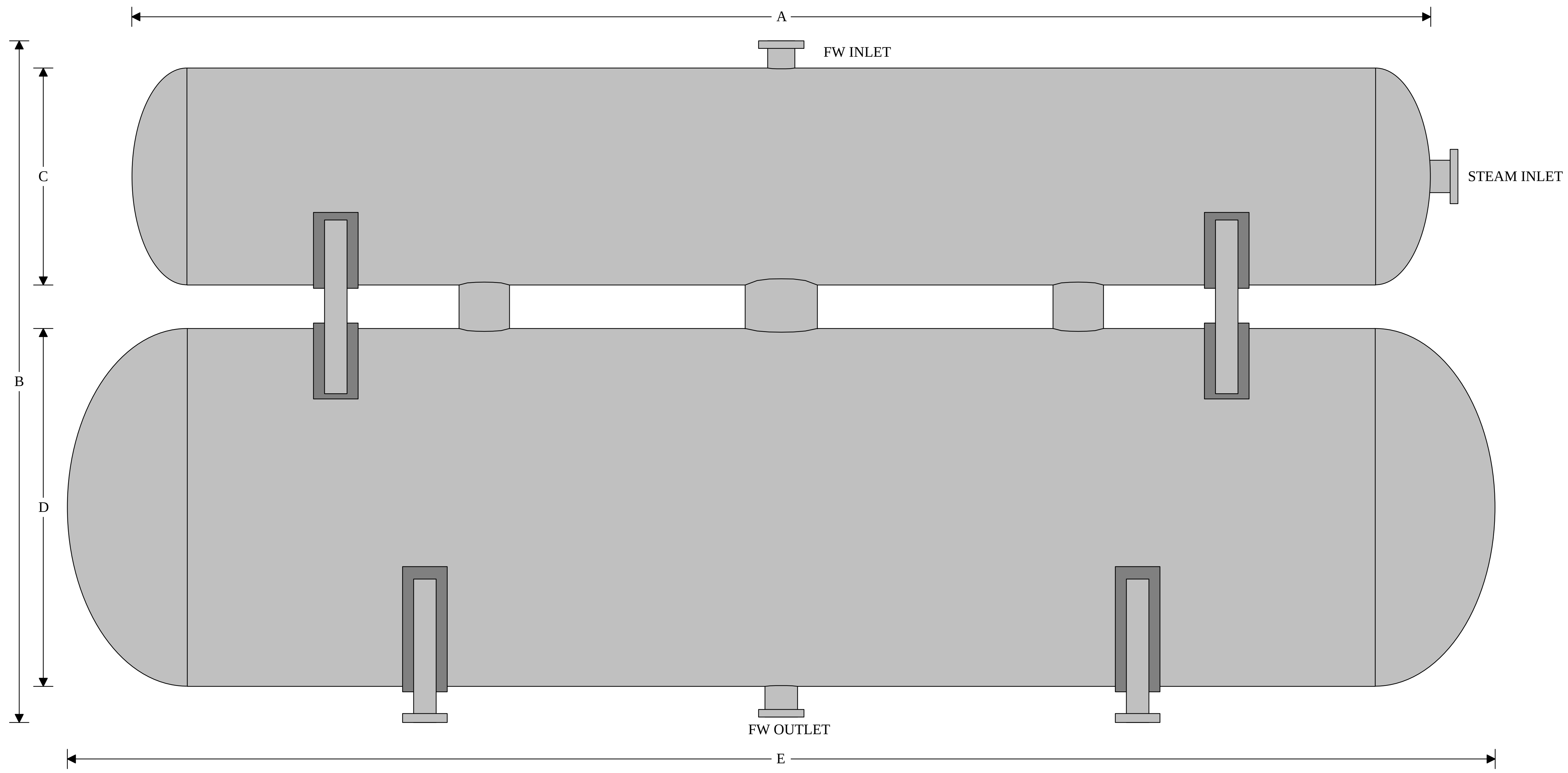


A	B	C	D	E	F	G	H	I	J
18.37 m	15.86 m	0.8561 m	1.608 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 4-D SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

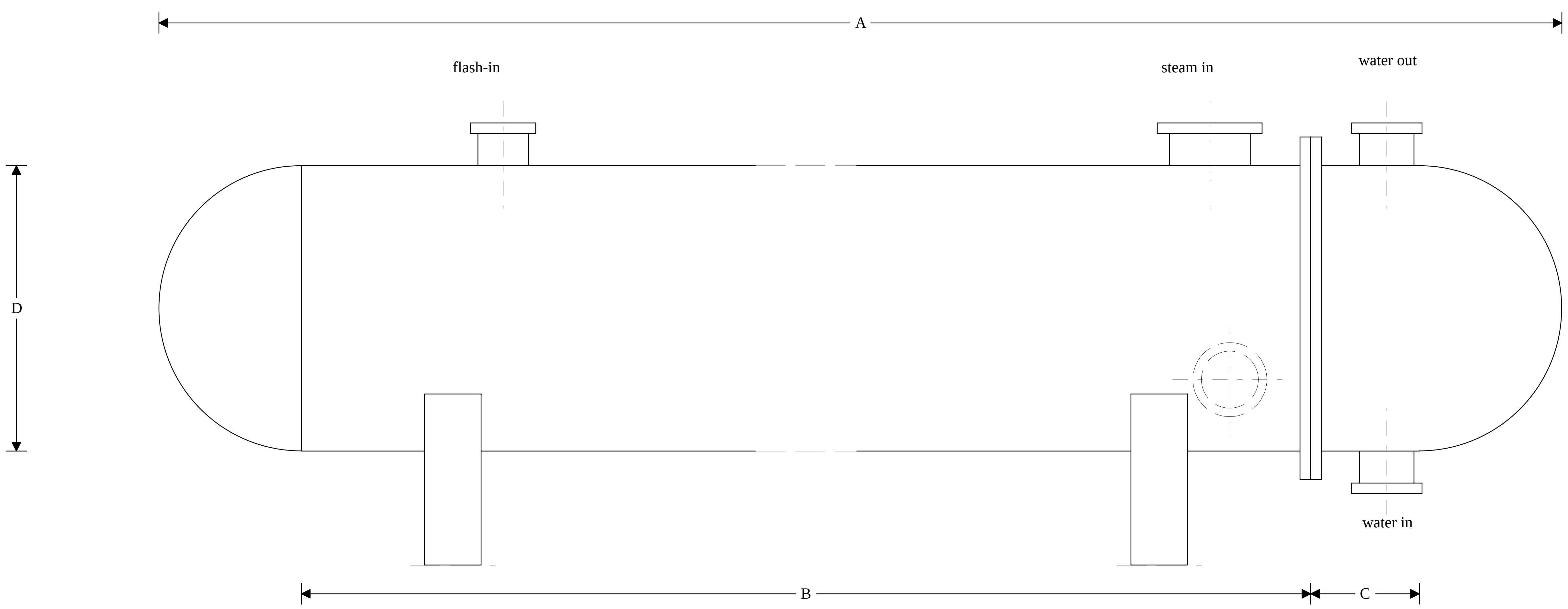


A	B	C	D	E	F	G	H	I	J
16.59 m	7.955 m	2.773 m	4.572 m	18.24 m	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM HEATED DEAERATOR
	ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

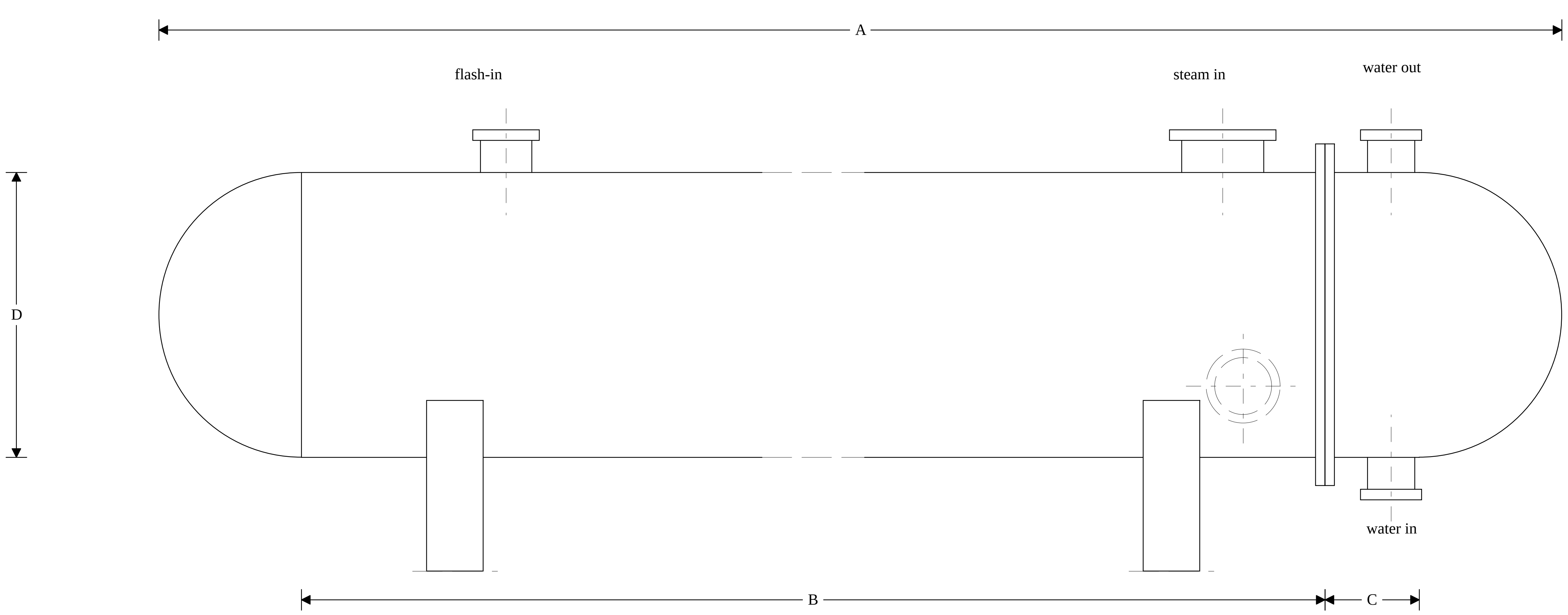
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
11.99 m	9.058 m	0.6978 m	1.773 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 6-D (6A, 6B)
	SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

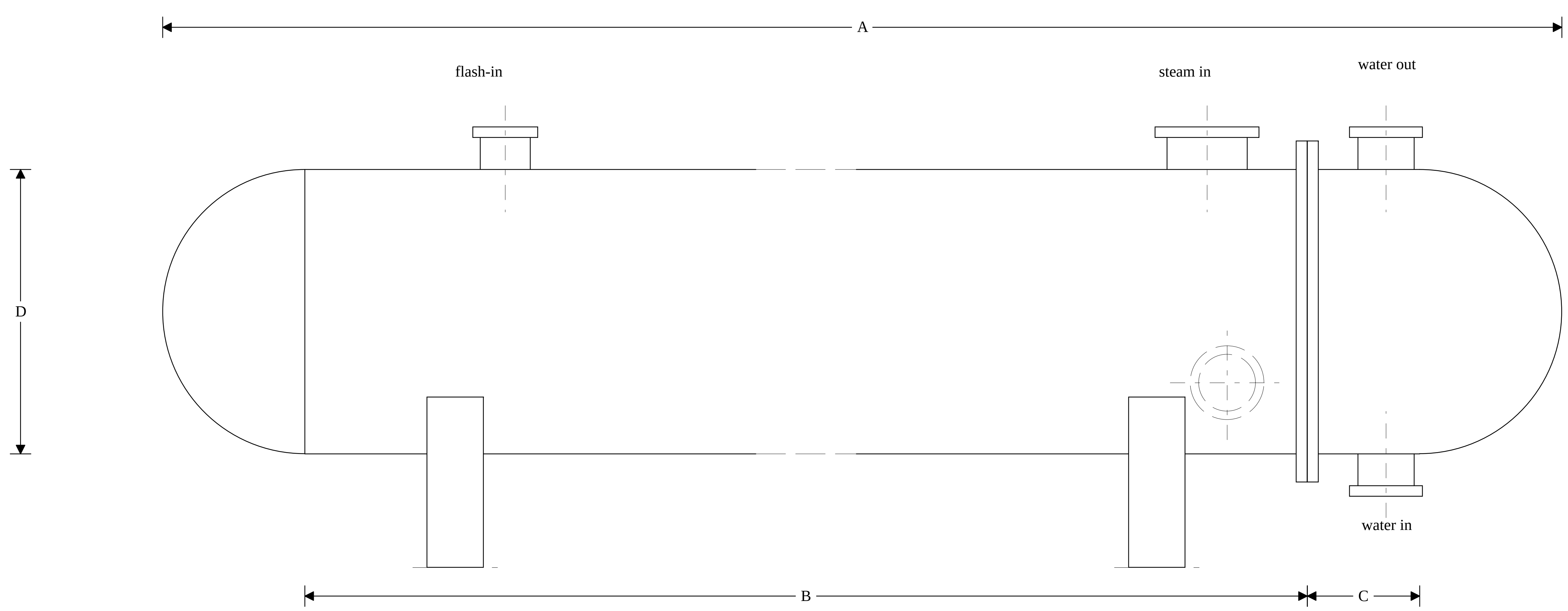


A	B	C	D	E	F	G	H	I	J
13.11 m	10.04 m	0.7078 m	2.002 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 7-D (7A, 7B)
	SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

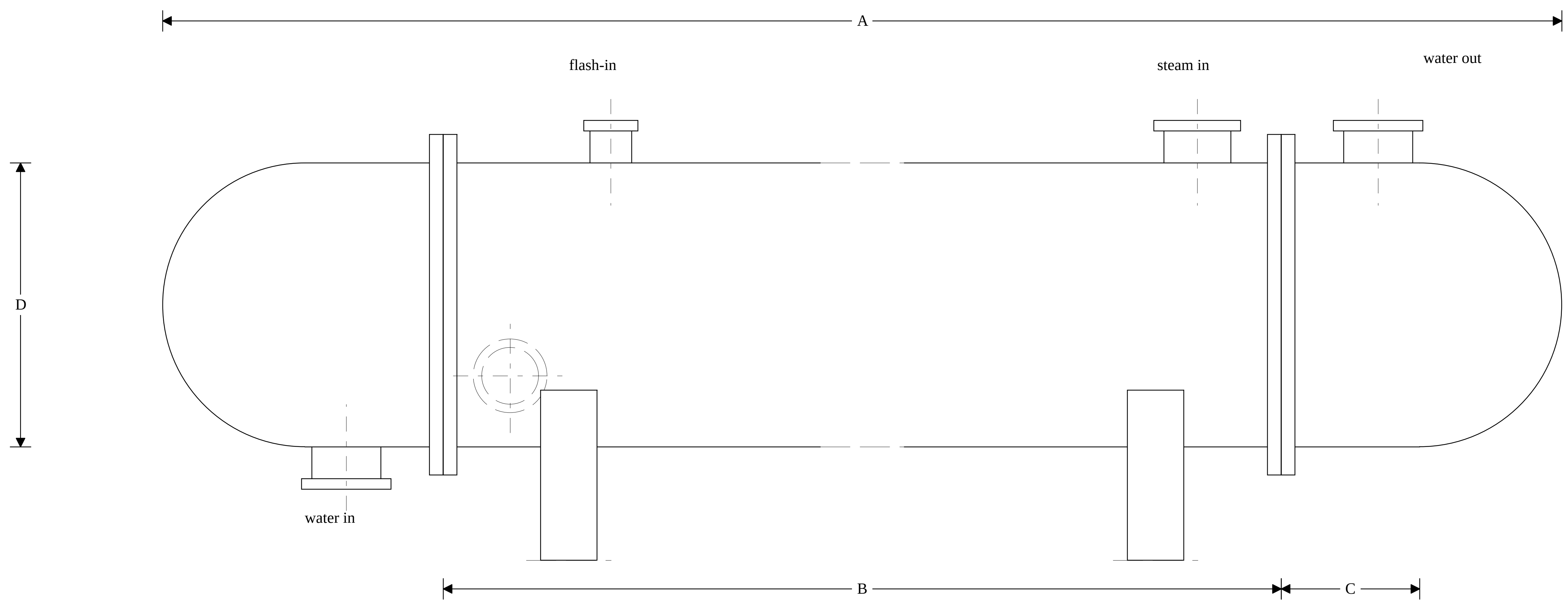


A	B	C	D	E	F	G	H	I	J
12.49 m	9.417 m	0.7237 m	1.942 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 8-D (8A, 8B) SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

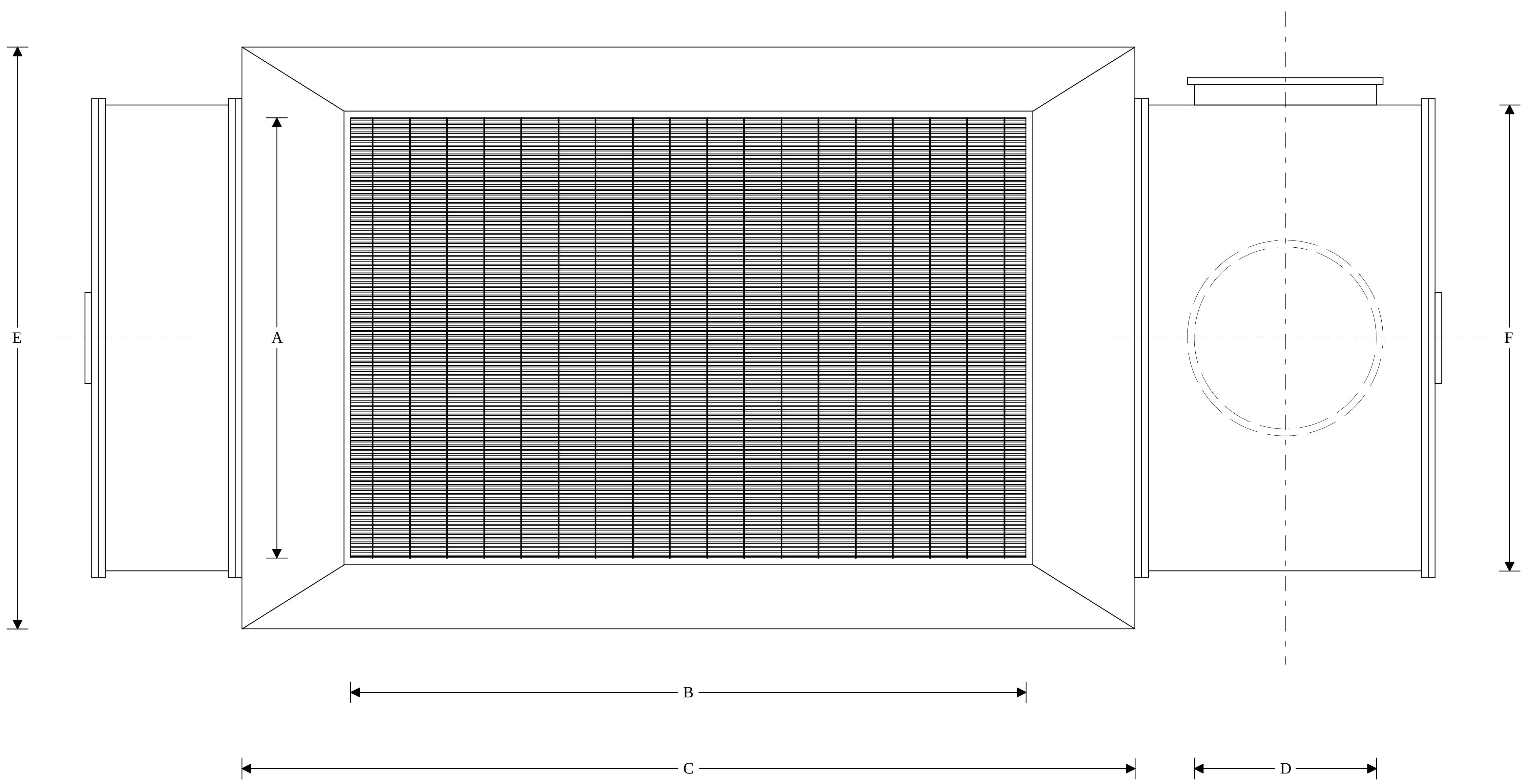
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
6.551 m	2.993 m	0.7425 m	1.521 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 9-S (9A, 9B)
	SIDE ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

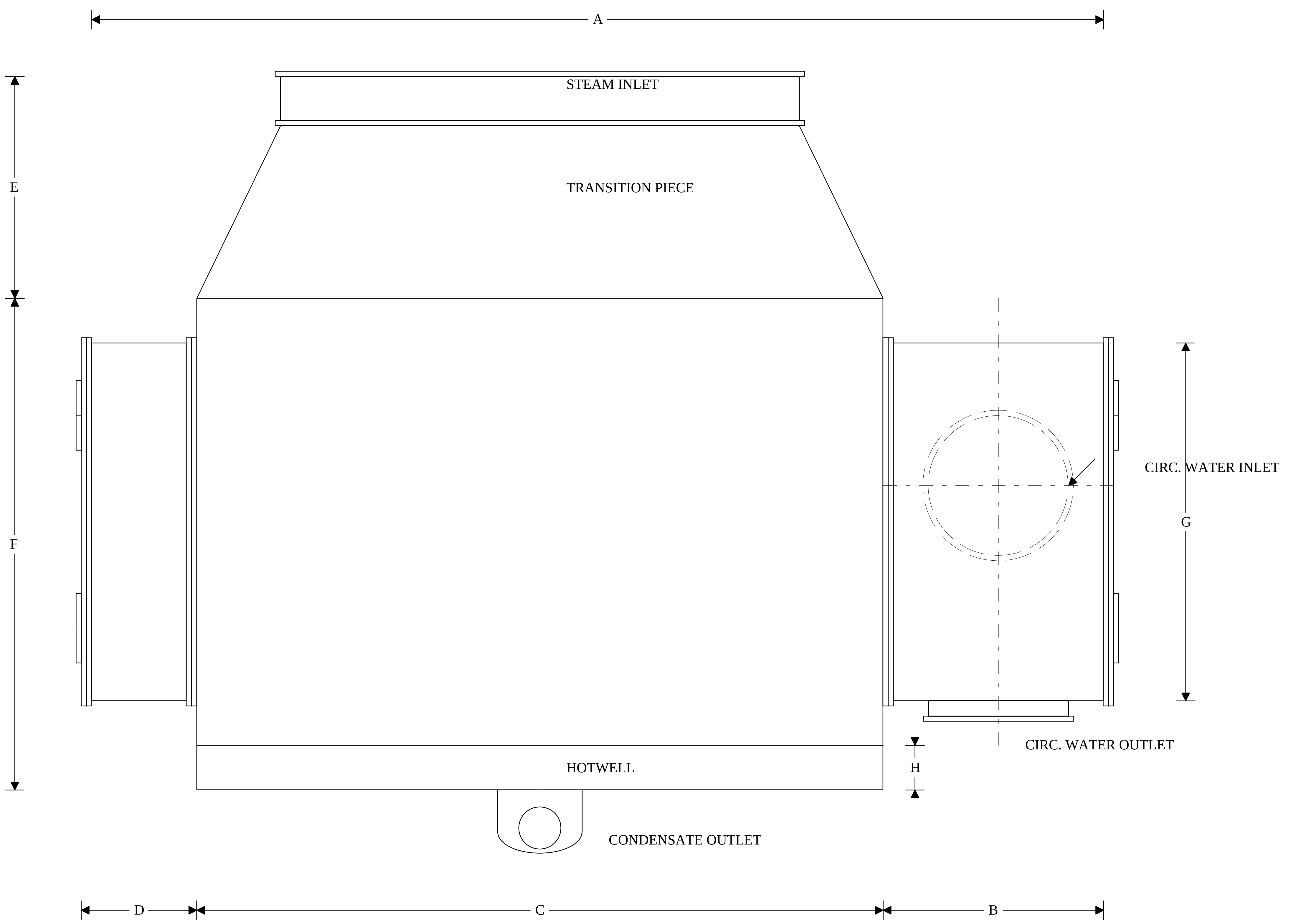
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
6.565 m	10.07 m	13.32 m	2.718 m	8.681 m	6.95 m	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	WCC
	PLAN
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY



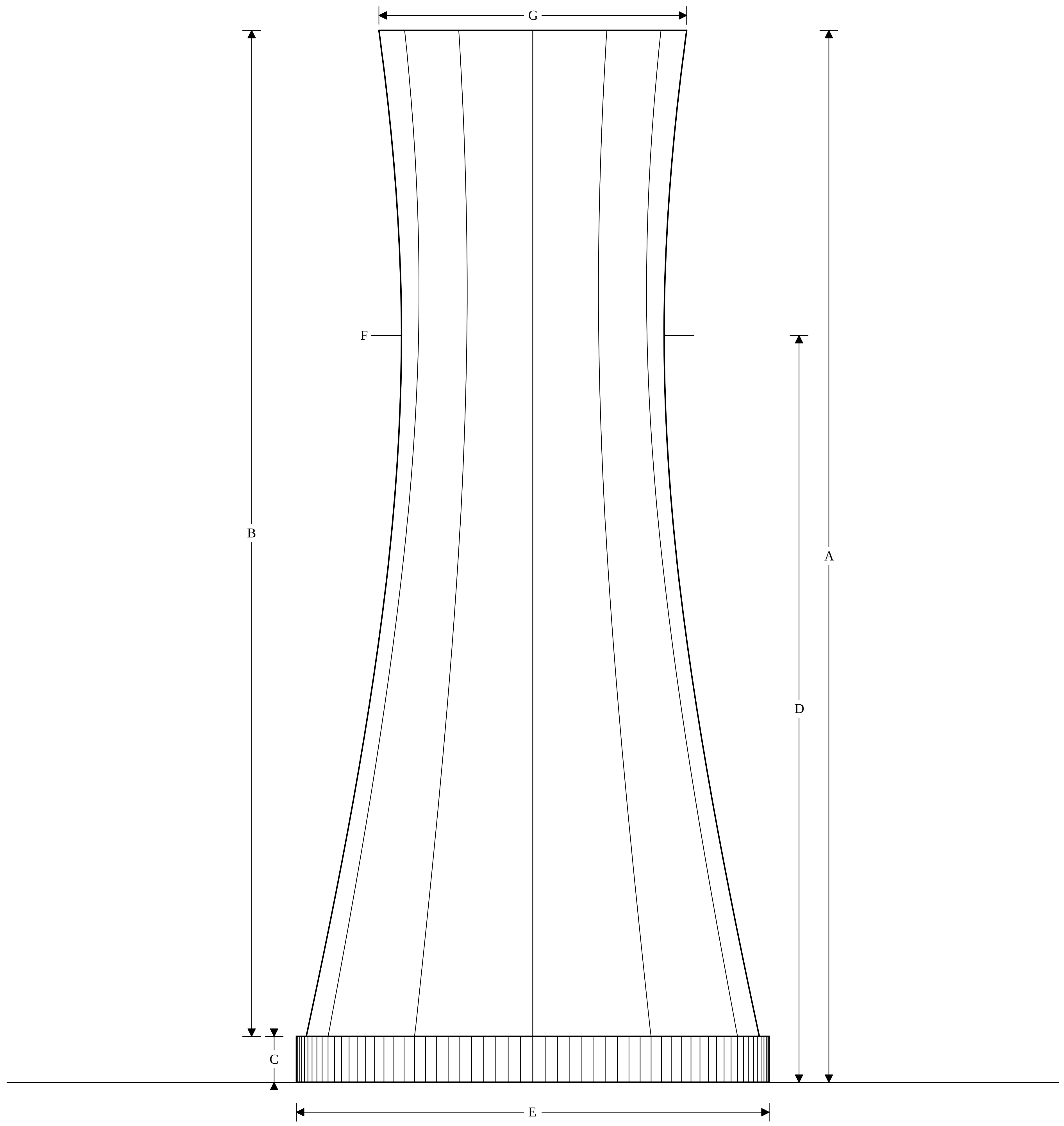
A	B	C	D	E	F	G	H	I	J
19.44 m	4.077 m	13.32 m	2.038 m	4.309 m	9.548 m	6.95 m	0.8666 m	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	WCC SIDE ELEVATION
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

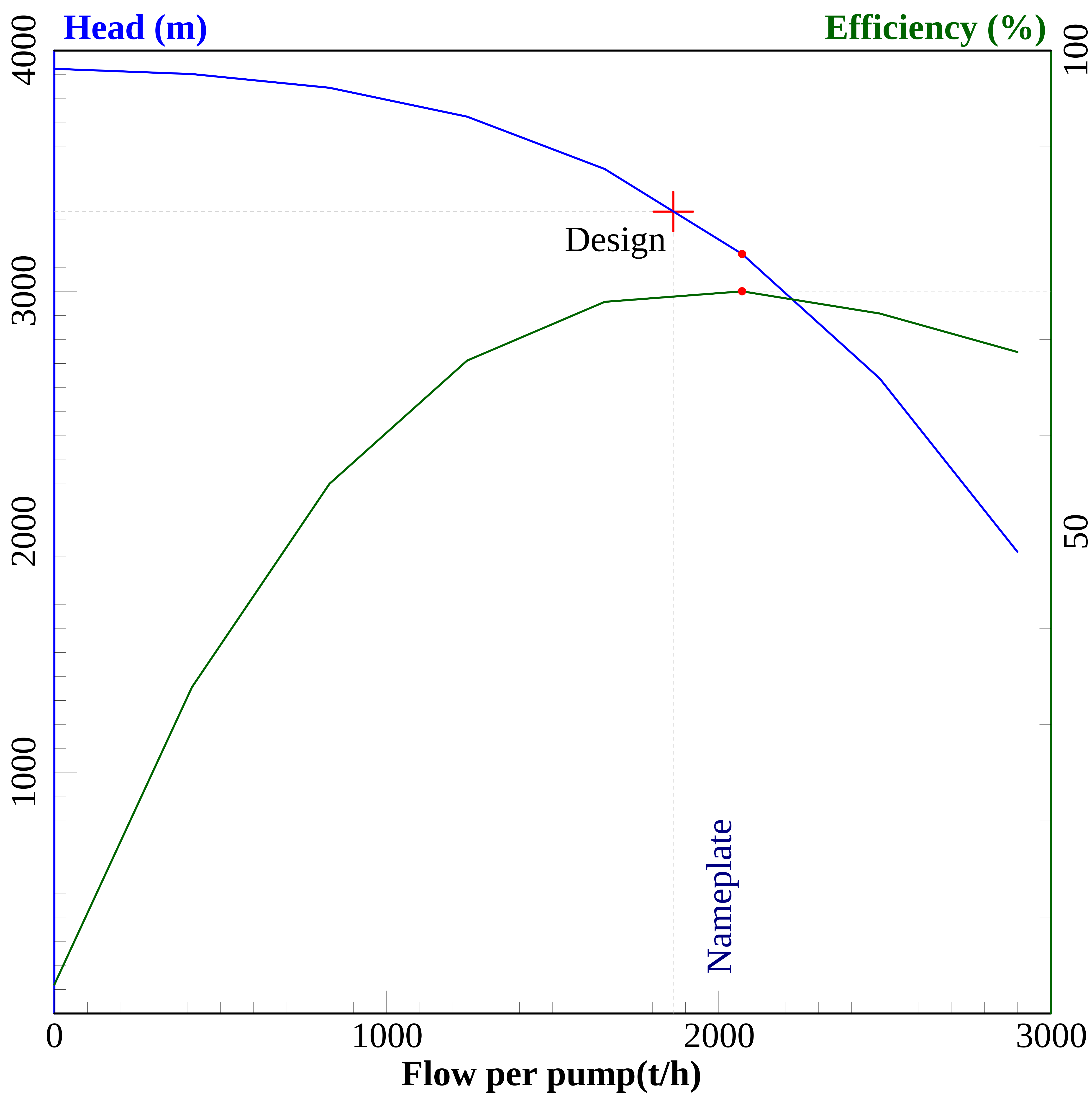
Average shell thickness = 457.2 mm
Basin area = 6,920 m^2



A	B	C	D	E	F	G	H	I	J
208.8 m	199.6 m	9.144 m	148.2 m	93.85 m	52.14 m	61.11 m	-	-	-

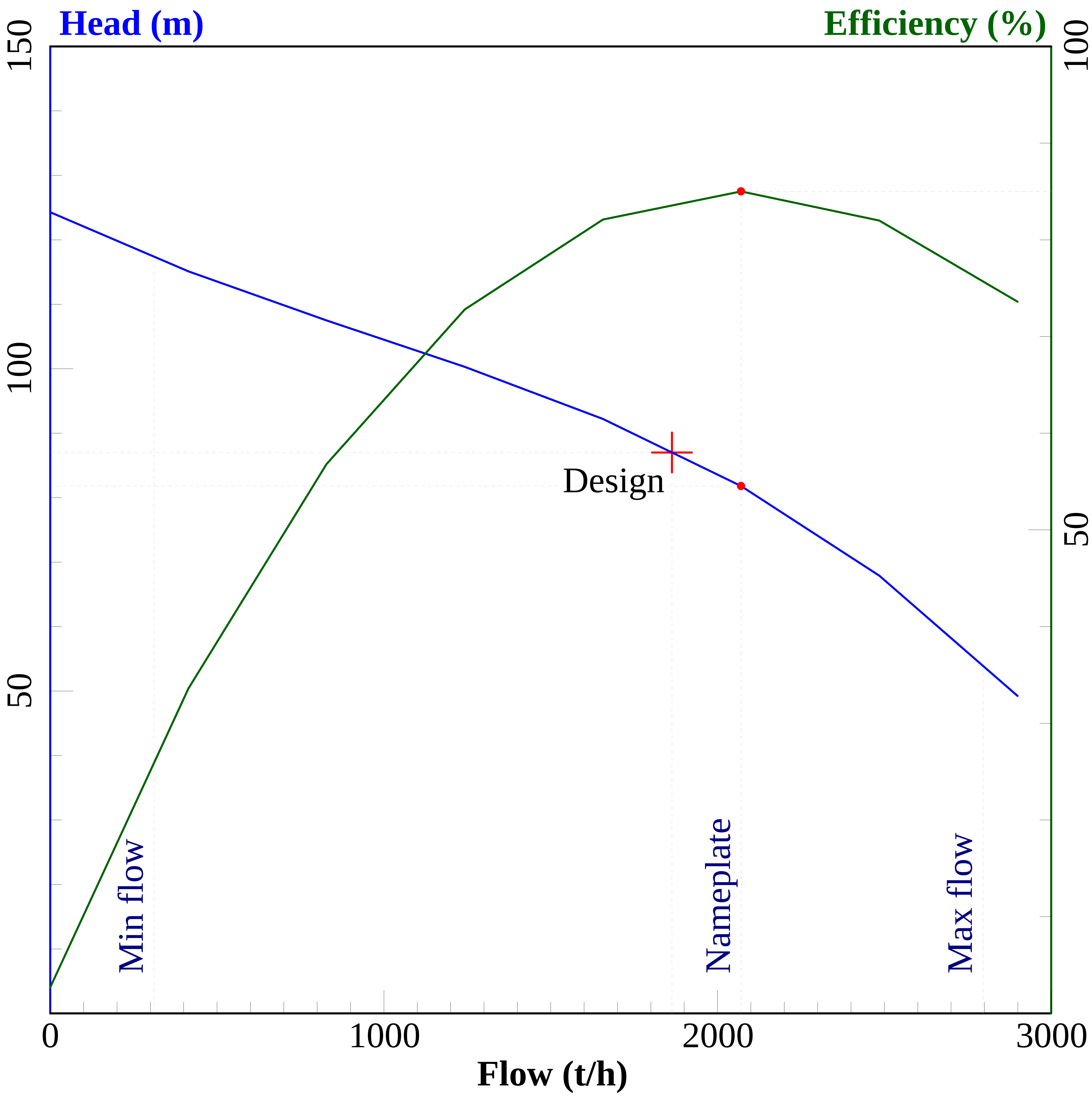
Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ELEVATION
Date: 04/11/17	
Drawing No:	

Boiler Feed Pump (P1)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2070.6 t/h
Nameplate head	3155 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	3170 m
Nameplate RPM	3000
Design flow	1863.6 t/h
Design head	3331 m
Design RPM	3000

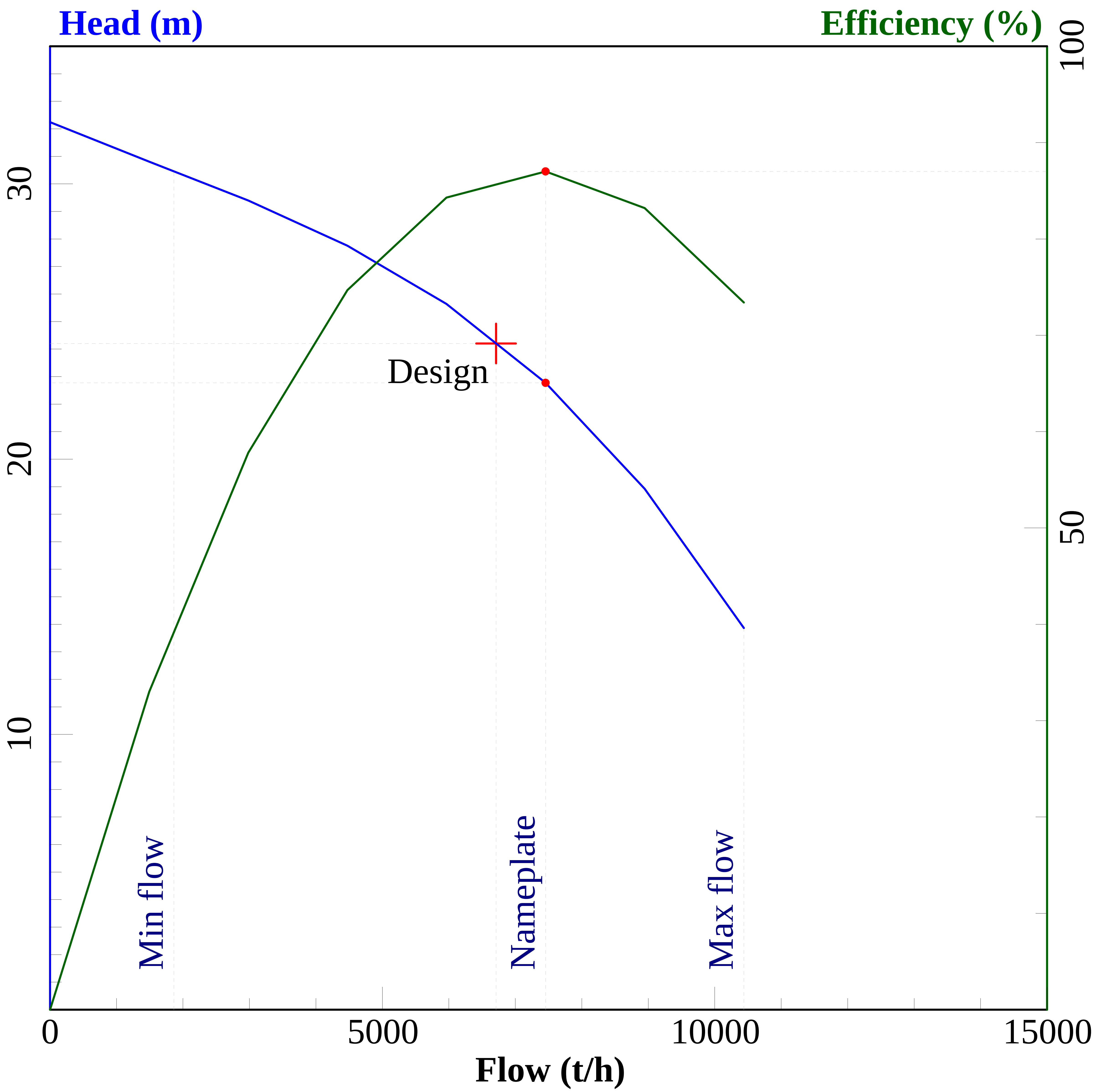
Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Pump (P1)
Date: 04/11/17	
Drawing No:	



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2070.6 t/h
Nameplate head	81.81 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	83.82 m
Nameplate RPM	600
Design flow	1863.6 t/h
Design head	87.01 m
Design RPM	600
Minimum continuous flow	310.6 t/h
Maximum continuous flow	2795.3 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Booster Pump (P3)
Date: 04/11/17	
Drawing No:	

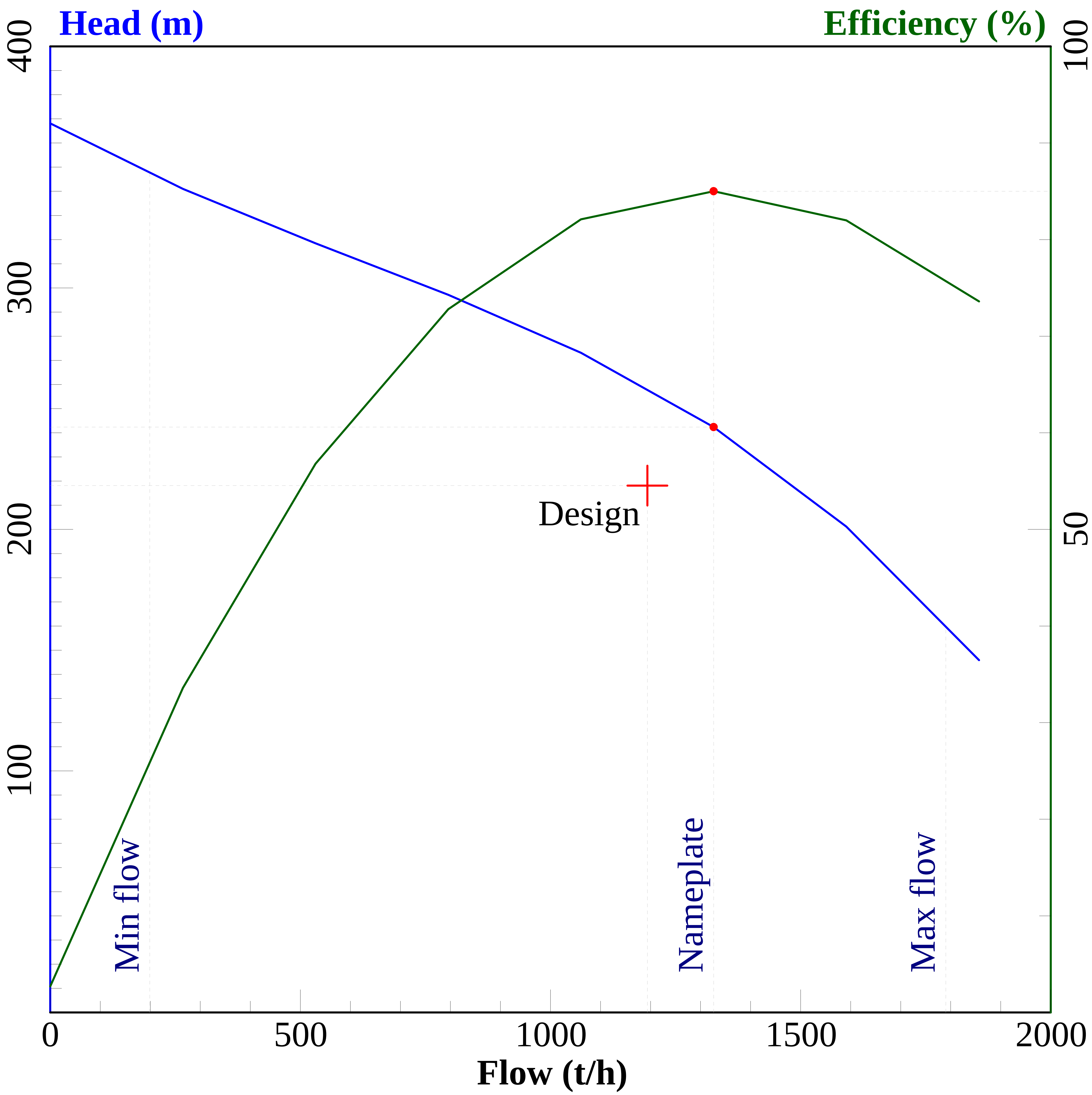
Condenser C.W. Pump (P4)



No. per ST	8
No. operating per ST	8
Nameplate flow	7455 t/h
Nameplate head	22.77 m
Nameplate flow (nominal)	124919 lpm
Nameplate head (nominal)	24.38 m
Nameplate RPM	500
Design flow	6710 t/h
Design head	24.2 m
Design RPM	500
Minimum continuous flow	1863.8 t/h
Maximum continuous flow	10437 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Condenser C.W. Pump (P4)
Date: 04/11/17	
Drawing No:	

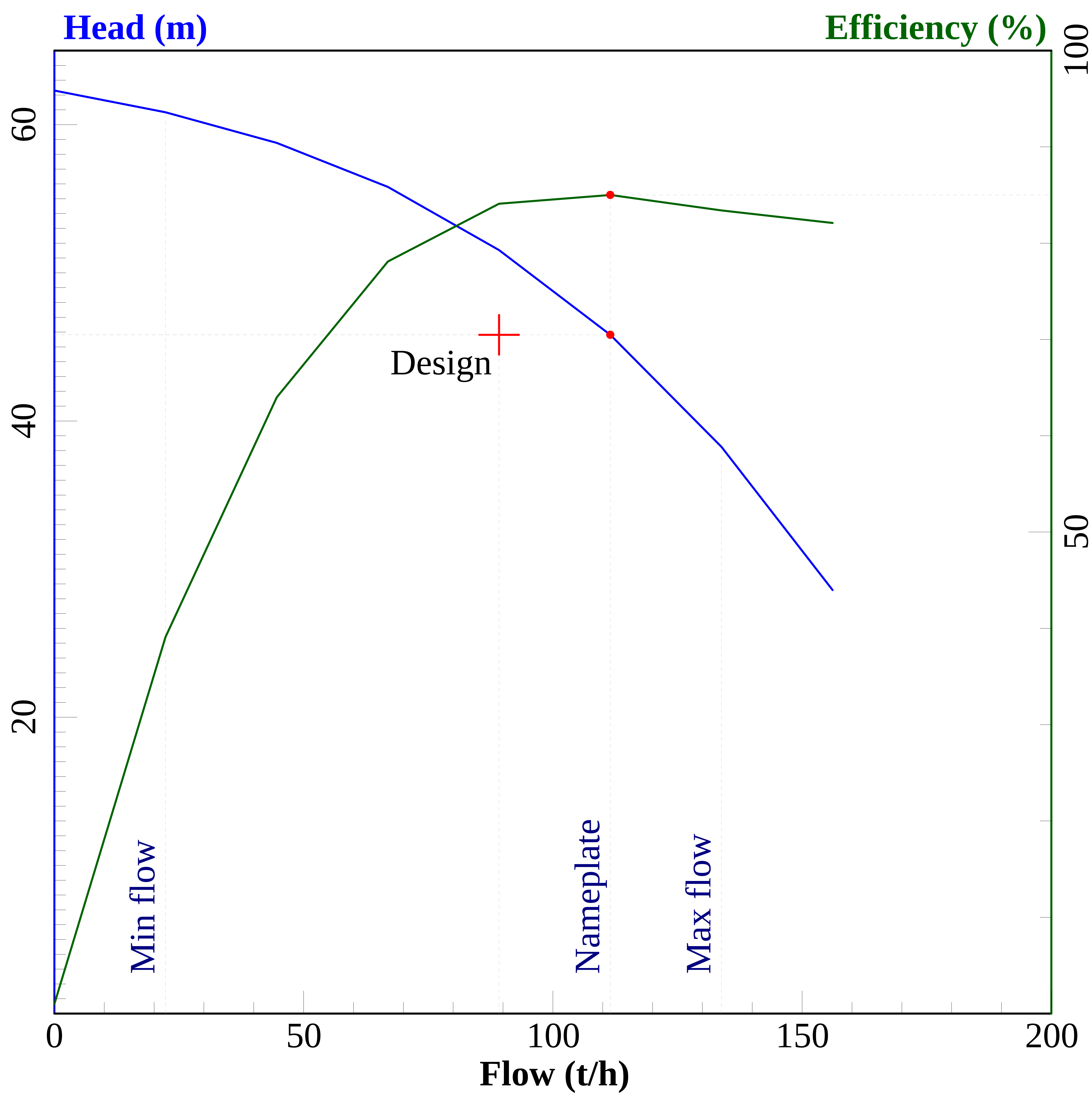
Condensate Forwarding Pump (P6)



No. per ST	2
No. operating per ST	1
Nameplate flow	1326.2 t/h
Nameplate head	242.4 m
Nameplate flow (nominal)	22712 lpm
Nameplate head (nominal)	243.8 m
Nameplate RPM	1500
Design flow	1193.6 t/h
Design head	218.1 m
Design RPM	1500
Minimum continuous flow	198.9 t/h
Maximum continuous flow	1790.4 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Condensate Forwarding Pump (P6)
Date: 04/11/17	
Drawing No:	

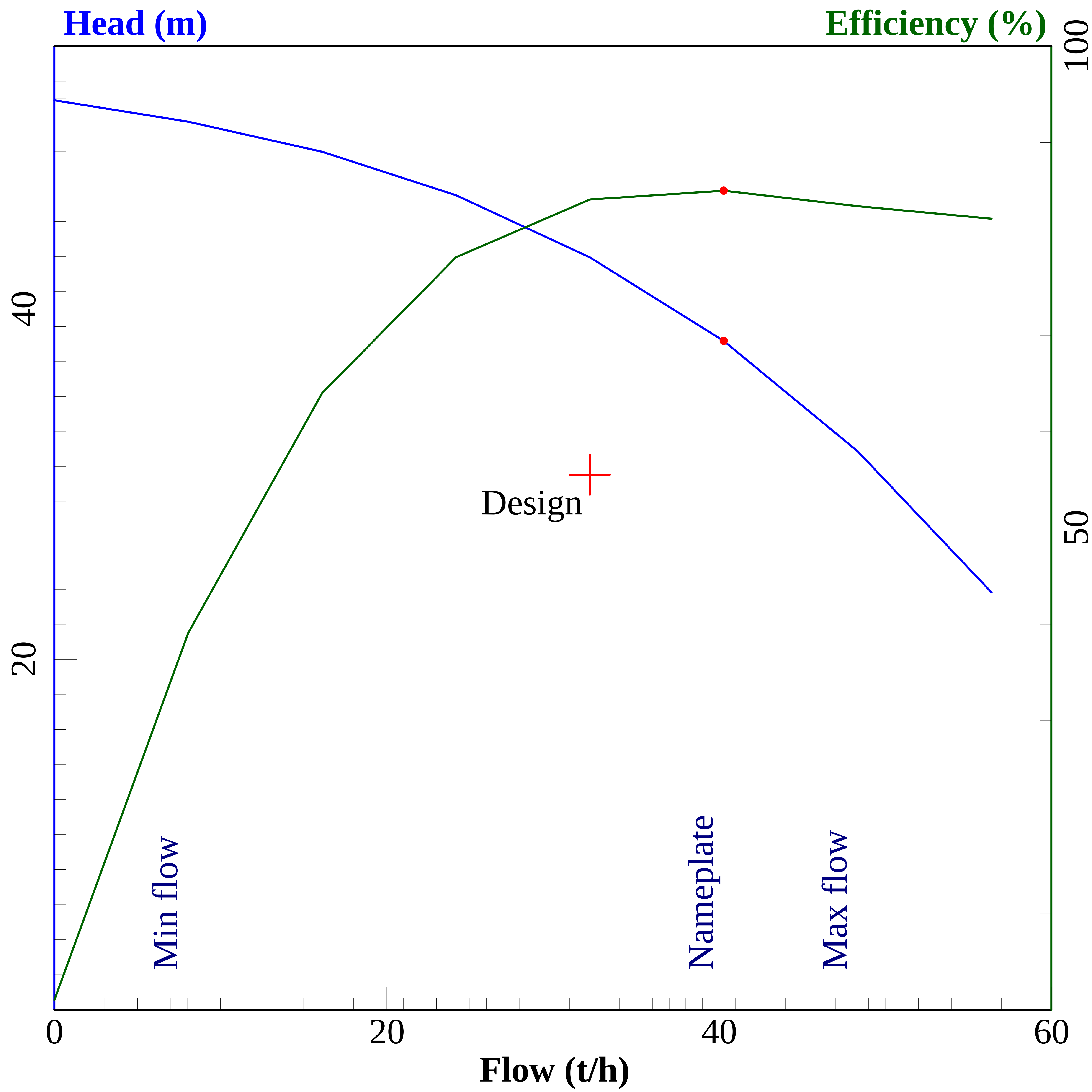
Fuel Oil Unloading Pump (P8)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	111.5 t/h
Nameplate head	45.81 m
Nameplate flow (nominal)	2271.2 lpm
Nameplate head (nominal)	53.34 m
Nameplate RPM	3000
Design flow	89.21 t/h
Design head	45.81 m
Design RPM	3000
Minimum continuous flow	22.3 t/h
Maximum continuous flow	133.8 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Fuel Oil Unloading Pump (P8)
Date: 04/11/17	
Drawing No:	

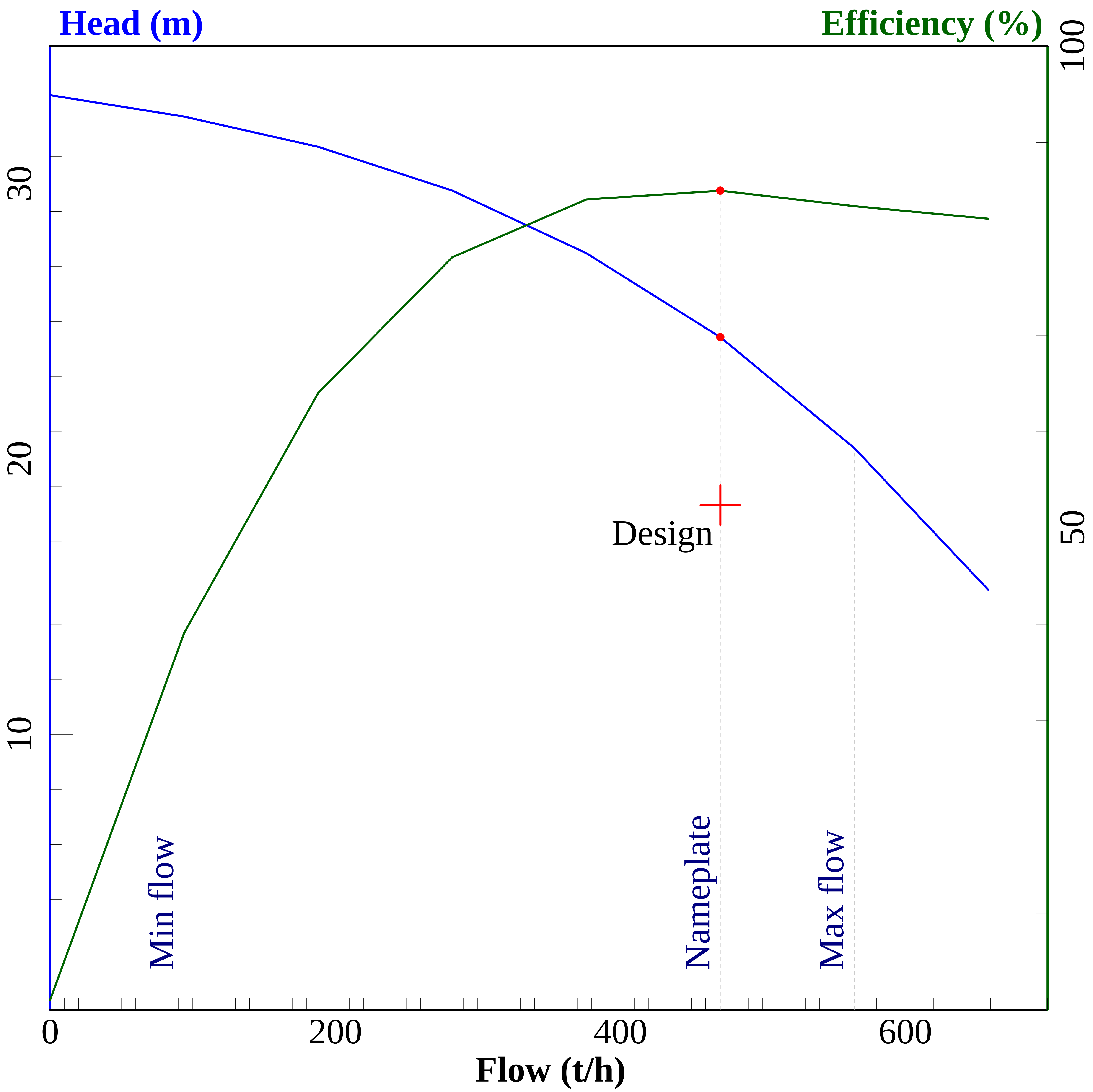
Fuel Oil Forwarding Pump (P9)



No. per Plant	2
No. operating per Plant	1
Nameplate flow	40.29 t/h
Nameplate head	38.17 m
Nameplate flow (nominal)	851.7 lpm
Nameplate head (nominal)	45.72 m
Nameplate RPM	3000
Design flow	32.23 t/h
Design head	30.54 m
Design RPM	3000
Minimum continuous flow	8.057 t/h
Maximum continuous flow	48.34 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Fuel Oil Forwarding Pump (P9)
Date: 04/11/17	
Drawing No:	

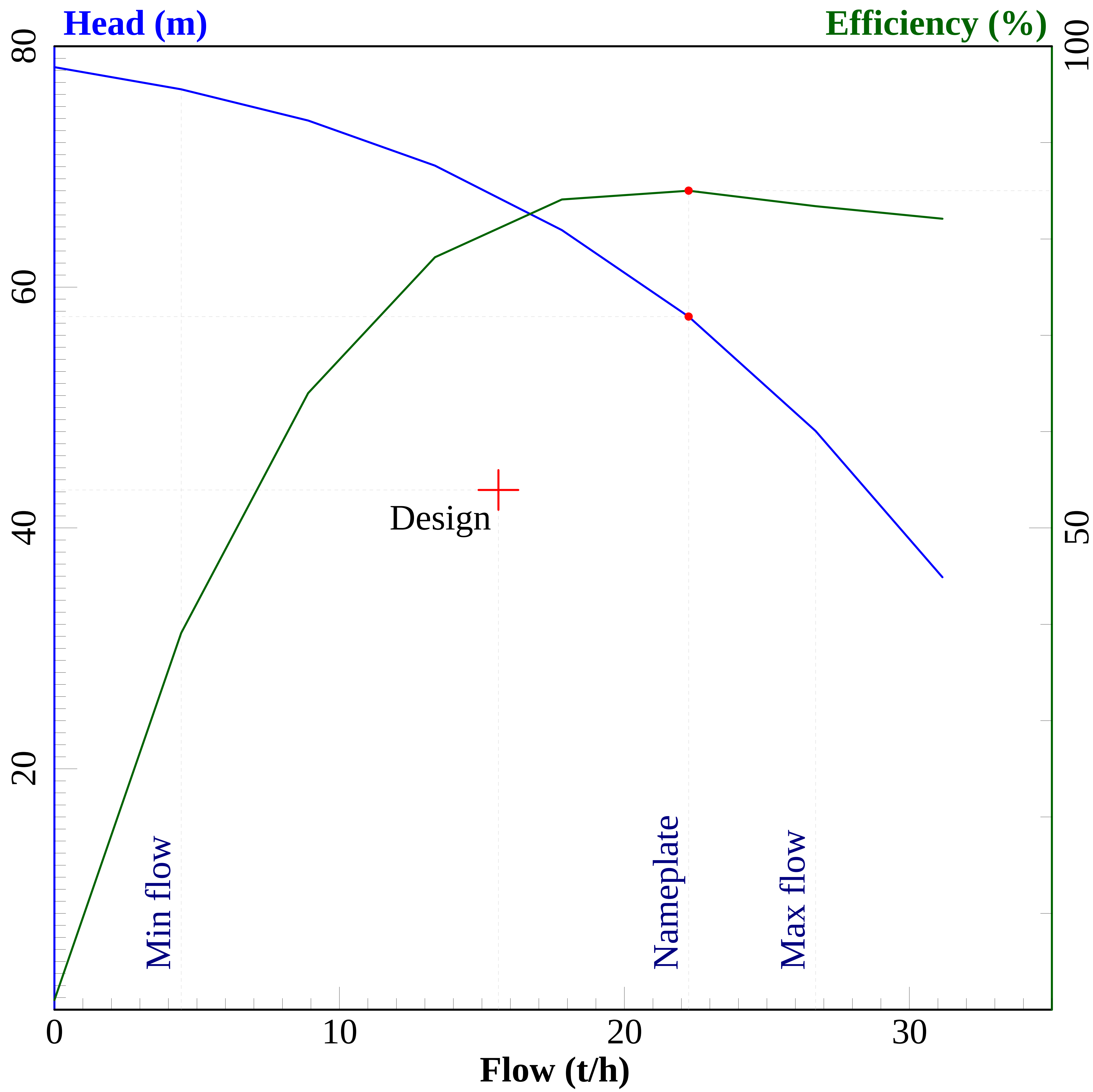
Aux Cooling Water Pump (closed loop) (P10)



No. per Plant	2
No. operating per Plant	1
Nameplate flow	470.4 t/h
Nameplate head	24.43 m
Nameplate flow (nominal)	8517 lpm
Nameplate head (nominal)	27.43 m
Nameplate RPM	1500
Design flow	470.4 t/h
Design head	18.32 m
Design RPM	1500
Minimum continuous flow	94.08 t/h
Maximum continuous flow	564.5 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Aux Cooling Water Pump (closed loop) (P10)
Date: 04/11/17	
Drawing No:	

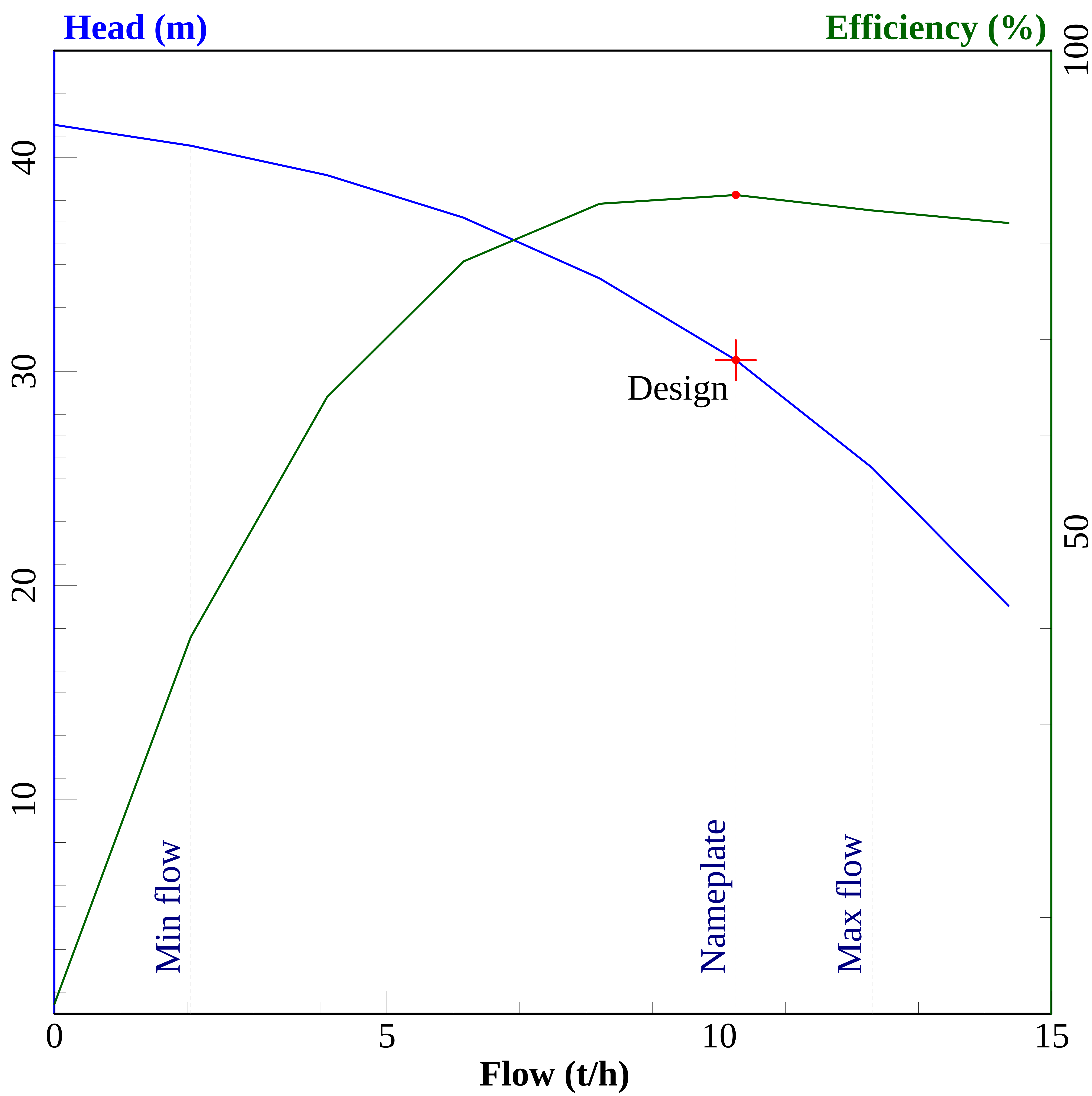
Treated Water Pump (P11)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	22.26 t/h
Nameplate head	57.55 m
Nameplate flow (nominal)	378.5 lpm
Nameplate head (nominal)	60.96 m
Nameplate RPM	3000
Design flow	15.58 t/h
Design head	43.16 m
Design RPM	3000
Minimum continuous flow	4.452 t/h
Maximum continuous flow	26.71 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Treated Water Pump (P11)
Date: 04/11/17	
Drawing No:	

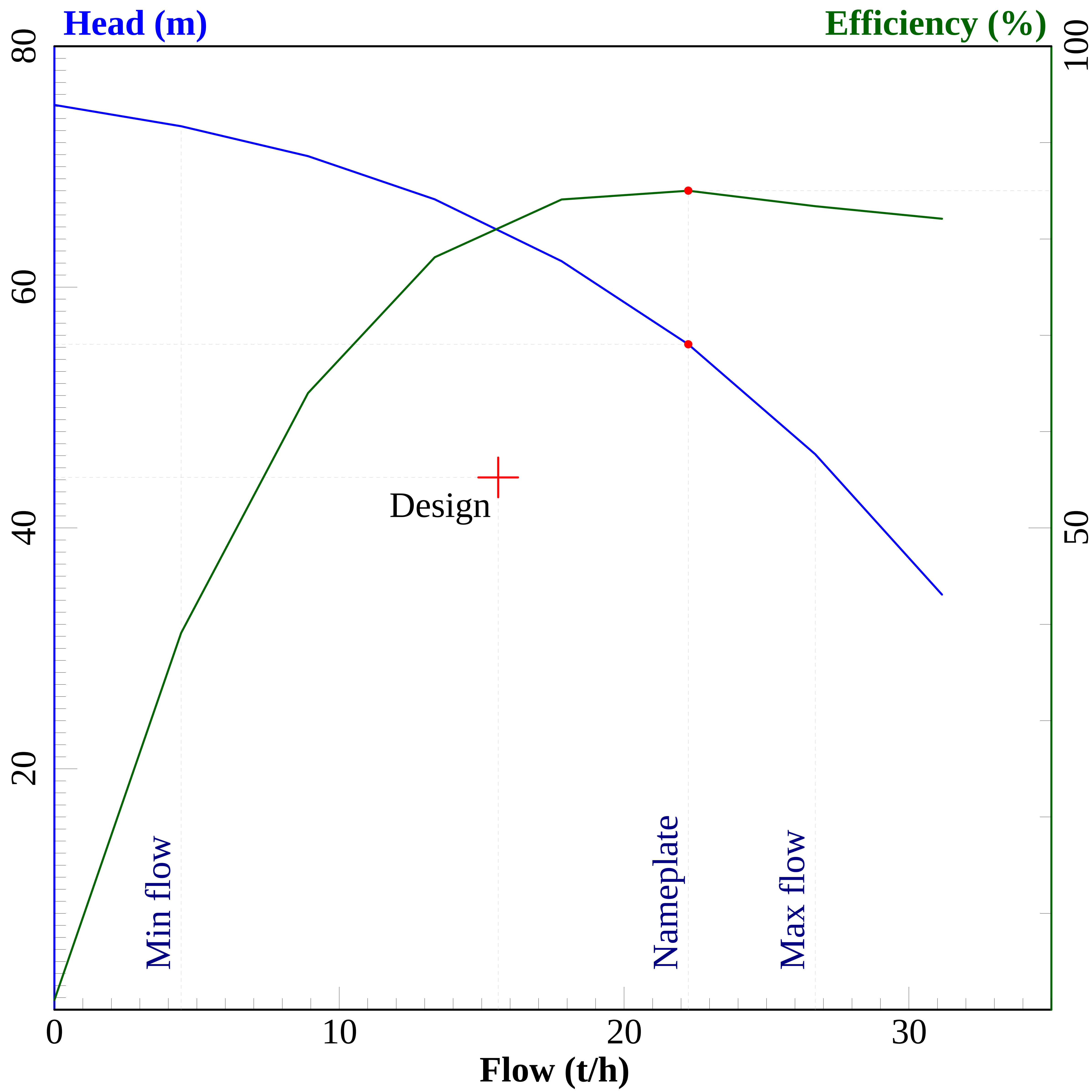
Jockey Fire Pump (P14)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	10.25 t/h
Nameplate head	30.54 m
Nameplate flow (nominal)	170.3 lpm
Nameplate head (nominal)	38.1 m
Nameplate RPM	3000
Design flow	10.25 t/h
Design head	30.54 m
Design RPM	3000
Minimum continuous flow	2.051 t/h
Maximum continuous flow	12.31 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Jockey Fire Pump (P14)
Date: 04/11/17	
Drawing No:	

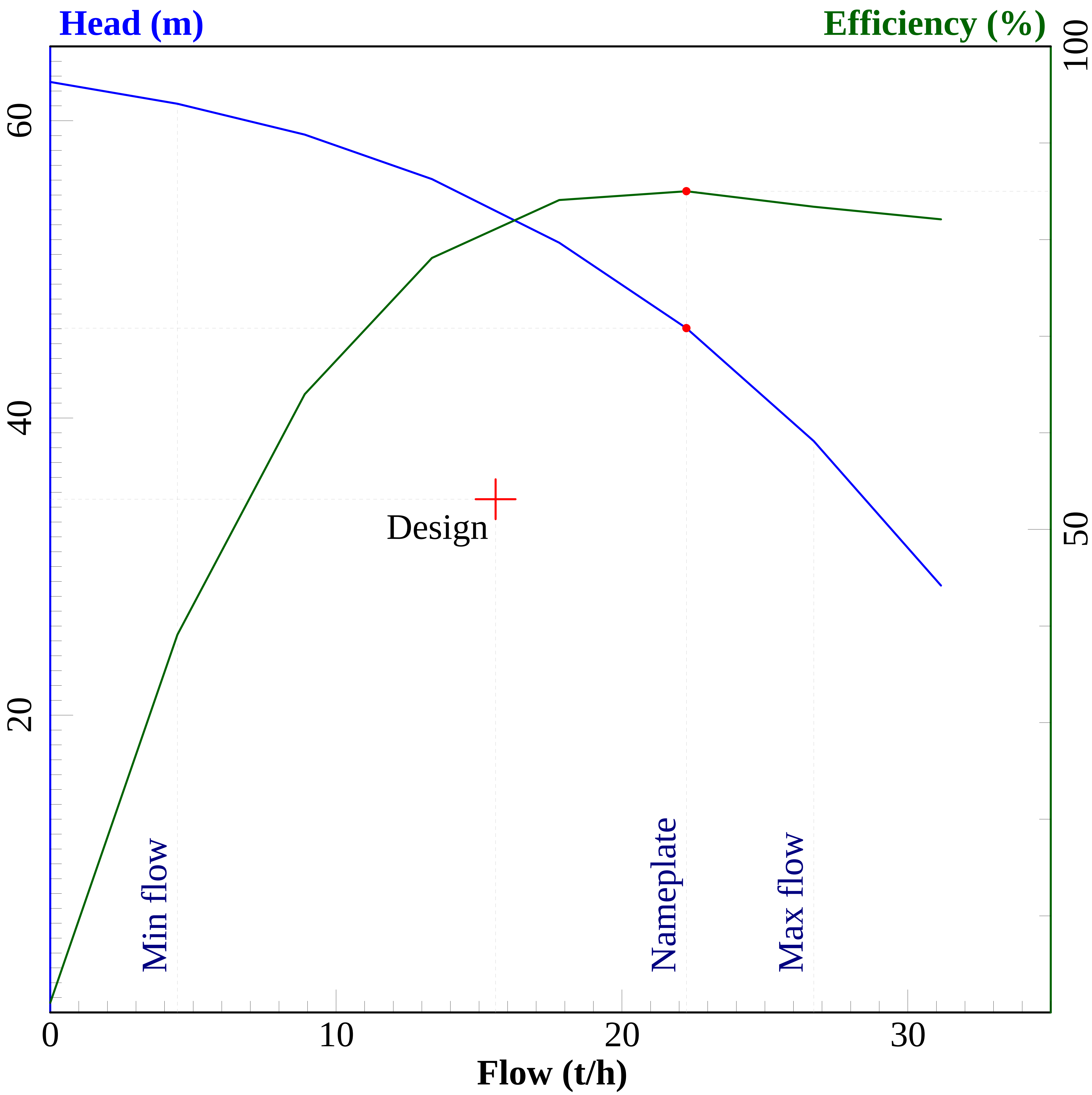
Demin Water Pump (P23)



No. per Plant	2
No. operating per Plant	1
Nameplate flow	22.26 t/h
Nameplate head	55.24 m
Nameplate flow (nominal)	378.5 lpm
Nameplate head (nominal)	60.96 m
Nameplate RPM	3000
Design flow	15.58 t/h
Design head	44.2 m
Design RPM	3000
Minimum continuous flow	4.452 t/h
Maximum continuous flow	26.71 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Demin Water Pump (P23)
Date: 04/11/17	
Drawing No:	

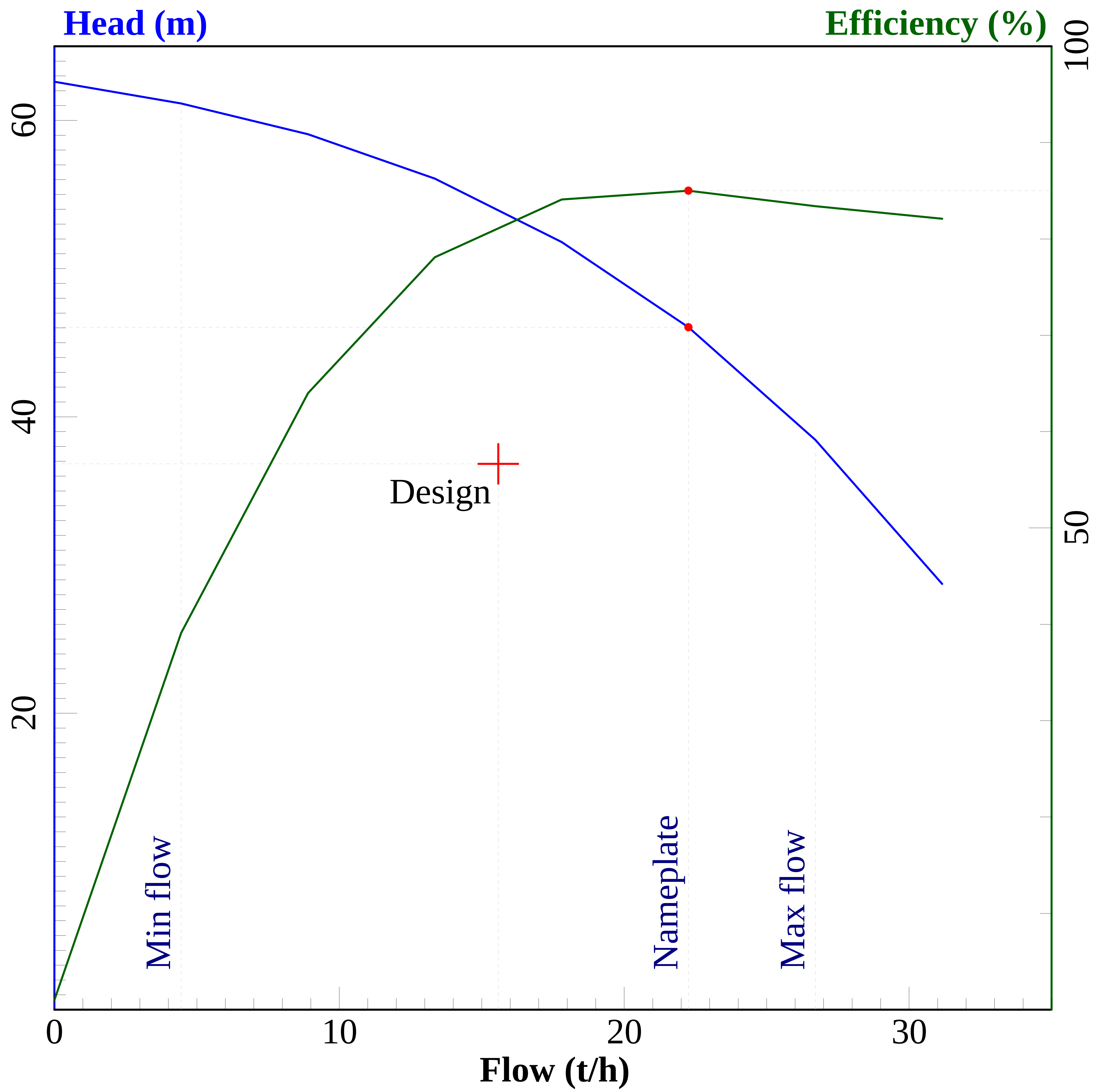
Raw Water Pump 1 (P26)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	22.26 t/h
Nameplate head	46.04 m
Nameplate flow (nominal)	378.5 lpm
Nameplate head (nominal)	53.34 m
Nameplate RPM	3000
Design flow	15.58 t/h
Design head	34.53 m
Design RPM	3000
Minimum continuous flow	4.452 t/h
Maximum continuous flow	26.71 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Raw Water Pump 1 (P26)
Date: 04/11/17	
Drawing No:	

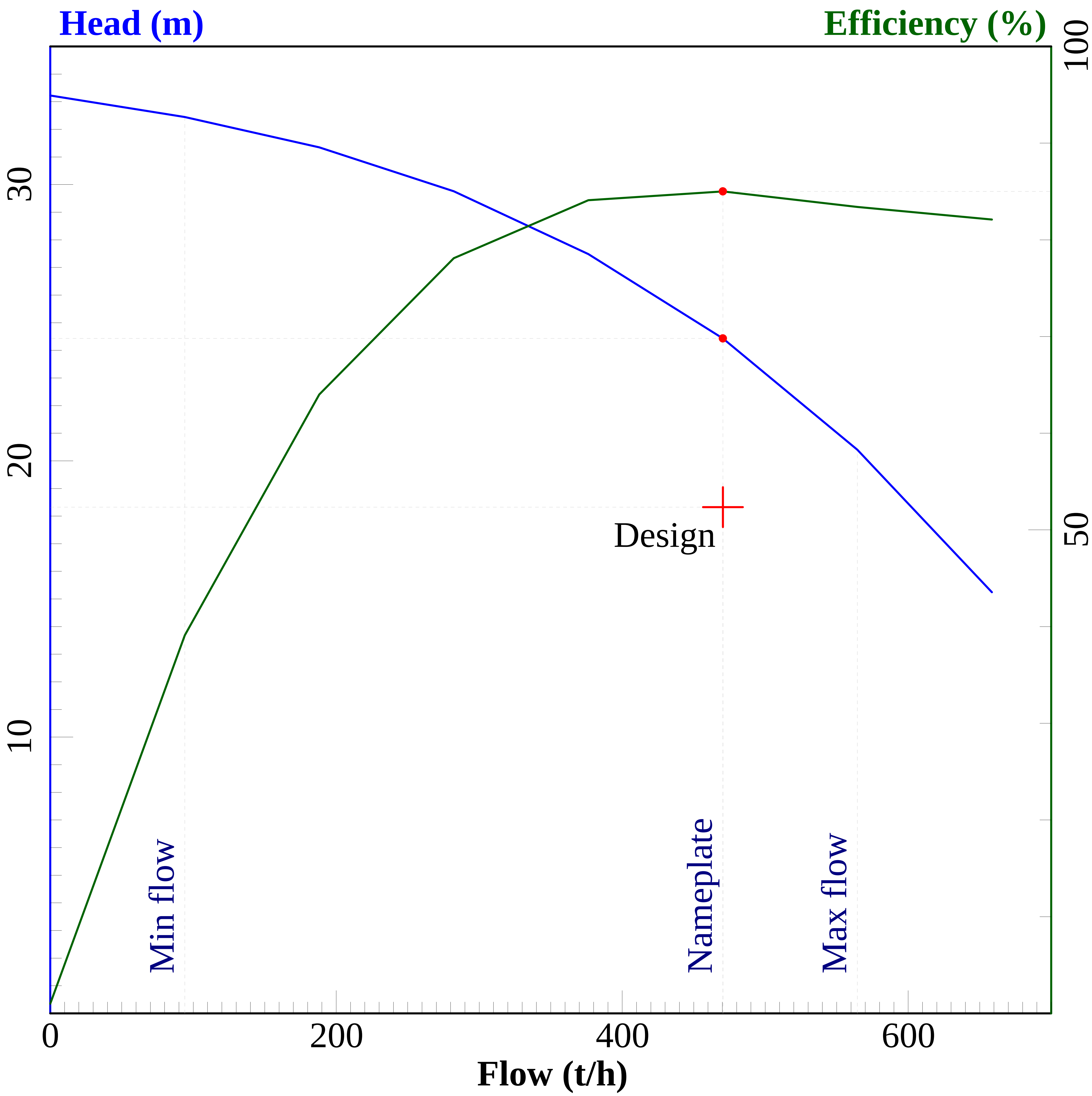
Raw Water Pump 2 (P27)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	22.26 t/h
Nameplate head	46.04 m
Nameplate flow (nominal)	378.5 lpm
Nameplate head (nominal)	53.34 m
Nameplate RPM	3000
Design flow	15.58 t/h
Design head	36.83 m
Design RPM	3000
Minimum continuous flow	4.452 t/h
Maximum continuous flow	26.71 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Raw Water Pump 2 (P27)
Date: 04/11/17	
Drawing No:	

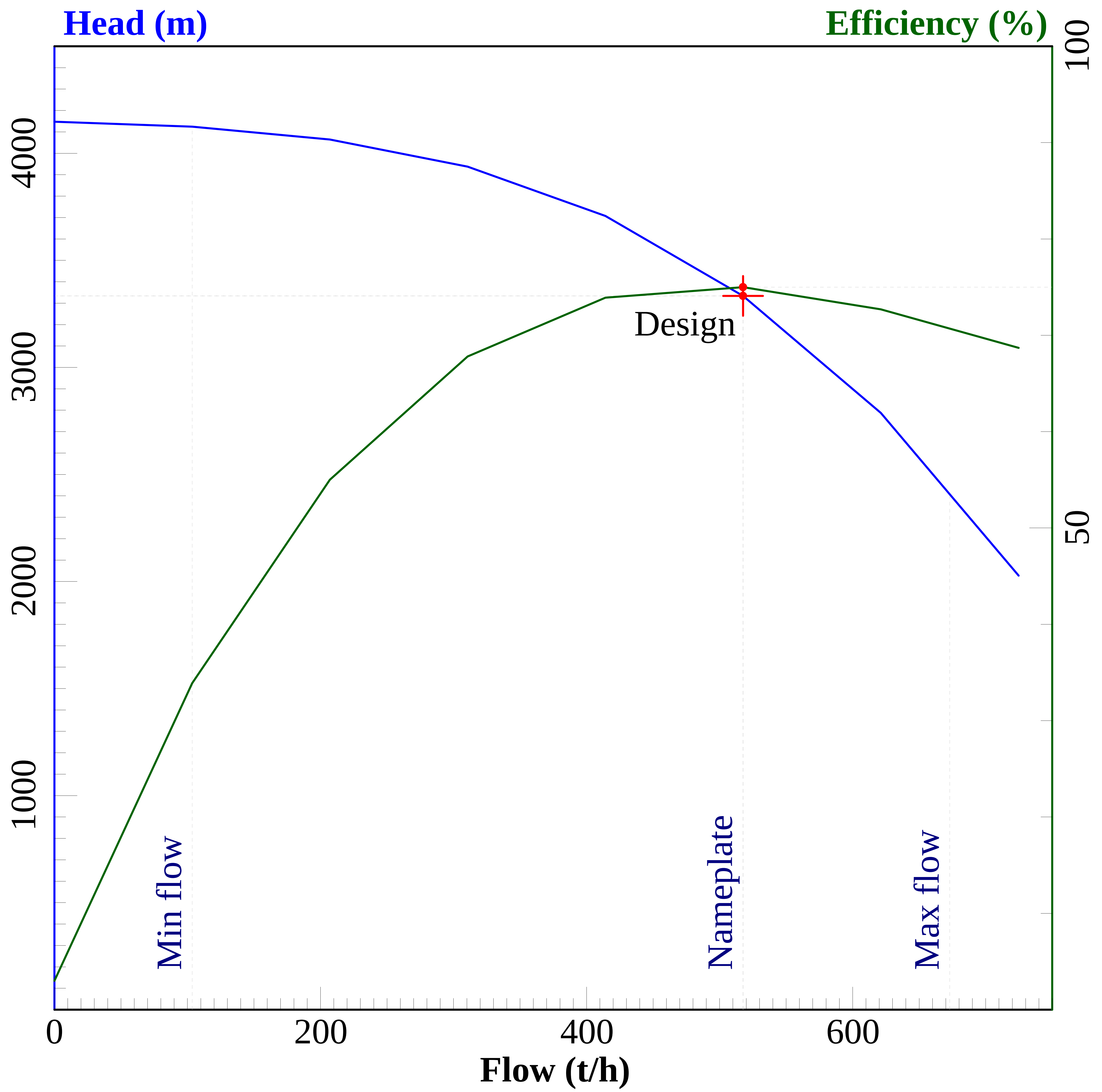
Aux Cooling Water Pump (open loop) (P30)



No. per Plant	2
No. operating per Plant	1
Nameplate flow	470.4 t/h
Nameplate head	24.43 m
Nameplate flow (nominal)	8517 lpm
Nameplate head (nominal)	27.43 m
Nameplate RPM	1500
Design flow	470.4 t/h
Design head	18.32 m
Design RPM	1500
Minimum continuous flow	94.08 t/h
Maximum continuous flow	564.5 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Aux Cooling Water Pump (open loop) (P30)
Date: 04/11/17	
Drawing No:	

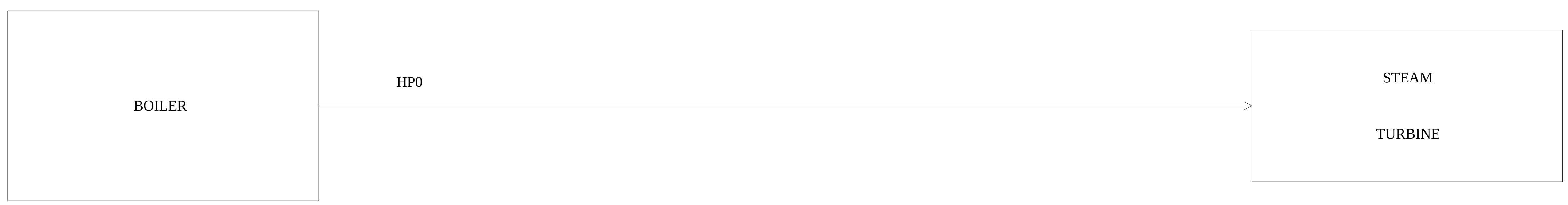
Startup Boiler Feed Pump (P2)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	517.7 t/h
Nameplate head	3334 m
Nameplate flow (nominal)	10410 lpm
Nameplate head (nominal)	3353 m
Nameplate RPM	3000
Design flow	517.7 t/h
Design head	3334 m
Design RPM	3000
Minimum continuous flow	103.5 t/h
Maximum continuous flow	673 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Startup Boiler Feed Pump (P2)
Date: 04/11/17	
Drawing No:	

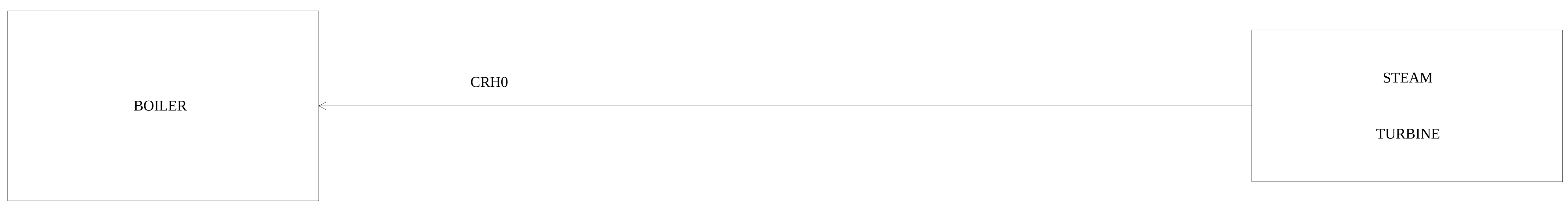
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
HP0 x 1	450.9	169.5	Custom	TP347HFG	280.1	606	1863.6	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	HP PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

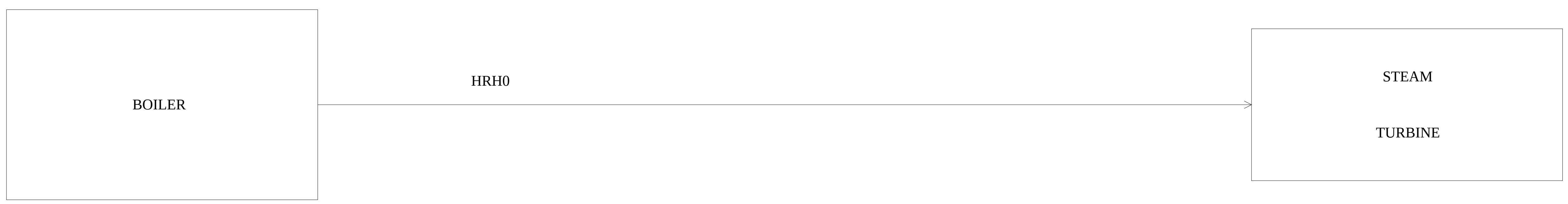
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
CRH0 x 1	717.6	178.3	Custom	P-22	64.3	374.5	1689.2	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	RH PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

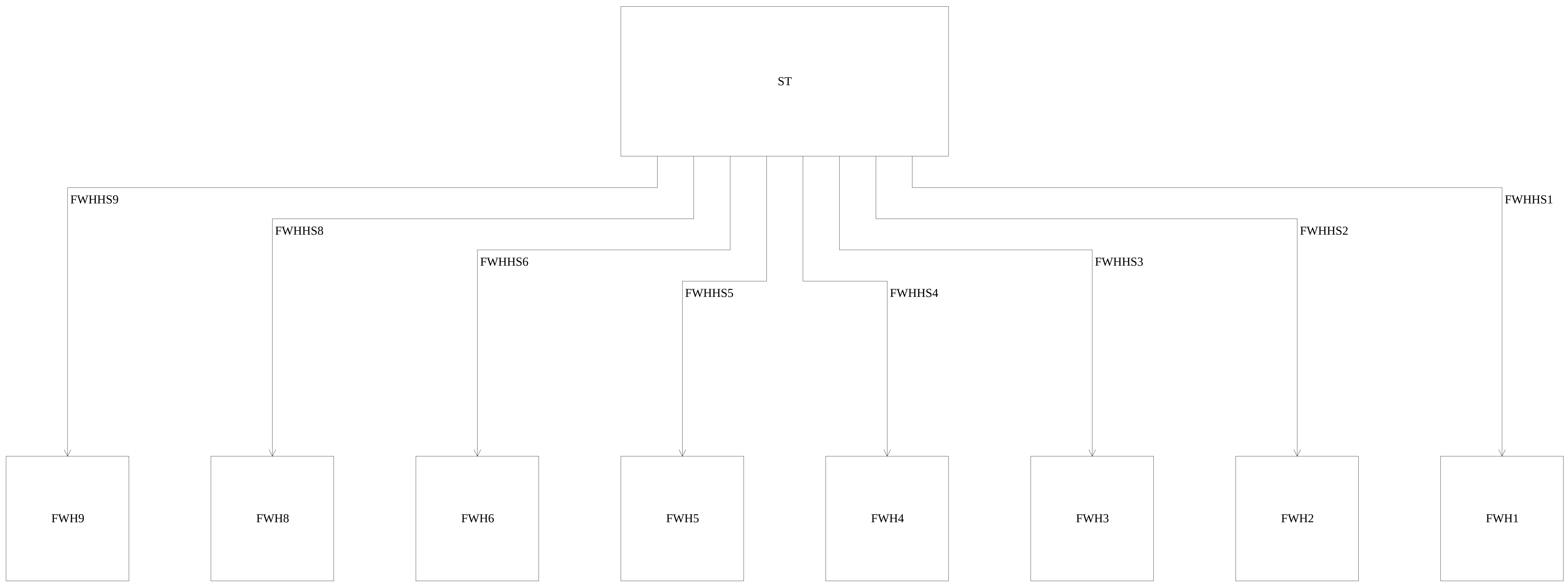
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
HRH0 x 1	800.1	187.1	Custom	TP347HFG	61.2	605.4	1689.2	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	RH PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

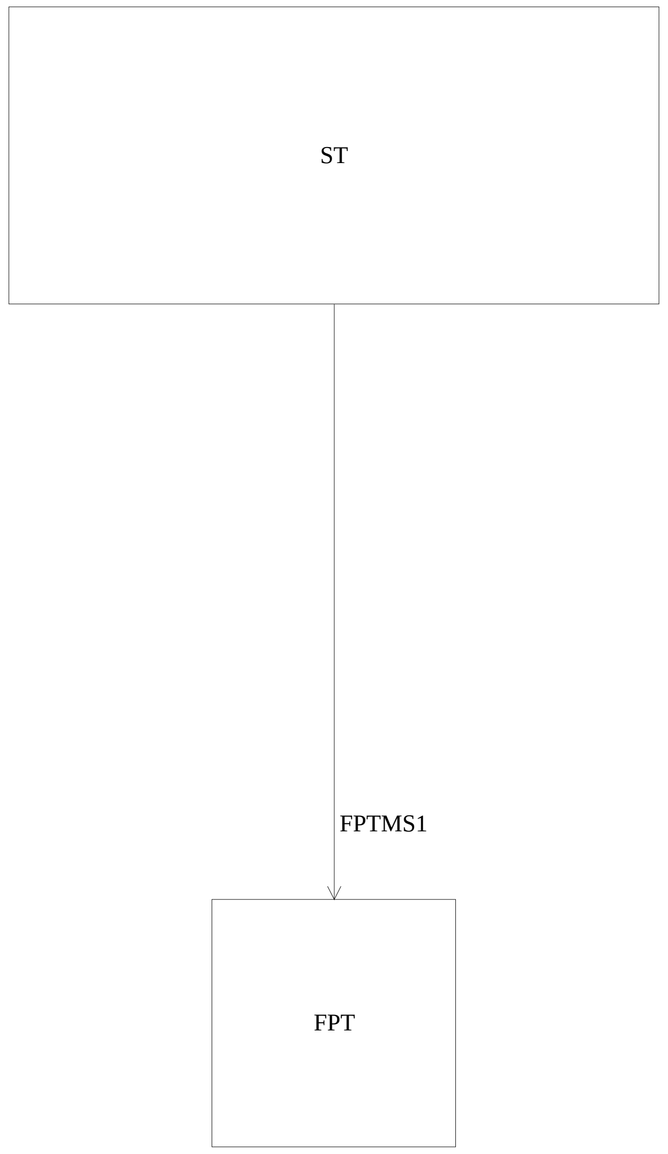
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FWHHS1 x 1	914.4	12.19	10	A-106	0.363	73.57	58.43	
FWHHS2 x 1	762	24.08	10	A-106	1.167	113	69.06	
FWHHS3 x 1	508	35.97	40	A-106	3.083	205.1	73.43	
FWHHS4 x 1	406.4	47.85	40	A-106	7	296.5	77.12	
FWHHS5 x 1	406.4	101.8	40	A-106	13.04	375.4	74.55	
FWHHS6 x 2	203.2	41.76	40	P-11	22.9	454.3	31.95	
FWHHS8 x 2	203.2	53.65	60	P-22	64.3	374.5	64.32	
FWHHS9 x 2	203.2	59.74	60	P-91	42.67	549.7	59.82	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH HEATING STEAM PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

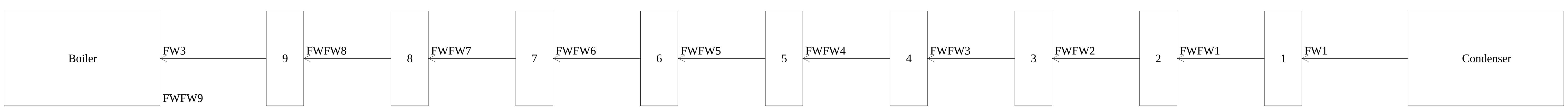
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FPTMS1 x 1	508	72.85	40	A-106	7	296.5	133.4	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	OTHER HEATING STEAM PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FW1 x 1	457.2	39.93	20	A-106	21.6	40.08	1193.6	20030
FWFW1 x 1	457.2	19.81	20	A-106	19.62	69.65	1193.6	20325
FWFW2 x 1	508	21.34	20	A-106	17.71	99.84	1476.8	25665
FWFW3 x 1	609.6	23.17	20	A-106	16.18	130	1476.8	26318
FWFW4 x 1	609.6	101.8	20	A-106	14.9	160.2	1476.8	27121
FWFW5 x 1	609.6	101.8	20	A-106	12.66	190.4	1863.6	35377
FWFW6 x 2	406.4	13.72	Custom	A-106	308	220.1	931.8	17988
FWFW7 x 2	419.1	14.94	Custom	A-106	307.4	250.7	931.8	18809
FWFW8 x 2	431.8	14.33	Custom	A-106	306.8	279.9	931.8	19797
FWFW9 x 2	431.8	7.62	Custom	A-106	306.7	287.7	931.8	20107
FW3 x 1	609.6	173.4	Custom	A-106	306.7	287.7	1863.6	40215
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FEEDWATER PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
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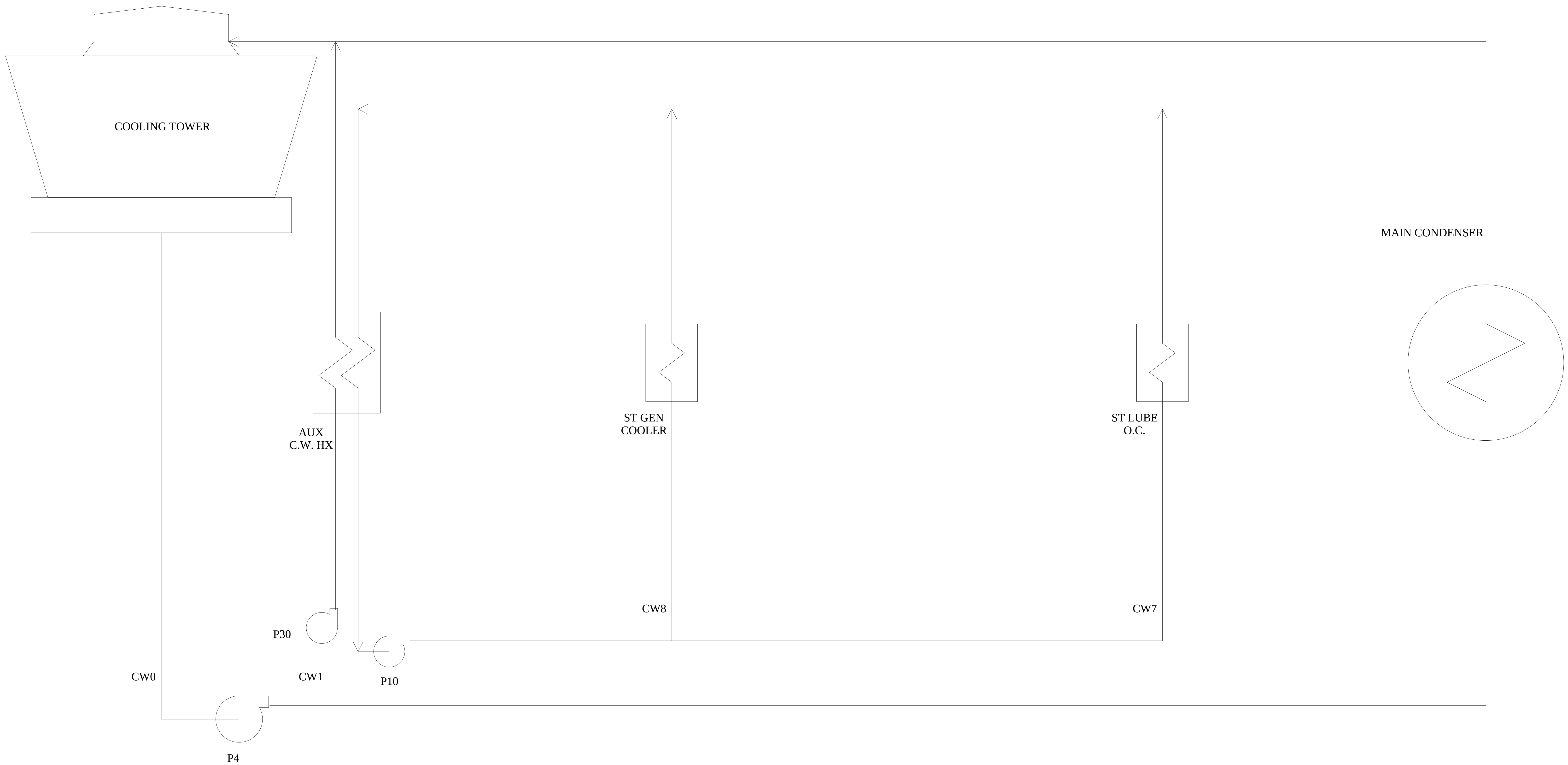
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
CW0 x 3	1524	401.4	150psi	Ductile iron	2.495	37.8	18050	302888
CW1 x 1	304.8	607.2	40	A-106	6.895	25	470.4	7860
CW7 x 1	152.4	177.1	40	A-106	6.895	25	152.1	2541.1
CW8 x 1	254	177.1	40	A-106	6.895	25	318.3	5319
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	COOLING WATER PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
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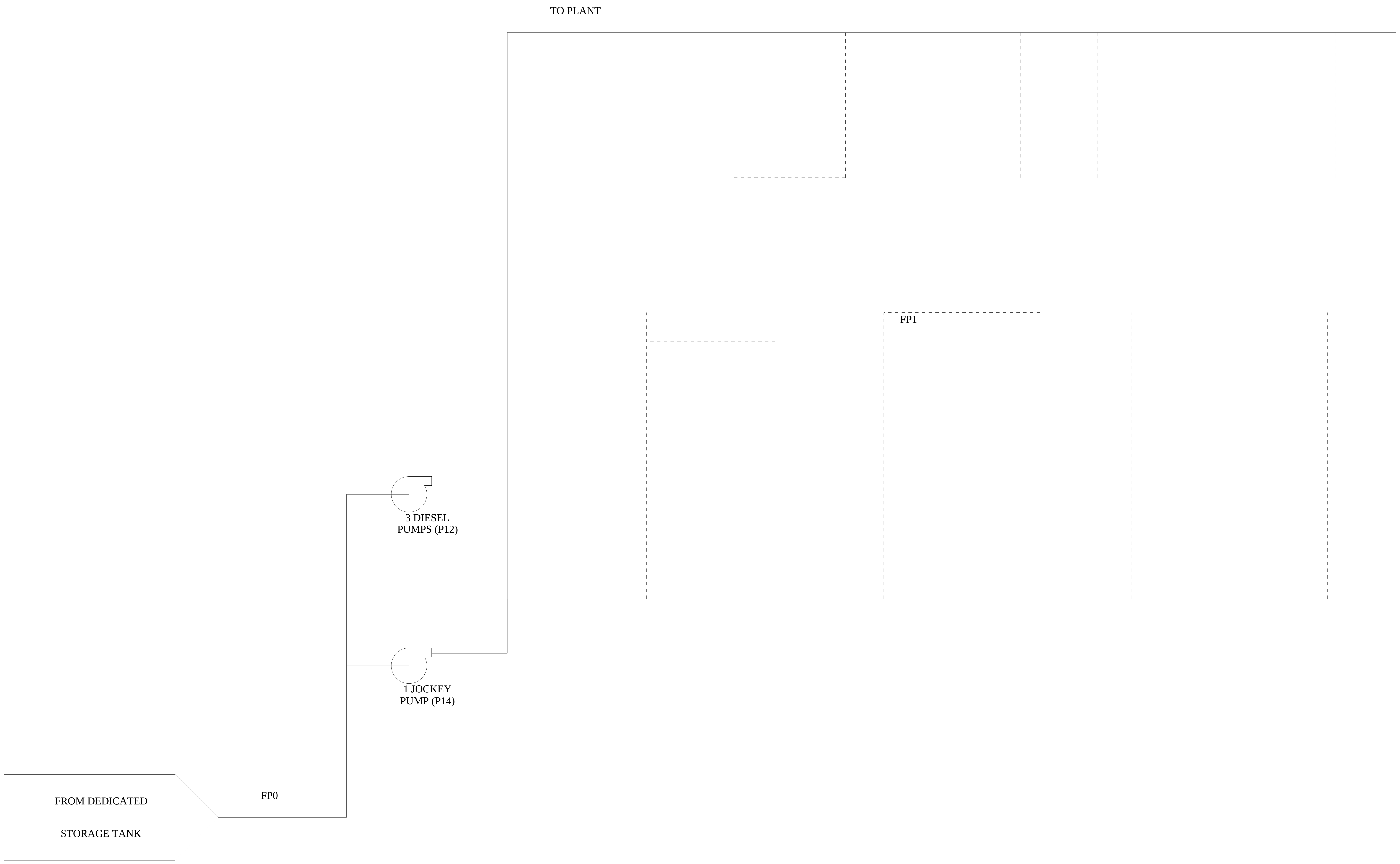
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FP0 x 1	508	1062.2	20	A-106	6.895	15	1362	22712
FP1 x 1	406.4	1062.2	20	A-106	6.895	15	681	11356
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FIRE PROTECTION PIPING DIAGRAM
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

FOR QUALITATIVE INDICATION ONLY

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Electrical One-line Diagram
	DIAGRAM
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

D

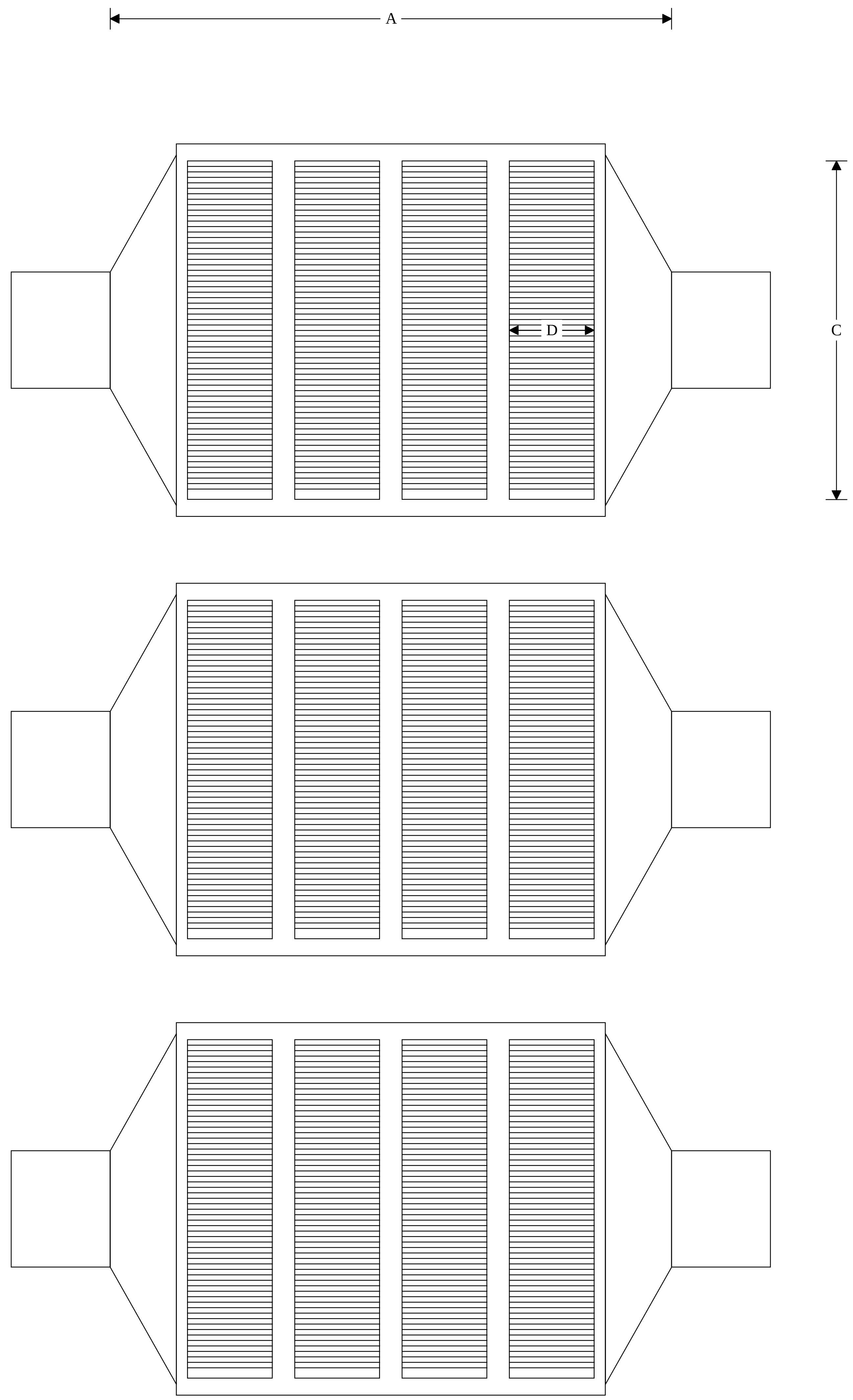
NUMBER OF ABSORBER MODULES = 1

A	B	C	D	E	F	G	H	I
-	-	-	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	WFGD
Date: 04/11/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = C:\Users\dcbaptie\Desktop\HELE documentation\Model\USC model_wet cooling.stp

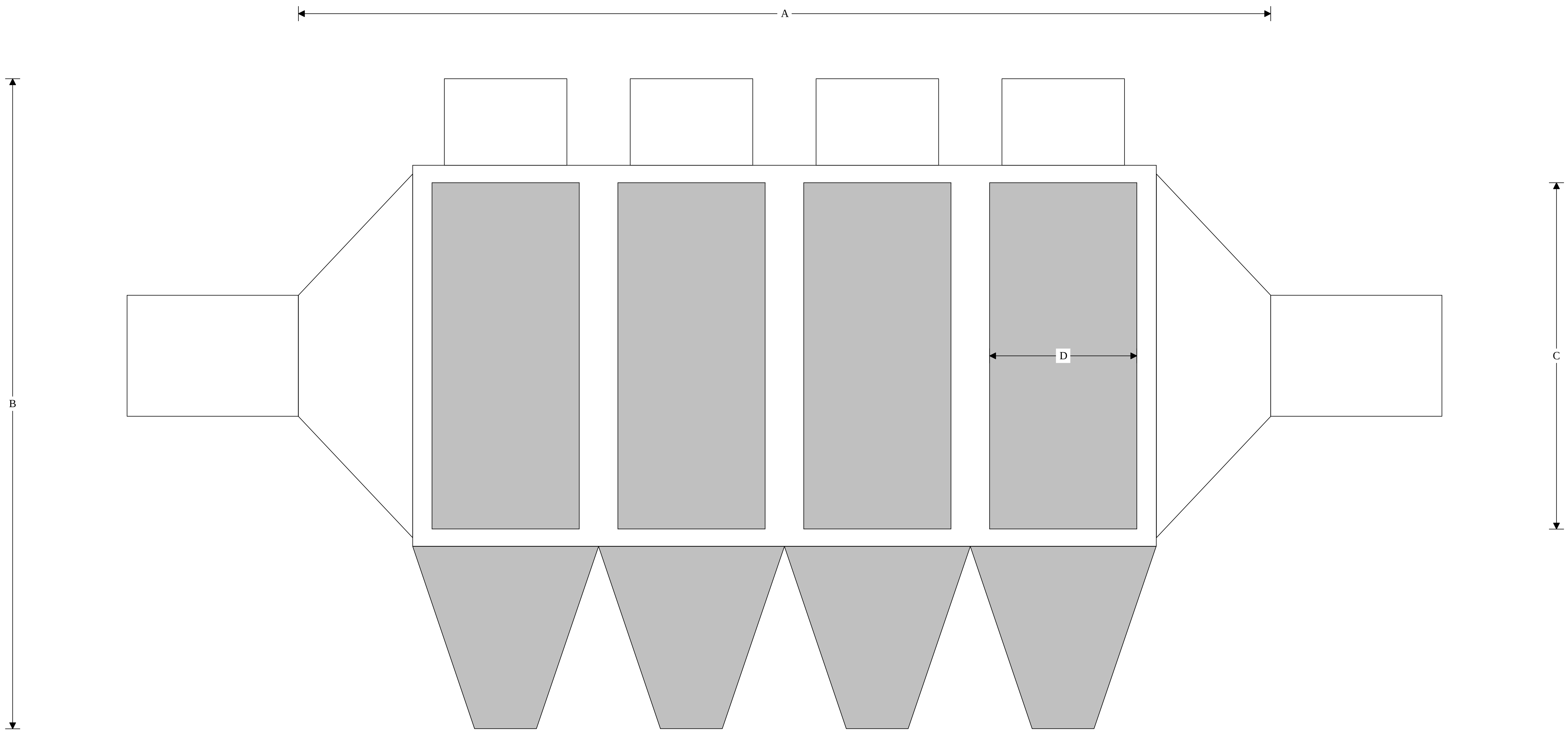
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I
30.8 m	68.67 m	18.59 m	4.671 m	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ESP
	PLAN VIEW
Date: 04/11/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY



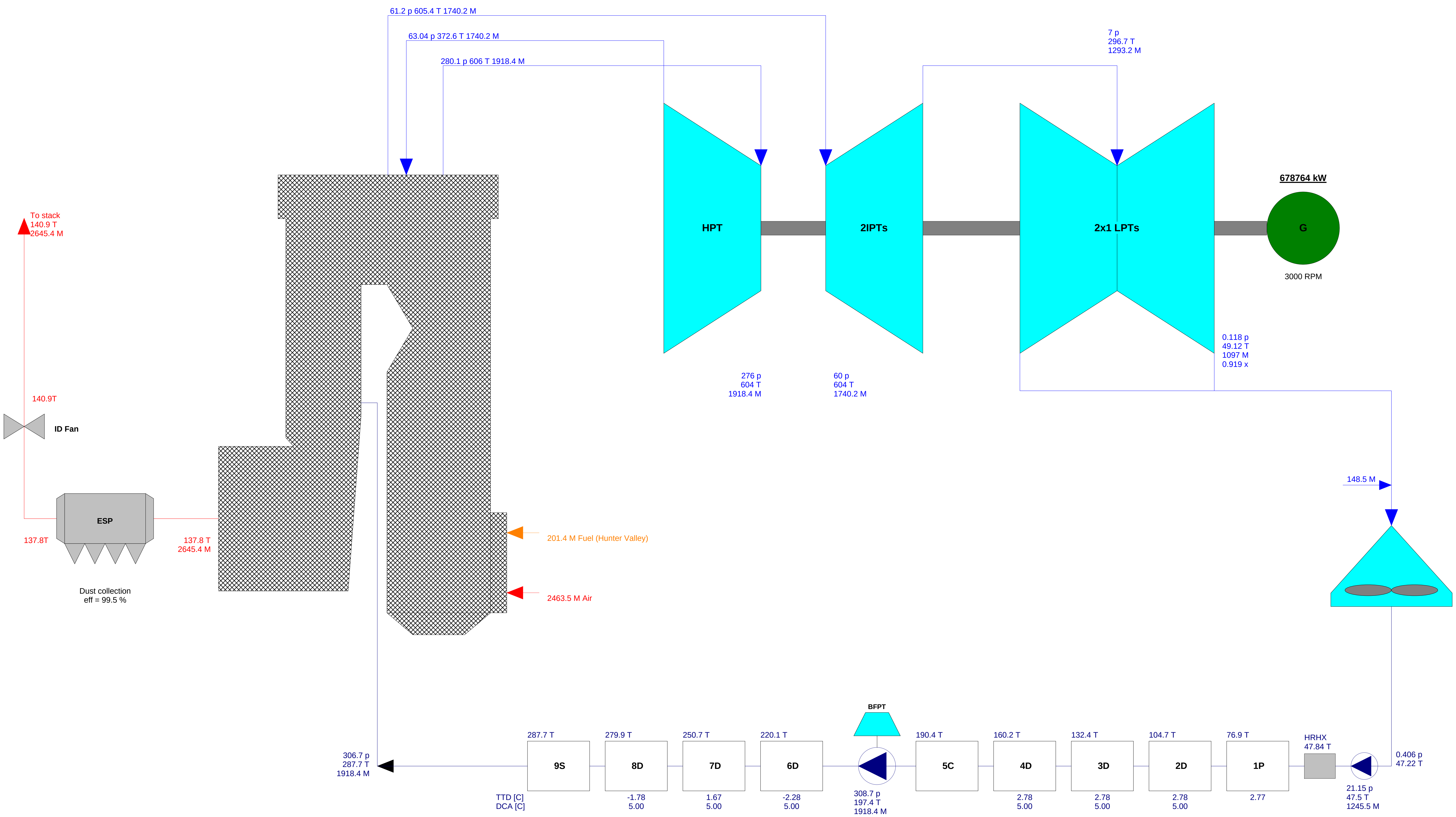
A	B	C	D	E	F	G	H	I
30.8 m	20.58 m	10.97 m	4.671 m	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ESP ELEVATION VIEW
Date: 04/11/17	
Drawing No:	

Appendix B – PEACE and STEAM PRO Results for the Dry Cooling Case

Plant gross power	678764	kW
Plant net power	649886	kW
Number of units	1	
Plant net HR (HHV)	8963	kJ/kWh
Plant net HR (LHV)	8646	kJ/kWh
Plant net eff (HHV)	40.16	%
Plant net eff (LHV)	41.64	%
Aux. & losses	28878	kW
Fuel heat input (HHV)	5825	GJ/h
Fuel heat input (LHV)	5619	GJ/h
Fuel flow	4832	t/day

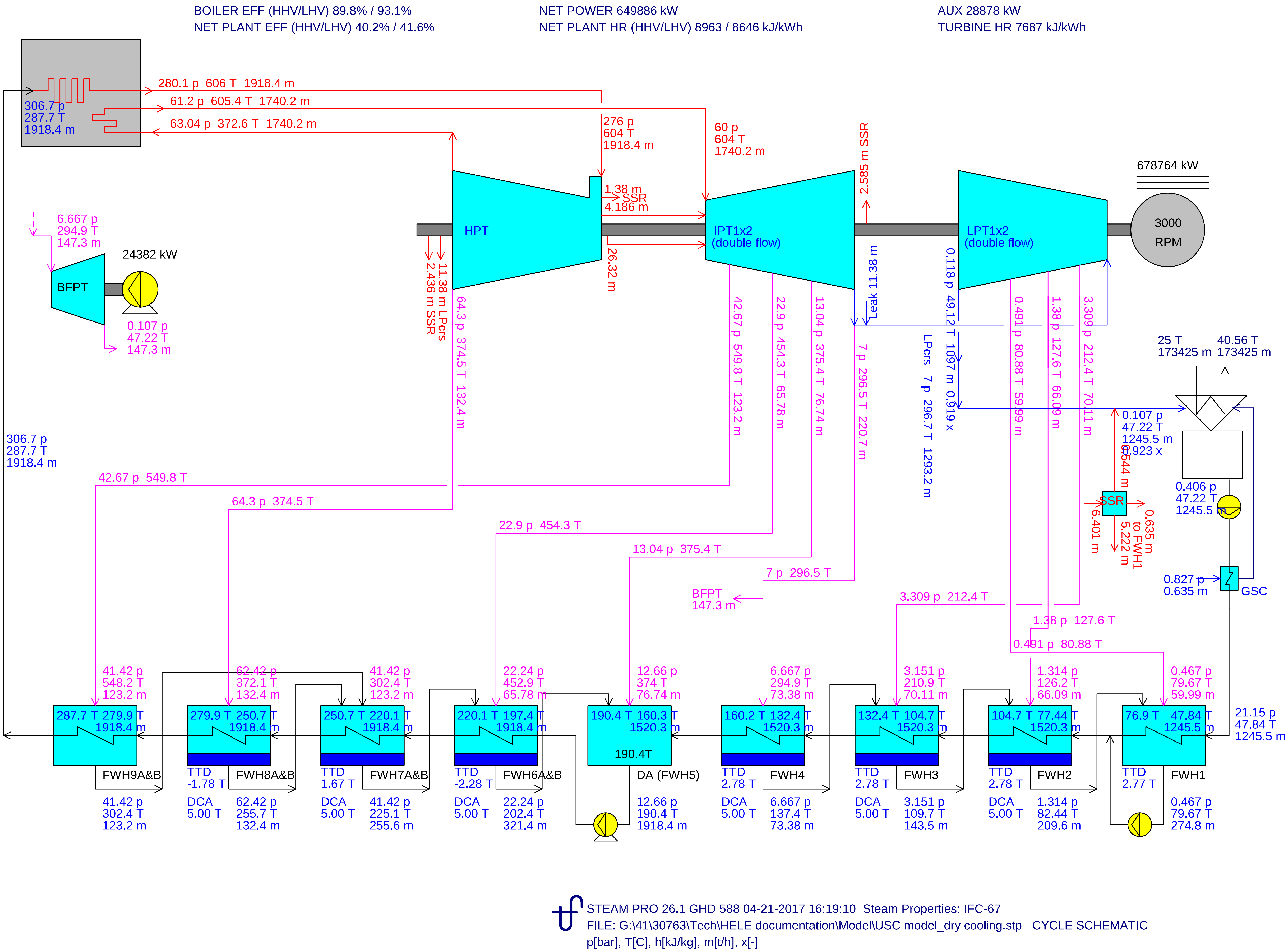
Ambient
1 p
25 T
60% RH
19.45 T wet bulb



Double HP Feed Water Heater Train & Single LP Feed Water Heater Train

p [bar] T [C] M [t/h] x [-]

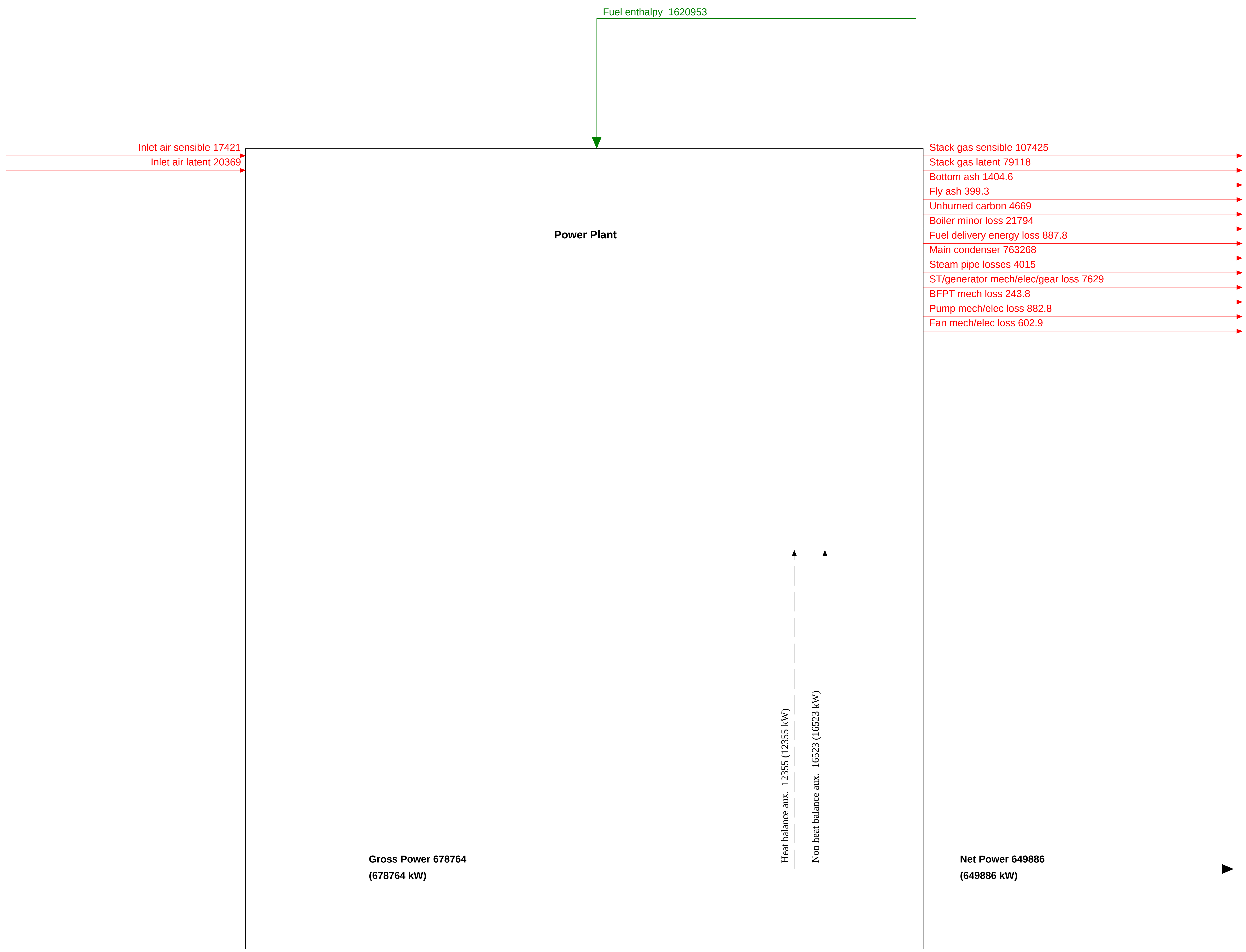
STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp



BOILER EFF (HHV/LHV) 89.8% / 93.1%
NET PLANT EFF (HHV/LHV) 40.2% / 41.6%
NET POWER 649886 kW
NET PLANT HR (HHV/LHV) 8963 / 8646 kJ/kWh
AUX 28878 kW
TURBINE HR 7687 kJ/kWh
280.1 p 606 T 1918.4 m
61.2 p 605.4 T 1740.2 m
63.04 p 372.6 T 1740.2 m
306.7 p
287.7 T
1918.4 m
276 p
604 T
1918.4 m
60 p
604 T
1740.2 m
2.585 m SSR
678764 kW
1.38 m
SSR
4.186 m
HPT
IPT1x2
(double flow)
LPT1x2
(double flow)
3000
RPM
26.32 m
11.38 m LPcrs
2.436 m SSR
64.3 p 374.5 T 132.4 m
42.67 p 549.8 T 123.2 m
22.9 p 454.3 T 65.78 m
13.04 p 375.4 T 76.74 m
7 p 296.5 T 220.7 m
Leak 11.38 m
0.118 p 49.12 T 1097 m 0.919 x
LPcrs 7 p 296.7 T 1293.2 m
0.491 p 80.88 T 59.99 m
1.38 p 127.6 T 66.09 m
3.309 p 212.4 T 70.11 m
6.667 p
294.9 T
147.3 m
24382 kW
BFPT
0.107 p
47.22 T
147.3 m
25 T
173425 m
40.56 T
173425 m
0.107 p
47.22 T
1245.5 m
0.923 x
0.544 m
SSR
6.401 m
5.222 m
0.635 m
to FWH1
0.406 p
47.22 T
1245.5 m
0.827 p
0.635 m
GSC
306.7 p
287.7 T
1918.4 m
42.67 p 549.8 T
64.3 p 374.5 T
22.9 p 454.3 T
13.04 p 375.4 T
7 p 296.5 T
BFPT
147.3 m
3.309 p 212.4 T
1.38 p 127.6 T
0.491 p 80.88 T
41.42 p
548.2 T
123.2 m
62.42 p
372.1 T
132.4 m
41.42 p
302.4 T
123.2 m
22.24 p
452.9 T
65.78 m
12.66 p
374 T
76.74 m
6.667 p
294.9 T
73.38 m
3.151 p
210.9 T
70.11 m
1.314 p
126.2 T
66.09 m
0.467 p
79.67 T
59.99 m
287.7 T 279.9 T
1918.4 m
279.9 T 250.7 T
1918.4 m
250.7 T 220.1 T
1918.4 m
220.1 T 197.4 T
1918.4 m
190.4 T 160.3 T
1520.3 m
160.2 T 132.4 T
1520.3 m
132.4 T 104.7 T
1520.3 m
104.7 T 77.44 T
1520.3 m
76.9 T 47.84 T
1245.5 m
21.15 p
47.84 T
1245.5 m
190.4T
FWH9A&B
TTD
-1.78 T
FWH8A&B
TTD
1.67 T
FWH7A&B
TTD
-2.28 T
FWH6A&B
DA (FWH5)
TTD
2.78 T
FWH4
TTD
2.78 T
FWH3
TTD
2.78 T
FWH2
TTD
2.77 T
FWH1
41.42 p
302.4 T
123.2 m
DCA
5.00 T
62.42 p
255.7 T
132.4 m
DCA
5.00 T
41.42 p
225.1 T
255.6 m
DCA
5.00 T
22.24 p
202.4 T
321.4 m
12.66 p
190.4 T
1918.4 m
DCA
5.00 T
6.667 p
137.4 T
73.38 m
DCA
5.00 T
3.151 p
109.7 T
143.5 m
DCA
5.00 T
1.314 p
82.44 T
209.6 m
0.467 p
79.67 T
274.8 m
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp CYCLE SCHEMATIC
p[bar], T[C], h[kJ/kg], m[t/h], x[-]

Fuel chemical LHV input = 1560772 kJ/s
Fuel chemical HHV input = 1618114 kJ/s

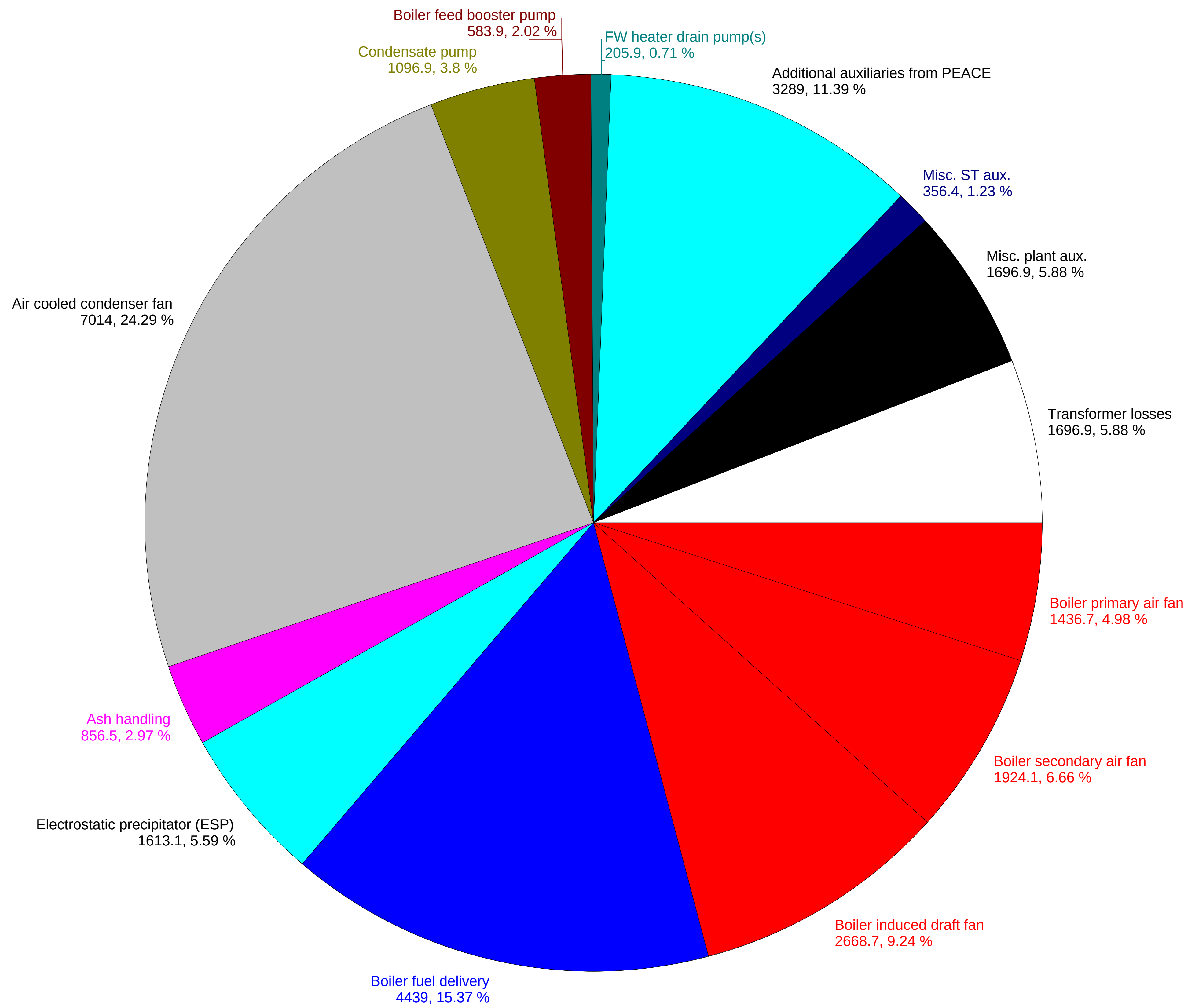
Plant Energy Flow Schematic [kJ/s]

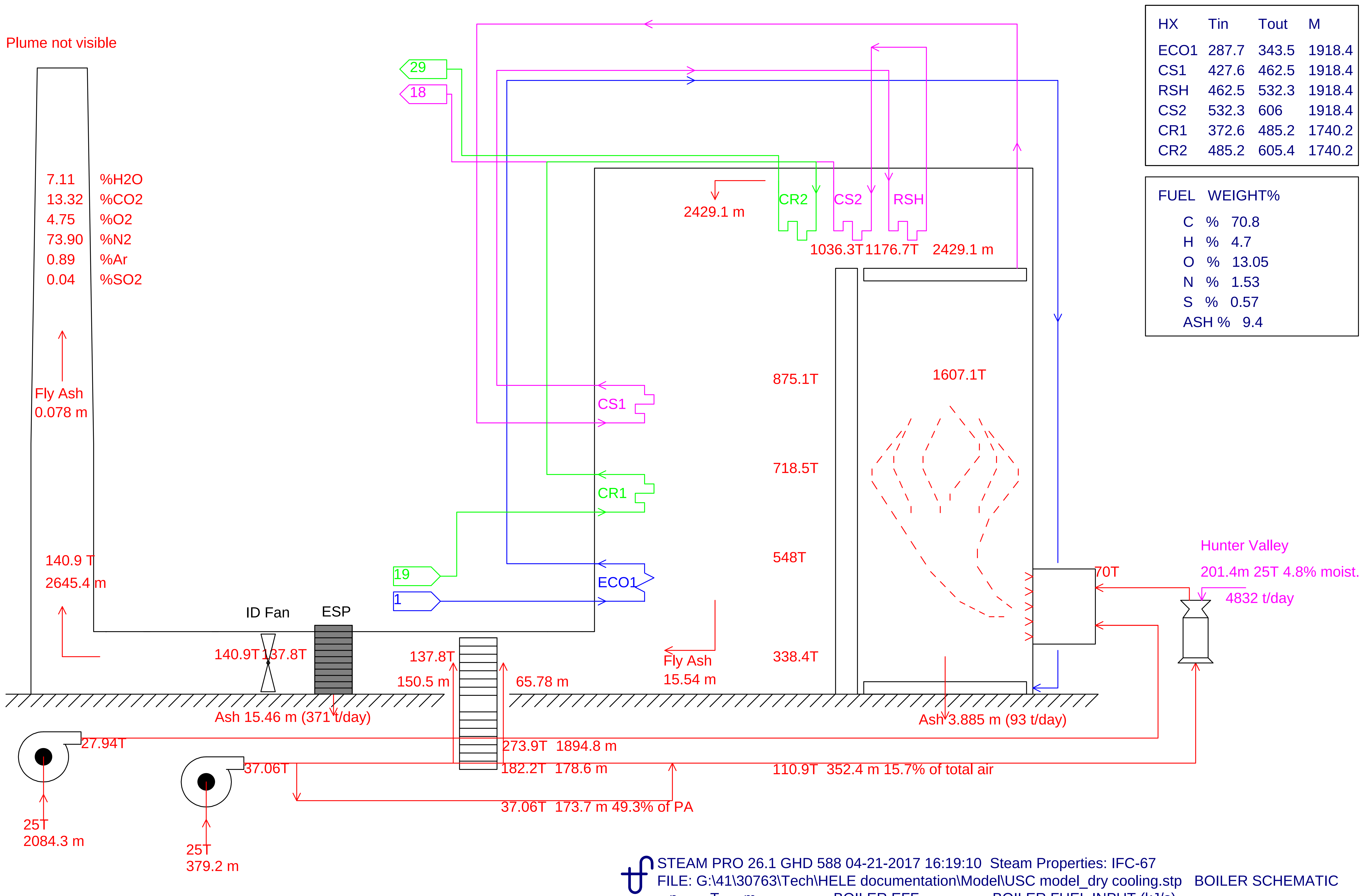


Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

Auxiliaries & Losses [kW]

Total auxiliaries & transformer losses = 28878 kW

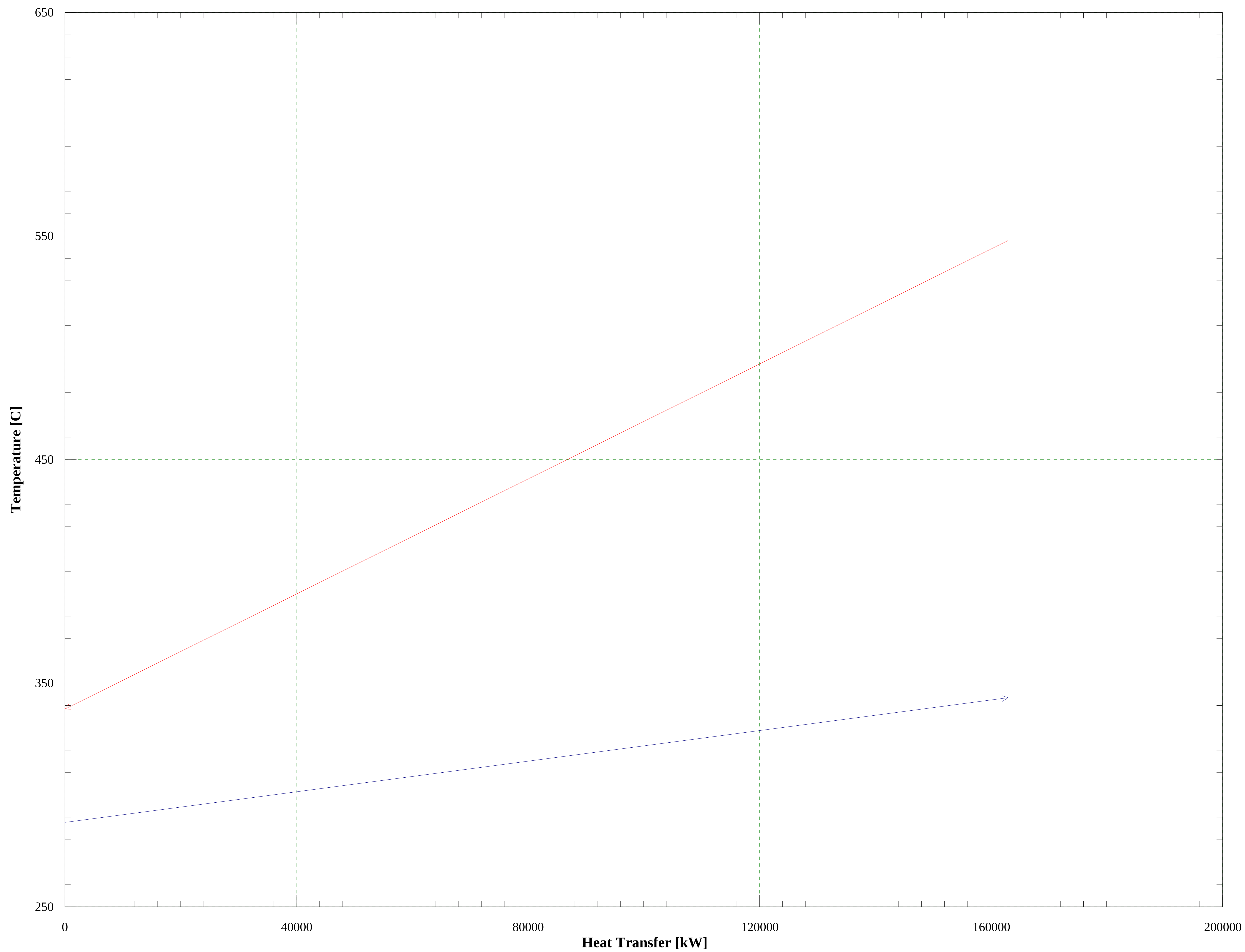



Plume not visible
7.11 %H2O
13.32 %CO2
4.75 %O2
73.90 %N2
0.89 %Ar
0.04 %SO2
Fly Ash
0.078 m
140.9 T
2645.4 m
ID Fan
ESP
140.9T
137.8T
Ash 15.46 m (371 t/day)
29
18
19
1
CS1
CR1
ECO1
CR2
CS2
RSH
2429.1 m
1036.3T
1176.7T
2429.1 m
875.1T
718.5T
548T
338.4T
1607.1T
70T
137.8T
150.5 m
65.78 m
Fly Ash
15.54 m
Ash 3.885 m (93 t/day)
27.94T
37.06T
273.9T 1894.8 m
182.2T 178.6 m
110.9T 352.4 m 15.7% of total air
37.06T 173.7 m 49.3% of PA
25T
2084.3 m
25T
379.2 m
Hunter Valley
201.4m 25T 4.8% moist.
4832 t/day
HX Tin Tout M
ECO1 287.7 343.5 1918.4
CS1 427.6 462.5 1918.4
RSH 462.5 532.3 1918.4
CS2 532.3 606 1918.4
CR1 372.6 485.2 1740.2
CR2 485.2 605.4 1740.2
FUEL WEIGHT%
C % 70.8
H % 4.7
O % 13.05
N % 1.53
S % 0.57
ASH % 9.4
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp BOILER SCHEMATIC
p T m BOILER EFF BOILER FUEL INPUT (kJ/s)
bar C t/h 89.8 % (HHV) 93.1 % (LHV) 1618114(HHV) 1560772(LHV)

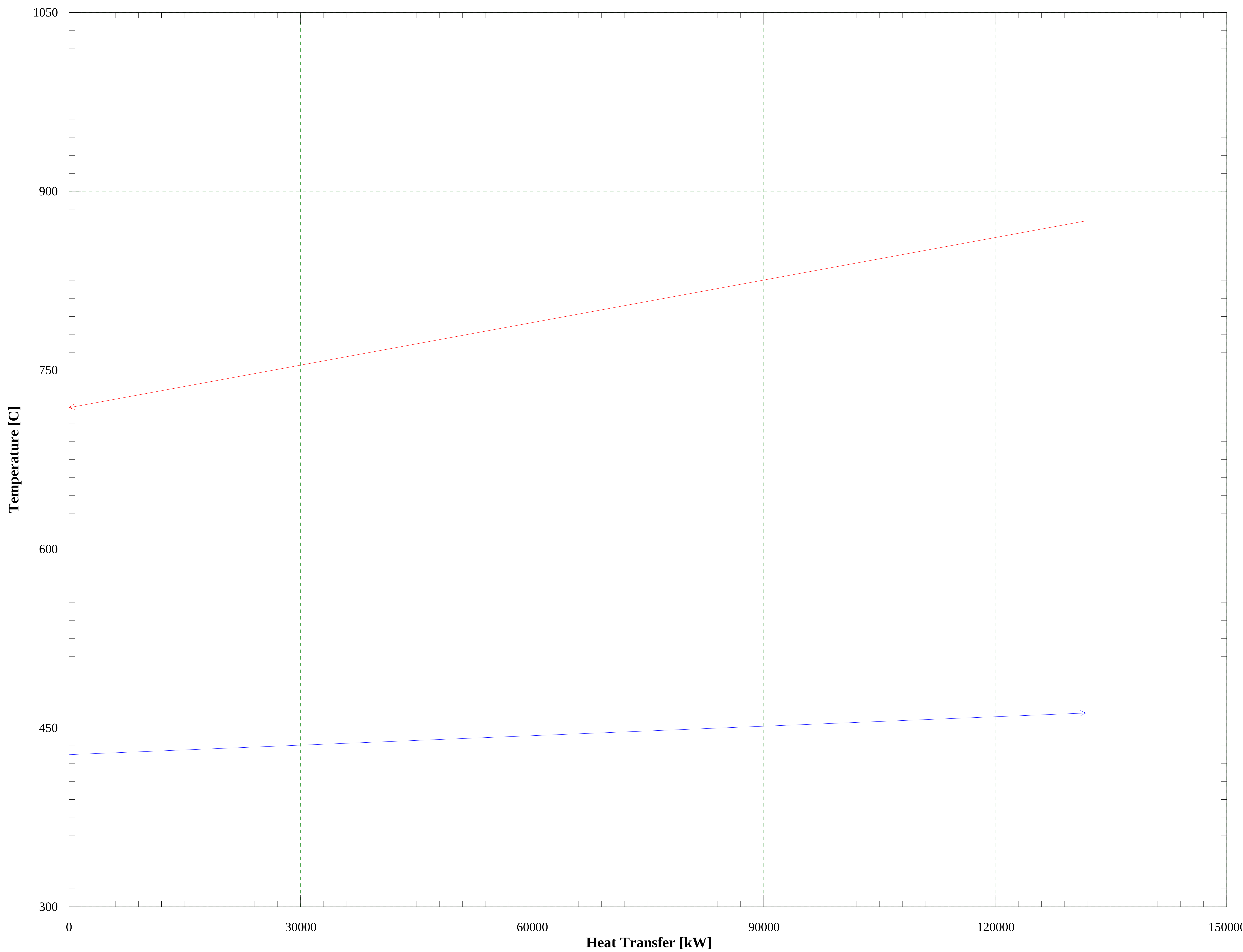
Boiler - TQ Diagram

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

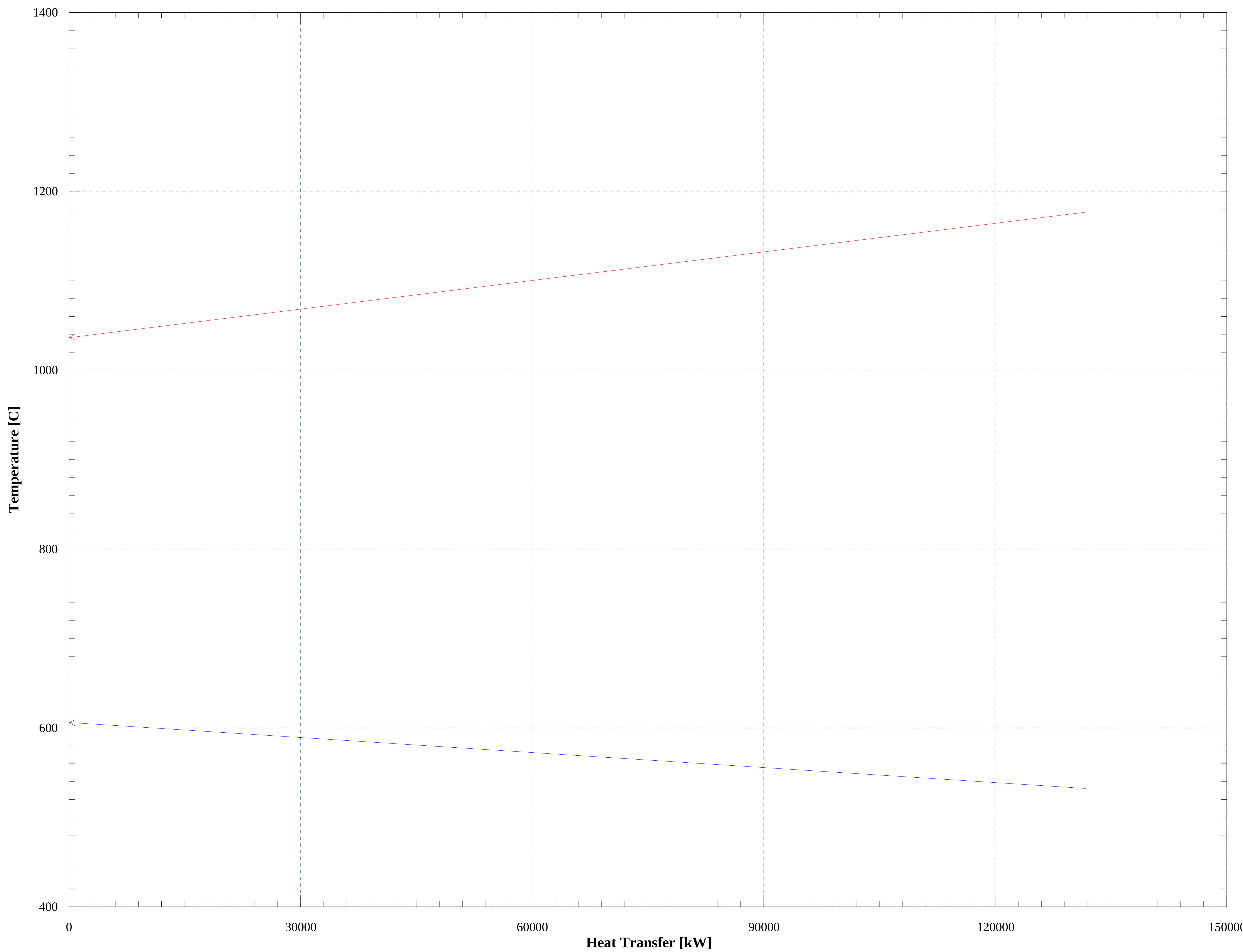
ECO1 - TQ Diagram



CS1 - TQ Diagram

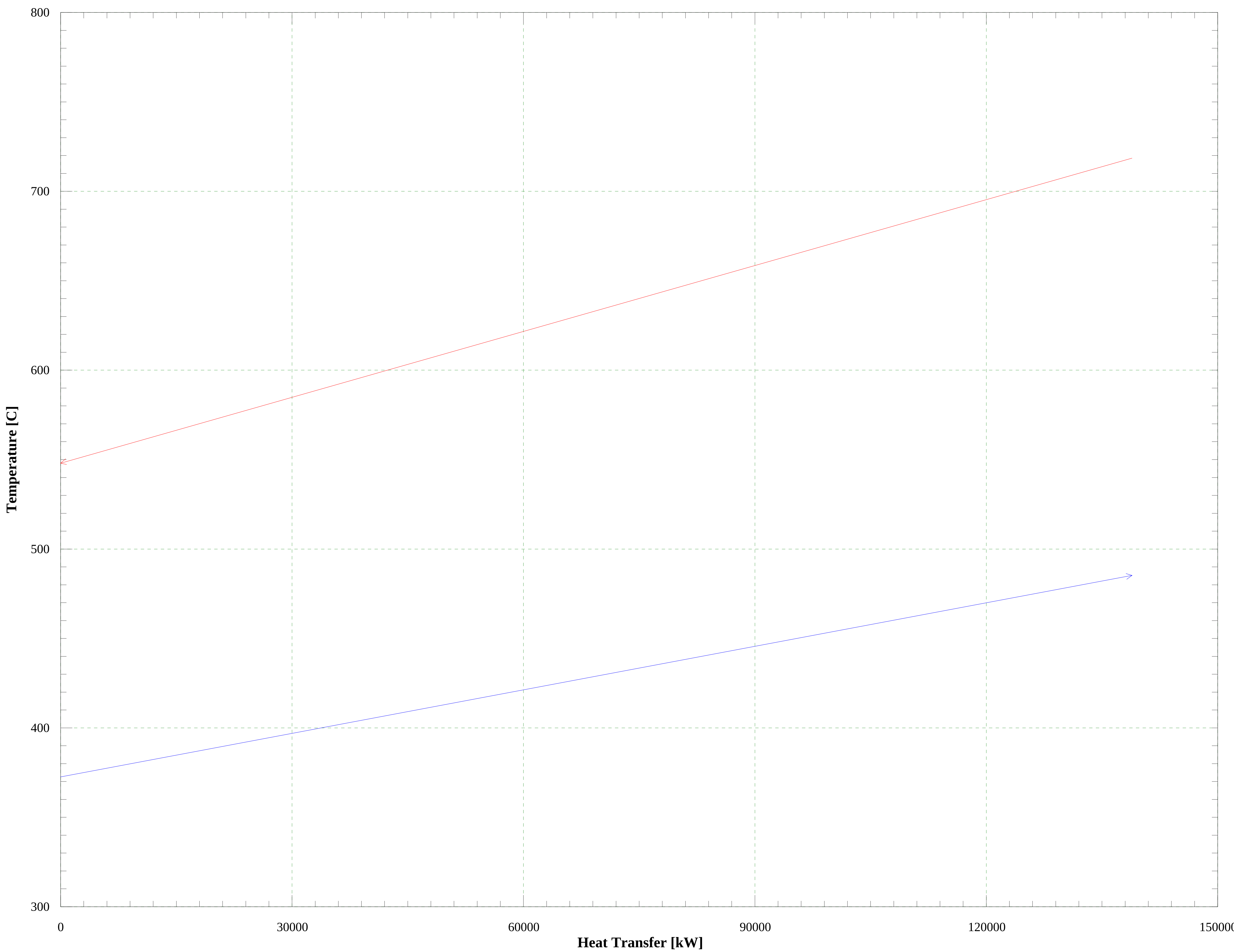


CS2 - TQ Diagram

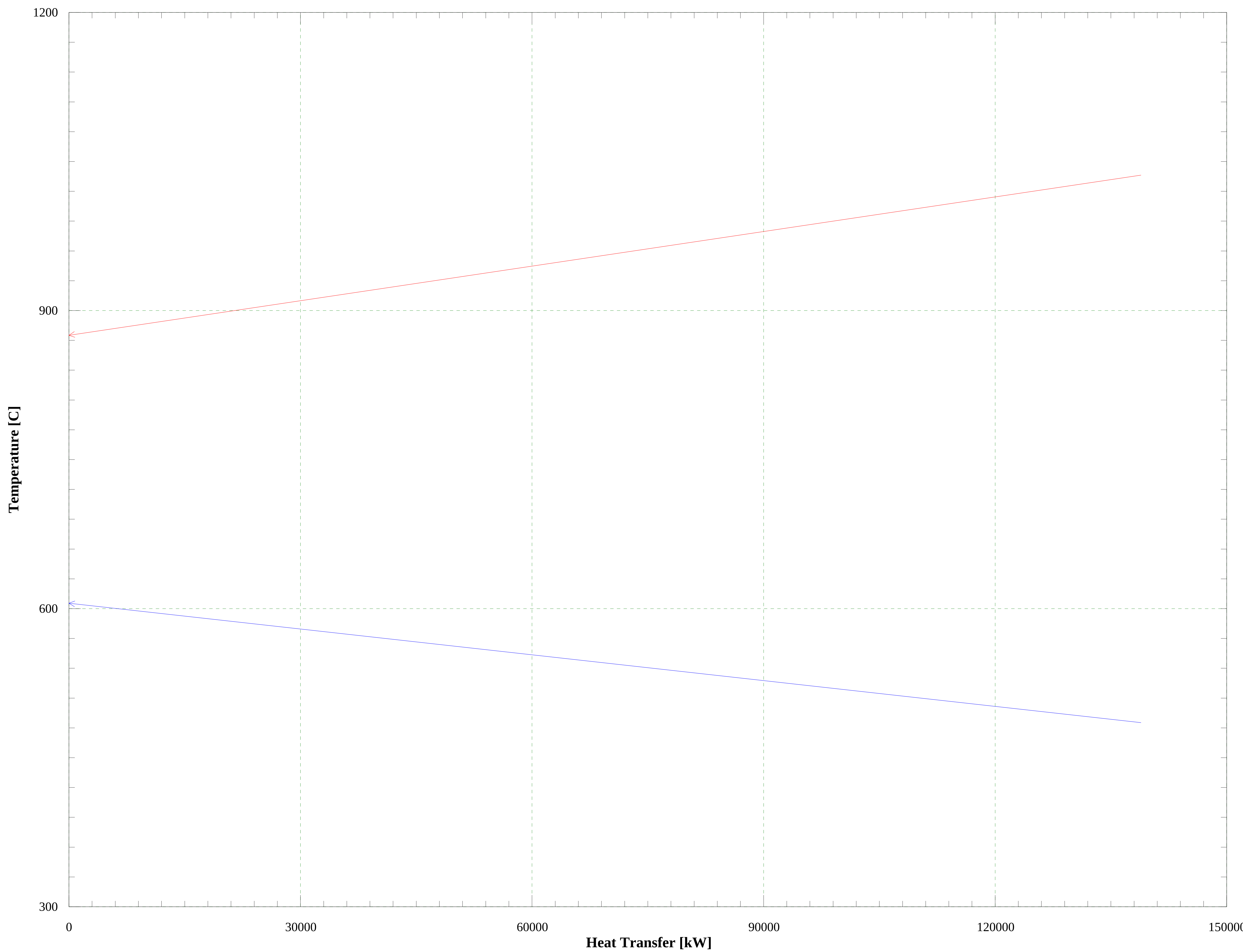


STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

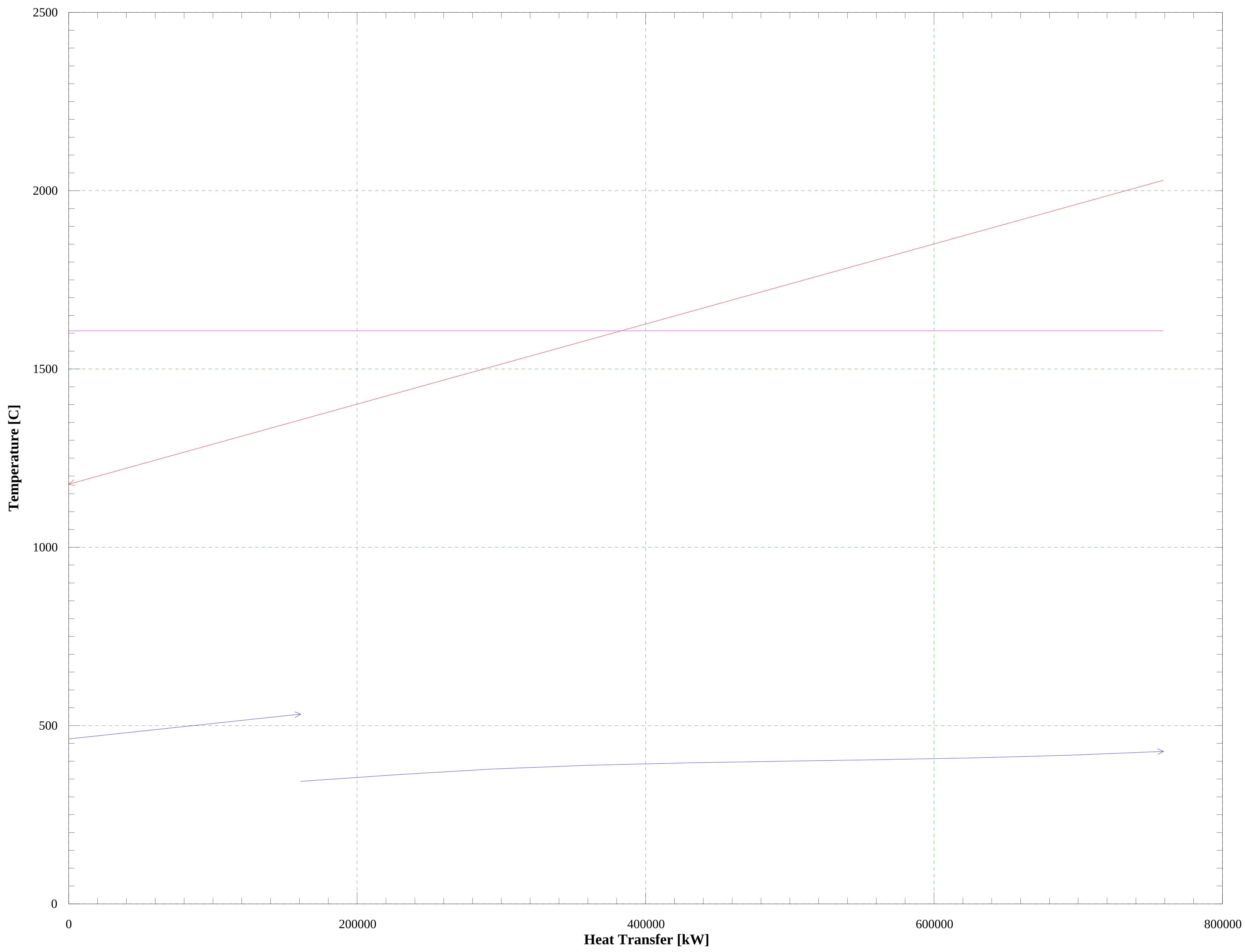
CR1 - TQ Diagram



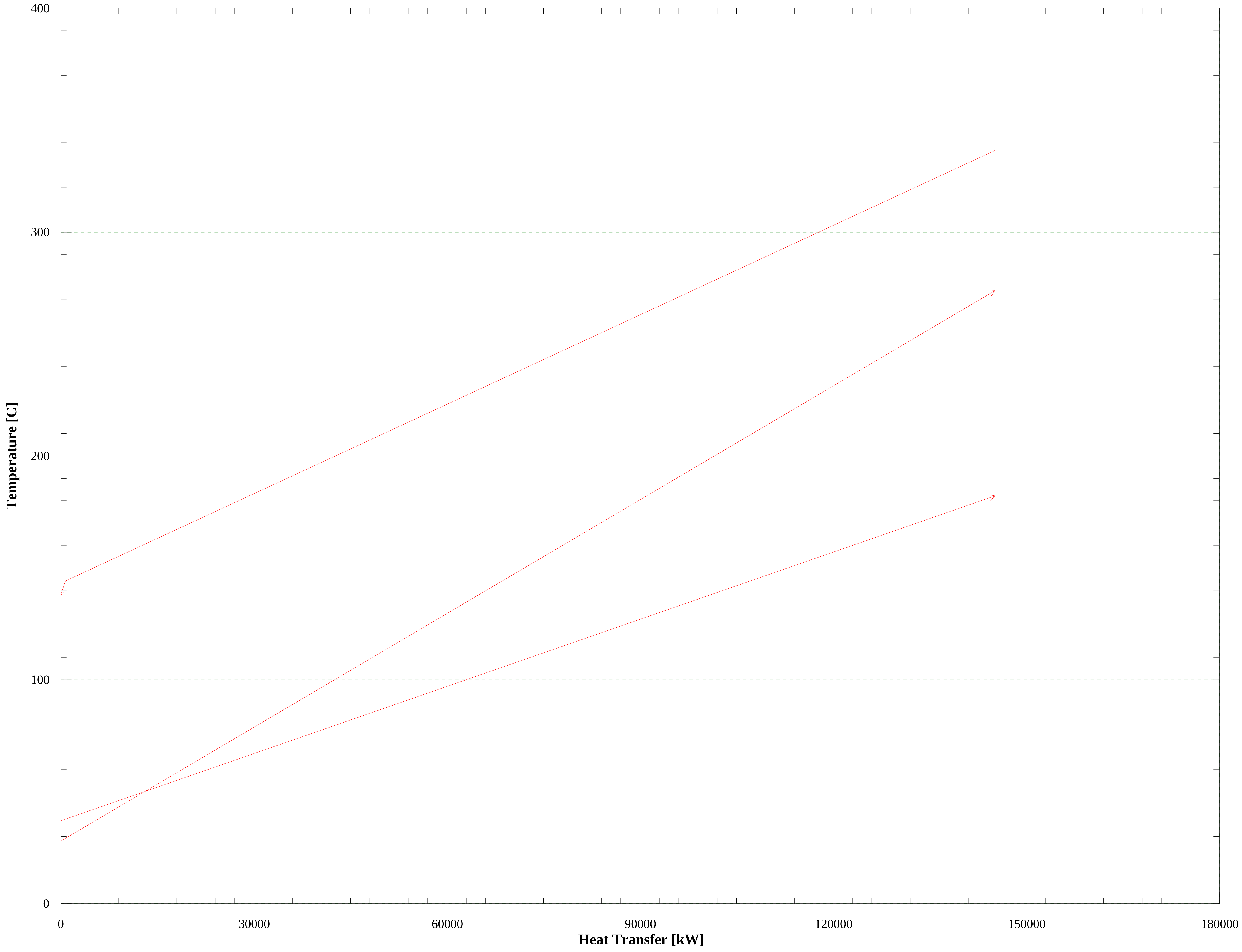
CR2 - TQ Diagram



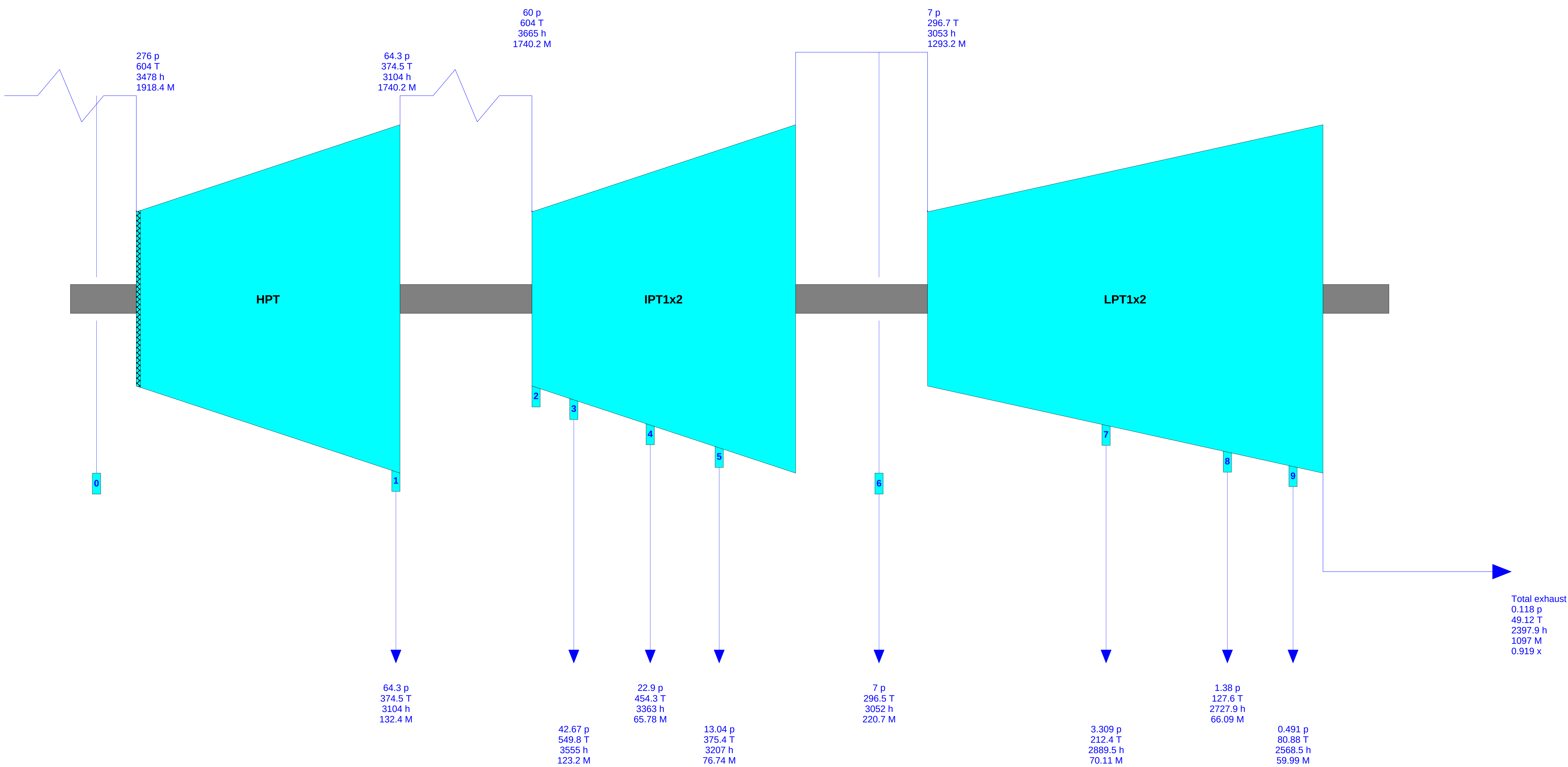
Furnace - TQ Diagram



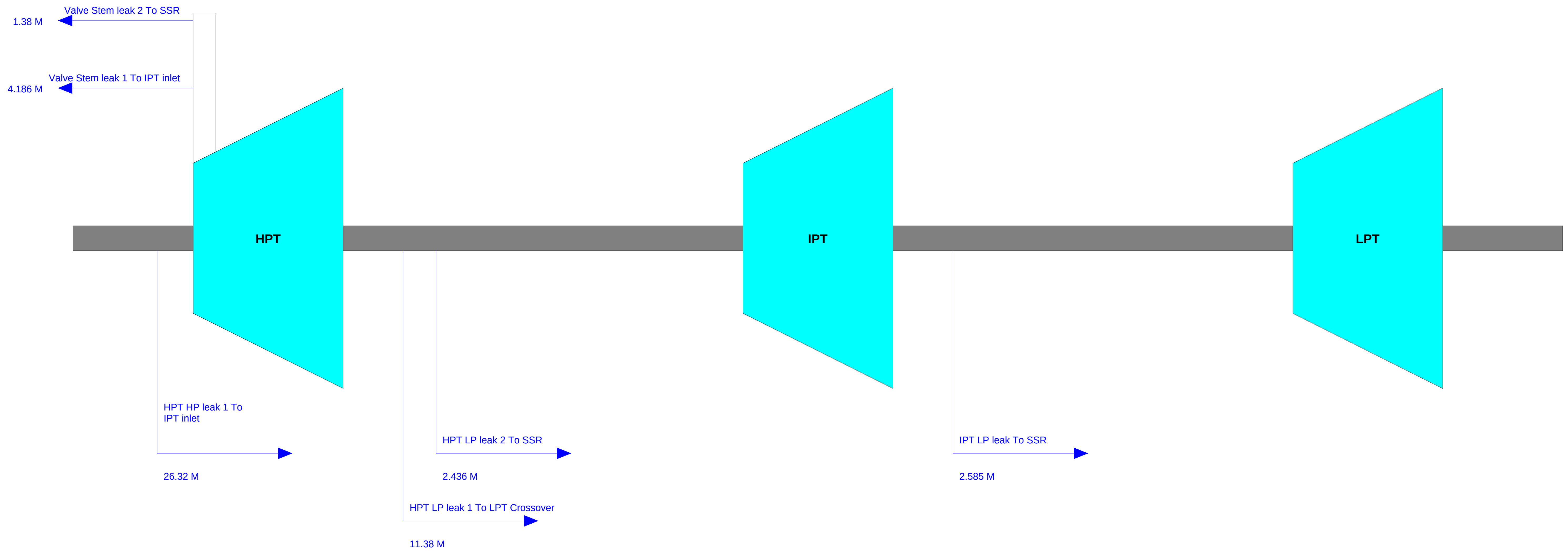
Rotary Air Heater - TQ Diagram



Expansion power	686393	kW
Mechanical loss	1716	kW
Generator loss	5913	kW
Generator power	678764	kW



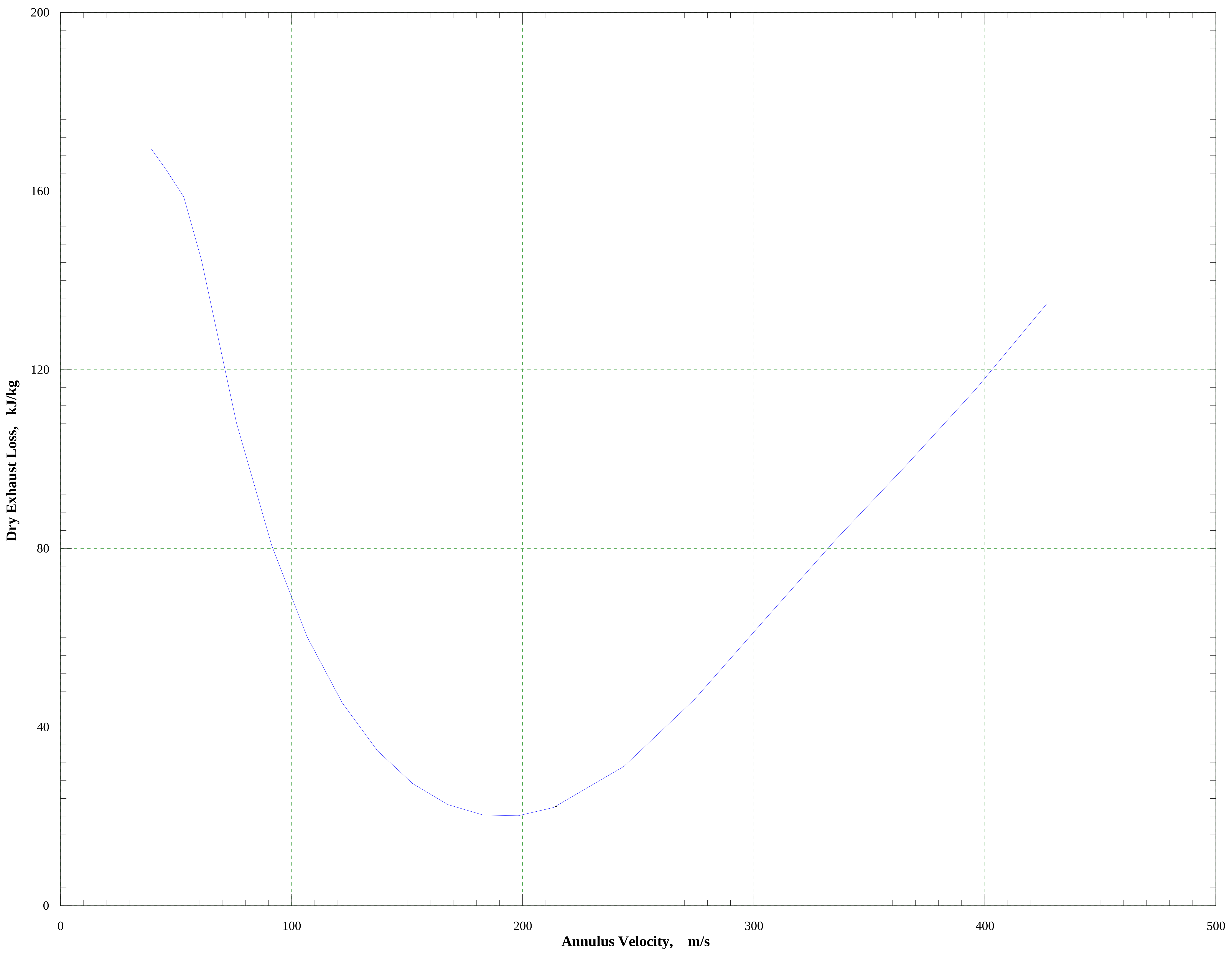
p [bar] T [C] h [kJ/kg] M [t/h] x [-]

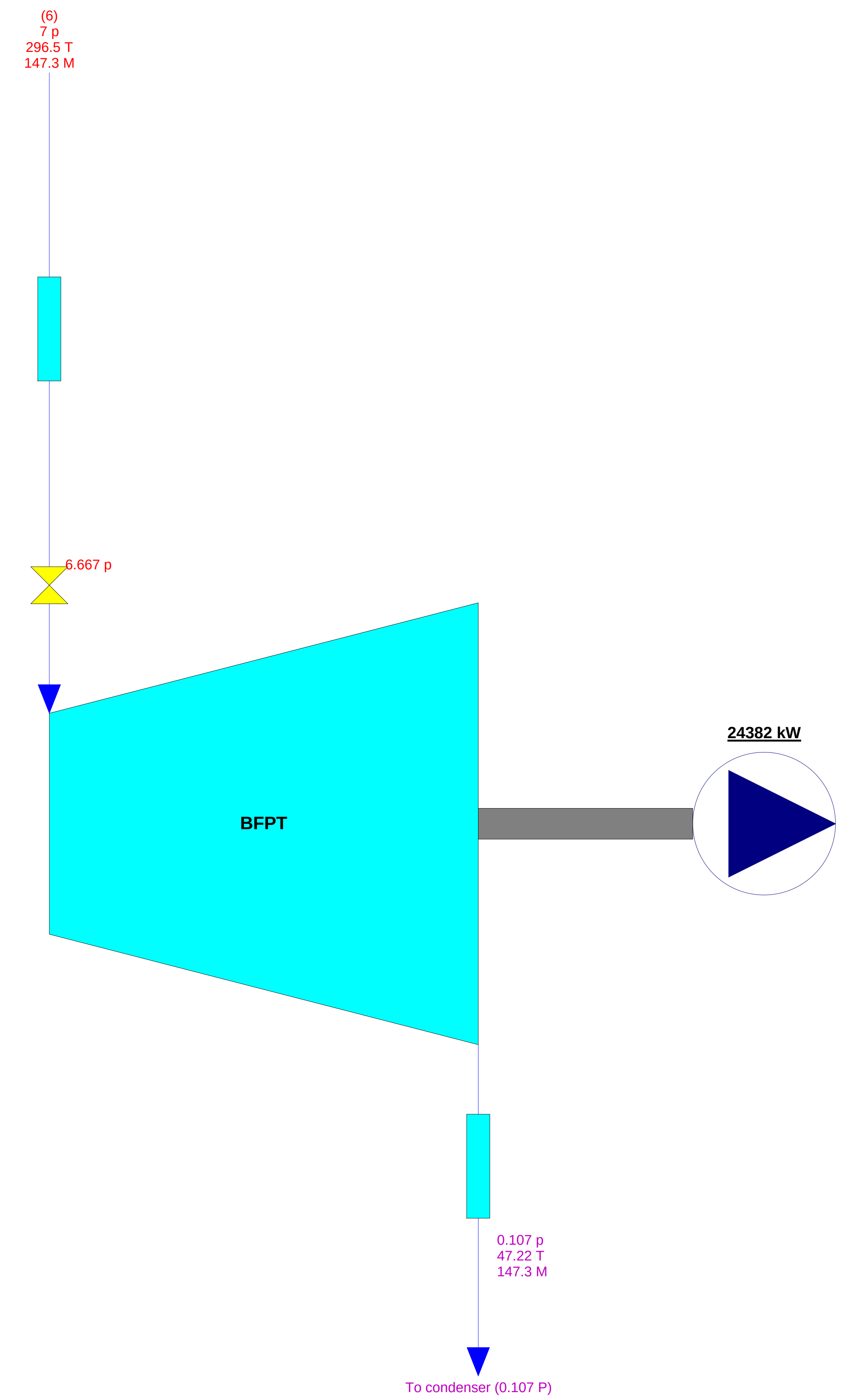


p [bar] T [C] h [kJ/kg] M [t/h] x [-]

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

Steam Turbine Exhaust Loss



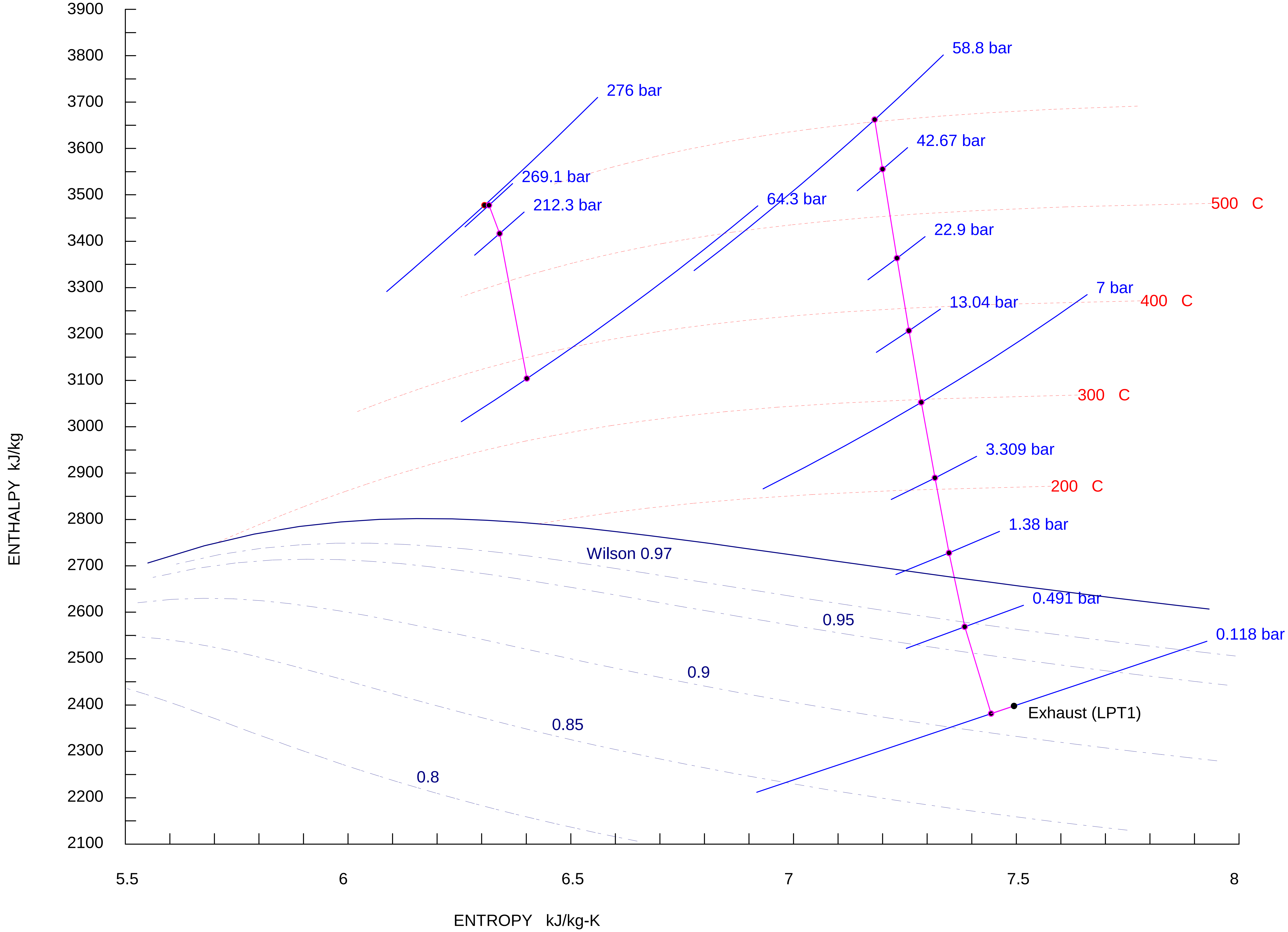


p [bar] T [C] M [t/h] x [-]

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

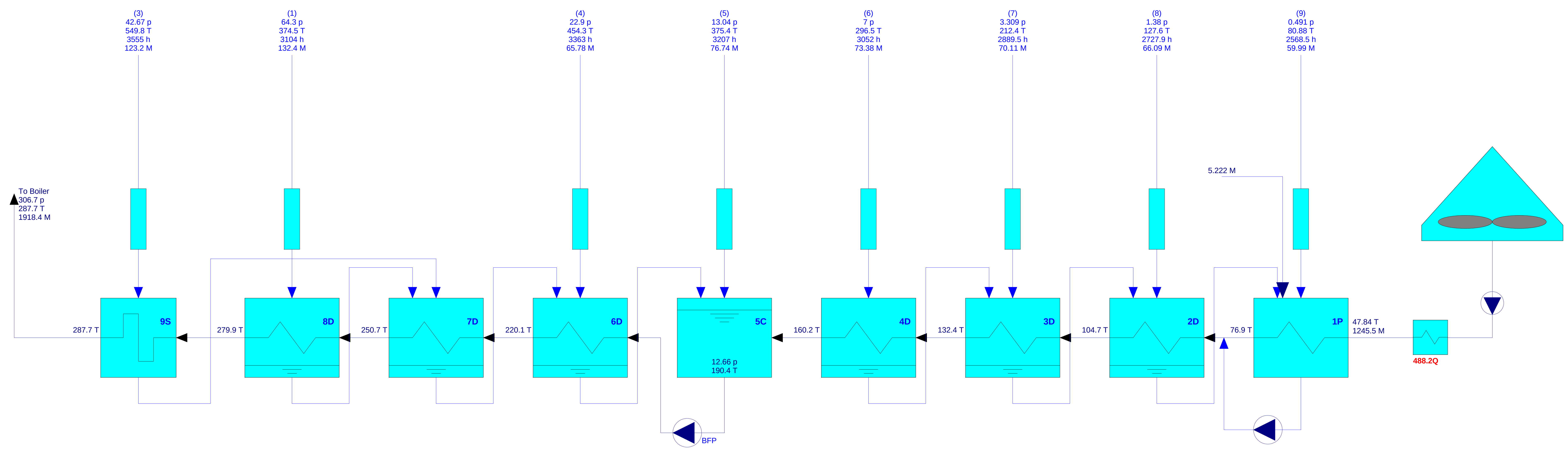
STEAM PRO 26.1 GHD

Steam Turbine Expansion Path



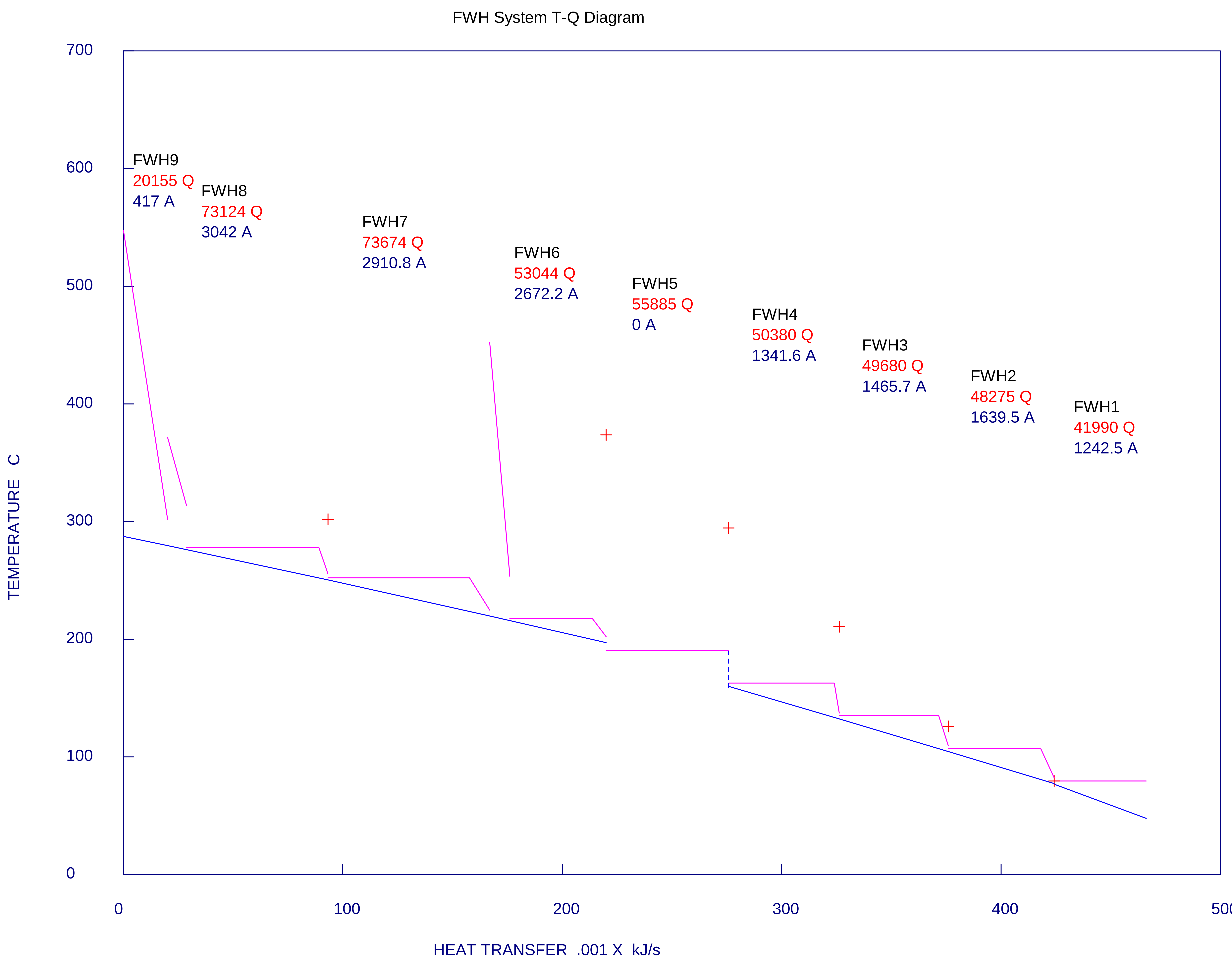
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

Double HP Feed Water Heater Train & Single LP Feed Water Heater Train



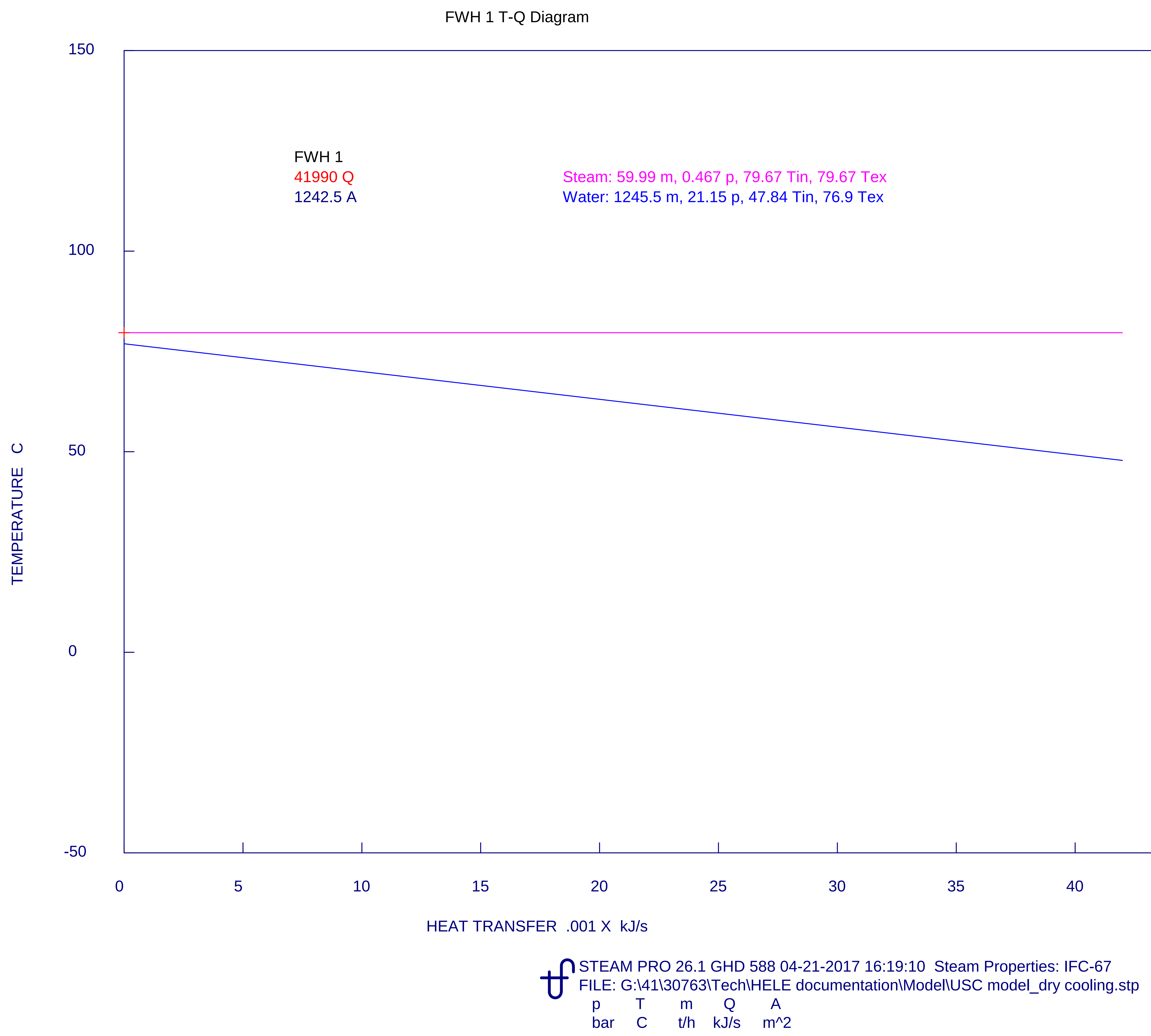
p [bar] T [C] h [kJ/kg] M [t/h] Q [kJ/s] x [-]

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

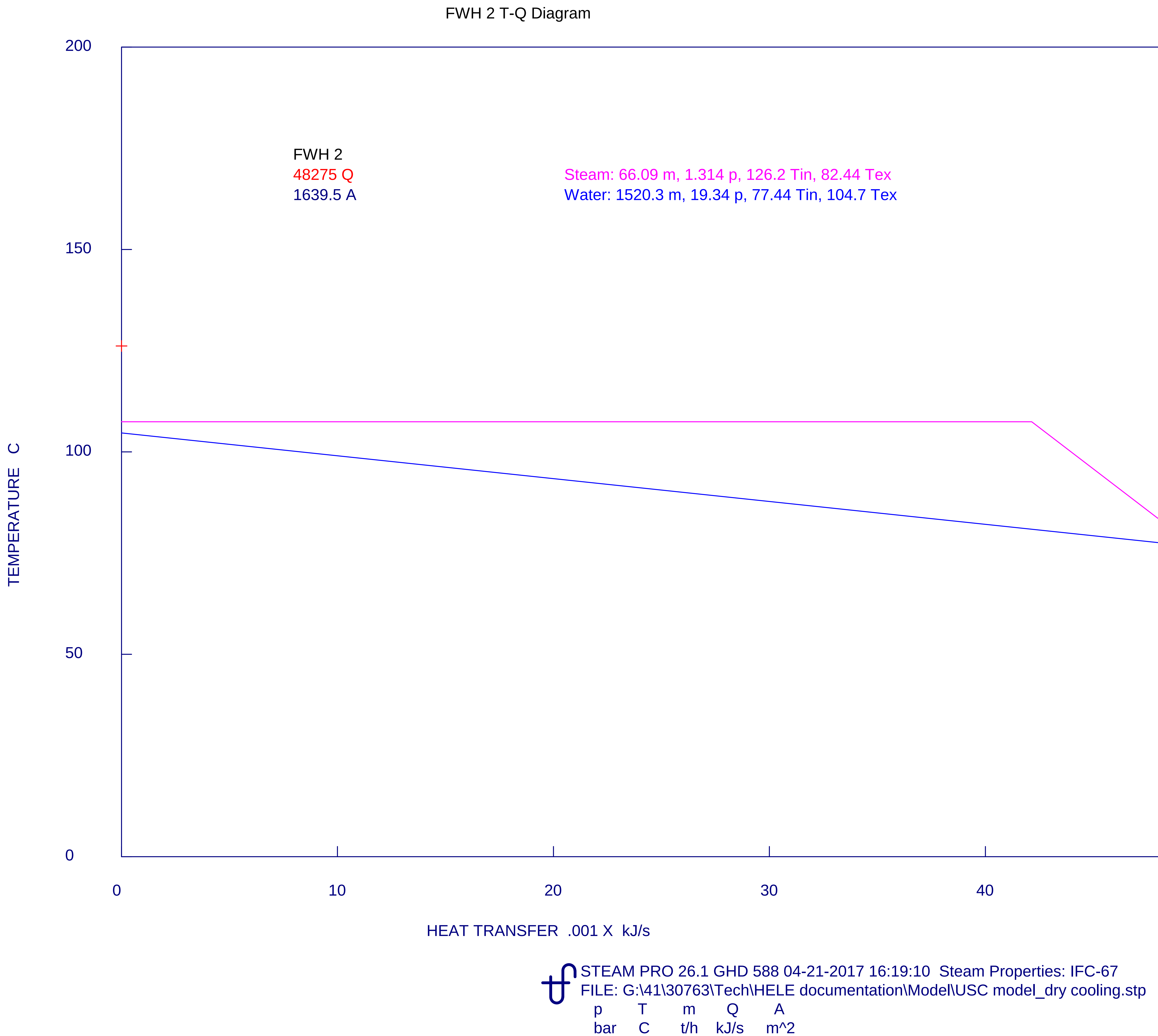


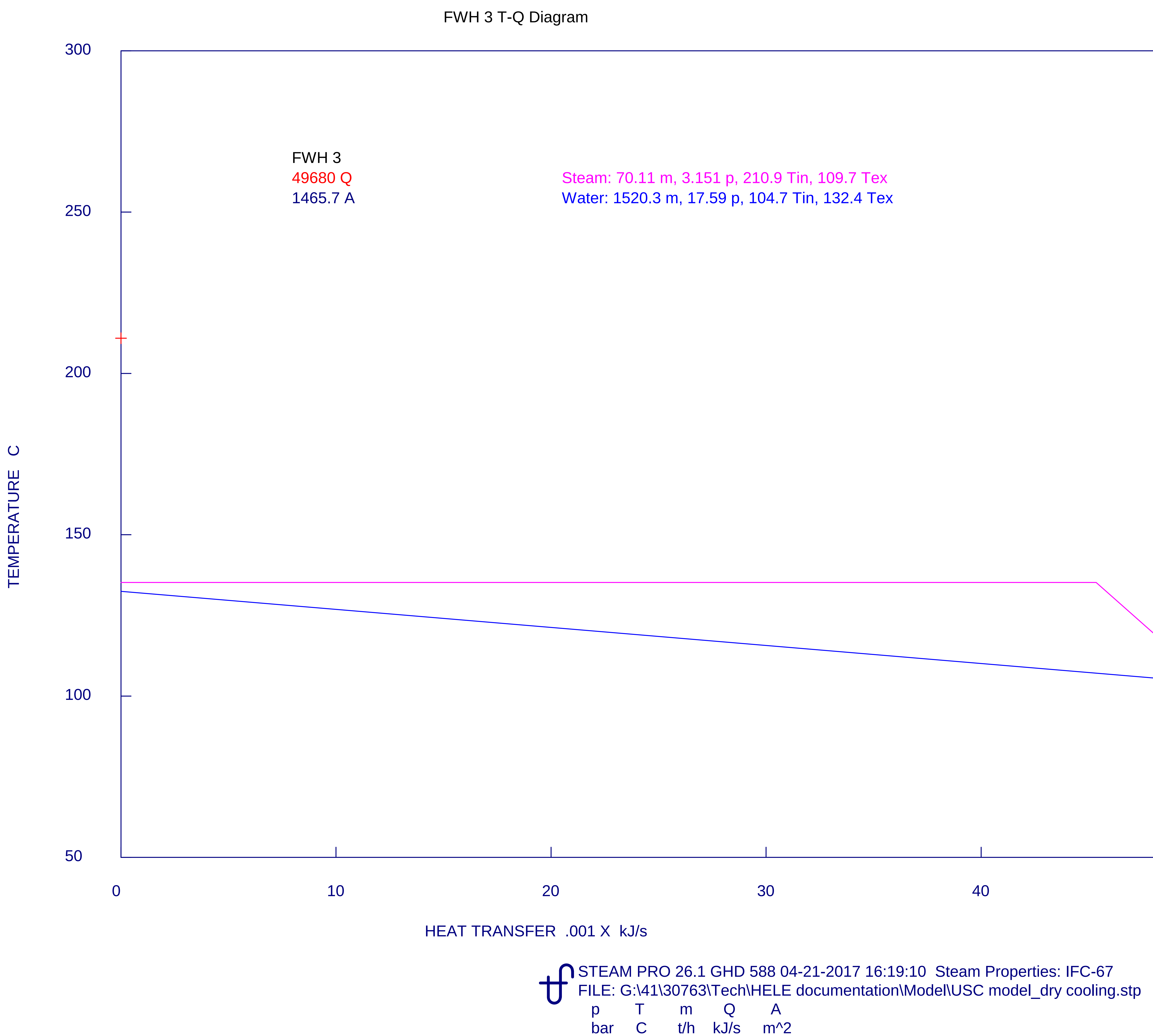
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

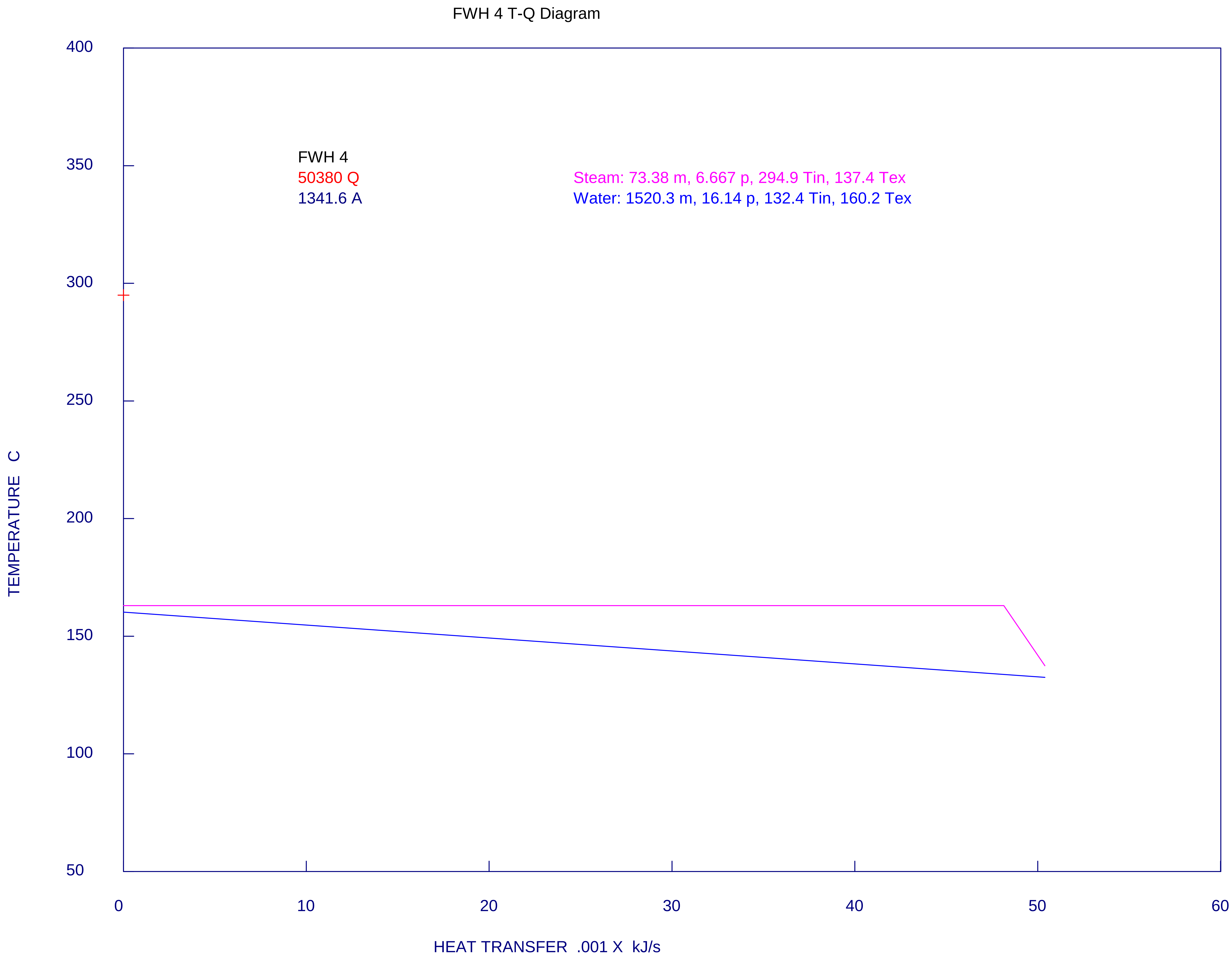
p	T	m	Q	A
bar	C	t/h	kJ/s	m^2



FWH 1 T-Q Diagram
FWH 1
41990 Q
1242.5 A
Steam: 59.99 m, 0.467 p, 79.67 Tin, 79.67 Tex
Water: 1245.5 m, 21.15 p, 47.84 Tin, 76.9 Tex
150
100
50
0
-50
TEMPERATURE C
0
5
10
15
20
25
30
35
40
45
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
p T m Q A
bar C t/h kJ/s m^2

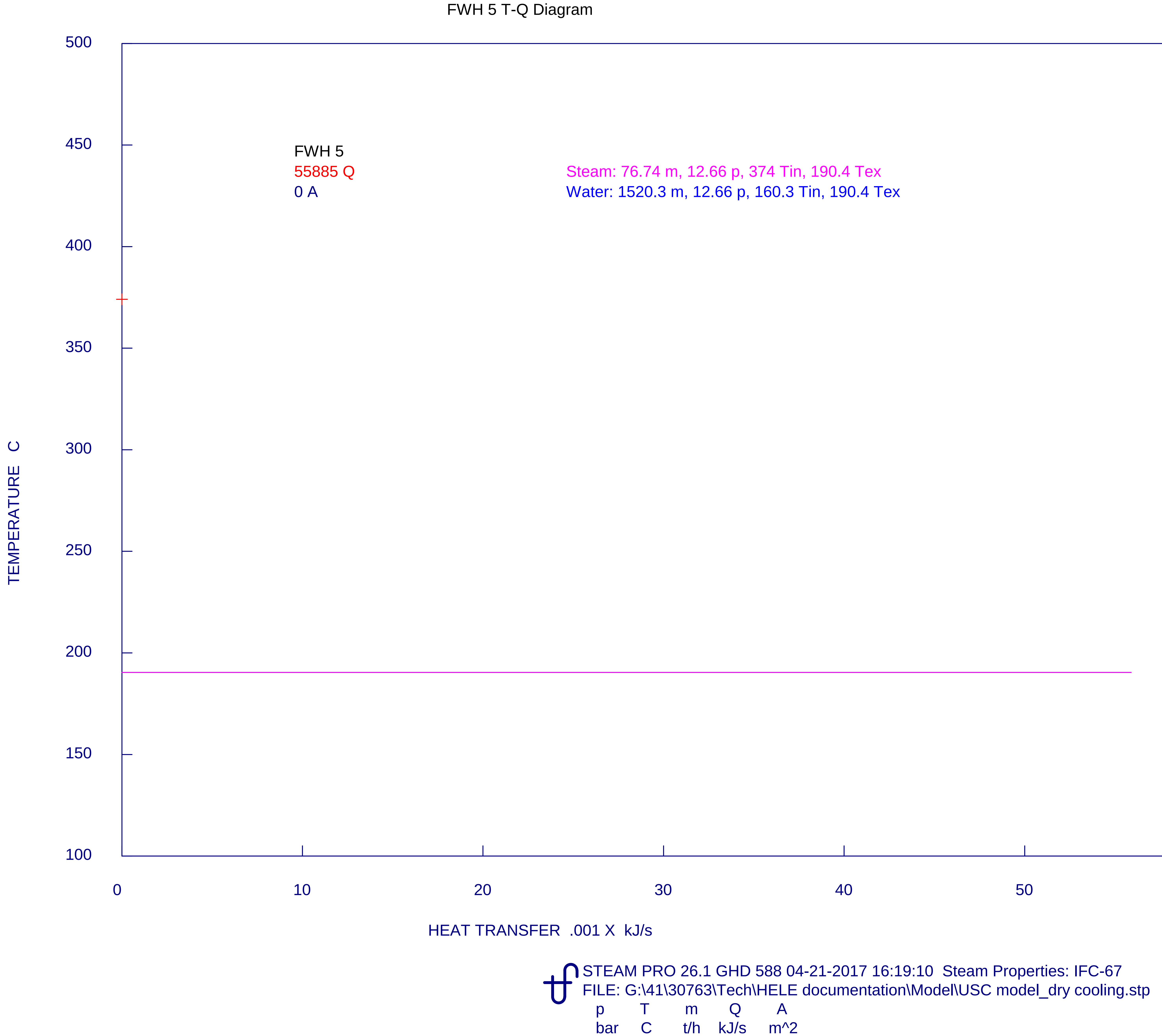

FWH 2 T-Q Diagram
FWH 2
48275 Q
1639.5 A
Steam: 66.09 m, 1.314 p, 126.2 Tin, 82.44 Tex
Water: 1520.3 m, 19.34 p, 77.44 Tin, 104.7 Tex
200
150
100
50
0
TEMPERATURE C
0
10
20
30
40
50
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
p T m Q A
bar C t/h kJ/s m^2


FWH 3 T-Q Diagram
FWH 3
49680 Q
1465.7 A
Steam: 70.11 m, 3.151 p, 210.9 Tin, 109.7 Tex
Water: 1520.3 m, 17.59 p, 104.7 Tin, 132.4 Tex
300
250
200
150
100
50
TEMPERATURE C
0
10
20
30
40
50
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
p T m Q A
bar C t/h kJ/s m^2

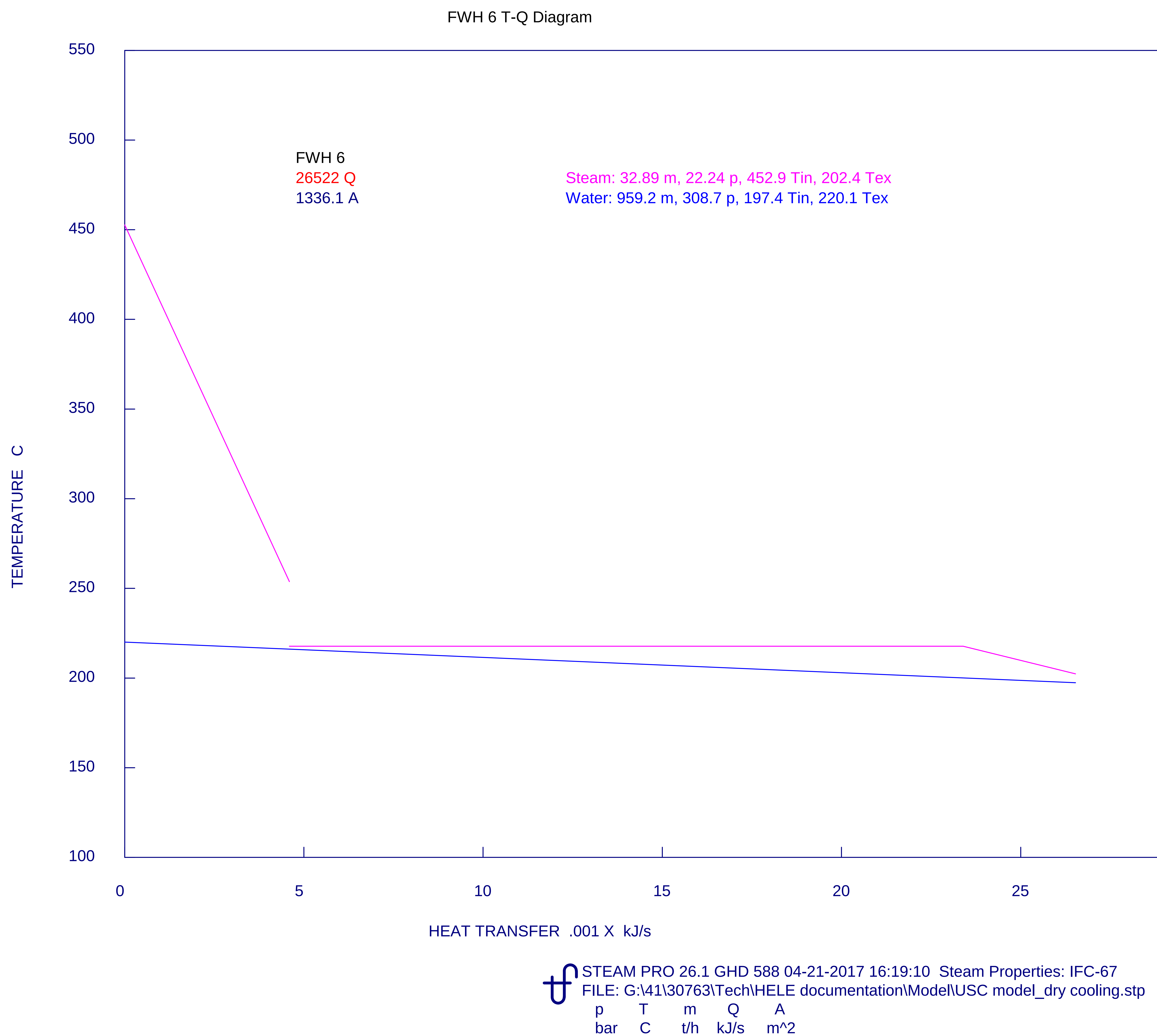


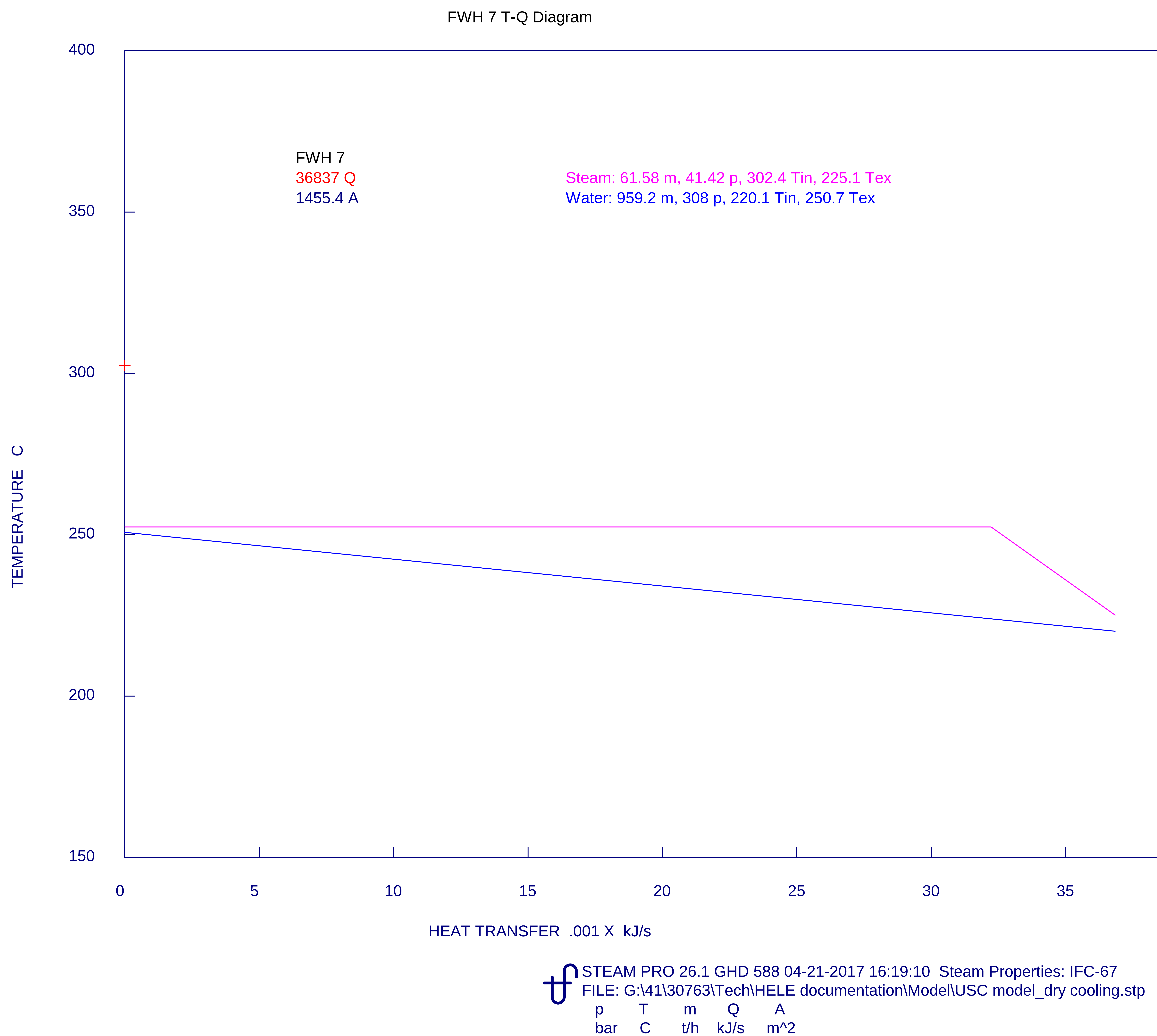
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

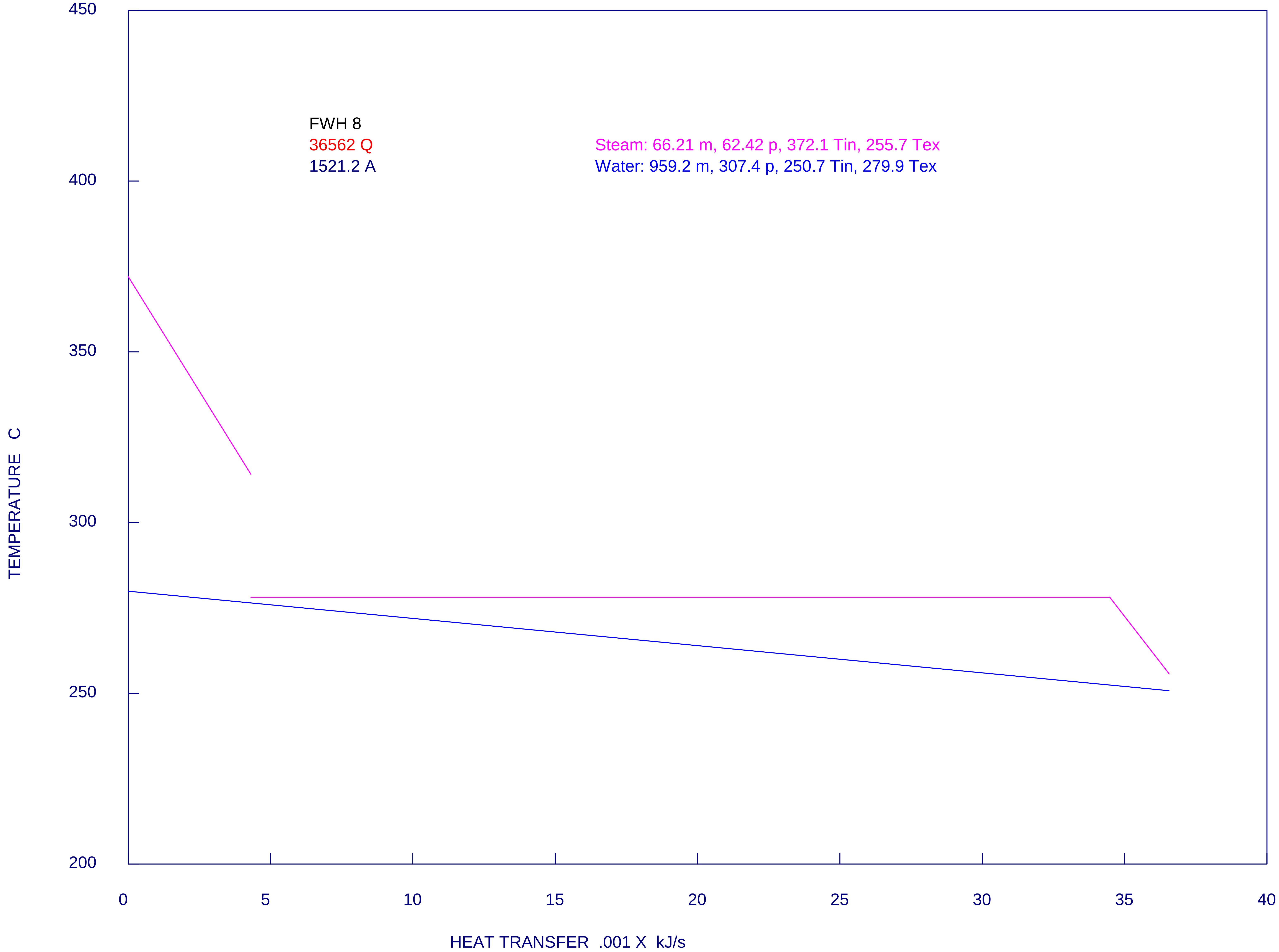


FWH 5 T-Q Diagram
500
450
400
350
300
250
200
150
100
TEMPERATURE C
FWH 5
55885 Q
0 A
Steam: 76.74 m, 12.66 p, 374 Tin, 190.4 Tex
Water: 1520.3 m, 12.66 p, 160.3 Tin, 190.4 Tex
0
10
20
30
40
50
60
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
p T m Q A
bar C t/h kJ/s m^2


FWH 6 T-Q Diagram
FWH 6
26522 Q
1336.1 A
Steam: 32.89 m, 22.24 p, 452.9 Tin, 202.4 Tex
Water: 959.2 m, 308.7 p, 197.4 Tin, 220.1 Tex
TEMPERATURE C
550
500
450
400
350
300
250
200
150
100
0
5
10
15
20
25
30
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
p T m Q A
bar C t/h kJ/s m^2

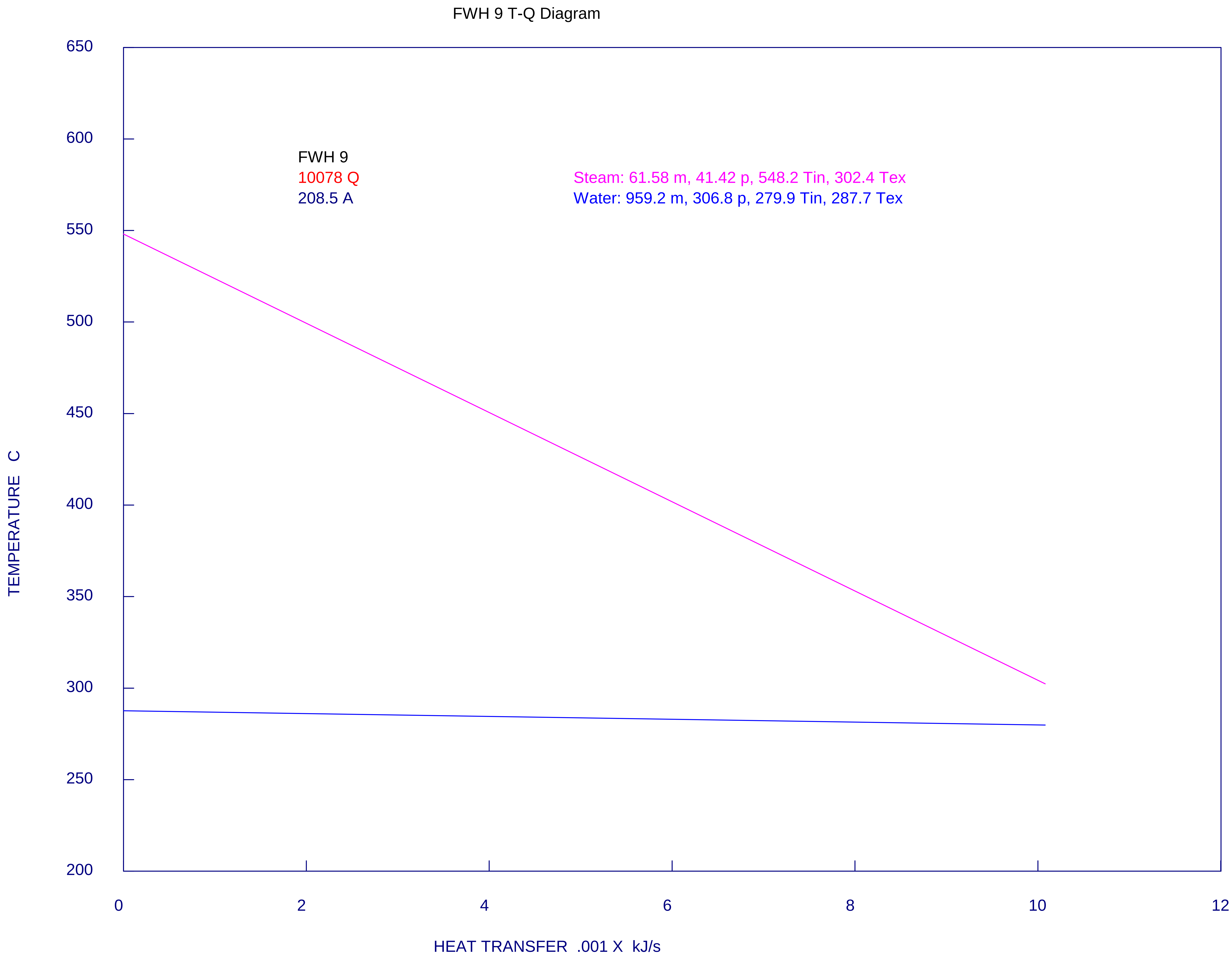

FWH 7 T-Q Diagram
FWH 7
36837 Q
1455.4 A
Steam: 61.58 m, 41.42 p, 302.4 Tin, 225.1 Tex
Water: 959.2 m, 308 p, 220.1 Tin, 250.7 Tex
400
350
300
250
200
150
TEMPERATURE C
0
5
10
15
20
25
30
35
40
HEAT TRANSFER .001 X kJ/s
STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
p T m Q A
bar C t/h kJ/s m^2

FWH 8 T-Q Diagram



STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

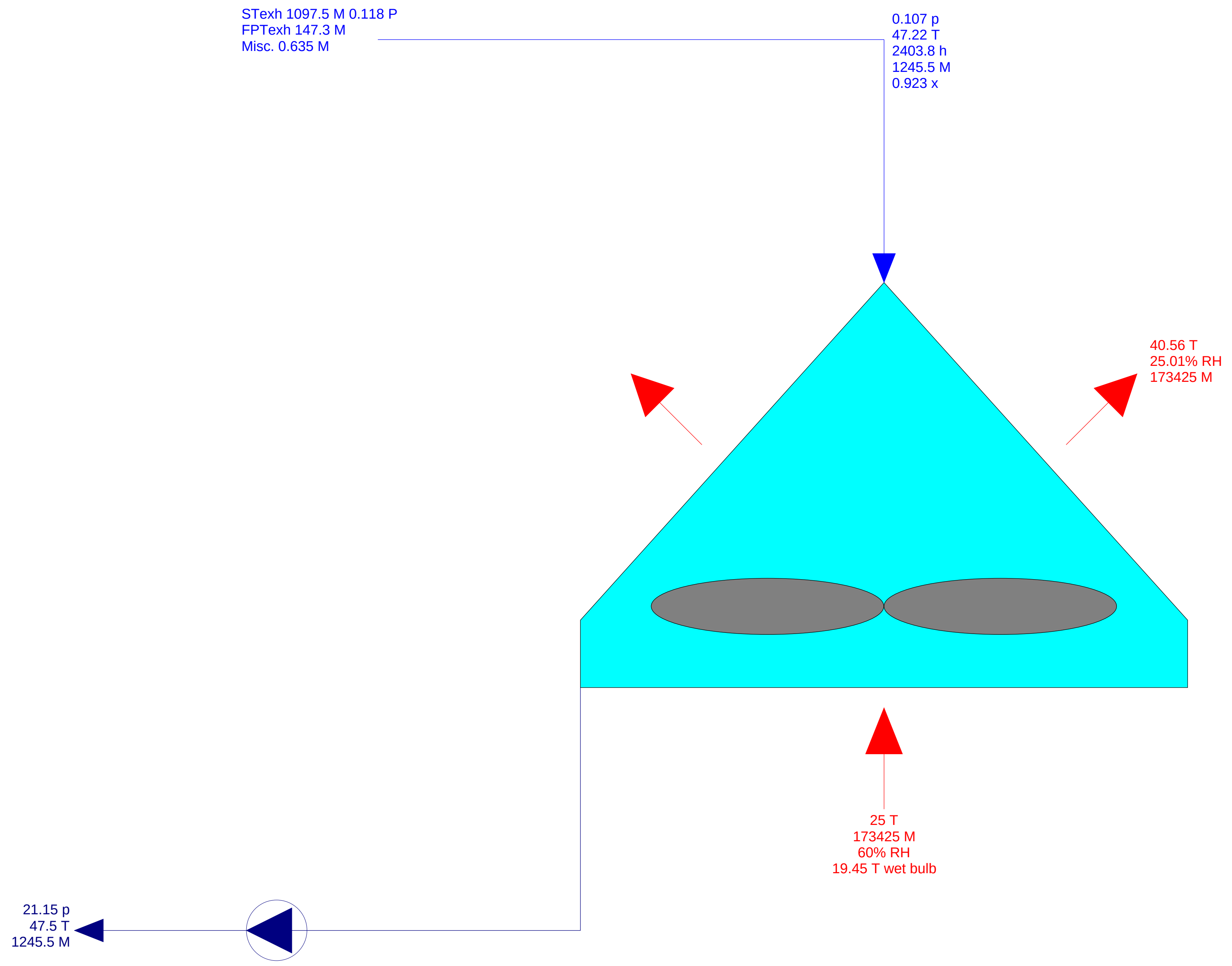
p	T	m	Q	A
bar	C	t/h	kJ/s	m^2



STEAM PRO 26.1 GHD 588 04-21-2017 16:19:10 Steam Properties: IFC-67
FILE: G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

p	T	m	Q	A
bar	C	t/h	kJ/s	m^2

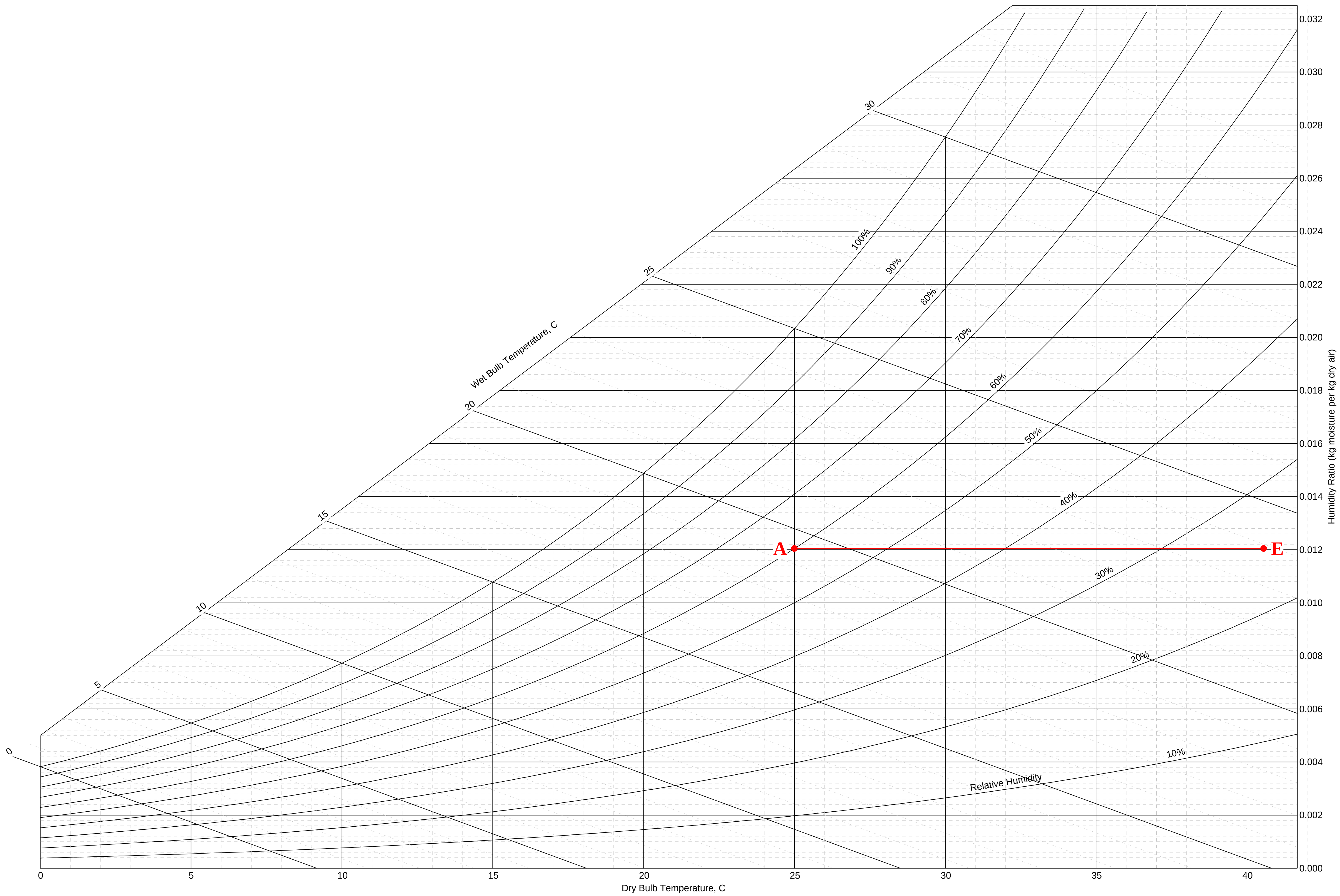
Condenser heat rejection	763268	kJ/s
Condensate pump power	1096.9	kW
Fan power	7014	kW



p [bar] T [C] h [kJ/kg] M [t/h] x [-]

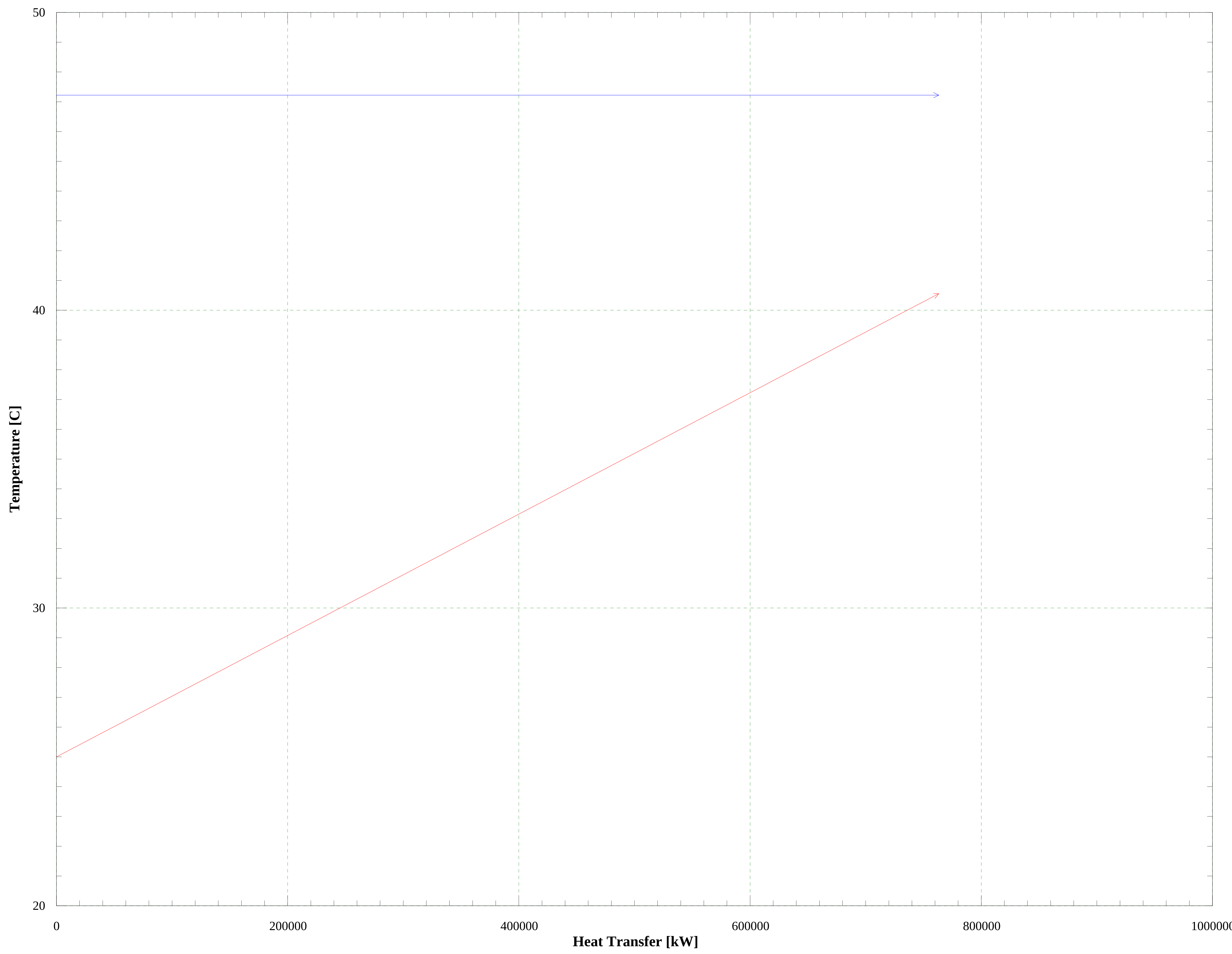
AIR STATES:
A) Ambient or Inlet:
Pressure = 1 bar
Dry bulb = 25 C
Wet bulb = 19.45 C
RH = 60 %
E) Air Exit:
Dry bulb = 40.56 C
Wet bulb = 23.94 C
RH = 25.01 %
Plume invisible
(Plume Visibility
index = 0.00)

Psychrometric Chart



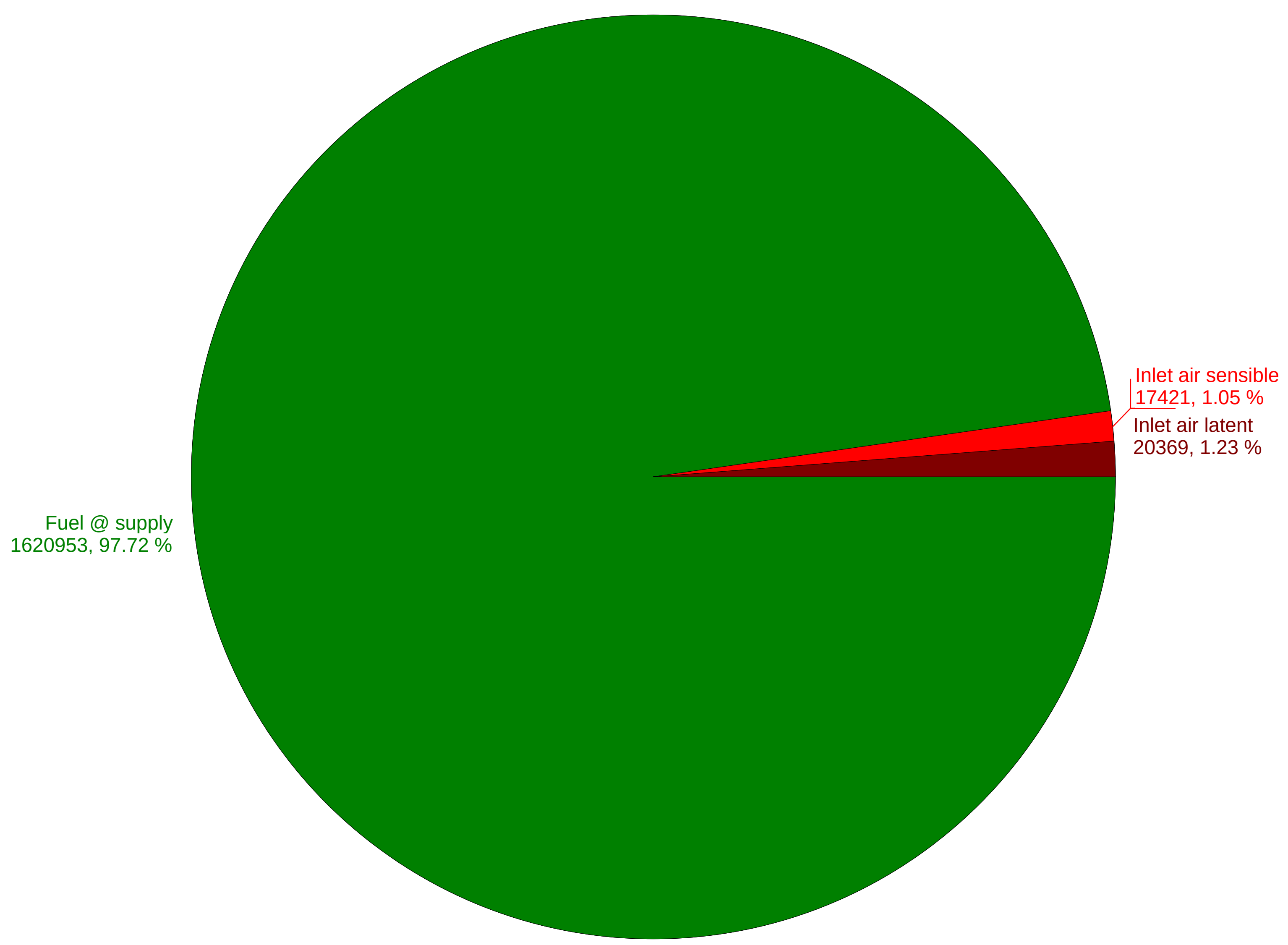
Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Dry air-cooled condenser
Date: 04/21/17	
Drawing No:	

Dry air-cooled condenser - TQ Diagram



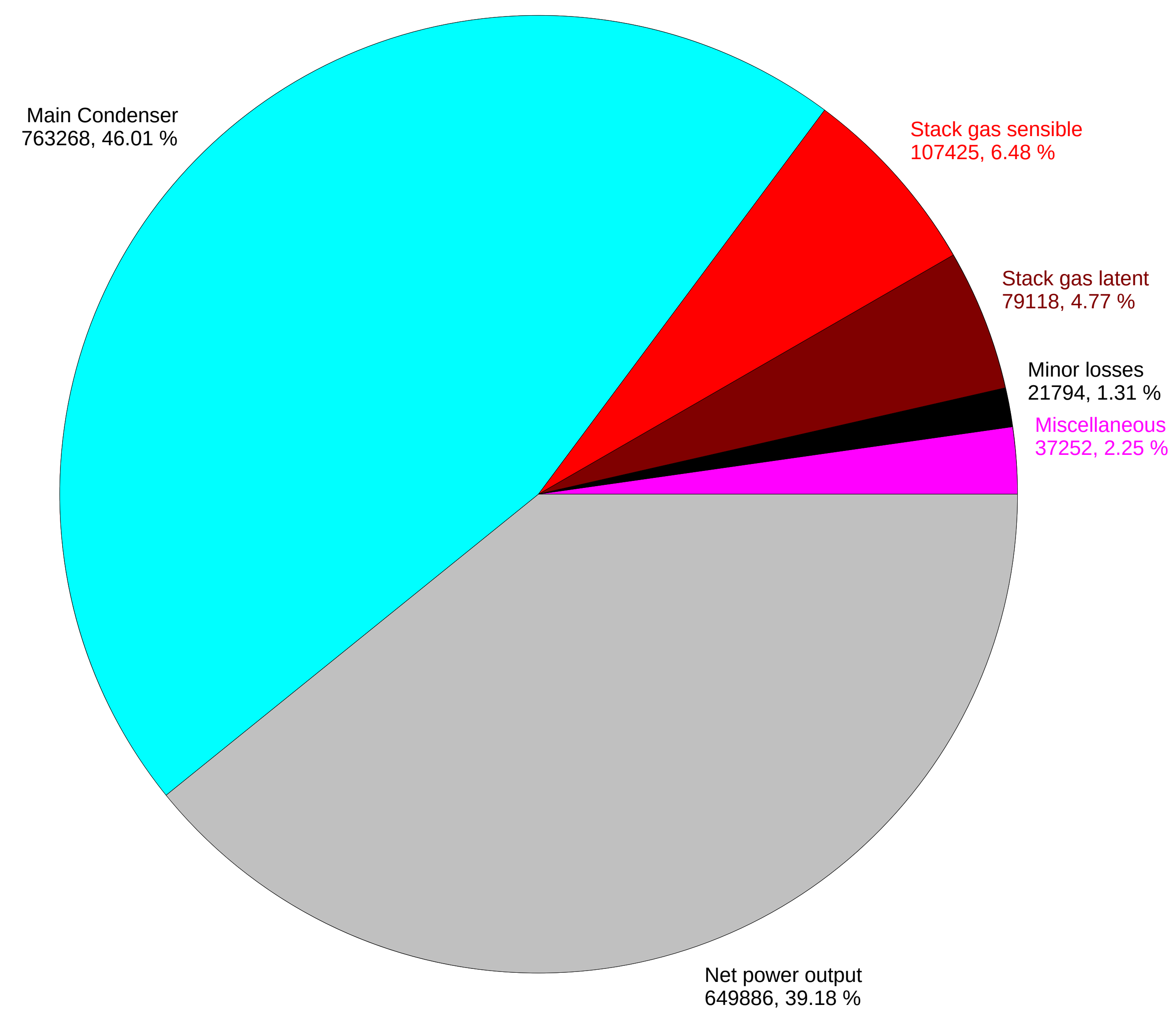
Plant Energy In [kJ/s]

Plant energy in = 1658743 kJ/s
Plant fuel chemical LHV input = 1560772 kJ/s, HHV = 1618114 kJ/s



Plant Energy Out [kJ/s]

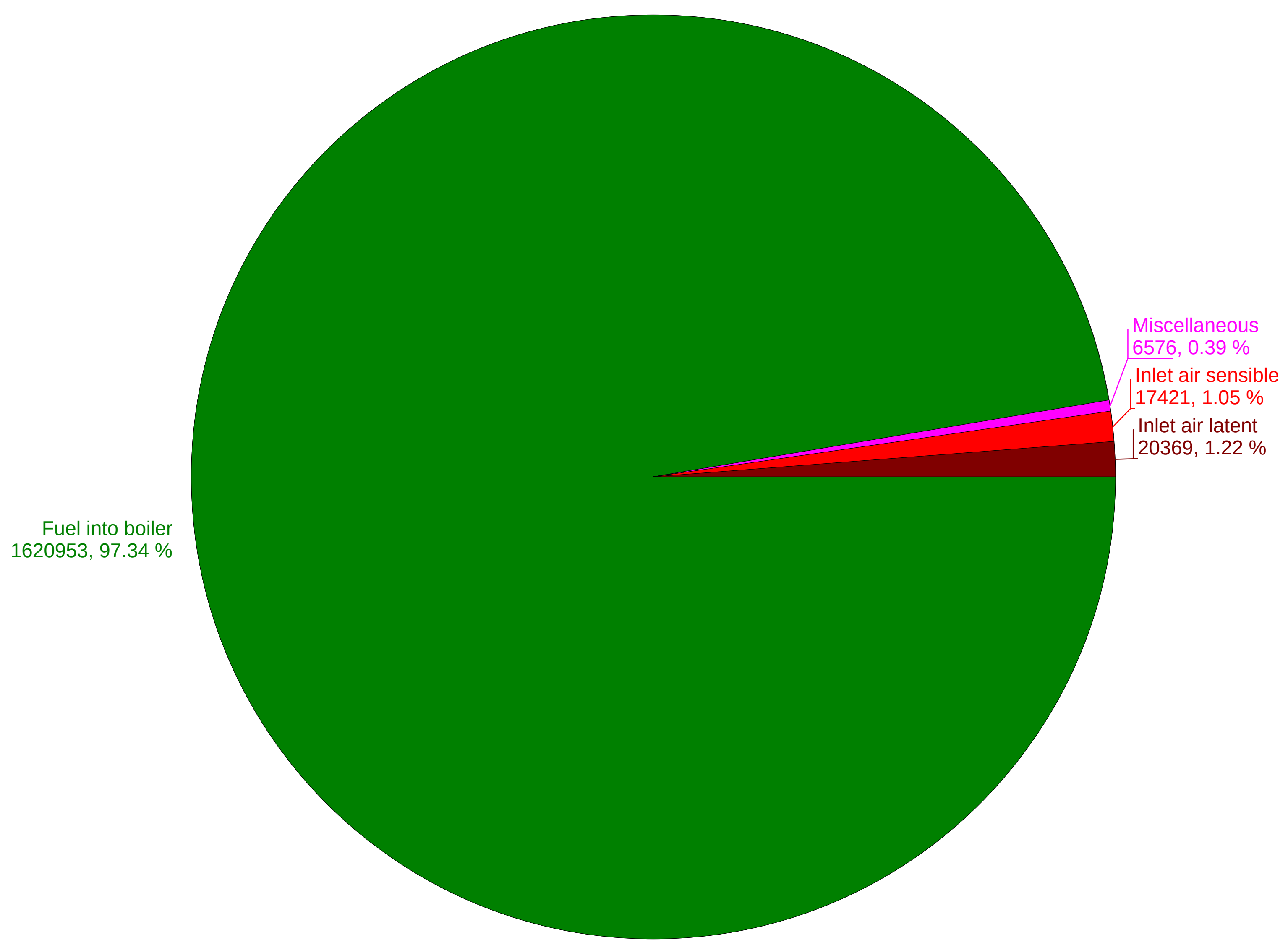
Plant energy out = 1658748 kJ/s



Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

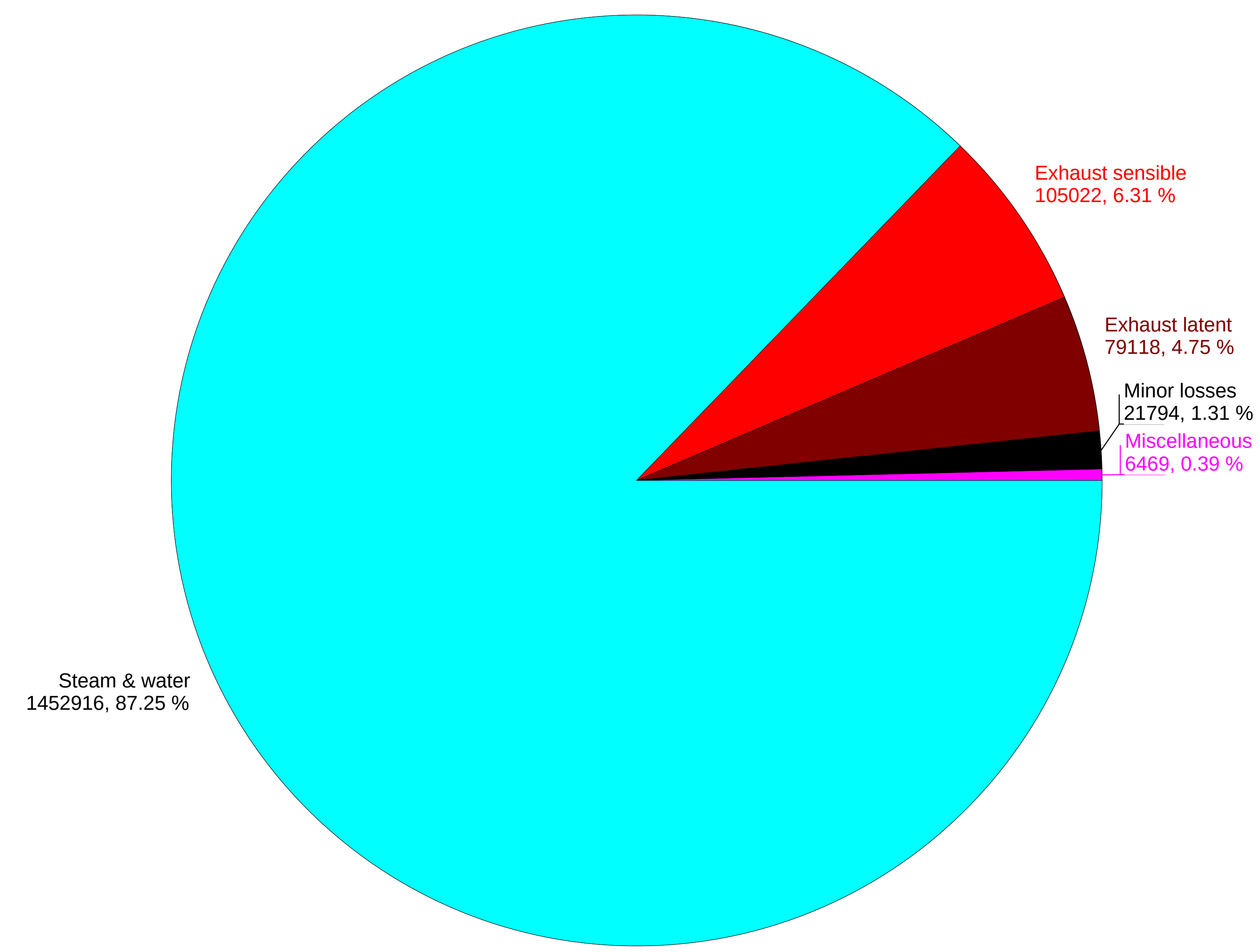
Boiler Energy In [kJ/s]

Boiler energy in = 1665318 kJ/s
Plant fuel chemical LHV input = 1560772 kJ/s, HHV = 1618114 kJ/s



Boiler Energy Out [kJ/s]

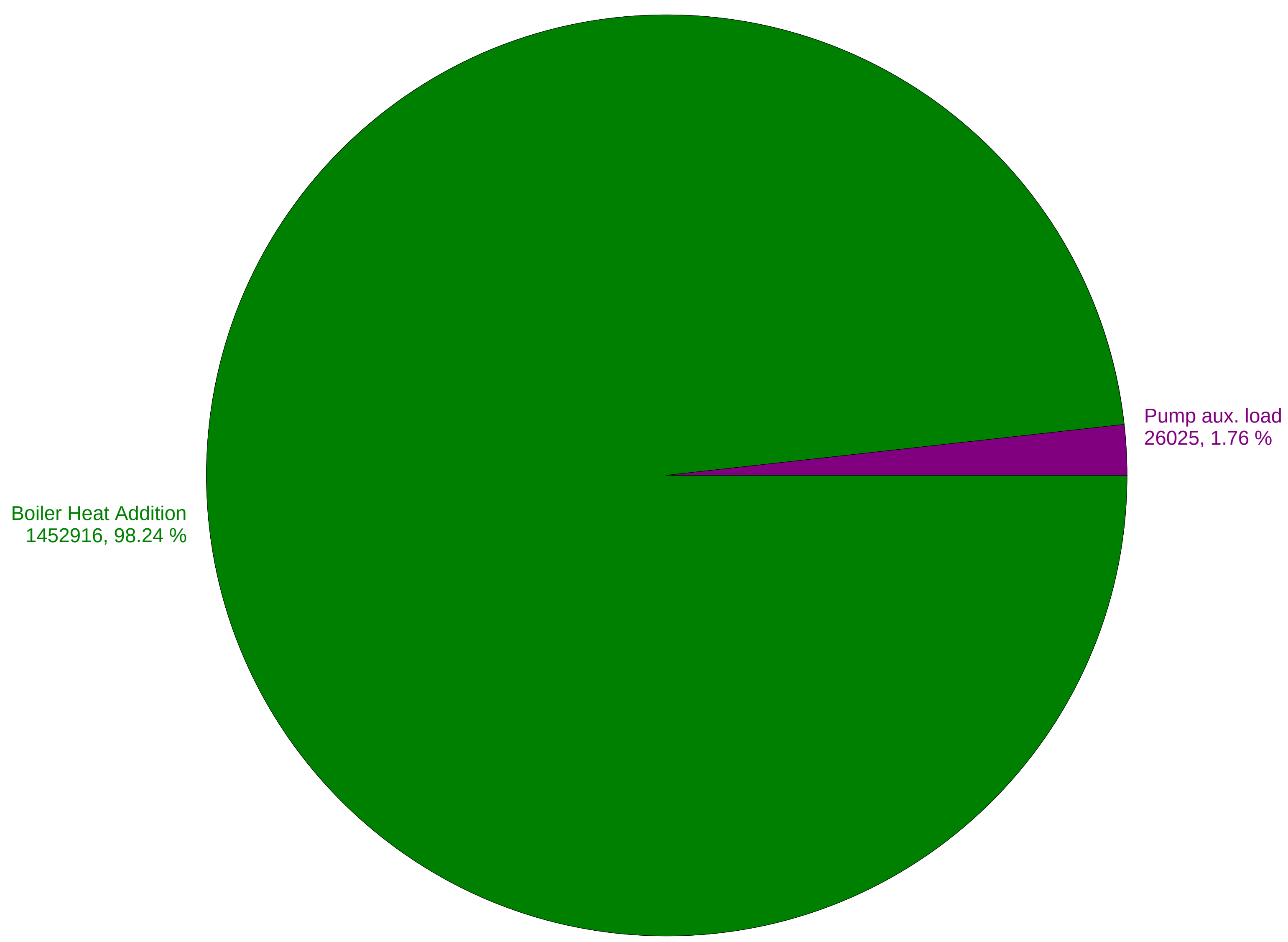
Boiler energy out = 1665323 kJ/s



Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

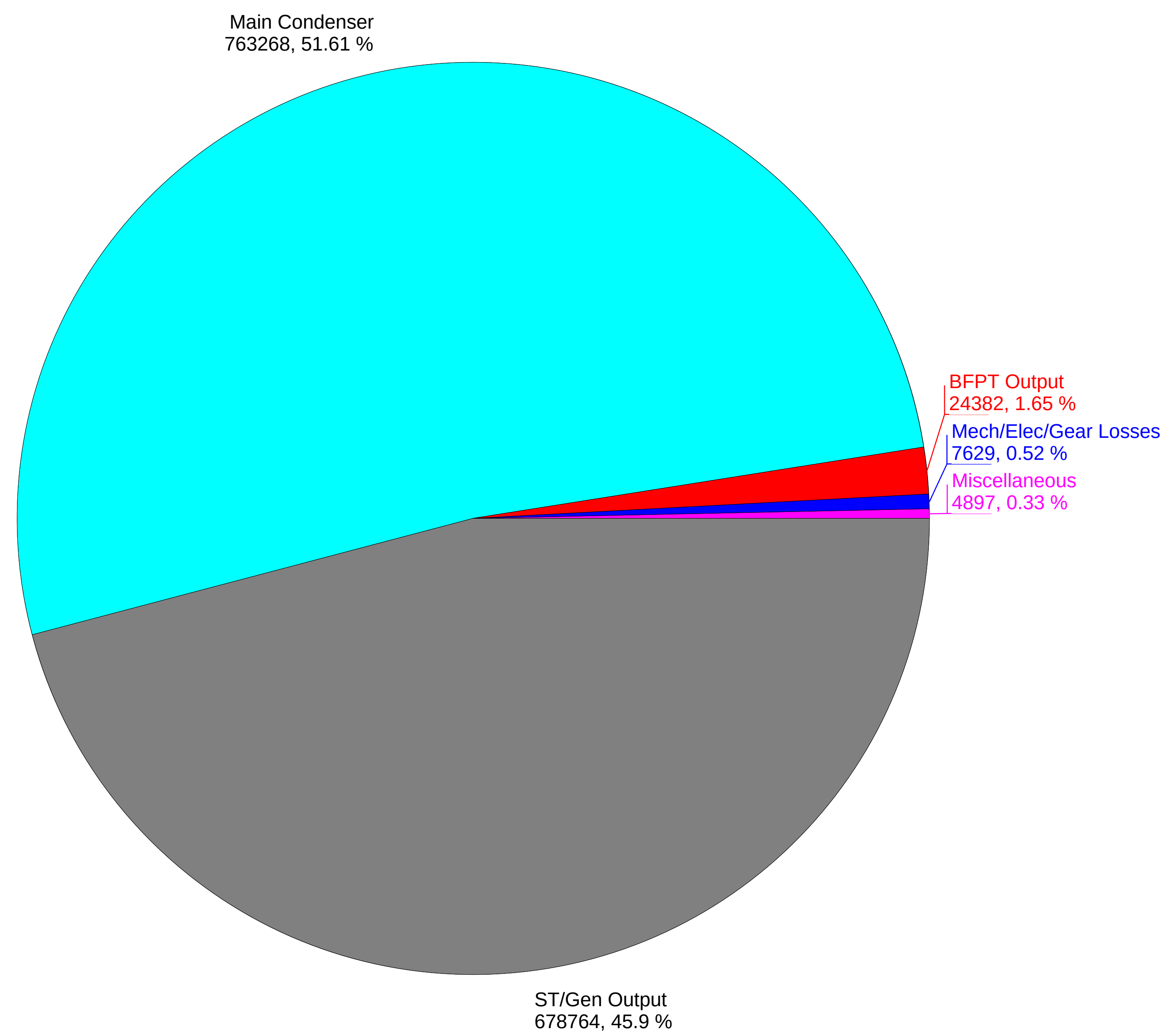
Steam Cycle Energy In [kJ/s]

Steam cycle energy in = 1478941 kJ/s



Steam Cycle Energy Out [kJ/s]

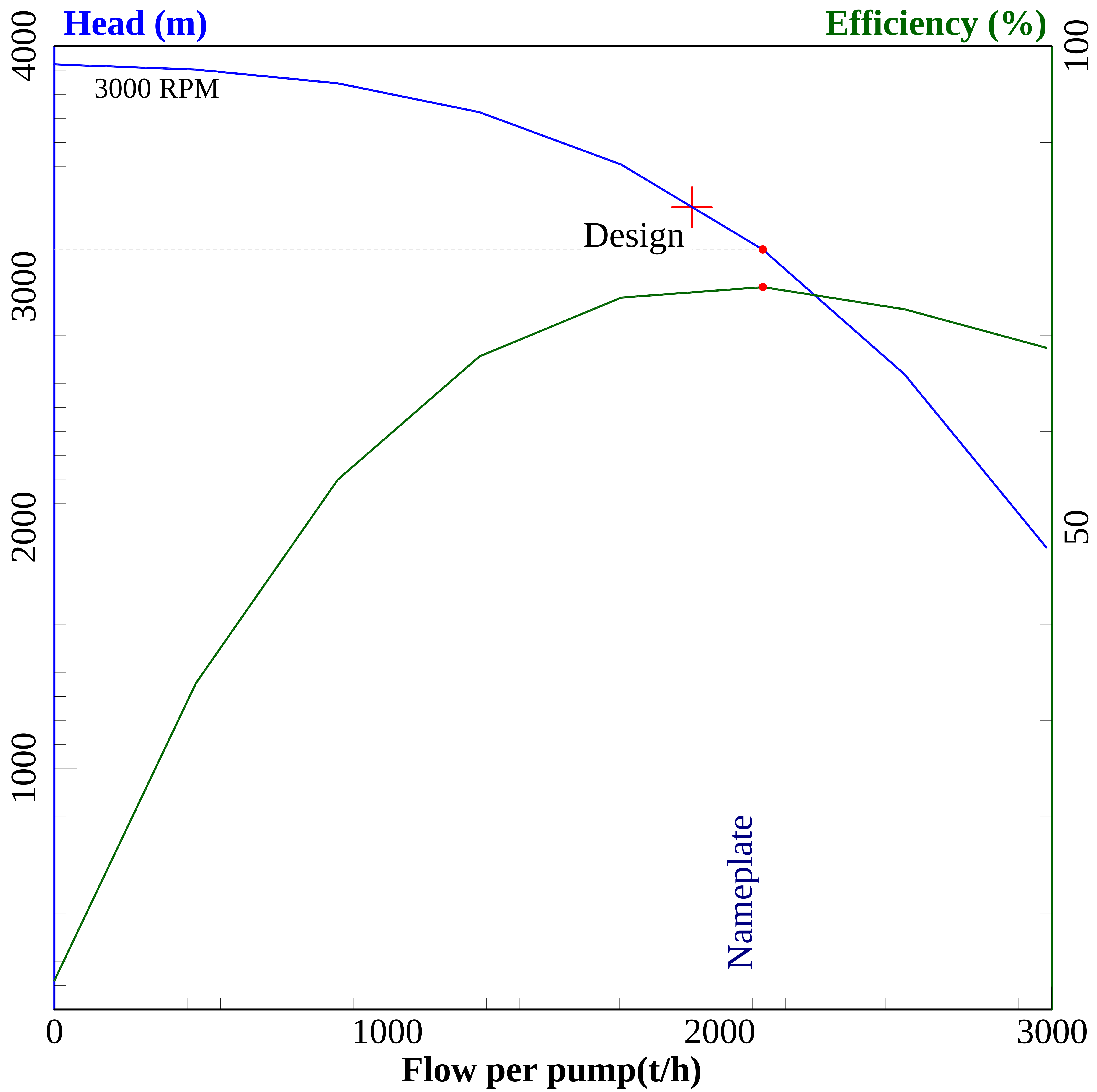
Steam cycle energy out = 1478941 kJ/s



Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

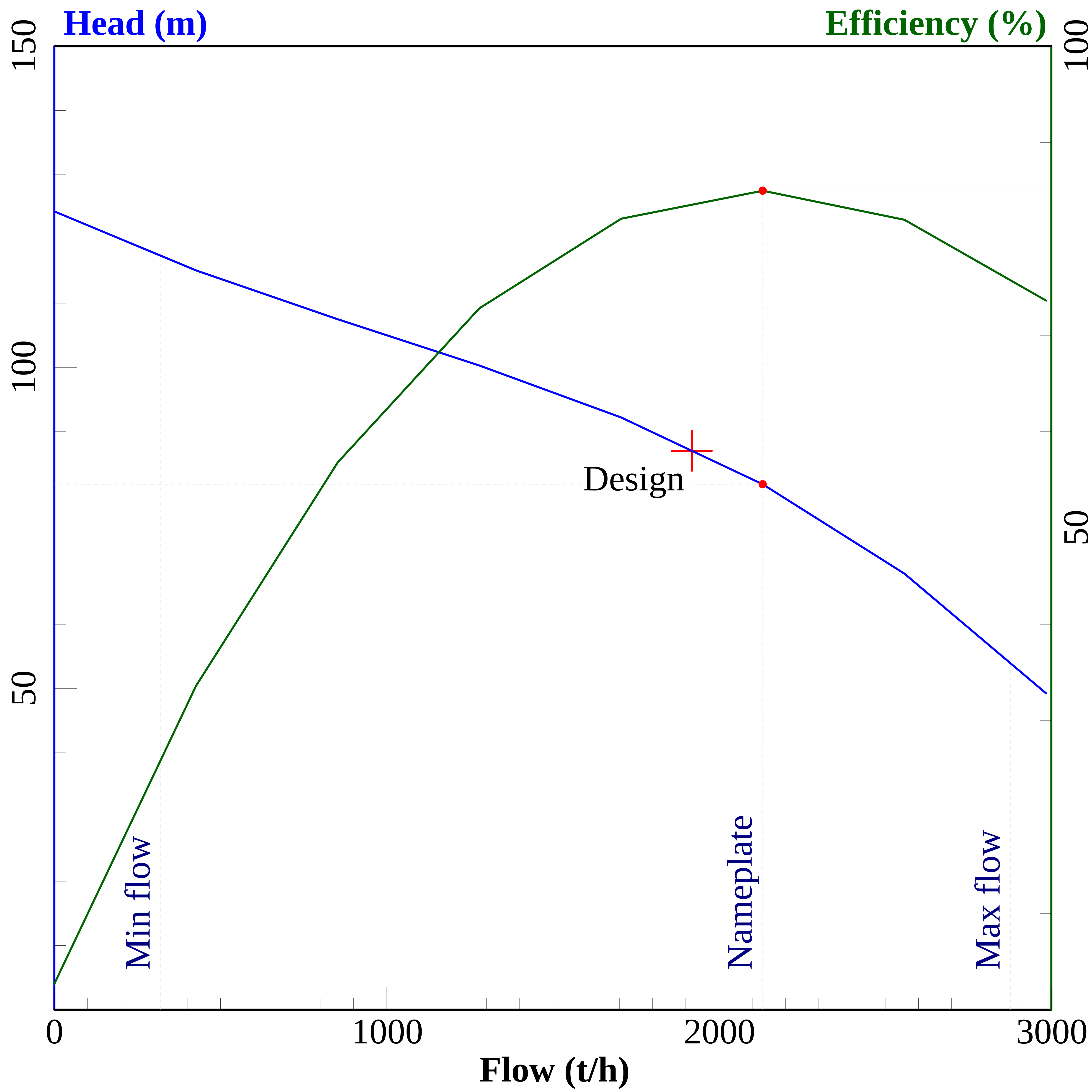
Boiler Feed Pump (P1)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2131.5 t/h
Nameplate head	3155 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	3170 m
Nameplate RPM	3000
Design flow	1918.4 t/h
Design head	3332 m
Design RPM	3000

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Pump (P1)
Date: 04/21/17	
Drawing No:	

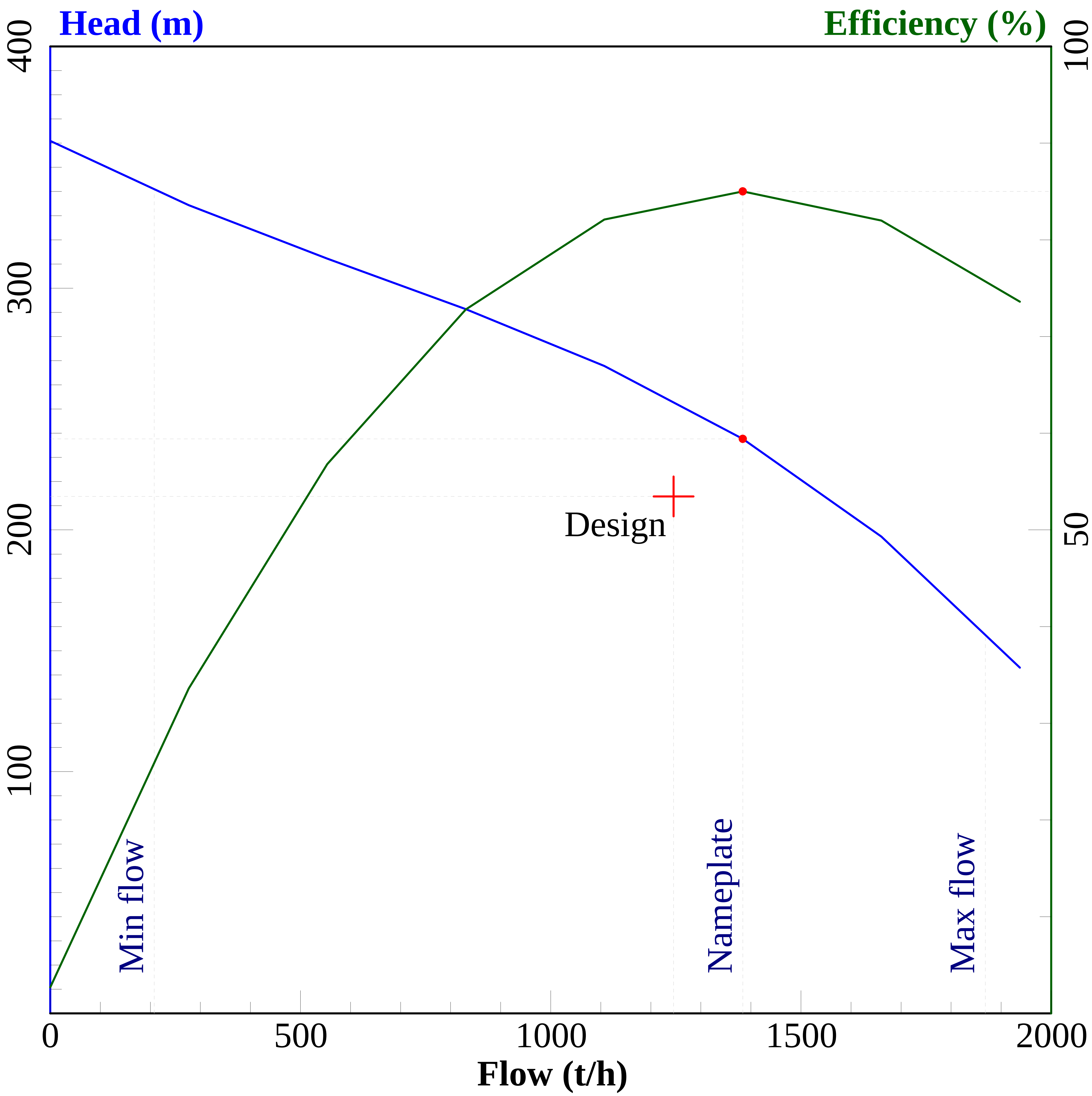
Boiler Feed Booster Pump (P3)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2131.5 t/h
Nameplate head	81.81 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	83.82 m
Nameplate RPM	600
Design flow	1918.4 t/h
Design head	87.01 m
Design RPM	600
Minimum continuous flow	319.7 t/h
Maximum continuous flow	2877.6 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Booster Pump (P3)
Date: 04/21/17	
Drawing No:	

Condensate Forwarding Pump (P6)



No. per ST	2
No. operating per ST	1
Nameplate flow	1383.9 t/h
Nameplate head	237.6 m
Nameplate flow (nominal)	24605 lpm
Nameplate head (nominal)	243.8 m
Nameplate RPM	750
Design flow	1245.5 t/h
Design head	213.9 m
Design RPM	750
Minimum continuous flow	207.6 t/h
Maximum continuous flow	1868.2 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Condensate Forwarding Pump (P6)
Date: 04/21/17	
Drawing No:	

STEAM PRO 26.1 GHD GHD Pty Ltd						
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp						
Program revision date: February 16, 2017						
Steam source: Conventional boiler						
Steam turbine: Single reheat condensing turbine 3000+3000/3000						
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train						
Cooling system: Dry air cooled condenser						
Steam Property Formulation: IFC-67						

SYSTEM SUMMARY

	Power Output (kW)		**Fuel Input (kJ/s)**		**Fuel Flows**	
	Gross	**Net**	**LHV**	**HHV**	**t/h**	**t/day**
Plant Total	**678764**	**649886**	**1560773**	**1618114**	**201.4**	**4832**

Number of units =	1	
Net process heat output =	0	kJ/s
as % of total output (net elec. + net heat) =	0	%

PLANT EFFICIENCY AND HEAT RATE

	LHV*		**HHV***		**Boiler Heat Input****		
	Gross	**Net**	**Gross**	**Net**	**Gross**	**Net**	
Heat rate	**8278**	**8646**	**8582**	**8963**	**8278**	**8646**	**kJ/kWh**
Electric efficiency	**43.49**	**41.64**	**41.95**	**40.16**	**43.49**	**41.64**	**%**
CHP (Total) efficiency		**41.64**		**40.16**		**41.64**	**%**
U.S. PURPA efficiency		**41.64**		**40.16**		**41.64**	**%**

* Heat input is based on fuel chemical energy, LHV or HHV, at 77 F/25 C

** Boiler heat input includes fuel chemical LHV energy at 77 F/ 25 C, plus enthalpy of supply air (gas) in excess of ambient temperature.

Total heat input (LHV adjusted) =	1560772	kJ/s
Fuel input to boiler (LHV adjusted) =	1560768	kJ/s.

STEAM CYCLE/BOILER PERFORMANCE

Steam cycle heat rate	**7706**	**kJ/kWh**
Steam cycle efficiency	**46.72**	**%**
Turbine heat rate	**7687**	**kJ/kWh**
Boiler LHV adjusted efficiency	**93.09**	**%**
Boiler HHV adjusted efficiency	**89.79**	**%**

ESTIMATED PLANT AUXILIARIES		
Boiler primary air fan*	1436.7	kW
Boiler secondary air fan*	1924.1	kW
Boiler induced draft fan*	2668.7	kW
Boiler fuel delivery*	4439.1	kW
Boiler forced circulation pump	0.0	kW
Electrostatic precipitator (ESP)	1613.1	kW
Ash handling	856.5	kW
Condenser cooling water pump	0.0	kW
Air cooled condenser fan	7013.7	kW
Condensate pump*	1096.9	kW
Contact heater feed forward pump(s)*	0.0	kW
Boiler feed pump*	0.0	kW
Boiler feed booster pump*	583.9	kW
FW heater drain pump(s)*	205.9	kW
Aux. from PEACE running motor/load list	3289.0	kW
Miscellaneous ST auxiliaries	356.4	kW
Miscellaneous plant auxiliaries	1696.9	kW
Constant plant auxiliary load	0.0	kW
Program estimated overall plant auxiliaries	27180.7	kW
Actual (user input) overall plant auxiliaries	27180.7	kW
Transformer losses	1696.9	kW
Total auxiliaries & transformer losses	**28877.7**	**kW**
* Heat balance related auxiliaries		

PLANT HEAT BALANCE				
Energy In	**1658743**	**kW**		
Ambient air sensible	17421	kW		
Ambient air latent	20369	kW		
Fuel enthalpy @ supply	1620953	kW		
External steam	0	kW		
External water	0	kW		
Makeup, process return, and blowdown recovery	0	kW		
FGD water	0	kW		
FGD oxidation air	0	kW		
CO2 capture makeup water	0	kW		
Condensate external heating or cooling	0	kW		
Energy Out	**1658748**	**kW**		
Net power output	649886	kW		
Stack gas sensible	107425	kW		
Stack gas latent	79118	kW		
Bottom ash	1404.6	kW		
Fly ash	399.3	kW		
Unburned carbon	4669	kW		
Boiler minor loss	21794	kW		
Fuel delivery energy loss	887.8	kW		
Main condenser	763268	kW		
BFPT condenser	0	kW		
Process steam	0	kW		
Process water	0	kW		
District heat	0	kW		
Discharged seal steam	0	kW		
Blowdown	0	kW		
Steam pipe losses	4015	kW		
ST/generator mech/elec/gear loss	7629	kW		
BFPT mech loss	243.8	kW		
Pumps mech/elec loss	882.8	kW		
Fans mech/elec loss	602.9	kW		
ESP heat loss	0	kW		
FGD energy loss	0	kW		
CO2 capture energy loss	0	kW		
Desal heat	0	kW		
Non-heat balance related auxiliaries	16523	kW		
Other	0	kW		
Energy In - Energy Out	**-5.143**	**kW**	**-0.0003**	**%**
Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)				

STEAM PRO Streams	P	T	h	M	s
	bar	C	kJ/kg	t/h	kJ/kg-C
Note: This is a fixed format table. Not all					H2O: ref @ 32F
streams are applicable to current heat balance.					
Zero enthalpy: steam & liquid water at 32 F (273.15 K).					
1 Feedwater into boiler	306.7	287.7	1266.98	1918.37	-
2 Feedwater leaving grate cooling HX	306.7	287.7	1266.98	1918.37	-
3 Water leaving 1st economiser	303.7	343.5	1568.27	1918.37	-
4 Water entering 2nd economiser	303.7	343.5	1568.27	1918.37	-
5 Water leaving 2nd economiser	303.7	343.5	1568.27	1918.37	-
6 Boiler blowdown	-	-	-	-	-
7 Steam leaving CEV	-	-	-	-	-
8 Steam leaving REV	288.5	427.6	2690.99	1918.37	-
9 Steam leaving CEV+REV	288.5	427.6	2690.99	1918.37	-
10 1st superheater inlet	288.5	427.6	2690.99	1918.37	-
11 1st superheater exit	285.9	462.5	2934.53	1918.37	-
12 2nd superheater inlet	285.9	462.5	2934.53	1918.37	-
13 2nd superheater exit	282.7	532.3	3236.35	1918.37	-
14 3rd superheater inlet	282.7	532.3	3236.35	1918.37	-
15 3rd superheater exit	280.1	606.0	3479.90	1918.37	-
16 4th superheater inlet	280.1	606.0	3479.90	1918.37	-
17 4th superheater exit	280.1	606.0	3479.90	1918.37	-
18 Steam leaving superheater	280.1	606.0	3479.89	1918.37	-
19 Cold reheat after pipe	63.04	372.6	3101.52	1740.25	-
20 Mixing cold reheat with steam add.	63.04	372.6	3101.52	1740.25	-
21 1st reheater inlet	63.04	372.6	3101.52	1740.25	-
22 1st reheater exit	62.12	485.2	3384.59	1740.25	-
23 2nd reheater inlet	62.12	485.2	3384.59	1740.25	-
24 2nd reheater exit	62.12	485.2	3384.59	1740.25	-
25 3rd reheater inlet	62.12	485.2	3384.59	1740.25	-
26 3rd reheater exit	61.2	605.4	3667.67	1740.25	-
27 4th reheater inlet	61.2	605.4	3667.67	1740.25	-
28 4th reheater exit	61.2	605.4	3667.67	1740.25	-
29 Steam leaving reheater	61.2	605.4	3667.67	1740.25	-
30 Cold LP reheat after pipe	-	-	-	-	-
31 Mixing cold LP reheat with steam add.	-	-	-	-	-
32 1st LP reheater inlet	-	-	-	-	-
33 1st LP reheater exit	-	-	-	-	-
34 2nd LP reheater inlet	-	-	-	-	-
35 2nd LP reheater exit	-	-	-	-	-
36 3rd LP reheater inlet	-	-	-	-	-
37 3rd LP reheater exit	-	-	-	-	-
38 4th LP reheater inlet	-	-	-	-	-
39 4th LP reheater exit	-	-	-	-	-
40 Steam leaving LP reheater	-	-	-	-	-
41 HPT inlet, before stop valves	276	604.0	3477.57	1918.37	6.306
42 HPT inlet, after stop valves	269.1	601.9	3477.57	1886.48	-
43 HPT exit	64.3	374.5	3103.85	1740.25	6.402
44 PIPT inlet, before intercept valve	-	-	-	-	-
45 PIPT exit	-	-	-	-	-
46 IPT inlet, before intercept valve	60	604.0	3665.34	1740.25	7.177
47 IPT bowl	58.8	602.2	3662.10	1770.75	7.182
48 LPT crossover	7	296.7	3052.60	1293.18	7.287
49 LPT exhaust	0.1181	49.1	2397.86	1096.99	7.495
50 ST group 1 inlet	269.1	601.9	3477.57	1886.48	6.317
51 ST group 1 blading exit	212.3	562.3	3416.45	1886.48	6.34
52 ST group 1 addition / extraction	-	-	-	-	-
53 ST group 2 inlet	212.3	562.3	3416.45	1886.48	6.34
54 ST group 2 blading exit	64.3	374.5	3103.85	1886.48	6.402
55 ST group 2 addition / extraction	64.3	374.5	3103.85	-132.43	6.402
56 ST group 3 inlet	58.8	602.2	3662.10	1770.75	7.182
57 ST group 3 blading exit	42.67	549.8	3555.30	1770.75	7.2
58 ST group 3 addition / extraction	42.67	549.8	3555.30	-123.16	7.2
59 ST group 4 inlet	42.67	549.8	3555.30	1647.59	7.2
60 ST group 4 blading exit	22.9	454.3	3363.31	1647.59	7.232
61 ST group 4 addition / extraction	22.9	454.3	3363.31	-65.78	7.232
62 ST group 5 inlet	22.9	454.3	3363.31	1581.81	7.232
63 ST group 5 blading exit	13.04	375.4	3206.92	1581.81	7.259
64 ST group 5 addition / extraction	13.04	375.4	3206.92	-76.74	7.259
65 ST group 6 inlet	13.04	375.4	3206.92	1505.07	7.259
66 ST group 6 blading exit	7	296.5	3052.14	1505.07	7.286
67 ST group 6 addition / extraction	7	296.5	3052.14	-220.68	7.286
68 ST group 7 inlet	7	296.7	3052.60	1293.18	7.287
69 ST group 7 blading exit	3.309	212.4	2889.47	1293.18	7.317
70 ST group 7 addition / extraction	3.309	212.4	2889.47	-70.11	7.317
71 ST group 8 inlet	3.309	212.4	2889.47	1223.07	7.317
72 ST group 8 blading exit	1.38	127.6	2727.87	1223.07	7.349
73 ST group 8 addition / extraction	1.38	127.6	2727.87	-66.09	7.349
74 ST group 9 inlet	1.38	127.6	2727.87	1156.98	7.349
75 ST group 9 blading exit	0.4907	80.9	2568.49	1156.98	7.384
76 ST group 9 addition / extraction	0.4907	80.9	2568.49	-59.99	7.384
77 ST group 10 inlet	0.4907	80.9	2568.49	1096.99	7.384
78 ST group 10 blading exit	0.1181	49.1	2381.26	1096.99	7.443
79 ST group 10 addition / extraction	0.1181	49.1	2397.86	1096.99	7.495
80 ST group 11 inlet	-	-	-	-	-

STEAM PRO Streams	**P**	**T**	**h**	**M**	**s**
	bar	**C**	**kJ/kg**	**t/h**	**kJ/kg-C**
81 ST group 11 blading exit	-	-	-	-	-
82 ST group 11 addition / extraction	-	-	-	-	-
83 ST group 12 inlet	-	-	-	-	-
84 ST group 12 blading exit	-	-	-	-	-
85 ST group 12 addition / extraction	-	-	-	-	-
86 ST group 13 inlet	-	-	-	-	-
87 ST group 13 addition / extraction	-	-	-	-	-
88 ST group 13 blading exit	-	-	-	-	-
89 ST group 14 inlet	-	-	-	-	-
90 ST group 14 blading exit	-	-	-	-	-
91 ST group 14 addition / extraction	-	-	-	-	-
92 ST group 15 inlet	-	-	-	-	-
93 ST group 15 blading exit	-	-	-	-	-
94 ST group 15 addition / extraction	-	-	-	-	-
95 ST group 16 inlet	-	-	-	-	-
96 ST group 16 addition / extraction	-	-	-	-	-
97 ST group 16 blading exit	-	-	-	-	-
98 ST group 17 inlet	-	-	-	-	-
99 ST group 17 blading exit	-	-	-	-	-
100 ST group 17 addition / extraction	-	-	-	-	-
101 ST group 18 inlet	-	-	-	-	-
102 ST group 18 blading exit	-	-	-	-	-
103 ST group 18 addition / extraction	-	-	-	-	-
104 ST group 19 inlet	-	-	-	-	-
105 ST group 19 blading exit	-	-	-	-	-
106 ST group 19 addition / extraction	-	-	-	-	-
107 FW into condensate pump	0.4064	47.2	197.63	1245.47	-
108 FW after condensate pump	21.15	47.5	200.60	1245.47	-
109 FW after recovery HXs before 1st FWH	21.15	47.8	202.01	1245.47	-
110 FW before booster pump	14.9	190.4	809.24	1918.37	-
111 FW after booster pump	22.38	190.5	810.26	1918.37	-
112 FW into boiler feed pump	22.38	190.5	810.26	1918.37	-
113 FW after boiler feed pump	308.7	197.4	854.14	1918.37	-
114 FWH1 heating steam	0.4673	79.7	2566.17	59.99	-
115 FWH1 feedwater inlet	21.15	47.8	202.01	1245.47	-
116 FWH1 feedwater exit	19.34	76.9	323.38	1245.47	-
117 FWH1 drain	0.4673	79.7	333.52	274.79	-
118 FWH2 heating steam	1.314	126.2	2725.54	66.09	-
119 FWH2 feedwater inlet	19.34	77.4	325.65	1520.26	-
120 FWH2 feedwater exit	17.59	104.7	439.96	1520.26	-
121 FWH2 drain	1.314	82.4	345.20	209.58	-
122 FWH3 heating steam	3.151	210.9	2887.15	70.11	-
123 FWH3 feedwater inlet	17.59	104.7	439.96	1520.26	-
124 FWH3 feedwater exit	16.14	132.4	557.60	1520.26	-
125 FWH3 drain	3.151	109.7	460.02	143.49	-
126 FWH4 heating steam	6.667	294.9	3049.82	73.38	-
127 FWH4 feedwater inlet	16.14	132.4	557.60	1520.26	-
128 FWH4 feedwater exit	14.9	160.2	676.90	1520.26	-
129 FWH4 drain	6.667	137.4	578.33	73.38	-
130 FWH5 heating steam	12.66	374.0	3204.60	76.74	-
131 FWH5 feedwater inlet	12.66	160.3	676.90	1520.26	-
132 FWH5 feedwater exit	12.66	190.4	809.24	1520.26	-
133 FWH5 drain	12.66	190.4	809.24	398.11	-
134 FWH6 heating steam	22.24	452.9	3360.99	65.78	-
135 FWH6 feedwater inlet	308.7	197.4	854.14	1918.37	-
136 FWH6 feedwater exit	308	220.1	953.68	1918.37	-
137 FWH6 drain	22.24	202.4	863.27	321.37	-
138 FWH7 heating steam	41.42	302.4	2963.86	123.16	-
139 FWH7 feedwater inlet	308	220.1	953.68	1918.37	-
140 FWH7 feedwater exit	307.4	250.7	1091.94	1918.37	-
141 FWH7 drain	41.42	225.1	967.53	255.59	-
142 FWH8 heating steam	62.42	372.1	3101.52	132.43	-
143 FWH8 feedwater inlet	307.4	250.7	1091.94	1918.37	-
144 FWH8 feedwater exit	306.8	279.9	1229.16	1918.37	-
145 FWH8 drain	62.42	255.7	1113.67	132.43	-
146 FWH9 heating steam	41.42	548.2	3552.98	123.16	-
147 FWH9 feedwater inlet	306.8	279.9	1229.16	1918.37	-
148 FWH9 feedwater exit	306.7	287.7	1266.98	1918.37	-
149 FWH9 drain	41.42	302.4	2963.86	123.16	-
150 FWH10 heating steam	-	-	-	-	-
151 FWH10 feedwater inlet	-	-	-	-	-
152 FWH10 feedwater exit	-	-	-	-	-
153 FWH10 drain	-	-	-	-	-
154 FWH11 heating steam	-	-	-	-	-
155 FWH11 feedwater inlet	-	-	-	-	-
156 FWH11 feedwater exit	-	-	-	-	-
157 FWH11 drain	-	-	-	-	-
158 FWH12 heating steam	-	-	-	-	-
159 FWH12 feedwater inlet	-	-	-	-	-
160 FWH12 feedwater exit	-	-	-	-	-
161 FWH12 drain	-	-	-	-	-
162 Condenser inlet steam	0.1073	47.2	2403.81	1245.47	7.554
163 Condenser condensate exit	0.4064	47.2	197.63	1245.47	-
164 Condenser CW inlet	-	-	-	-	-

STEAM PRO Streams	P	T	h	M	s
	bar	C	kJ/kg	t/h	kJ/kg-C
165 Condenser CW exit	-	-	-	-	-
166 CW into cooling tower	-	-	-	-	-
167 CW leaving cooling tower basin	-	-	-	-	-
168 CW after circulation pump	-	-	-	-	-
169 FPT inlet before valve	6.667	294.9	3049.82	147.30	7.304
170 FPT 1st group inlet	5.333	293.3	3049.82	147.30	7.406
171 FPT extraction 1	0.1073	47.2	2453.93	147.30	7.71
172 FPT 2nd group inlet	-	-	-	-	-
173 FPT extraction 2	-	-	-	-	-
174 FPT 3rd group inlet	-	-	-	-	-
175 FPT extraction 3	-	-	-	-	-
176 FPT condenser condensate exit	-	-	-	-	-
177 FPT condenser CW inlet	-	-	-	-	-
178 FPT condenser CW exit	-	-	-	-	-
179 External steam source 1	-	-	-	-	-
180 External steam source 2	-	-	-	-	-
181 Process stream 1	-	-	-	-	-
182 Process stream 2	-	-	-	-	-
183 Process stream 3	-	-	-	-	-
184 Process stream 4	-	-	-	-	-
185 Process stream 5	-	-	-	-	-
186 Steam addition 1	-	-	-	-	-
187 Steam addition 2	-	-	-	-	-
188 Steam addition 3	-	-	-	-	-
189 Water extraction 1	-	-	-	-	-
190 Water extraction 2	-	-	-	-	-
191 Water extraction 3	-	-	-	-	-
192 Water addition 1	-	-	-	-	-
193 Water addition 2	-	-	-	-	-
194 Water addition 3	-	-	-	-	-
195 DHW return	-	-	-	-	-
196 DHTR1 heating steam	-	-	-	-	-
197 DHTR1 DHW inlet	-	-	-	-	-
198 DHTR1 DHW exit	-	-	-	-	-
199 DHTR1 drain	-	-	-	-	-
200 DHTR2 heating steam	-	-	-	-	-
201 DHTR2 DHW inlet	-	-	-	-	-
202 DHTR2 DHW exit	-	-	-	-	-
203 DHTR2 drain	-	-	-	-	-
204 SSR inlet steam	1.241	344.4	3163.56	6.40	8.267
205 GSC inlet steam	0.8274	344.0	3163.56	0.63	-
206 SAH1 heating steam	-	-	-	-	-
207 SAH1 drain	-	-	-	-	-
208 SAH2 heating steam	-	-	-	-	-
209 SAH2 drain	-	-	-	-	-
210 Fuel heater heating stream	-	-	-	-	-
211 Fuel heater drain	-	-	-	-	-
212 CO2 capture first steam after pipe	-	-	-	-	-
213 CO2 capture first condensate after pump	-	-	-	-	-
214 CO2 capture second steam after pipe	-	-	-	-	-
215 CO2 capture second condensate after pump	-	-	-	-	-
216 CO2 capture CW inlet	-	-	-	-	-
217 CO2 capture CW exit	-	-	-	-	-
218 Total desalinated water from desalination plant	-	-	-	-	-
219 Desalinated water from MSF plant	-	-	-	-	-
220 MSF plant heating steam before pipe	-	-	-	-	-
221 MSF plant heating steam after pipe	-	-	-	-	-
222 MSF plant vacuum steam	-	-	-	-	-
223 MSF plant condensate return	-	-	-	-	-
224 Seawater supply to MSF plant	-	-	-	-	-
225 Seawater discharge from MSF plant	-	-	-	-	-
226 Brine discharge from MSF plant	-	-	-	-	-
227 Desalinated water from RO plant	-	-	-	-	-
228 Seawater supply to RO plant	-	-	-	-	-
229 Brine discharge from RO plant	-	-	-	-	-

Warning Messages	
	No warning messages
Advisory Messages	
	No advisory messages
Remarks	
1.	FWH 6 exit water temperature has been cut-off at minimum pinch of 1.667 C.
	Desired = 220.6 C, Actual = 220.1 C
2.	FWH 8 exit water temperature has been cut-off at minimum pinch of 1.667 C.
	Desired = 280.9 C, Actual = 279.9 C
3.	CS2: The user-defined water-side pressure drop (0.9264 % or 2.595 bar) is much higher than the pressure
	drop determined by the HX hardware (0.0834 % or 0.2338 bar). The water-side pressure drop correction
	factor which will be used for off-design has been set to the maximum value (1.922). When converted to
	off-design, your computed pressure drop may be lower than the present value.

STEAM PRO 26.1 GHD GHD Pty Ltd						
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp						
Program revision date: February 16, 2017						
Steam source: Conventional boiler						
Steam turbine: Single reheat condensing turbine 3000+3000/3000						
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train						
Cooling system: Dry air cooled condenser						
Steam Property Formulation: IFC-67						

BOILER HEAT BALANCE

Energy in =	**1665319**	**kJ/s**				
Fuel enthalpy to boiler	**Heat from Steam/Water Air Heater**	**Sorbent Sensible**	**Energy Gain from Sulfation**	**Inlet Air Sensible**	**Inlet Air Latent**	**Other***
1620953	**0**	**0**	**0**	**17421**	**20369**	**6576**

Energy out =	**1665323**	**kJ/s**				
Water & Steam	**Bottom Ash Sensible**	**Fly Ash Sensible**	**Calcination of Sorbent**	**Exhaust Gas**	**Minor Losses**	**Unburned Carbon**
1452916	**1405**	**399**	**0**	**184140**	**21794**	**4669**

* 'Others' includes energy of fan (excluding ID fan) and fuel delivery power.

Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

Heat Balance Error (In - Out) =	-4.4	kJ/s	=	-0.0003	%

BOILER AIR/GAS ZONE SUMMARY

Zone	Name	T	Dp	Q	M	M.W.	Mole Composition [%]						Ash
		C	millibar	kJ/s	t/h		N2	O2	CO2	H2O	Ar	SO2	t/h
		25.0			2084.3	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
1	FD Fan		30.517	1732									
		27.9			2084.3	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
		25											
3	PA Fan		129.506	1293	379.2								
		37.06											
					-173.7	Pulverizer tempering air							
					-17.86	Cold end leakage							
		37.06											
3	PA Heater		4.873	7747									
		182.2			187.6	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
					-8.932	Hot end leakage							
					173.7	Pulverizer tempering air							
					-132.6	Cold end leakage							
		27.94											
3	SA Heater		6.212	137411									
		273.9			1951.7	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
					-56.85	Hot end leakage							
		248.6			2247.2	28.76	76.60	20.55	0.03	1.90	0.92	0.00	
4	Burner		12.463	1560773									
		Adiabatic flame			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	19.43
		Adiabatic flame											
5	Furnace		0.000	778790									
		1176.7			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.54
		1176.7											
7	CS2		0.129	123422									
		1036.3			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.54
		1036.3											
8	CR2		0.176	138893									
		875.1			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.54
		875.1											
10	CS1		0.247	131731									
		718.5			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.54
		718.5											
11	CR1		0.572	138893									
		548.0			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.54
		548.0											
14	ECO1		0.699	162962									
		338.4			2429.1	29.84	73.65	3.29	14.55	7.59	0.89	0.04	15.54

					56.85	Secondary air hot leakage							
					8.932	Primary air hot leakage							
		336.5											
16	**Air Heater**		9.111	-145157									
	(gas side)	**144.1**			2494.9	29.81	73.73	3.76	14.15	7.43	0.89	0.04	15.54
					132.6	Secondary air cold leakage							
					17.86	Primary air cold leakage							
		137.8											
19	**ESP**		8.101	0									
		137.8			2645.4	29.74	73.90	4.75	13.32	7.11	0.89	0.04	0.08
		137.8											
20	**ID Fan**		24.303	2402									
		140.9			2645.4	29.74	73.90	4.75	13.32	7.11	0.89	0.04	0.08
		140.9											
30	**STK**		-2.832	0									
		140.9			2645.4	29.74	73.90	4.75	13.32	7.11	0.89	0.04	0.08

Excess Air =	20	%
Adiabatic flame temperature is greater than	1093.3	C
Miscellaneous & ducts air-side pressure drop =	12.45	millibar
Miscellaneous & ducts gas-side pressure drop =	7.472	millibar

BOILER HEAT EXCHANGER SUMMARY									
Zone	Tg	Tw	DT	Afrn	DP	Mg	Qg	Vg	Tube
/path	C	C	C	m^2	millibar	t/h	kJ/s	m/s	rows
5	1176.7	427.6	749.1						
	REV				0.0	2429.1	607256	10.0	
	1176.7	343.5	833.2						
6	1176.7	532.3	644.3						
	RSH				0.0	2429.1	163245	10.0	
	1176.7	462.5	714.2						
7	1176.7	532.3	644.3						
0	CS2			362.9	0.1	2444.7	123422	10.4	14.0
	1036.3	606.0	430.3						
8	1036.3	485.2	551.0						
0	CR2			362.9	0.2	2444.7	138893	9.6	20.0
	875.1	605.4	269.7						
10	875.1	462.5	412.7						
0	CS1			353.4	0.2	2444.7	131734	10.3	16.0
	718.5	427.6	290.9						
11	718.5	485.2	233.3						
0	CR1			353.4	0.6	2444.7	138893	10.5	24.0
	548.0	372.6	175.4						
14	548.0	343.5	204.5						
0	ECO1			353.4	0.7	2444.7	162960	7.5	20.0
	338.4	287.7	50.7						
Totals					1.8		1466402		94.0

Note: g = gas + ash

BOILER HEAT TRANSFER SURFACES							
	Economizers	Evaporators	Superheaters	HP Reheaters	LP Reheaters	TOTAL	
Q	160553	598281	420401	273680	0	1452916	kJ/s
A	48090	5270	13383	19679	0	86423	m^2

BOILER WATER/STEAM SUMMARY								
Stream	P	T	h	M	s	UA	Q	A
	bar	C	kJ/kg	t/h	kJ/kg-K	kJ/s-K	kJ/s	m^2
ECO1 inlet	306.75	287.7	1267.0	1918.4	3.0652			
ECO1 exit	303.71	343.5	1568.3	1918.4	3.5772	1455.8	160552	48092
REV exit	288.54	427.6	2691.0	1918.4	5.2705		598281	5270
CS1 inlet	288.54	427.6	2691.0	1918.4	5.2705			
CS1 exit	285.95	462.5	2934.5	1918.4	5.6130	372.7	129787	7169
RSH inlet	285.95	462.5	2934.5	1918.4	5.6130			
RSH exit	282.74	532.3	3236.3	1918.4	6.0099		160810	1884.9
CS2 inlet	282.74	532.3	3236.3	1918.4	6.0099			
CS2 exit	280.14	606.0	3479.9	1918.4	6.3032	244.6	129784	4330
HP steam	280.14	606.0	3479.9	1918.4	6.3032			
Cold RH steam	63.04	372.6	3101.5	1740.2	6.4062			
CR1 inlet	63.04	372.6	3101.5	1740.2	6.4062			
CR1 exit	62.12	485.2	3384.6	1740.2	6.8173	674.2	136840	13140
CR2 inlet	62.12	485.2	3384.6	1740.2	6.8173			
CR2 exit	61.20	605.4	3667.7	1740.2	7.1705	347.5	136840	6540
Hot RH steam	61.20	605.4	3667.7	1740.2	7.1705			

FUEL - 'Hunter Valley' (Solid)		
Fuel Name: Hunter Valley		
Thermoflow library fuel		
Coal, High-volatile B bituminous		
Fuel supply temp.	25.00	C
Heating Values		
LHV	27904.8	kJ/kg
HHV	28930.0	kJ/kg
Ultimate Analysis (weight %)		
Moisture	4.80	%
Ash	9.40	%
Carbon	70.72	%
Hydrogen	4.16	%
Nitrogen	1.53	%
Chlorine	0.04	%
Sulfur	0.57	%
Oxygen	8.78	%
Total	100.00	%
Proximate Analysis (weight %)		
Moisture	4.80	%
Ash	9.40	%
Volatile Matter	31.70	%
Fixed Carbon	54.10	%
Total	100.00	%
Ash Analysis (weight %)		
SiO_2	63.90	%
Al_2O_3	22.30	%
Fe_2O_3	7.40	%
CaO	0.80	%
MgO	0.70	%
Na_2O	0.20	%
K_2O	1.60	%
TiO_2	0.80	%
P_2O_5	0.70	%
SO_3	0.50	%
Other	1.10	%
Total	100.00	%
Ash Characteristics		
Fouling	Low/Medium	
Initial deformation temperature	1280.00	C
Softening temperature	1480.00	C
Bulk density	768.89	kg/m^3
Mercury content (dry basis)	0.00	ppmw

Pseudo molecular weight	7.8810	
Mole flow	6.4298	kg-mol/s
Mass flow (ash-free)	182.4252	t/h
Mass flow	201.3523	t/h
Mass flow	4832	t/day
LHV (ash-free) @ 25 C	30800.00	kJ/kg
LHV (adjusted)* @ 25 C	30800.00	kJ/kg
Enthalpy (ash-free) ref. to 0 C	31987.67	kJ/kg
Atomic percentage		
C	51.25	%
H	40.56	%
O	7.09	%
N	0.95	%
S	0.15	%
Ar	0.00	%

* Adjusted heating values include fuel sensible enthalpy
above 77 F/25 C and are on an ash-free basis

ASME Boiler Energy Balance			
Energy In	**HHV based**	**LHV based**	
Energy input from fuel*	1618114	1560772	kW
Credit due to entering dry air	2959	2959	kW
Credit due to moisture in entering air	65.83	65.83	kW
Credit due to sensible heat in fuel	0	0	kW
Credit due to sulfation	0	0	kW
Credit due to sensible heat in sorbent	0	0	kW
Credit due to auxiliary equipment power	3551	3551	kW
Total credits	6576	6576	kW
Total energy in	1624690	1567348	kW
Energy Out			
Energy output to steam and water	1452916	1452916	kW
Loss due to sensible heat in dry gas	79443	79443	kW
Loss due to moisture in fuel	7130	570.6	kW
Loss due to moisture from burning hydrogen	55213	4419	kW
Loss due to moisture in air	1730.6	1730.6	kW
Loss due to unburned carbon	4669	4669	kW
Loss due to calcination of sorbent	0	0	kW
Loss due to radiation and unmeasured losses	23598	23598	kW
Total losses	171783	114430	kW
Total energy out	1624699	1567347	kW
ASME fuel efficiency (Output/Input)	**89.79**	**93.09**	**%**
ASME gross efficiency (Output/(Input+Credits))	**89.43**	**92.7**	**%**
*Energy input from fuel is based upon fuel heating value at 77 F/25 C			
Zero enthalpy: dry gases & liquid water at 77 F/25 C			
The entering air enthalpy is calculated based on air temperature before air heater.			
The leaving gas enthalpy is calculated based on flue gas temperature after air heater.			

Solid Fuel		
Fuel Name: Hunter Valley		
Type: Coal, High-volatile B bituminous		
Fuel supply temperature	25	C
Total LHV + Sensible heat @ 25C	27905	kJ/kg
Total fuel enthalpy referenced to 0C	28981	kJ/kg
Heating Values (at 25C)		
LHV (moisture and ash included)	27905	kJ/kg
HHV (moisture and ash included)	28930	kJ/kg
Ultimate Analysis (weight %)		
Moisture	4.8	%
Ash	9.4	%
Carbon	70.72	%
Hydrogen	4.16	%
Nitrogen	1.53	%
Chlorine	0.04	%
Sulfur	0.57	%
Oxygen	8.78	%
Total	100	%
Proximate Analysis (weight %)		
Moisture	4.8	%
Ash	9.4	%
Volatile Matter	31.7	%
Fixed Carbon	54.1	%
Total	100	%
Other Properties		
Specific Heat @ 25C, dry	1.214	kJ/kg-C
Specific Heat @ 300C, dry	1.968	kJ/kg-C
Bulk density	768.9	kg/m^3
Hardgrove Grindability Index (HGI)	50	
Mercury content (dry basis)	0	ppmw
Ash Analysis (weight %)		
SiO_2	63.9	%
Al_2O_3	22.3	%
Fe_2O_3	7.4	%
CaO	0.8	%
MgO	0.7	%
Na_2O	0.2	%
K_2O	1.6	%
TiO_2	0.8	%
P_2O_5	0.7	%
SO_3	0.5	%
Other	1.1	%
Total	100	%
Ash Characteristics		
Fouling	Low/Medium	
Ash Initial Deformation Temperature (reducing atm.)	1280	C
Ash Softening Temperature (reducing atm.)	1480	C

Pulverizer		
Design Data		
Pulverizer type	Vertical air-swept mill	
Number per boiler	7	
Number operating	6	
Capacity margin	15	%
Nameplate capacity at standard condition* (each)	38.59	tonne/hr
Full load capacity at current condition** (each)	38.59	tonne/hr
Fineness correction factor	1	
HGI correction factor	1	
Moisture correction factor	1	
Total correction factor	1	
Nameplate specific power consumption	22.05	kWh/tonne
Specific power consumption at current condition	22.05	kWh/tonne
* Nameplate condition: Fineness = 70%, Moisture = 8%, HGI = 50		
** Current condition: Fineness = 70%, Moisture = 4.8%, HGI = 50		
Heat Balance (each)		
Desired pulverizer exit temperature	70	C
Desired fuel outlet moisture	1.734	%
Air/fuel mass ratio	1.75	
Total power consumption	739.8	kW
Fuel in		
Flow	33.56	t/h
Temperature	25	C
Moisture	4.8	%
LHV	27905	kJ/kg
HHV	28930	kJ/kg
Fuel out		
Flow	32.51	t/h
Temperature	70	C
Moisture	1.734	%
LHV	28882	kJ/kg
HHV	29862	kJ/kg
Hot gas inlet		
Hot gas flow	29.77	t/h
Hot gas pressure	1.125	bar
Hot gas temperature	182.2	C
Tempering air flow	28.95	t/h
Tempering air pressure	1.125	bar
Tempering air temperature	37.06	C
Drying air flow	58.73	t/h
Drying air temperature	110.9	C
Pressure	1.125	bar
Percentage of tempering air over drying air	49.3	%
Gas outlet		
Mass flow	59.77	t/h
Pressure	1.1	bar
Temperature	70	C
Gauge pressure	99.63	millibar
Dew point	33.16	C
Relative humidity	16.28	%
Volume flow	15.14	m^3/s
Pulverizer(integral) Performance		
Total moisture evaporated	6.282	t/h
Actual percentage of fuel moisture evaporated	65	%
Total power consumption	4439	kW
Pressure drop	24.91	millibar
Energy in		
Energy provided by drying fluid	680.5	kW
Grinding heat	591.9	kW
Total	1272.4	kW
Energy consumed		
Fuel heating	593.8	kW
Moisture evaporation	678.6	kW
Total	1272.4	kW

ECO1		
Heat Balance		
Inlet Water		
Mass flow	1918.4	t/h
Pressure	306.7	bar
Temperature	287.7	C
Enthalpy	1267	kJ/kg
Exit Water		
Mass flow	1918.4	t/h
Pressure	303.7	bar
Temperature	343.5	C
Enthalpy	1568.3	kJ/kg
Gas		
Mass flow	2429.1	t/h
Flyash mass flow	15.54	t/h
Inlet temperature	548	C
Exit temperature	338.4	C
Sulfur dew point temperature	119.8	C
Dew point temperature	40.5	C
Static pressure drop	0.6981	millibar
Heat Transfer		
Heat from gas	161895	kW
Heat from ash	1065	kW
Heat transfer to water/steam	160552	kW
Heat loss	2408.3	kW
Hardware		
Tubes		
Fin-tube type	Solid fins	
Tube arrangement	In line	
Tube material	T22	
Number of tube rows (longitudinal)	20	
Number of tubes per row (transverse)	136	
Number of rows per waterside flow pass	2	
Longitudinal row pitch	101.6	mm
Gas path transverse width	18.99	m
Tube length	18.61	m
Tube outer diameter	50.8	mm
Tube wall thickness	7.62	mm
Transverse tube pitch	139.6	mm
Tube metal conductivity @ 500F (260C)	36.86	W/m-C
Tube metal conductivity slope	-0.0109	W/m-C^2
Fins		
Fin material	T22	
Fin height	19.05	mm
Fin spacing	8.959	mm
Fin thickness	1.905	mm
Number of fins per meter	92.05	per meter
Fin metal conductivity @ 500F (260C)	36.86	W/m-C
Fin metal conductivity slope	-0.0109	W/m-C^2
Overall Data		
Gas path frontal area	353.4	m^2
Min. gas free flow cross section / frontal area	0.5883	
H.T. surface area / min. free flow cross section	11.57	
Primary tube surface / total heat transfer surf.	0.1385	
Water side flow cross section area	0.2701	m^2
Heat exchanger prime outside surface	6661	m^2
Heat exchanger total fin area	41431	m^2
Heat exchanger total outside area	48092	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	4.404	m/s
Face mass flux	6.918	t/h-m^2
Velocity at minimum flow area	7.486	m/s
Mass flux at minimum flow area	11.76	t/h-m^2
Reynolds number	5381	
Prandtl number	0.7196	
Convective Nusselt number	42.99	
Convective heat transfer coefficient	40.81	W/m^2-C
Radiative heat transfer coefficient	2.299	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	43.11	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1801	
Friction factor Re coefficient	3.223	
Radiation beam mean length	0.2569	m
Pressure drop correction factor	0.9	
Pressure drop	0.6981	millibar

ECO1		
Water Side		
Mass flux	7101	t/h-m^2
Mean velocity	2.727	m/s
Reynolds number	797852	
Prandtl number	0.8345	
Nusselt number	1141.2	
Heat transfer coefficient	18021	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	1.351	
User-defined pressure drop	3.037	bar
Hardware determined pressure drop	2.248	bar
Overall Performance		
Fin effectiveness	0.7939	
Effective / total external area	0.8224	
Overall heat transfer coefficient	30.27	W/m^2-C
Tube metal mean temperature	322.9	C
Fin metal mean temperature	340.2	C
Estimated minimum tube surface temperature	293.5	C
Estimated maximum tube wall temperature	366.8	C
Maximum allowable tube wall metal temperature	732.2	C
Estimated maximum fin tip temperature	415.1	C
Recommended maximum fin metal temperature	732.2	C
Estimated maximum allowable water side pressure	392.7	bar
Heat transfer rate from gas	161895	kW
Heat from fly ash	1065	kW
Heat transfer rate to water	160552	kW
Heat loss	2408.3	kW
Overall heat transfer coefficient X total outer area, (UA)	1455.8	kW/C
Heat exchanger effectiveness	0.8052	

CS1		
Heat Balance		
Inlet Steam		
Mass flow	1918.4	t/h
Pressure	288.5	bar
Temperature	427.6	C
Enthalpy	2691	kJ/kg
Exit Steam		
Mass flow	1918.4	t/h
Pressure	285.9	bar
Temperature	462.5	C
Enthalpy	2934.5	kJ/kg
Gas		
Mass flow	2429.1	t/h
Flyash mass flow	15.54	t/h
Inlet temperature	875.1	C
Exit temperature	718.5	C
Static pressure drop	0.247	millibar
Heat Transfer		
Heat from gas	130897	kW
Heat from ash	837.1	kW
Heat transfer to water/steam	129787	kW
Heat loss	1946.8	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	T91	
Number of tube rows (longitudinal)	16	
Number of tubes per row (transverse)	120	
Number of rows per waterside flow pass	2	
Longitudinal row pitch	76.2	mm
Gas path transverse width	18.88	m
Tube length	18.72	m
Tube outer diameter	63.5	mm
Tube wall thickness	7.62	mm
Transverse tube pitch	157.3	mm
Tube metal conductivity @ 500F (260C)	27	W/m-C
Tube metal conductivity slope	0.0053	W/m-C^2
Overall Data		
Gas path frontal area	353.4	m^2
Min. gas free flow cross section / frontal area	0.5964	
H.T. surface area / min. free flow cross section	2.126	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	0.439	m^2
Heat exchanger prime outside surface	7169	m^2
Heat exchanger total outside area	7169	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	6.154	m/s
Face mass flux	6.918	t/h-m^2
Velocity at minimum flow area	10.32	m/s
Mass flux at minimum flow area	11.6	t/h-m^2
Reynolds number	5330	
Prandtl number	0.7172	
Convective Nusselt number	41.93	
Convective heat transfer coefficient	42.27	W/m^2-C
Radiative heat transfer coefficient	14.58	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	56.85	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1769	
Friction factor Re coefficient	0.1002	
Radiation beam mean length	0.1497	m
Pressure drop correction factor	0.9	
Pressure drop	0.247	millibar
Water Side		
Mass flux	4370	t/h-m^2
Mean velocity	8.548	m/s
Reynolds number	1941470	
Prandtl number	1.556	
Nusselt number	2854.8	
Heat transfer coefficient	7547	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	1.922	
User-defined pressure drop	2.595	bar
Hardware determined pressure drop	2.467	bar

CS1		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	51.99	W/m^2-C
Tube metal mean temperature	452	C
Estimated minimum tube surface temperature	439.1	C
Estimated maximum tube wall temperature	478.8	C
Maximum allowable tube wall metal temperature	732.2	C
Estimated maximum allowable water side pressure	340.4	bar
Heat transfer rate from gas	130897	kW
Heat from fly ash	837.1	kW
Heat transfer rate to water	129787	kW
Heat loss	1946.8	kW
Overall heat transfer coefficient X total outer area, (UA)	372.7	kW/C
Heat exchanger effectiveness	0.35	

CS2		
Heat Balance		
Inlet Steam		
Mass flow	1918.4	t/h
Pressure	282.7	bar
Temperature	532.3	C
Enthalpy	3236	kJ/kg
Exit Steam		
Mass flow	1918.4	t/h
Pressure	280.1	bar
Temperature	606	C
Enthalpy	3480	kJ/kg
Gas		
Mass flow	2429.1	t/h
Flyash mass flow	15.54	t/h
Inlet temperature	1176.7	C
Exit temperature	1036.3	C
Static pressure drop	0.1285	millibar
Heat Transfer		
Heat from gas	122712	kW
Radiant heat influx	8309	kW
Heat from ash	710.6	kW
Heat transfer to water/steam	129784	kW
Heat loss	1946.8	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	TP347 HFG	
Number of tube rows (longitudinal)	14	
Number of tubes per row (transverse)	82	
Number of rows per waterside flow pass	7	
Longitudinal row pitch	76.2	mm
Gas path transverse width	19.2	m
Tube length	18.9	m
Tube outer diameter	63.5	mm
Tube wall thickness	8.342	mm
Transverse tube pitch	234.1	mm
Tube metal conductivity @ 500F (260C)	18.34	W/m-C
Tube metal conductivity slope	0.015	W/m-C^2
Overall Data		
Gas path frontal area	362.9	m^2
Min. gas free flow cross section / frontal area	0.7287	
H.T. surface area / min. free flow cross section	1.169	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	0.9881	m^2
Heat exchanger prime outside surface	4330	m^2
Heat exchanger total outside area	4330	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	7.564	m/s
Face mass flux	6.737	t/h-m^2
Velocity at minimum flow area	10.38	m/s
Mass flux at minimum flow area	9.244	t/h-m^2
Reynolds number	3664	
Prandtl number	0.716	
Convective Nusselt number	28.9	
Convective heat transfer coefficient	35.29	W/m^2-C
Radiative heat transfer coefficient	28.91	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	64.2	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1557	
Friction factor Re coefficient	0.0688	
Radiation beam mean length	0.2481	m
Pressure drop correction factor	0.9	
Pressure drop	0.1285	millibar
Water Side		
Mass flux	1941.5	t/h-m^2
Mean velocity	6.219	m/s
Reynolds number	747985	
Prandtl number	1.043	
Nusselt number	1166.3	
Heat transfer coefficient	2616.8	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	1.922	
User-defined pressure drop	2.595	bar
Hardware determined pressure drop	0.2338	bar

CS2		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	56.5	W/m^2-C
Tube metal mean temperature	588	C
Estimated minimum tube surface temperature	577.6	C
Estimated maximum tube wall temperature	636.2	C
Maximum allowable tube wall metal temperature	1093.3	C
Estimated maximum allowable water side pressure	296.9	bar
Heat transfer rate from gas	122712	kW
Radiant heat influx	8309	kW
Heat from fly ash	710.6	kW
Heat transfer rate to water	129784	kW
Heat loss	1946.8	kW
Overall heat transfer coefficient X total outer area, (UA)	244.6	kW/C
Heat exchanger effectiveness	0.2179	

CR1		
Heat Balance		
Inlet Steam		
Mass flow	1740.2	t/h
Pressure	63.04	bar
Temperature	372.6	C
Enthalpy	3102	kJ/kg
Exit Steam		
Mass flow	1740.2	t/h
Pressure	62.12	bar
Temperature	485.2	C
Enthalpy	3385	kJ/kg
Gas		
Mass flow	2429.1	t/h
Flyash mass flow	15.54	t/h
Inlet temperature	718.5	C
Exit temperature	548	C
Static pressure drop	0.5717	millibar
Heat Transfer		
Heat from gas	137975	kW
Heat from ash	917.3	kW
Heat transfer to water/steam	136840	kW
Heat loss	2052.6	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	T91	
Number of tube rows (longitudinal)	24	
Number of tubes per row (transverse)	148	
Number of rows per waterside flow pass	4	
Longitudinal row pitch	76.2	mm
Gas path transverse width	19.06	m
Tube length	18.54	m
Tube outer diameter	63.5	mm
Tube wall thickness	2.794	mm
Transverse tube pitch	128.8	mm
Tube metal conductivity @ 500F (260C)	27	W/m-C
Tube metal conductivity slope	0.0053	W/m-C^2
Overall Data		
Gas path frontal area	353.4	m^2
Min. gas free flow cross section / frontal area	0.5069	
H.T. surface area / min. free flow cross section	3.057	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	1.559	m^2
Heat exchanger prime outside surface	13140	m^2
Heat exchanger total outside area	13140	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	5.316	m/s
Face mass flux	6.918	t/h-m^2
Velocity at minimum flow area	10.49	m/s
Mass flux at minimum flow area	13.65	t/h-m^2
Reynolds number	6747	
Prandtl number	0.7177	
Convective Nusselt number	51.92	
Convective heat transfer coefficient	47.61	W/m^2-C
Radiative heat transfer coefficient	9.889	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	57.5	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1879	
Friction factor Re coefficient	0.1365	
Radiation beam mean length	0.1128	m
Pressure drop correction factor	0.9	
Pressure drop	0.5717	millibar
Water Side		
Mass flux	1116	t/h-m^2
Mean velocity	14.85	m/s
Reynolds number	699696	
Prandtl number	0.992	
Nusselt number	1087.7	
Heat transfer coefficient	1201	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	0.8695	
User-defined pressure drop	0.918	bar
Hardware determined pressure drop	0.8279	bar

CR1		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	51.31	W/m^2-C
Tube metal mean temperature	435.3	C
Estimated minimum tube surface temperature	383.5	C
Estimated maximum tube wall temperature	499.8	C
Maximum allowable tube wall metal temperature	732.2	C
Estimated maximum allowable water side pressure	105.1	bar
Heat transfer rate from gas	137975	kW
Heat from fly ash	917.3	kW
Heat transfer rate to water	136840	kW
Heat loss	2052.6	kW
Overall heat transfer coefficient X total outer area, (UA)	674.2	kW/C
Heat exchanger effectiveness	0.4929	

CR2		
Heat Balance		
Inlet Steam		
Mass flow	1740.2	t/h
Pressure	62.12	bar
Temperature	485.2	C
Enthalpy	3385	kJ/kg
Exit Steam		
Mass flow	1740.2	t/h
Pressure	61.2	bar
Temperature	605.4	C
Enthalpy	3668	kJ/kg
Gas		
Mass flow	2429.1	t/h
Flyash mass flow	15.54	t/h
Inlet temperature	1036.3	C
Exit temperature	875.1	C
Static pressure drop	0.1755	millibar
Heat Transfer		
Heat from gas	138079	kW
Heat from ash	814.1	kW
Heat transfer to water/steam	136840	kW
Heat loss	2052.6	kW
Hardware		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	TP347 HFG	
Number of tube rows (longitudinal)	20	
Number of tubes per row (transverse)	86	
Number of rows per waterside flow pass	5	
Longitudinal row pitch	76.2	mm
Gas path transverse width	19.04	m
Tube length	19.06	m
Tube outer diameter	63.5	mm
Tube wall thickness	2.794	mm
Transverse tube pitch	221.4	mm
Tube metal conductivity @ 500F (260C)	18.34	W/m-C
Tube metal conductivity slope	0.015	W/m-C^2
Overall Data		
Gas path frontal area	362.9	m^2
Min. gas free flow cross section / frontal area	0.7132	
H.T. surface area / min. free flow cross section	1.264	
Primary tube surface / total heat transfer surf.	1	
Water side flow cross section area	1.133	m^2
Heat exchanger prime outside surface	6540	m^2
Heat exchanger total outside area	6540	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	6.832	m/s
Face mass flux	6.737	t/h-m^2
Velocity at minimum flow area	9.58	m/s
Mass flux at minimum flow area	9.446	t/h-m^2
Reynolds number	3957	
Prandtl number	0.7165	
Convective Nusselt number	30.95	
Convective heat transfer coefficient	35.18	W/m^2-C
Radiative heat transfer coefficient	23.91	W/m^2-C
Convective h.t.c. adjustment factor	1	
Total gas side adjusted heat transfer coefficient	59.1	W/m^2-C
Fouling resistance	0.0008806	m^2-C/W
Nusselt number Re coefficient	0.1585	
Friction factor Re coefficient	0.0715	
Radiation beam mean length	0.2319	m
Pressure drop correction factor	0.9	
Pressure drop	0.1755	millibar
Water Side		
Mass flux	1536.4	t/h-m^2
Mean velocity	25.11	m/s
Reynolds number	807330	
Prandtl number	0.9309	
Nusselt number	1194.3	
Heat transfer coefficient	1588.8	W/m^2-C
Fouling resistance	1.7612E-04	m^2-C/W
Pressure drop correction factor	0.8695	
User-defined pressure drop	0.918	bar
Hardware determined pressure drop	1.284	bar

CR2		
Overall Performance		
Effective / total external area	1	
Overall heat transfer coefficient	53.14	W/m^2-C
Tube metal mean temperature	556.4	C
Estimated minimum tube surface temperature	515	C
Estimated maximum tube wall temperature	620	C
Maximum allowable tube wall metal temperature	1093.3	C
Estimated maximum allowable water side pressure	93.08	bar
Heat transfer rate from gas	138079	kW
Heat from fly ash	814.1	kW
Heat transfer rate to water	136840	kW
Heat loss	2052.6	kW
Overall heat transfer coefficient X total outer area, (UA)	347.5	kW/C
Heat exchanger effectiveness	0.2925	

Furnace		
Design Heat Balance: Once through - Coal fired		
Furnace gage pressure	-0.6226	millibar
Excess air	20	%
Secondary Air		
Temperature	273.9	C
Mass flow	1894.8	t/h
Primary Air into Pulverizer		
Temperature	182.2	C
Mass flow	178.6	t/h
Tempering Air into Pulverizer		
Temperature	37.06	C
Mass flow	173.7	t/h
Pulverizer inlet Dry Air		
Temperature	110.9	C
Mass flow	352.4	t/h
Pulverizer outlet Gas		
Temperature	70	C
Mass flow	358.6	t/h
Gage pressure	124.5	millibar
Flue Gas		
Temperature	1176.7	C
Mass flow	2429.1	t/h
Ash mass flow	15.54	t/h
Mole percent N2	73.65	%
Mole percent O2	3.287	%
Mole percent CO2	14.55	%
Mole percent H2O	7.587	%
Mole percent SO2	0.044	%
Mole percent Ar	0.8853	%
SO3 in flue gas	2.2	ppm
Emission		
Reference O2 content	6	%
Actual O2 content in exit gas	3.287	%
H2O content in exit gas	7.587	%
Hg from combustion	0	kg/hr
Hg in exit gas	0	kg/hr
HCl in exit gas	66.26	kg/hr
NOx production	0	kg/hr
NOx volume concentration in exit gas	0	ppmv
NOx mass concentration in exit gas	0	ppm
Exit Steam		
Steam produced by waterwall	1918.4	t/h
Pressure	288.5	bar
Temperature	427.6	C
Enthalpy	2691	kJ/kg
Inlet Water		
Mass flow	1918.4	t/h
Pressure	303.7	bar
Temperature	343.5	C
Enthalpy	1568.3	kJ/kg
Radiant Superheater Exit Steam		
Mass flow	1918.4	t/h
Pressure	282.7	bar
Temperature	532.3	C
Enthalpy	3236	kJ/kg
Radiant Superheater Inlet Steam		
Pressure	285.9	bar
Temperature	462.5	C
Enthalpy	2934.5	kJ/kg
Inlet Fuel : Solid		
Fuel mass flow	201.4	t/h
LHV @ 77 F (25 C)	27905	kJ/kg
HHV @ 77 F (25 C)	28930	kJ/kg
Fuel input (LHV)	1560.8	MW
Fuel input (HHV)	1618.1	MW
Weight percent ash	9.4	%
Fuel ash flow	18.93	t/h
Fuel inlet temperature	25	C
Exit Ash		
Bottom ash flow	3.885	t/h
Unburnt carbon flow in bottom ash	0.0997	t/h

Furnace		
Unburnt carbon in bottom ash	2.566	%
Fly ash flow	15.54	t/h
Unburnt carbon flow in fly ash	0.3987	t/h
Unburnt carbon in fly ash	2.566	%
Total unburnt carbon flow in ash	0.4984	t/h
Combustion efficiency	99.7	%
Heat Transfer		
Heat transfer to waterwall	598281	kW
Heat transfer to radiant superheater	160810	kW
Unburnt carbon in ash	4669	kW
Heat losses	11385	kW
Radiant flux past screen	8309	kW
Bottom ash (bed drain) sensible heat	1404.6	kW
Fly ash sensible heat	5618	kW
Performance		
Fuel delivery power	4439	kW
Ash handling power	856.5	kW
Heat Transfer		
Furnace Ratings		
Heat absorption rate	107.2	kW/m^2
Heat release rate	235.5	kW/m^2
Volumetric heat release rate	74.07	kW/m^3
Heat Transfer and Heat Balance		
Energy In		
Fuel input	1560768	kW
Fuel delivery energy included in heat balance calculation	3551	kW
Air input	143562	kW
Total Energy In	1707881	kW
Energy Out		
Flue gas	917381	kW
Heat transfer to waterwall	598281	kW
Heat transfer to radiant superheater	160810	kW
Heat losses	11385	kW
Radiant flux past screen	8309	kW
Unburnt carbon in ash	4669	kW
Bottom ash (bed drain) sensible heat	1404.6	kW
Fly ash sensible heat	5618	kW
Total Energy Out	1707858	kW
Heat Balance Error	**0.0013**	**%**
Heat Transfer Characteristics		
Gas emissivity	0.8438	
Gas absorptivity	0.8638	
Radiating mean beam length	14.72	m
Adiabatic temperature	2029.4	C
Effective radiating temperature	1607.1	C
Waterwall surface temperature	1163.3	C
Furnace exit temperature	1176.7	C
Gas mass flux @ aperture	6.737	t/h-m^2
Gas velocity leaving aperture @ furnace exit temperature	7.564	m/s
Furnace velocity @ Effective radiating temperature	10.01	m/s
Radiant flux to waterwall effective projected heat transfer surface	112.8	kW/m^2
Mean flux to waterwall effective projected heat transfer surface	113.5	kW/m^2

Rotary Air Heater		
Heat Balance		
Number per station	3	
Number operating	3	
Primary Air Path (station)		
Primary air flow	178.6	t/h
Primary air temperature	182.2	C
Inlet air flow	205.4	t/h
Inlet pressure	1.13	bar
Inlet temperature	37.06	C
Cold side leakage	17.86	t/h
Hot side leakage	8.932	t/h
Pressure drop	4.869	millibar
Channel velocity	6.761	m/s
Reynolds number	3147	
Stanton number	0.005	
Heat transfer coefficient	49.73	W/m^2-C
Secondary Air Path (station)		
Secondary air flow	1894.8	t/h
Secondary air temperature	273.9	C
Inlet pressure	1.018	bar
Inlet temperature	27.94	C
Cold side leakage to flue gas	132.6	t/h
Hot side leakage to flue gas	56.85	t/h
Pressure drop	6.207	millibar
Channel velocity	8.317	m/s
Reynolds number	2914.5	
Stanton number	0.0051	
Heat transfer coefficient	50.78	W/m^2-C
Flue Gas Path (station)		
Flue gas flow	2429.1	t/h
Fly ash flow	15.54	t/h
Flue gas temperature	338.4	C
After mixing with hot side leakages	336.5	C
Exit temperature (uncorrected)	144.1	C
Exit temperature with leakage (corrected)	137.8	C
Exit flow	2645.4	t/h
Pressure @ heater inlet	0.9976	bar
Pressure drop	9.101	millibar
Channel velocity	11.58	m/s
Reynolds number	3137	
Stanton number	0.0051	
Heat transfer coefficient	60.73	W/m^2-C
Performance (station)		
Flue gas heat transfer to air paths	144282	kW
Fly ash heat transfer to air paths	875.2	kW
Secondary air heat transfer	137411	kW
Primary air heat transfer	7747	kW
Average cold end temperature (ACET)	86.04	C
Cold end minimum metal temperature	68.33	C
Flue gas exit water dew point temperature	39.09	C
Flue gas exit SO3	2.014	ppm
Flue gas exit sulfur dew point temperature	118.1	C
Flue gas sulfur dew point temperature within air heater	119.1	C
Heat transfer effectiveness	77.07	%
Modified number of transfer units (NTU0)	2.602	

Heat Balance Results			
Stack			
Inlet			
Pressure	0.9972	bar	
Temperature	140.9	C	
Mass flow	2645.4	t/h	
Exit to air			
Pressure	0.9823	bar	
Temperature	140.9	C	
Water dew point temperature	39.25	C	
Sulfur dew point temperature	138	C	
Mass flow	2645.4	t/h	
Mercury (Hg)	0	kg/hr	
Exit Velocity	18.29	m/s	
Miscellaneous			
Heat loss	0	kW	
Buoyancy (DPc-DPh)	5.487	millibar	
-- Pressure by cold air column outside stack (DPc)	17.67	millibar	
-- Pressure by hot air column inside stack (DPh)	12.18	millibar	
Pressure drop (inlet to ambient)	-2.83	millibar	
-- Entrance loss	0.8655	millibar	
-- Leaving loss	1.443	millibar	
-- Friction loss	0.3488	millibar	
-- Buoyancy gain	5.487	millibar	
Emissions	**ng/J25C HHV @**	**mg/Nm^3 @ 6% O2, dry**	**ppmv @ 6% O2, dry**
Dust load	13.34	39.6	
Sulfur Dioxide (SO2)	393.9	1169.2	409.1
Nitrogen Oxides (NOx)	0	0	0
Mercury (Hg)	0	0	0
Plume invisible			
Plume visibility index	0		

STEAM PRO 26.1 GHD GHD Pty Ltd	
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp	
Program revision date: February 16, 2017	
Steam source: Conventional boiler	
Steam turbine: Single reheat condensing turbine 3000+3000/3000	
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train	
Cooling system: Dry air cooled condenser	
Steam Property Formulation: IFC-67	

STEAM CYCLE HEAT BALANCE

Energy in =	**1478941**	**kJ/s**				
Boiler Heat Addition	**External Steam**	**External Water**	**Makeup**	**Process Return**	**Pump Aux. Load**	**Blowdown Recovery**
1452916	**0**	**0**	**0**	**0**	**26025**	**0**

Energy out =		**1478941**	**kJ/s**								
ST/Gen	**BFPT**	**Mech/Elec/**	**Main**	**BFPT**	**Process**		**Pipe**	**CO2**	**Desal**	**Others***
Output	**Output**	**Gear Losses**	**Condenser**		**Steam**	**Water**	**Losses**	**Capture**		
678764	**24382**	**7629**	**763269**	**0**	**0**	**0**	**4015**	**0**	**0**	**883**

* 'Others' includes pump losses, heat to air heater, fuel heater, district heating system,
misc heat to/from condensate, discharged seal steam and blowdown.

Zero enthalpy: dry gases & liquid water @ 32 F (273.15 K)

Heat Balance Error (In - Out) =	0.0	kJ/s	=	0.0000	%

STEAM TURBINE FLOWS

	P	T	h	M	s	Super-	Quality	Exp Pwr	Eff	# of
	bar	C	kJ/kg	t/h	kJ/kg-K	heat, C		kW	%	Stages
HP steam	280.140	606.0	3479.9	1918.371						
HP pipe inlet	280.140	606.0	3479.9	1918.371						
HP pipe outlet	276.000	604.0	3477.6	1918.371						
ST inlet	276.000	604.0	3477.6	1918.371	6.3065	211.2				
After HPT stop valve	269.100	601.9	3477.6							
-Valve Stem leak 1			3477.6	-4.186						
-Valve Stem leak 2			3477.6	-1.380						
-HPT HP leak 1			3477.6	-26.321						
HPT Casing: Group 1										
GROUP IN	269.100	601.9	3477.6	1886.483	6.3166	211.2			68.51*	1
GROUP OUT	212.308	562.3	3416.5	1886.483	6.3403	191.6		32027	75.61**	
HPT Casing: Group 2										
GROUP IN	212.308	562.3	3416.5	1886.483	6.3403	191.6			88.82*	9
GROUP OUT	64.297	374.5	3103.8	1886.483	6.4017	94.4		163816	88.82**	
Port (1) extraction	64.297	374.5	3103.8	-132.426	6.4017	94.4				
-HPT LP leak 1			3103.8	-11.376						
-HPT LP leak 2			3103.8	-2.436						
Cold RH pipe inlet	64.297	374.5	3103.8	1740.245	6.4017	94.4				
Cold RH pipe outlet	63.036	372.6	3101.5	1740.245						
RH steam	61.200	605.4	3667.7	1740.245						
Hot RH pipe inlet	61.200	605.4	3667.7	1740.245						
Hot RH pipe outlet	60.000	604.0	3665.3	1740.245						
IPT inlet	60.000	604.0	3665.3	1740.245	7.1767	328.4				
+Valve Stem leak 1			3477.6	4.186						
+HPT HP leak 1			3477.6	26.321						
IP bowl	58.800	602.2	3662.1	1770.753	7.1820	328.0				
IPT1 Casing: Group 3										
GROUP IN	58.800	602.2	3662.1	1770.753	7.1820	328.0			82.62*	3
GROUP OUT	42.666	549.8	3555.3	1770.753	7.2002	295.6		52535	87.62**	
Port (3) extraction	42.666	549.8	3555.3	-123.163	7.2002	295.6				
IPT1 Casing: Group 4										
GROUP IN	42.666	549.8	3555.3	1647.590	7.2002	295.6			89.23*	4
GROUP OUT	22.902	454.3	3363.3	1647.590	7.2322	235.0		87868	89.23**	
Port (4) extraction	22.902	454.3	3363.3	-65.782	7.2322	235.0				

IPT1 Casing: Group 5										
GROUP IN	22.902	454.3	3363.3	1581.808	7.2322	235.0			90.07*	3
GROUP OUT	13.040	375.4	3206.9	1581.808	7.2589	183.7		68717	90.07**	
Port (5) extraction	13.040	375.4	3206.9	-76.741	7.2589	183.7				
IPT1 Casing: Group 6										
GROUP IN	13.040	375.4	3206.9	1505.068	7.2589	183.7			90.93*	3
GROUP OUT	7.000	296.5	3052.1	1505.068	7.2862	131.5		64710	90.93**	
Port (6) extraction	7.000	296.5	3052.1	-220.682	7.2862	131.5				
-IPT LP leak			3052.1	-2.585						
+HPT LP leak 1			3103.8	11.376						
LPT crossover	7.000	296.7	3052.6	1293.177	7.2870	131.7				
LPT1 Casing: Group 7										
GROUP IN	7.000	296.7	3052.6	1293.177	7.2870	131.7			91.7*	2
GROUP OUT	3.309	212.4	2889.5	1293.177	7.3174	75.5		58599	91.7**	
Port (7) extraction	3.309	212.4	2889.5	-70.109	7.3174	75.5				
LPT1 Casing: Group 8										
GROUP IN	3.309	212.4	2889.5	1223.068	7.3174	75.5			92.74*	2
GROUP OUT	1.380	127.6	2727.9	1223.068	7.3492	18.7		54904	92.74**	
Port (8) extraction	1.380	127.6	2727.9	-66.088	7.3492	18.7				
LPT1 Casing: Group 9										
GROUP IN	1.380	127.6	2727.9	1156.980	7.3492	18.7			92.74*	2
GROUP OUT	0.491	80.9	2568.5	1156.980	7.3844		0.967	51221	92.74**	
Port (9) extraction	0.491	80.9	2568.5	-59.989	7.3844		0.967			
LPT1 Casing: Group 10										
GROUP IN	0.491	80.9	2568.5	1096.991	7.3844		0.967		82.75*	2
GROUP OUT	0.118	49.1	2381.3	1096.991	7.4433		0.912		90.79**	
After LL	0.118	49.1	2397.9	1096.991	7.4948		0.919	51996		
To condenser	0.118	49.1	2397.9	1096.991	7.4948		0.919			

*There are 2 symmetric IPT paths, each same as IPT1

*The LPT mass flow rates are multiplied by 2

* : Group overall efficiency (including control valve and/or leaving losses)

**: Group blading efficiency (excluding control valve and/or leaving losses)

STEAM TURBINE DESIGN

Group	Adj Nozzle Area, m^2	No. of Steps	Dry Step Eff., %	Group Blading Eff., %	Group Overall Eff., %
1	0.028	1	75.61	75.61	68.51
2	0.022	9	87.38	88.82	88.82
3	0.114	3	86.79	87.62	82.62
4	0.116	4	88.58	89.23	89.23
5	0.200	3	89.65	90.07	90.07
6	0.308	3	90.53	90.93	90.93
7	0.443	2	91.33	91.70	91.70
8	0.795	2	92.37	92.74	92.74
9	1.593	2	92.71	92.74	92.74
10	3.789	2	95.00	90.79	82.75

No. of parallel paths at LPT	1 x 2	
Last stage rotor exit angle	63.47	degree
Last stage blade length	947.33	mm
Last stage pitch diameter	2734.07	mm
Exhaust annulus area / end	8.14	m^2

DRY EXHAUST LOSS

Annulus Vel m/s	Exh Loss kJ/kg	Annulus Vel m/s	Exh Loss kJ/kg	Annulus Vel m/s	Exh Loss kJ/kg
39	169.61	122	45.40	244	31.18
46	164.81	137	34.72	274	46.16
53	158.69	152	27.32	305	64.02
61	144.63	168	22.64	335	81.80
76	108.02	183	20.31	366	98.44
91	80.59	198	20.13	396	115.70
107	60.27	213	21.97	427	134.67

EXHAUST END VELOCITIES AND LOSSES

	LPT1	
Annulus velocity	214.4	m/s
Dry exhaust loss	22.18	kJ/kg
Corrected exhaust loss	16.60	kJ/kg

STEAM TURBINE CASING POWER	
Casing	Expansion Power (kW)
HPT	195843
IPT1	273830
LPT1 x 2	216720

H2 COOLED GENERATOR 50 Hz		
Turbine Shaft Speed	3000 RPM	
Expansion power	686393	kW
ST mechanical loss	1716	kW
ST shaft power	684677	kW
Generator efficiency	99.14	%
Generator electrical & mechanical loss	5913.3	kW
- Generator electrical & windage loss	5161.8	kW
- Generator mechanical loss	751.5	kW
Generator power	678763.8	kW

STEAM TURBINE LEAKAGES						
Group	Leakage	Destination	Leakage Flow	C Factor	h	M
No.			Model	m^2	kJ/kg	t/h
1	Valve Stem leak 1	IPT inlet	Automatic	8.1	3477.6	4.186
2	Valve Stem leak 2	SSR	Automatic	9.3	3477.6	1.380
4	HPT HP leak 1	IPT inlet	Automatic	49.9	3477.6	26.321
7	HPT LP leak 1	LPT cROssover	Automatic	75.5	3103.8	11.376
8	HPT LP leak 2	SSR	Automatic	123.1	3103.8	2.436
16	IPT LP leak	SSR	Automatic	63.9	3052.1	2.585

SEALING STEAM REGULATOR & GLAND SEAL CONDENSER (IF ANY)				
Stream	P	T	h	M
	bar	C	kJ/kg	t/h
Valve Stem leak 2			3477.6	1.38
HPT LP leak 2			3103.8	2.436
IPT LP leak			3052.1	2.585
Steam at SSR inlet	1.241	344.4	3163.6	6.401
LPT SS to condenser			3163.6	0.5443
LPT SS packing exhaust to GSC			3163.6	0.6349
SS to FWH1 from SSR			3163.6	5.222
Steam at GSC inlet	0.8274	344.0	3163.6	0.6349
GSC drain to Condendser			395.5	0.6349

CONDENSER: Dry air cooled condenser				
	P	T	h	M
	bar	C	kJ/kg	t/h
LPT exhaust	0.1181	49.12	2397.9	1097
LPT SS to condenser			3163.6	0.5443
FPT exhaust	0.1073	47.22	2453.9	147.3
Drain from GSC	0.827	94.47	395.5	0.6349
Condenser in	0.1073	47.22	2403.8	1245.5
Condensate	0.4064	47.22	197.6	1245.5
Cooling air in		25.00		173425
Cooling air out		40.56		173425
Main condenser heat rejection =	763268	kJ/s		

CONDENSATE, MAKEUP WATER & FEEDWATER				
	P	T	h	M
	bar	C	kJ/kg	t/h
Condenser condensate	0.4064	47.22	197.6	1245.5
Condensate pump suction	0.4064	47.22	197.6	1245.5
Condensate pump exit	21.15	47.50	200.6	1245.5
To SJAE, GSC & recovery heat exchangers	21.15	47.50	200.6	1245.5
-Enthalpy change due to GSC			1.41	
Feedwater to 1st feedwater heater	21.15	47.84	202.0	1245.5

BOILER FEED PUMP TURBINE (Condensing)					
The plant has 1 boiler feed pump turbine in operation					
Stream	(Port)	P	T	h	M
		bar	C	kJ/kg	t/h
Turbine inlet from LPT cross	(6)	6.667	294.9	3049.8	147.3
1st group inlet		5.333	293.3	3049.8	147.3
Exhaust to main condenser		0.1073	47.2	2453.9	147.3

Boiler feed pump shaft power =	24137.9	kW
Feed pump turbine power =	24381.8	kW
Feed pump turbine efficiency =	82.08	%
Group 1 adjusted nozzle area =	0.058	m^2
Number of steps in Group 1 =	6	

HP casing - Group 1		
Number of governing stage rows	1	
Governing stage pitch diameter	1.165	m
Number of paths	1	
Number of stages	1	
Dry step efficiency	75.61	%
Group efficiency	68.51	%
Group inlet mass flow	1886.5	t/h
Shaft speed	3000	RPM
Before Valve		
Pressure	276	bar
Temperature	604	C
Enthalpy	3478	kJ/kg
Blading Inlet		
Pressure	269.1	bar
Temperature	601.9	C
Enthalpy	3478	kJ/kg
Volume flow	6.827	m^3/s
Nozzle area	0.0281	m^2
Blading Exit		
Pressure	212.3	bar
Temperature	562.3	C
Enthalpy	3416	kJ/kg
Volume flow	8.298	m^3/s

HP casing - Group 2		
Number of paths	1	
Number of stages	9	
Dry step efficiency	87.38	%
Group efficiency	88.82	%
Group inlet mass flow	1886.5	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	212.3	bar
Temperature	562.3	C
Enthalpy	3416	kJ/kg
Volume flow	8.298	m^3/s
Nozzle area	0.0225	m^2
Blading Exit		
Pressure	64.3	bar
Temperature	374.5	C
Enthalpy	3104	kJ/kg
Volume flow	21.72	m^3/s
Port at Group Exit		
Pressure	64.3	bar
Temperature	374.5	C
Enthalpy	3104	kJ/kg
Extraction mass flow	132.4	t/h

IP casing - Group 3		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	86.79	%
Group efficiency	82.62	%
Group inlet mass flow (per path)	885.4	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	58.8	bar
Temperature	602.2	C
Enthalpy	3662	kJ/kg
Volume flow (per path)	16.41	m^3/s
Nozzle area (per path)	0.057	m^2
Blading Exit		
Pressure	42.67	bar
Temperature	549.8	C
Enthalpy	3555	kJ/kg
Volume flow (per path)	21.31	m^3/s
Port at Group Exit		
Pressure	42.67	bar
Temperature	549.8	C
Enthalpy	3555	kJ/kg
Extraction mass flow (per path)	61.58	t/h

IP casing - Group 4		
Number of paths	2	
Number of stages (per path)	4	
Dry step efficiency	88.58	%
Group efficiency	89.23	%
Group inlet mass flow (per path)	823.8	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	42.67	bar
Temperature	549.8	C
Enthalpy	3555	kJ/kg
Volume flow (per path)	19.83	m^3/s
Nozzle area (per path)	0.0579	m^2
Blading Exit		
Pressure	22.9	bar
Temperature	454.3	C
Enthalpy	3363	kJ/kg
Volume flow (per path)	32.77	m^3/s
Port at Group Exit		
Pressure	22.9	bar
Temperature	454.3	C
Enthalpy	3363	kJ/kg
Extraction mass flow (per path)	32.89	t/h

IP casing - Group 5		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	89.65	%
Group efficiency	90.07	%
Group inlet mass flow (per path)	790.9	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	22.9	bar
Temperature	454.3	C
Enthalpy	3363	kJ/kg
Volume flow (per path)	31.46	m^3/s
Nozzle area (per path)	0.1001	m^2
Blading Exit		
Pressure	13.04	bar
Temperature	375.4	C
Enthalpy	3207	kJ/kg
Volume flow (per path)	49.41	m^3/s
Port at Group Exit		
Pressure	13.04	bar
Temperature	375.4	C
Enthalpy	3207	kJ/kg
Extraction mass flow (per path)	38.37	t/h

IP casing - Group 6		
Number of paths	2	
Number of stages (per path)	3	
Dry step efficiency	90.53	%
Group efficiency	90.93	%
Group inlet mass flow (per path)	752.5	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	13.04	bar
Temperature	375.4	C
Enthalpy	3207	kJ/kg
Volume flow (per path)	47.01	m^3/s
Nozzle area (per path)	0.1541	m^2
Blading Exit		
Pressure	7	bar
Temperature	296.5	C
Enthalpy	3052	kJ/kg
Volume flow (per path)	77.12	m^3/s

LP casing - Group 7		
Number of paths	2	
Number of stages (per path)	2	
Dry step efficiency	91.33	%
Group efficiency	91.7	%
Group inlet mass flow (per path)	646.6	t/h
Shaft speed	3000	RPM
Port upstream of LP casing		
Pressure	7	bar
Temperature	296.5	C
Enthalpy	3052	kJ/kg
Extraction mass flow	220.7	t/h
Blading Inlet		
Pressure	7	bar
Temperature	296.7	C
Enthalpy	3053	kJ/kg
Volume flow (per path)	66.29	m^3/s
Nozzle area (per path)	0.2216	m^2
Blading Exit		
Pressure	3.309	bar
Temperature	212.4	C
Enthalpy	2889.5	kJ/kg
Volume flow (per path)	119.7	m^3/s
Port at Group Exit		
Pressure	3.309	bar
Temperature	212.4	C
Enthalpy	2889.5	kJ/kg
Extraction mass flow (per path)	35.05	t/h

LP casing - Group 8		
Number of paths	2	
Number of stages (per path)	2	
Dry step efficiency	92.37	%
Group efficiency	92.74	%
Group inlet mass flow (per path)	611.5	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	3.309	bar
Temperature	212.4	C
Enthalpy	2889.5	kJ/kg
Volume flow (per path)	113.3	m^3/s
Nozzle area (per path)	0.3973	m^2
Blading Exit		
Pressure	1.38	bar
Temperature	127.6	C
Enthalpy	2727.9	kJ/kg
Volume flow (per path)	224.2	m^3/s
Port at Group Exit		
Pressure	1.38	bar
Temperature	127.6	C
Enthalpy	2727.9	kJ/kg
Extraction mass flow (per path)	33.04	t/h

LP casing - Group 9		
Number of paths	2	
Number of stages (per path)	2	
Dry step efficiency	92.71	%
Group efficiency	92.74	%
Group inlet mass flow (per path)	578.5	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	1.38	bar
Temperature	127.6	C
Enthalpy	2727.9	kJ/kg
Volume flow (per path)	212.1	m^3/s
Nozzle area (per path)	0.7964	m^2
Blading Exit		
Pressure	0.4907	bar
Temperature	80.88	C
Enthalpy	2568.5	kJ/kg
Volume flow (per path)	512.3	m^3/s
Port at Group Exit		
Pressure	0.4907	bar
Temperature	80.88	C
Enthalpy	2568.5	kJ/kg
Extraction mass flow (per path)	29.99	t/h

LP casing - Group 10		
Number of paths	2	
Number of stages (per path)	2	
Dry step efficiency	95	%
Group efficiency	82.75	%
Group inlet mass flow (per path)	548.5	t/h
Shaft speed	3000	RPM
Blading Inlet		
Pressure	0.4907	bar
Temperature	80.88	C
Enthalpy	2568.5	kJ/kg
Volume flow (per path)	485.8	m^3/s
Nozzle area (per path)	1.895	m^2
Blading Exit		
Pressure	0.1181	bar
Temperature	49.12	C
Enthalpy	2381.3	kJ/kg
Volume flow (per path)	1744.9	m^3/s
Annulus area (per path)	8.137	m^2
Annulus velocity	214.4	m/s
Pitch Diameter	2734.1	mm
Bucket Length	947.3	mm
Pitch Speed	429.5	m/s
Tip Speed	578.3	m/s
After leaving loss		
Pressure	0.1181	bar
Temperature	49.12	C
Enthalpy	2397.9	kJ/kg

STEAM PRO 26.1 GHD GHD Pty Ltd
588 04-21-2017 16:19:10 G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp
Program revision date: February 16, 2017
Steam source: Conventional boiler
Steam turbine: Single reheat condensing turbine 3000+3000/3000
Feedwater heaters: SDDDCDDDP, single LP FWH train & double HP FWH train
Cooling system: Dry air cooled condenser
Steam Property Formulation: IFC-67

THERMAL OUTPUT

FWH1: Pump Forward

Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					LPT1 port (9)	0.4907	80.9	2568.5	59.99	
Feedwater in	21.15	47.8	202.0	1245.5	Steam in	0.4673	79.7	2566.2	59.99	79.7
					Flash back			345.2	209.6	
					SSR seal steam			3163.6	5.222	
Feedwater out	19.34	76.9	323.4	1245.5	Drain before pump	0.4673	79.7	333.5	274.8	
					Drain to FWH2	19.34		335.9	274.8	

Terminal temperature difference = 2.77 C

FWH2: Flash Back with Drain Cooler

Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					LPT1 port (8)	1.38	127.6	2727.9	66.09	
FWH1 drain			335.9	274.8						
Feedwater in	19.34	77.4	325.6	1520.3	Steam in	1.314	126.2	2725.5	66.09	107.4
					Flash back			460.0	143.5	
Feedwater out	17.59	104.7	440.0	1520.3	Drain to FWH1	1.314	82.4	345.2	209.6	

Terminal temperature difference = 2.78 C
Drain cooler approach = 5.00 C

FWH3: Flash Back with Drain Cooler

Feedwater					Bleed Steam					
Stream	P	T	h	M	Stream	P	T	h	M	Tsat
	bar	C	kJ/kg	t/h		bar	C	kJ/kg	t/h	C
					LPT1 port (7)	3.309	212.4	2889.5	70.11	
Feedwater in	17.59	104.7	440.0	1520.3	Steam in	3.151	210.9	2887.1	70.11	135.2
					Flash back			578.3	73.38	
Feedwater out	16.14	132.4	557.6	1520.3	Drain to FWH2	3.151	109.7	460.0	143.5	

Terminal temperature difference = 2.78 C
Drain cooler approach = 5.00 C

FWH4: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					LPT cross port (6)	**7**	**296.5**	**3052.1**	**73.38**	
Feedwater in	**16.14**	**132.4**	**557.6**	**1520.3**	**Steam in**	**6.667**	**294.9**	**3049.8**	**73.38**	**163.0**
Feedwater out	**14.9**	**160.2**	**676.9**	**1520.3**	**Drain to FWH3**	**6.667**	**137.4**	**578.3**	**73.38**	

Terminal temperature difference =	2.78	C
Drain cooler approach =	5.00	C

FWH5: Deaerator										
Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					IPT1 port (5)	**13.04**	**375.4**	**3206.9**	**76.74**	
Feedwater in	**12.66**	**160.3**	**676.9**	**1520.3**	**Steam in**	**12.66**	**374.0**	**3204.6**	**76.74**	**190.4**
					Flash back			**863.3**	**321.4**	
Feedwater out	**12.66**	**190.4**	**809.2**	**1918.4**						
Booster pump in	**14.9**	**190.4**	**809.2**	**1918.4**						
FW pump in	**22.38**	**190.5**	**810.3**	**1918.4**						
FW pump out	**308.7**	**197.4**	**854.1**	**1918.4**						

FWH6: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					IPT1 port (4)	**22.9**	**454.3**	**3363.3**	**65.78**	
Feedwater in	**308.7**	**197.4**	**854.1**	**1918.4**	**Steam in**	**22.24**	**452.9**	**3361.0**	**65.78**	**217.8**
					Flash back			**967.5**	**255.6**	
Feedwater out	**308**	**220.1**	**953.7**	**1918.4**	**Drain to FWH5**	**22.24**	**202.4**	**863.3**	**321.4**	

Terminal temperature difference =	-2.28	C
Drain cooler approach =	5.00	C

FWH7: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					Sup. cooler exit	**41.42**	**302.4**	**2963.9**	**123.2**	
Feedwater in	**308**	**220.1**	**953.7**	**1918.4**	**Steam in**	**41.42**	**302.4**	**2963.9**	**123.2**	**252.4**
					Flash back			**1113.7**	**132.4**	
Feedwater out	**307.4**	**250.7**	**1091.9**	**1918.4**	**Drain to FWH6**	**41.42**	**225.1**	**967.5**	**255.6**	

Terminal temperature difference =	1.67	C
Drain cooler approach =	5.00	C

FWH8: Flash Back with Drain Cooler										
Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					HPT exit port (1)	**64.3**	**374.5**	**3103.8**	**132.4**	
Feedwater in	**307.4**	**250.7**	**1091.9**	**1918.4**	**Steam in**	**62.42**	**372.1**	**3101.5**	**132.4**	**278.1**
Feedwater out	**306.8**	**279.9**	**1229.2**	**1918.4**	**Drain to FWH7**	**62.42**	**255.7**	**1113.7**	**132.4**	
Terminal temperature difference =			-1.78	C						
Drain cooler approach =			5.00	C						

FWH9: Superheat Cooler										
Feedwater					Bleed Steam					
Stream	**P**	**T**	**h**	**M**	**Stream**	**P**	**T**	**h**	**M**	**Tsat**
	bar	**C**	**kJ/kg**	**t/h**		**bar**	**C**	**kJ/kg**	**t/h**	**C**
					IPT1 port (3)	**42.67**	**549.8**	**3555.3**	**123.2**	
Feedwater in	**306.8**	**279.9**	**1229.2**	**1918.4**	**Steam in**	**41.42**	**548.2**	**3553.0**	**123.2**	**252.4**
Feedwater out	**306.7**	**287.7**	**1267.0**	**1918.4**	**Drain to FWH7**	**41.42**	**302.4**	**2963.9**	**123.2**	
To boiler	**306.7**	**287.7**	**1267.0**	**1918.4**						

Total bleed steam for FWH system =	667.7	t/h	577001	kJ/s	

DESIGN PARAMETERS OF FEEDWATER HEATERS		
FWH1: Pump Forward		
1. Heat transfer rate Q	41990	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	2837	W/m^2-K
4. Overall h.t.c. in drain cooling section	0	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1243	m^2
7. Drain cooler heat transfer area	0	m^2
8. Total heat transfer area	1243	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	18.4	m
13. No. of passes	2	
14. No. of tubes	1128	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.774	C
17. Drain cooler approach (DCA)	N/A	
FWH2: Flash Back with Drain Cooler		
1. Heat transfer rate Q	48275	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3173	W/m^2-K
4. Overall h.t.c. in drain cooling section	1328	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1261	m^2
7. Drain cooler heat transfer area	378	m^2
8. Total heat transfer area	1640	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	19.5	m
13. No. of passes	2	
14. No. of tubes	1402	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.776	C
17. Drain cooler approach (DCA)	5	C

FWH3: Flash Back with Drain Cooler		
1. Heat transfer rate Q	49680	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3440	W/m^2-K
4. Overall h.t.c. in drain cooling section	1279	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1204	m^2
7. Drain cooler heat transfer area	262	m^2
8. Total heat transfer area	1466	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	17.1	m
13. No. of passes	2	
14. No. of tubes	1432	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.777	C
17. Drain cooler approach (DCA)	5	C

FWH4: Flash Back with Drain Cooler		
1. Heat transfer rate Q	50380	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3647	W/m^2-K
4. Overall h.t.c. in drain cooling section	979	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1172	m^2
7. Drain cooler heat transfer area	170	m^2
8. Total heat transfer area	1342	m^2
9. Water velocity	2.90	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	1.245	mm
12. Tube length per pass	15.3	m
13. No. of passes	2	
14. No. of tubes	1470	
15. Tube material	TP 304	
16. Terminal temperature difference (TTD)	2.778	C
17. Drain cooler approach (DCA)	5	C

FWH5: Deaerator		
1. Heat transfer rate Q	55885	kJ/s
FWH6: Flash Back with Drain Cooler (Each of FWH6A, FWH6B)		
1. Heat transfer rate Q	26522	kJ/s
2. Overall h.t.c. in desuperheating section	491	W/m^2-K
3. Overall h.t.c. in condensing section	2948	W/m^2-K
4. Overall h.t.c. in drain cooling section	1120	W/m^2-K
5. Desuperheater heat transfer area	106	m^2
6. Condensing section heat transfer area	941	m^2
7. Drain cooler heat transfer area	289	m^2
8. Total heat transfer area	1336	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	22.225	mm
11. Tube wall thickness	3.810	mm
12. Tube length per pass	11.7	m
13. No. of passes	2	
14. No. of tubes	1642	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	-2.277	C
17. Drain cooler approach (DCA)	5	C
FWH7: Flash Back with Drain Cooler (Each of FWH7A, FWH7B)		
1. Heat transfer rate Q	36837	kJ/s
2. Overall h.t.c. in desuperheating section	0	W/m^2-K
3. Overall h.t.c. in condensing section	3021	W/m^2-K
4. Overall h.t.c. in drain cooling section	1116	W/m^2-K
5. Desuperheater heat transfer area	0	m^2
6. Condensing section heat transfer area	1129	m^2
7. Drain cooler heat transfer area	327	m^2
8. Total heat transfer area	1455	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	19.050	mm
11. Tube wall thickness	3.404	mm
12. Tube length per pass	10.0	m
13. No. of passes	2	
14. No. of tubes	2422	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	1.667	C
17. Drain cooler approach (DCA)	5	C

FWH8: Flash Back with Drain Cooler (Each of FWH8A, FWH8B)		
1. Heat transfer rate Q	36562	kJ/s
2. Overall h.t.c. in desuperheating section	749	W/m^2-K
3. Overall h.t.c. in condensing section	2929	W/m^2-K
4. Overall h.t.c. in drain cooling section	735	W/m^2-K
5. Desuperheater heat transfer area	119	m^2
6. Condensing section heat transfer area	1173	m^2
7. Drain cooler heat transfer area	229	m^2
8. Total heat transfer area	1521	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	22.225	mm
11. Tube wall thickness	3.810	mm
12. Tube length per pass	12.2	m
13. No. of passes	2	
14. No. of tubes	1786	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	-1.781	C
17. Drain cooler approach (DCA)	5	C

FWH9: Superheat Cooler (Each of FWH9A, FWH9B)		
1. Heat transfer rate Q	10078	kJ/s
2. Overall h.t.c. in desuperheating section	505	W/m^2-K
3. Overall h.t.c. in condensing section	0	W/m^2-K
4. Overall h.t.c. in drain cooling section	0	W/m^2-K
5. Desuperheater heat transfer area	209	m^2
6. Condensing section heat transfer area	0	m^2
7. Drain cooler heat transfer area	0	m^2
8. Total heat transfer area	209	m^2
9. Water velocity	2.21	m/s
10. Tube outer diameter	22.225	mm
11. Tube wall thickness	4.191	mm
12. Tube length per pass	2.9	m
13. No. of passes	1	
14. No. of tubes	1029	
15. Tube material	Carbon steel	
16. Terminal temperature difference (TTD)	N/A	
17. Drain cooler approach (DCA)	N/A	

FWH Hardware	FWH 1	FWH 2	FWH 3	FWH 4	FWH 5	FWH 6	FWH 7	FWH 8	FWH 9
1. Type	P	D	D	D	C	D	D	D	S
2. Tube material	TP 304	TP 304	TP 304	TP 304		Carbon steel	Carbon steel	Carbon steel	Carbon steel
3. Tube outer diameter [mm]	19.05	19.05	19.05	19.05		22.23	19.05	22.23	22.23
4. Tube length (per pass) [m]	18.41	19.54	17.1	15.25		11.65	10.04	12.2	2.902
5. Number of tubes	1128	1402	1432	1470		1642	2422	1786	1029
6. Total heat transfer area [m^2]	1242.5	1639.6	1465.7	1341.7		1336.1	1455.5	1521.2	208.5
7. Number of passes	2	2	2	2		2	2	2	1
8. Tube wall thickness [mm]	1.245	1.245	1.245	1.245		3.81	3.404	3.81	4.191
9. Tube pitch [mm]	30.48	29.53	27.62	27.62		32.23	25.72	32.23	30
10. Tube thermal cond. @ 300 F [W/m-C]	16.61	16.61	16.61	16.61		49.5	49.5	49.5	49.5
11. Tube thermal conductivity slope [W/m-C^2]	0.0125	0.0125	0.0125	0.0125		-0.0249	-0.0249	-0.0249	-0.0249
12. Fouling resistance [m^2-C/W]	0	0	0	0		0	0	0	0
13. Desuperheater heat transfer area [m^2]	0	0	0	0		106.1	0	119	208.5
14. Condensing heat transfer area [m^2]	1242.5	1261.2	1203.8	1172.1		940.6	1128.6	1172.7	0
15. Drain cooler heat transfer area [m^2]	0	378.3	261.9	169.6		289.4	326.8	229.4	0

FWH 1 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Pump Forward Heater				
Saturation temperature		79.67		
Inlet Steam & Flash In Streams				
Heating steam from LPT1 - Port 9	0.49	80.9	2568.5	59.990
Heating steam into heater (after piping)	0.47	79.7	2566.2	59.990
Flash in			345.2	209.600
Steam from Sealing Steam Regulator			3164.0	5.222
Exit Drain				
FWH 1 drain to FWH 2	0.47	79.7	333.5	274.800
Feedwater				
Feedwater into heater	21.15	47.8	202.0	1245.500
Feedwater leaving heater	19.34	76.9	323.4	1245.500

FWH 2 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Flash Back with Drain Cooler				
Saturation temperature		107.4		
Inlet Steam & Flash In Streams				
Heating steam from LPT1 - Port 8	1.38	127.6	2727.9	66.090
Heating steam into heater (after piping)	1.31	126.2	2725.5	66.090
Flash in			460.0	143.500
Exit Drain				
FWH 2 drain to FWH 1	1.31	82.4	345.2	209.600
Feedwater				
Drain from FWH1			335.9	274.800
Feedwater into heater	19.34	77.4	325.6	1520.300
Feedwater leaving heater	17.59	104.7	440.0	1520.300

FWH 3 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Flash Back with Drain Cooler				
Saturation temperature		135.2		
Inlet Steam & Flash In Streams				
Heating steam from LPT1 - Port 7	3.31	212.4	2889.5	70.110
Heating steam into heater (after piping)	3.15	210.9	2887.1	70.110
Flash in			578.3	73.380
Exit Drain				
FWH 3 drain to FWH 2	3.15	109.7	460.0	143.500
Feedwater				
Feedwater into heater	17.59	104.7	440.0	1520.300
Feedwater leaving heater	16.14	132.4	557.6	1520.300

FWH 4 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Flash Back with Drain Cooler				
Saturation temperature		163		
Inlet Steam & Flash In Streams				
Heating steam from LPT cross - Port 6	7.00	296.5	3052.0	73.380
Heating steam into heater (after piping)	6.67	294.9	3050.0	73.380
Exit Drain				
FWH 4 drain to FWH 3	6.67	137.4	578.3	73.380
Feedwater				
Feedwater into heater	16.14	132.4	557.6	1520.300
Feedwater leaving heater	14.90	160.2	676.9	1520.300

FWH 5 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Type: Contact Heater				
Saturation temperature		190.4		
Inlet Steam & Flash In Streams				
Heating steam from IPT1 - Port 5	13.04	375.4	3207.0	76.740
Heating steam into heater (after piping)	12.66	374.0	3205.0	76.740
Flash in			863.3	321.400
Feedwater				
Feedwater into heater	12.66	160.3	676.9	1520.300
Feedwater leaving heater	12.66	190.4	809.2	1918.400
Boiler feedpump delivery	308.70	197.4	854.1	1918.400

FWH 6 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 6A & 6B)				
Type: Flash Back with Drain Cooler				
Saturation temperature		217.8		
Inlet Steam & Flash In Streams				
Heating steam from IPT1 - Port 4	22.90	454.3	3363.0	65.780
Heating steam into heater (after piping)	22.24	452.9	3361.0	65.780
Flash in			967.5	255.600
Exit Drain				
FWH 6 drain to FWH 5	22.24	202.4	863.3	321.400
Feedwater				
Feedwater into heater	308.70	197.4	854.1	1918.400
Feedwater leaving heater	308.00	220.1	953.7	1918.400

FWH 7 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 7A & 7B)				
Type: Flash Back with Drain Cooler				
Saturation temperature		252.4		
Inlet Steam & Flash In Streams				
Steam from superheat cooler exit	41.42	302.4	2963.9	123.200
Heating steam into heater (after piping)	41.42	302.4	2963.9	123.200
Flash in			1113.7	132.400
Exit Drain				
FWH 7 drain to FWH 6	41.42	225.1	967.5	255.600
Feedwater				
Feedwater into heater	308.00	220.1	953.7	1918.400
Feedwater leaving heater	307.40	250.7	1091.9	1918.400

FWH 8 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 8A & 8B)				
Type: Flash Back with Drain Cooler				
Saturation temperature		278.1		
Inlet Steam & Flash In Streams				
Heating steam from HPT exit - Port 1	64.30	374.5	3104.0	132.400
Heating steam into heater (after piping)	62.42	372.1	3102.0	132.400
Exit Drain				
FWH 8 drain to FWH 7	62.42	255.7	1113.7	132.400
Feedwater				
Feedwater into heater	307.40	250.7	1091.9	1918.400
Feedwater leaving heater	306.80	279.9	1229.2	1918.400

FWH 9 Thermodynamic Design	p [bar]	T [C]	h [kJ/kg]	m [t/h]
Total of two units (FWH 9A & 9B)				
Type: External Desuperheater				
Saturation temperature		252.4		
Inlet Steam & Flash In Streams				
Heating steam from IPT1 - Port 3	42.67	549.8	3555.0	123.200
Heating steam into heater (after piping)	41.42	548.2	3553.0	123.200
Exit Drain				
FWH 9 drain to FWH 7	41.42	302.4	2963.9	123.200
Feedwater				
Feedwater into heater	306.80	279.9	1229.2	1918.400
Feedwater leaving heater	306.70	287.7	1267.0	1918.400
Feedwater to boiler	306.70	287.7	1267.0	1918.400

CONDENSER: Dry air cooled condenser				
	P	T	h	M
	bar	C	kJ/kg	t/h
LPT exhaust	0.1181	49.12	2397.9	1097
LPT SS to condenser			3163.6	0.5443
FPT exhaust	0.1073	47.22	2453.9	147.3
Drain from GSC	0.827	94.47	395.5	0.6349
Condenser in	0.1073	47.22	2403.8	1245.5
Condensate	0.4064	47.22	197.6	1245.5
Cooling air in		25.00		173425
Cooling air out		40.56		173425
Main condenser heat rejection =	763268	kJ/s		

Dry air-cooled condenser		
Heat Balance		
Quantities are for all cells if not otherwise noted		
Total number of existing cells	64	
Total number of operating cells	64	
Condenser pressure	0.1073	bar
Condenser saturation temperature	47.22	C
Condenser heat rejection	763268	kW
Air draft loss across tube bundles	0.8245	millibar
Air face velocity	2.286	m/s
Inlet Steam		
Pressure	0.1073	bar
Temperature	47.22	C
Mass flow	1245.5	t/h
Enthalpy	2403.8	kJ/kg
Condensate @ bottom of hotwell		
Pressure	0.4064	bar
Temperature	47.22	C
Mass flow	1245.5	t/h
Enthalpy	197.6	kJ/kg
Cooling Air		
Inlet air		
Temperature	25	C
Mass flow	173425	t/h
Exit air		
Temperature	40.56	C
Mass flow	173425	t/h
Fans		
Total mass flow	173425	t/h
Total fan volume flow	41517	m^3/s
Total fan electricity consumption	7014	kW
Full speed fans		
Air axial velocity	8.217	m/s
Static pressure drop	0.8245	millibar
Dynamic pressure	0.3911	millibar
Total fan DP	1.216	millibar
Flash-in Stream		
Mass flow	0	t/h
Hardware		
Tubes		
Tube geometry	Rectangular	
Fin-tube type	Solid fins	
Tube arrangement	In line	
Tube material	Galvanized CS	
Number of tube rows (longitudinal)	1	
Number of tubes per row (transverse)	221	
Number of rows per waterside flow pass	1	
Gas path transverse width	13.15	m
Tube length	10.79	m
Tube outer width	20	mm
Tube outer height	200	mm
Tube wall thickness	1.905	mm
Transverse tube pitch	59.52	mm
Tube metal conductivity @ 500F (260C)	46.73	W/m-C
Tube metal conductivity slope	-0.0249	W/m-C^2
Fins		
Fin material	Aluminum	
Fin height	19	mm
Fin spacing	2.009	mm
Fin thickness	0.3	mm
Number of fins per meter	433.1	per meter
Fin metal conductivity @ 500F (260C)	167.6	W/m-C
Fin metal conductivity slope	0	W/m-C^2
Overall Data		
Gas path frontal area	283.8	m^2
Min. gas free flow cross section / frontal area	0.581	
H.T. surface area / min. free flow cross section	212	
Primary tube surface / total heat transfer surf.	0.0475	
Water side flow cross section area	1.522	m^2
Heat exchanger prime outside surface	1659.3	m^2
Heat exchanger total fin area	33291	m^2
Heat exchanger total outside area	34950	m^2
Heat Transfer		
Gas Side		
Inlet face velocity	2.286	m/s
Face mass flux	9.552	t/h-m^2

Dry air-cooled condenser		
Velocity at minimum flow area	4.038	m/s
Mass flux at minimum flow area	16.44	t/h-m^2
Reynolds number	872	
Prandtl number	0.708	
Convective Nusselt number	4.13	
Convective heat transfer coefficient	31.12	W/m^2-C
Radiative heat transfer coefficient	0	W/m^2-C
Convective h.t.c. adjustment factor	1.15	
Total gas side adjusted heat transfer coefficient	35.78	W/m^2-C
Fouling resistance	4.342508E-05	m^2-C/W
Nusselt number Re coefficient	0.0563	
Friction factor Re coefficient	28.52	
Radiation beam mean length	0	m
Pressure drop correction factor	1	
Pressure drop	0.8245	millibar
Water Side		
Condensing heat transfer coefficient	5962	W/m^2-C
Overall Performance		
Fin effectiveness	0.813	
Effective / total external area	0.8219	
Overall heat transfer coefficient	26.42	W/m^2-C
Heat transfer rate to gas	11926	kW
Heat transfer rate from water	11926	kW
Overall heat transfer coefficient X total outer area, (UA)	923.4	kW/C

Emissions	kg/hr	metric ton/year	kg/MWhr (gross)
Furnace Emissions			
NOx as NO2	0	0	0
SOx as SO2	2294.6	18586	3.381
CO2 (net)	520251	4214037	766.5
Particulate	15540	125877	22.9
Mercury as Hg	0	0	0
Electrostatic Precipitator Exit			
NOx as NO2	0	0	0
SOx as SO2	2294.6	18586	3.381
CO2 (net)	520250	4214028	766.5
Particulate	77.7	629.4	0.1145
Mercury as Hg	0	0	0
Plant Total Emissions			
NOx as NO2	0	0	0
SOx as SO2	2294.6	18586	3.381
CO2 (net)	520250	4214028	766.5
Particulate	77.7	629.4	0.1145
Mercury as Hg	0	0	0
Stack Levels	**ng/J HHV @25C**	**mg/Nm³**	**ppmv**
NOx as NO2	0	0 @ 6% O2, dry	0 @ 6% O2, dry
SOx as SO2	393.9	1169.3 @ 6% O2, dry	409.1 @ 6% O2, dry
Particulate	13.34	39.6 @ 6% O2, dry	
Mercury as Hg	0	0 @ 6% O2, dry	0 @ 6% O2, dry
Nm3 at 0 C, 101.325 kPa (32 F, 14.696 psia)			
Note:			
Boiler NOx emission is computed from the user-specified			
generation rate input on the Environment topic.			
The program DOES NOT predict NOx emissions.			
Therefore, it is incumbent on the user to input OEM-provided data			
consistent with equipment operation at this specific running condition.			

Plant Water/Steam Mass Flow Balance	Mass flow	
Mass Flow In	**113.9**	**t/h**
Steam cycle makeup	0	t/h
Cooling tower makeup	0	t/h
Wet air-cooled condenser makeup	0	t/h
Auxiliary cooling tower makeup	0	t/h
Total boiler desuperheating water from makeup	0	t/h
Total process steam desuperheating water from makeup	0	t/h
Total steam addition	0	t/h
Total water addition	0	t/h
Total external steam	0	t/h
Total process return	0	t/h
FGD makeup/cake wash	0	t/h
FGD water from reagent	0	t/h
FGD water from oxidation air	0	t/h
CO2 capture makeup	0	t/h
Water in combustion air	29.31	t/h
Water in fuel	9.665	t/h
Water from combustion of hydrogen in fuel	74.9	t/h
Seawater FGD evaporation	0	t/h
Mass Flow Out	**113.9**	**t/h**
Cooling tower blowdown	0	t/h
Cooling tower water evaporation	0	t/h
Wet air-cooled condenser blowdown	0	t/h
Wet air-cooled condenser water evaporation	0	t/h
Auxiliary cooling tower blowdown	0	t/h
Auxiliary cooling tower water evaporation	0	t/h
Boiler blowdown to external sink	0	t/h
Total process steam	0	t/h
Total water extraction	0	t/h
FGD blowdown/stacking water	0	t/h
FGD water in byproduct	0	t/h
CO2 capture drain	0	t/h
CO2 capture water evaporation	0	t/h
CO2 capture water removed with CO2 stream	0	t/h
ST leakage to external sink	0	t/h
Water in flue gas at stack exit	113.9	t/h
Seawater FGD condensation	0	t/h

Plant Water Accounting	Current flow	% included		
Total Water Consumption			0	t/h
Steam cycle makeup	0	100	0	t/h
Cooling tower makeup	0	100	0	t/h
Wet air-cooled condenser makeup	0	100	0	t/h
Auxiliary cooling tower makeup	0	100	0	t/h
FGD makeup/cake wash	0	100	0	t/h
CO2 capture makeup	0	100	0	t/h
Water addition 1	0	0	0	t/h
Water addition 2	0	0	0	t/h
Water addition 3	0	0	0	t/h
Process steam desuperheating water from makeup	0	100	0	t/h
Superheater desuperheating water from makeup	0	100	0	t/h
Reheater desuperheating water from makeup	0	100	0	t/h
LP reheater desuperheating water from makeup	0	100	0	t/h
Seawater FGD evaporation	0	0	0	t/h
Total Water Discharge			0	t/h
Cooling tower blowdown	0	100	0	t/h
Wet air-cooled condenser blowdown	0	100	0	t/h
Auxiliary cooling tower blowdown	0	100	0	t/h
Boiler blowdown to external sink	0	100	0	t/h
FGD blowdown/stacking water	0	100	0	t/h
CO2 capture drain	0	100	0	t/h
Water extraction 1	0	0	0	t/h
Water extraction 2	0	0	0	t/h
Water extraction 3	0	0	0	t/h
Seawater FGD condensation	0	0	0	t/h

ESP		
Heat Balance		
Flue Gas		
Flue gas inlet temperature	137.8	C
Flue gas outlet temperature	137.8	C
Flue gas mass flow (excluding particulate flow)	2,650	t/h
Flue gas volume flow	3,098,000	m^3/hr
Flue gas velocity	1.361	m/s
Performance		
Particulate collection efficiency	99.5	%
Inlet particulate load per energy input	2667.8	ng/J
Inlet particulate load per gas flow	7919	mg/Nm^3 @ 6% O2, dry
Outlet particulate load per energy input	13.34	ng/J
Outlet particulate load per gas flow	39.6	mg/Nm^3 @ 6% O2, dry
Inlet particulate flow	15.54	t/h
Particulate removal	15.46	t/h
Outlet particulate flow	0.0777	t/h
Pressure drop (including ductwork)	8.095	millibar
Electricity consumption	1613.1	kW
Flue gas SO2	402.7	ppm
Flue gas SO3 at inlet	2.014	ppm
Injected sulfur trioxide (SO3) for flue gas conditioning	0.1281	t/h
Flue gas SO3 after conditioning	20	ppm
Flue gas SO3 at exit	15	ppm
Heat loss	0	kW
Modified Deutsch-Anderson Equation		
Specific collecting area (SCA)	89.78	m^2 / m^3/s
Particulate resistivity	1.739211E+08	ohm-cm
Effective migration velocity	0.3062	m/s
Dimensionless K	0.5032	
Hardware		
Design collection efficiency	99.5	%
Design inlet temperature	137.8	C
Design flue gas mass flow	2,650	t/h
Design flue gas volume flow	3,098,000	m^3/hr
Design flue gas velocity	1.372	m/s
Overall Dimensions		
Number of chambers	3	
Number of fields	4	
Total length	30.74	m
Total width	70.68	m
Total height	20.57	m
Total weight	1,961,000	kg
Collecting Plates		
Design specific collecting area (SCA)	89.78	m^2 / m^3/s
Total collection surface area	77,250	m^2
Number of plates per chamber	64	
Collecting plates height	10.97	m
Collecting plates spacing	304.8	mm
Collecting plates bundle width per chamber	19.2	m
Collecting plates depth per field	4.656	m
Collecting length	18.62	m
Aspect ratio (Collecting length / Plate height)	1.697	

Heat Balance Results		
Boiler Feed Pump		
Type	Variable RPM	
Number per Boiler	1	
Number operating	1	
Suction Side (each)		
Pressure	22.38	bar
Temperature	190.5	C
Mass flow	1918.4	t/h
Enthalpy	810.3	kJ/kg
Density	876.2	kg/m^3
Delivery Side (each)		
Pressure	308.7	bar
Temperature	197.4	C
Mass flow	1918.4	t/h
Enthalpy	854.1	kJ/kg
Performance Data (each)		
Pump pressure rise	286.3 (3332)	bar (m)
Pressure rise after valve pressure drop	286.3 (3332)	bar (m)
Pump shaft speed	3000	RPM
Pump isentropic efficiency	74.45	%
Pump apparent isentropic efficiency	74.45	%
Pump hydraulic work	23386	kW
Pump mechanical efficiency	96.89	%
Pump shaft work	24138	kW
Boiler Feed Booster Pump		
Type	Fixed RPM	
Number per Boiler	1	
Number operating	1	
Suction Side (each)		
Pressure	14.9	bar
Temperature	190.4	C
Mass flow	1918.4	t/h
Enthalpy	809.2	kJ/kg
Density	875.8	kg/m^3
Delivery Side (each)		
Pressure	22.38	bar
Temperature	190.5	C
Mass flow	1918.4	t/h
Enthalpy	810.3	kJ/kg
Performance Data (each)		
Pump pressure rise	7.473 (87.01)	bar (m)
Pressure rise after valve pressure drop	7.473 (87.01)	bar (m)
Pump shaft speed	600	RPM
Pump isentropic efficiency	83.55	%
Pump apparent isentropic efficiency	83.55	%
Pump hydraulic work	544.2	kW
Pump mechanical efficiency	96.93	%
Pump shaft work	561.4	kW
Recirculation ratio	0	
Recirculation cooling load	0	kW
Motor efficiency	96.14	%
Electricity consumption	583.9	kW
Condenser C.W. Pump	**None**	
Condensate Forwarding Pump		
Type	Fixed RPM	
Number per ST	2	
Number operating	1	
Suction Side (each)		
Pressure	0.4064	bar
Temperature	47.22	C
Mass flow	1245.5	t/h
Enthalpy	197.6	kJ/kg
Density	989.3	kg/m^3
Delivery Side (each)		
Pressure	21.15	bar
Temperature	47.5	C
Mass flow	1245.5	t/h
Enthalpy	200.6	kJ/kg
Performance Data (each)		
Pump pressure rise	24.52 (252.7)	bar (m)
Pressure rise after valve pressure drop	20.75 (213.9)	bar (m)
Pump shaft speed	750	RPM

Heat Balance Results		
Pump isentropic efficiency	83.55	%
Pump apparent isentropic efficiency	70.71	%
Pump hydraulic work	1026.2	kW
Pump mechanical efficiency	96.93	%
Pump shaft work	1058.6	kW
Recirculation ratio	0	
Recirculation cooling load	0	kW
Motor efficiency	96.51	%
Electricity consumption	1096.9	kW
District Heating Pump	**None**	

PIPES	
Pipe name	**Pressure loss**
	bar
BLR to HPT	**4.14**
Cold Reheat	**1.26**
Hot Reheat	**1.20**
FWH 1 Heating	**0.02**
FWH 2 Heating	**0.07**
FWH 3 Heating	**0.16**
FWH 4 Heating	**0.33**
Deaerator (FWH 5) Heating	**0.38**
FWH 6 Heating	**0.67**
FWH 8 Heating	**1.87**
FWH 9 Heating	**1.24**
FPT Main Steam	**0.33**
FPT Exhaust (to condenser)	**0.00**

* Non-heat balance pipes are shown in PEACE output

Project Cost Summary	Reference Cost	Estimated Cost	
Power Plant:			
I Specialized Equipment	388,498,000	505,047,000	USD
II Other Equipment	65,782,000	85,517,000	USD
III Civil	62,628,000	101,083,000	USD
IV Mechanical	195,511,000	346,455,000	USD
V Electrical Assembly & Wiring	19,405,000	35,470,000	USD
VI Buildings & Structures	18,861,000	31,357,000	USD
VII Engineering & Plant Startup	56,261,000	57,134,000	USD
CO2 Capture Plant	NA	NA	
Desalination Plant	NA	NA	
Subtotal - Contractor's Internal Cost	806,945,000	1,162,062,000	USD
VIII Contractor's Soft & Miscellaneous Costs	136,215,000	224,948,000	USD
Contractor's Price	943,160,000	1,387,010,000	USD
IX Owner's Soft & Miscellaneous Costs	188,632,000	277,402,000	USD
Total - Owner's Cost (1 USD per US Dollar)	1,131,792,000	1,664,412,000	USD
Nameplate Net Plant Output	650	650	MW
Cost per kW - Contractor's	1451.3	2134.2	USD per kW
Cost per kW - Owner's	1741.5	2561.1	USD per kW
* Cost estimates as of August 2016.			
** Land cost, utility connection cost, and spare parts costs are zero.			
The user may want to edit those inputs for better cost estimates.			

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
I Specialized Equipment (USD)				388,498,000	505,047,000
1. Boiler		183,772,000	1	183,772,000	238,903,000
Furnace (incl. radiant platens)	64,209,000				
Convective Elements (incl. interconnecting piping)	68,236,000				
Additional Waterwall	5,673,000				
Soot Blowers	5,349,000				
Desuperheaters and Controls	7,622,000				
Air and Flue Gas Ducts	5,771,000				
Coal Pulverisers and Feeders	17,507,000				
FD Fan, PA Fan, ID Fan	1,713,000				
Structural Steel, Ladders, Walkways	3,291,000				
Steam Air Heater					
Rotary Air Heaters	4,401,000				
Approximate shipping to typical US site	incl.				
2. Steam Turbine Package		82,605,000	1	82,605,000	107,386,000
Turbine	incl.				
Generator	incl.				
Exhaust System	incl.				
Electrical/Control/Instrumentation Package	incl.				
Lube Oil Package w/ main, auxiliary & emergency pump	incl.				
High Voltage Generator					
Approximate shipping to typical US site	incl.				
3. Feedwater Heaters			13	9,964,000	12,954,000
Feedwater Heater 1-P	700,500		1		
Feedwater Heater 2	669,900		1		
Feedwater Heater 3	583,600		1		
Feedwater Heater 4	532,600		1		
Feedwater Heater 5-DA	985,600		1		
Feedwater Heater 6 (6A, 6B)	810,700		2		
Feedwater Heater 7 (7A, 7B)	830,100		2		
Feedwater Heater 8 (8A, 8B)	1,019,000		2		
Feedwater Heater 9-S (9A, 9B)	586,300		2		
Feedwater Heater 10					
Feedwater Heater 11					
Feedwater Heater 12					
4. Water-cooled Condensers					
Water-cooled Condenser 1					
Water-cooled Condenser 2					
Water-cooled Condenser 3					
Water-cooled Condenser 4					
Water-cooled Condenser 5					
Water-cooled Condenser 6					
Feed Pump Turbine Water-cooled Condenser					
5. Air-cooled Condenser		61,128,000	1	61,128,000	79,466,000
Tube Bundles	incl.				
Fans, Gears, and Motors	incl.				
Steam Duct & Condenser	incl.				
Turbine Exhaust Transition	incl.				
Steam Jet Air Ejector	incl.				
Condensate Receiver Tank	incl.				
Support Structures	incl.				
Approximate shipping to typical US site	incl.				
6. Particulate and Mercury Control		18,608,000	1	18,608,000	24,190,000
Electrostatic Precipitator (ESP)	incl.				
Active Carbon Injection Equipment					
Ductwork	incl.				
Instruments & Controls	incl.				
Approximate shipping to typical US site	incl.				
7. Flue Gas Desulfurization					
Reagent Feed System					
Absorber Tower & Ancillaries					
Active Carbon Injection Equipment					
Slurry Pumps					
Flue Gas Handling System					
Flue Gas Reheater					
Waste/Byproduct Handling System					
Support Equipment					
8. Nitrogen Oxide Control (SCR)					
9. Stack		11,294,000	1	11,294,000	14,682,000
10. Continuous Emissions Monitoring System		373,300	1	373,300	485,300
Enclosures	incl.				
Electronics, Display Units, Printers & Sensors	incl.				
11. Distributed Control System		1,444,000	1	1,444,000	1,878,000
Enclosures	incl.				
Electronics, Display Units, Printers & Sensors	incl.				
Approximate shipping to typical US site					
12. Transmission Voltage Equipment		11,359,000	1	11,359,000	14,766,000
Transformers	9,857,000				
Circuit Breakers	960,800				
Miscellaneous Equipment	540,900				
Approximate shipping to typical US site	incl.				
13. Generating Voltage Equipment		7,951,000	1	7,951,000	10,336,000
Generator Buswork	4,477,000				
Circuit Breakers	3,095,000				

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
Current Limiting Reactors					
Miscellaneous Equipment	378,600				
Approximate shipping to typical US site	incl.				
14. User-defined				**0**	**0**

	Unit Cost	Quantity	Ref. Cost	Est. Cost
II Other Equipment (USD)			65,782,000	85,517,000
1. Pumps			8,694,000	11,302,000
Boiler Feed Pump (turbine included)	7,109,000	1	7,109,000	9,242,000
Boiler Feed Booster Pump	128,900	1	128,900	167,550
Condenser C.W. Pump				
Condensate Forwarding Pump	266,650	2	533,300	693,300
Condenser Vacuum Pump				
Fuel Oil Unloading Pump	8,490	1	8,490	11,030
Fuel Oil Forwarding Pump	5,730	2	11,450	14,890
Aux Cooling Water Pump (closed loop)				
Treated Water Pump	5,930	1	5,930	7,700
Diesel Fire Pump	72,800	3	218,450	284,000
Electric Fire Pump				
Jockey Fire Pump	4,220	1	4,220	5,490
ST+Generator Lube Oil Coolant Pump	9,070	2	18,150	23,590
ST Generator Coolant Pump	15,800	2	31,610	41,090
Demin Water Pump	5,870	2	11,730	15,250
Raw Water Pump 1	5,620	1	5,620	7,310
Raw Water Pump 2	5,620	1	5,620	7,310
Raw Water Pump 3				
District Heating Pump				
Aux Cooling Water Pump (open loop)				
FGD Slurry Pump	elsewhere			
Startup Boiler Feed Pump	601,100	1	601,100	781,500
2. Tanks		7	530,300	689,300
Fuel Oil	187,250	1	187,250	243,400
Hydrous Ammonia				
Demineralized Water	50,350	1	50,350	65,450
Raw Water	50,350	1	50,350	65,450
Neutralized Water	34,790	1	34,790	45,220
Acid Storage	7,280	1	7,280	9,460
Caustic Storage	7,280	1	7,280	9,460
Waste Water				
Dedicated Fire Protection Water Storage	193,000	1	193,000	250,900
3. Cooling Tower				
4. Auxiliary Heat Exchangers			737,500	958,700
Auxiliary Cooling Water Heat Exchanger				
Auxiliary Cooling Tower				
Primary Air Fan Fin Fan Cooler	79,750	3	239,200	310,950
Induced Draft Fan Fin Fan Cooler	83,050	6	498,300	647,800
Miscellaneous Heat Exchangers				
5. District Heaters				
District Heater 1				
District Heater 2				
6. Auxiliary Boiler				
7. Makeup Water Treatment System	1,319,000	1	1,319,000	1,715,000
8. Waste Water Treatment System	168,250	1	168,250	218,700
9. Bridge Crane(s)	1,545,000	1	1,545,000	2,009,000
Steam Turbine Crane				
10. Station/Instrument Air Compressors	156,400	5	782,100	1,017,000
11. Reciprocating Engine Genset(s)		6	13,551,000	17,616,000
Emergency Generator	810,700	1	810,700	1,054,000
Black Start Generator	2,548,000	5	12,740,000	16,562,000
12. General Plant Instrumentation	371,250	1	371,250	482,600
13. Medium Voltage Equipment	3,906,000	1	3,906,000	5,078,000
Transformers	552,800			
Circuit Breakers	124,800			
Switchgear	1,171,000			
Motor Control Centers	1,872,000			
Miscellaneous	186,000			
14. Low Voltage Equipment	2,537,000	1	2,537,000	3,298,000
Transformers	862,200			
Circuit Breakers	844,200			
Switchgear				
Motor Control Centers	709,800			
Miscellaneous	120,800			
15. Coal Handling Equipment	24,108,000	1	24,108,000	31,341,000
16. Ash Handling Equipment	4,400,000	1	4,400,000	5,720,000
17. Miscellaneous Equipment	3,132,000		3,132,000	4,072,000
18. User-defined			0	0

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
III Civil (USD)						**62,628,000**	**101,083,000**
1. Site Work	**8,668,000**	**148,500**	**36**			**14,013,000**	**22,092,000**
Site Clearing	incl.	incl.					
Demolition	incl.	incl.					
Culverts & Drainage	incl.	incl.					
Erosion Control	incl.	incl.					
Fencing, Controlled Access Gates	incl.	incl.					
Finish Grading	incl.	incl.					
Finish Landscaping	incl.	incl.					
Material (Dirt, Sand, Stone)	incl.	incl.					
Waste Material Removal	incl.	incl.					
Obstacles R&R	incl.	incl.					
Miscellaneous	incl.	incl.					
2. Excavation & Backfill	**1,652,000**	**35,880**	**36**	**72.16**	**40,790 m^3**	**2,944,000**	**4,763,000**
Steam Turbine	164,950	3,600	36	66.77	4,410 m^3	294,650	477,050
Boiler	872,500	19,200	36	69.02	22,660 m^3	1,564,000	2,534,000
Stack	elsewhere	elsewhere					
Water Cooled Condenser(s)							
Cooling Tower							
Air Cooled Condenser	248,800	5,360	36	94.34	4,680 m^3	441,600	713,900
Particulate and Mercury Control	78,300	1,740	36	71.42	1,970 m^3	140,750	228,300
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Feedwater Heaters	24,480	698	36	61.03	813 m^3	49,620	82,750
District Heater(s)							
Underground Piping	92,450	1,460	36	74.96	1,930 m^3	144,900	226,400
Switchyard	5,130	114	36	90.48	102 m^3	9,220	14,950
Miscellaneous	165,350	3,710	36	70.86	4,220 m^3	298,950	485,500
3. Concrete	**24,426,000**	**566,800**	**36**	**1,360**	**33,070 m^3**	**44,829,000**	**73,070,000**
Steam Turbine	2,625,000	54,350	36	2,090	2,190 m^3	4,582,000	7,376,000
Laydown pads:	48,940	1,390	36		67.86 m^3	99,150	165,250
Steam Turbine	48,940	1,390	36	1,460	67.86 m^3	99,150	165,250
Boiler	11,238,000	257,250	36	1,380	14,820 m^3	20,499,000	33,363,000
Stack	elsewhere	elsewhere					
Water Cooled Condenser(s)							
Cooling Tower							
Air Cooled Condenser	837,700	22,330	36	1,570	1,050 m^3	1,641,000	2,717,000
Particulate and Mercury Control	504,800	11,740	36	1,140	811 m^3	927,600	1,512,000
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Underground Piping:							
Circulating Water							
Miscellaneous							
Makeup Water Treatment System	18,990	587	36	1,770	22.64 m^3	40,130	67,500
Auxiliary Boiler							
Electrical Power Equipment	1,186,000	30,470	36	1,430	1,600 m^3	2,283,000	3,763,000
Feedwater Heaters	197,150	7,810	36	871	549 m^3	478,250	825,600
Pumps	247,050	7,200	36	1,370	369 m^3	506,100	845,800
Auxiliary Heat Exchangers	45,030	1,840	36	1,140	97.33 m^3	111,150	192,450
District Heater(s)							
Station/Instrument Air Compressors	87,400	2,250	36	2,800	60.13 m^3	168,400	277,700
Bridge Crane(s)							elsewhere
Reciprocating Engine Genset(s)	498,600	13,350	36	1,470	664 m^3	979,400	1,622,000
Tanks:	345,000	10,430	36		567 m^3	720,600	1,209,000
Fuel Oil	142,850	4,110	36	1,100	264 m^3	290,650	484,950
Hydrous Ammonia							
Demineralized Water	29,680	942	36	1,610	39.58 m^3	63,600	107,250
Raw Water	29,680	942	36	1,610	39.58 m^3	63,600	107,250
Neutralized Water	20,120	661	36	2,170	20.21 m^3	43,920	74,350
Acid Storage	4,440	149	36	2,450	3.991 m^3	9,790	16,610
Caustic Storage	4,440	149	36	2,450	3.991 m^3	9,790	16,610
Waste Water							
Dedicated Fire Protection Water Storage	113,800	3,480	36	1,220	196 m^3	239,250	401,950
Switchyard	52,400	1,560	36	1,350	80.56 m^3	108,600	181,900
Fuel Handling System	4,273,000	92,650	36	1,070	7,120 m^3	7,609,000	12,309,000
Miscellaneous	2,221,000	51,500	36	1,360	3,010 m^3	4,075,000	6,643,000
4. Roads, Parking, Walkways	**756,200**	**2,290**	**37.63**			**842,300**	**1,157,000**
Pavement, Curbing, Striping	621,600	1,670	36	4.2	15070	681,500	929,500
Lighting	134,650	623	42	5,740	28	160,800	228,000
5. User-defined						**0**	**0**

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
IV Mechanical (USD)						**195,511,000**	**346,455,000**
1. On-Site Transportation & Rigging	**9,997,000**					**9,997,000**	**16,620,000**
2. Equipment Erection & Assembly	**18,950,000**	**2,572,000**	**41**			**124,393,000**	**238,157,000**
Steam Turbine Package	443,500	60,550	41	2,925,000	1	2,925,000	5,602,000
Boiler	10,610,000	1,448,000	41	69,982,000	1	69,982,000	134,022,000
Feedwater Heaters	73,800	10,070	41			486,850	932,300
Condenser(s)	1,954,000	266,650	41			12,885,000	24,677,000
Cooling Tower							
Particulate and Mercury Control	2,201,000	300,350	41	14,515,000	1	14,515,000	27,797,000
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Coal Handling System	934,500	127,550	41	6,164,000	1	6,164,000	11,805,000
Ash Handling System	889,200	121,350	41	5,865,000	1	5,865,000	11,232,000
Makeup Water Treatment System	147,350	6,440	41			411,200	725,800
Auxiliary Boiler							
Electrical Power Equipment	257,300	35,120	41			1,697,000	3,250,000
Pumps	52,900	7,220	41			348,950	668,300
Tanks + Auxiliary Heat Exchangers	44,810	6,120	41			295,550	566,000
District Heater(s)							
Station/Instrument Air Compressors	5,900	805	41			38,900	74,500
Bridge Crane(s)	8,990	1,230	41			59,300	113,600
Reciprocating Engine Genset(s)	6,000	819	41			39,580	75,800
Miscellaneous	1,322,000	179,450	41			8,679,000	16,616,000
3. Piping	**42,863,000**	**394,800**	**41**	**2,830**	**20,840 m**	**59,051,000**	**88,502,000**
High Pressure Steam	8,635,000	23,260	41	44,370	216 m	9,589,000	13,157,000
Cold Reheat Steam	2,217,000	20,670	41	16,930	181 m	3,065,000	4,598,000
Hot Reheat Steam	5,471,000	34,440	41	29,480	233 m	6,884,000	9,972,000
FWH Heating Steam	1,623,000	18,050	41	4,860	486 m	2,363,000	3,609,000
Other Steam & Heating	2,487,000	16,940	41	27,040	118 m	3,182,000	4,640,000
Feedwater	9,560,000	46,950	41	13,230	868 m	11,485,000	16,326,000
Circulating Water							
Auxiliary Cooling Water	251,900	4,770	41	1,280	349 m	447,700	723,900
Other Water	21,370	1,370	41	216	358 m	77,550	141,600
Raw Water	138,400	5,600	41	516	714 m	368,050	645,000
Service Water	271,550	10,350	41	567	1,230 m	695,800	1,212,000
Fuel Gas							
Fuel Oil							
Service Air	173,100	5,250	41	422	920 m	388,200	660,700
Vacuum Air	195,750	4,240	41	1,880	197 m	369,800	606,900
Ammonia							
Boiler & Equipment Drain	4,962,000	128,000	41	902	11,320 m	10,210,000	17,077,000
Boiler Blowdown							
Steam Blowoff	244,050	2,600	41	6,930	50.6 m	350,700	533,200
Fire Protection	3,619,000	44,790	41	2,540	2,150 m	5,456,000	8,424,000
Miscellaneous	2,990,000	27,550	41	2,830	1,450 m	4,120,000	6,175,000
4. Steel	**1,401,000**	**16,310**	**41**	**4,950**	**418**	**2,070,000**	**3,176,000**
Racks, Supports, Ladders, Walkways, Platforms	1,401,000	16,310	41	4,950	418	2,070,000	3,176,000
5. User-defined						**0**	**0**

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
V Electrical Assembly & Wiring (USD)						**19,405,000**	**35,470,000**
1. Controls	**699,300**	**241,100**	**42**			**10,826,000**	**21,415,000**
Steam Turbine Package	73,000	25,940	42	1,163,000	1	1,163,000	2,301,000
Boiler	354,400	125,900	42	5,643,000	1	5,643,000	11,170,000
Feedwater Heaters	2,300	817	42			36,600	72,450
Condenser(s)	132,450	47,050	42			2,109,000	4,174,000
Cooling Tower							
Particulate and Mercury Control	44,490	15,810	42	708,400	1	708,400	1,402,000
Flue Gas Desulfurization							
Nitrogen Oxide Control							
Coal Handling System	29,110	10,340	42	463,450	1	463,450	917,400
Ash Handling System	27,700	9,840	42	441,000	1	441,000	872,900
Makeup Water Treatment System	3,620	1,290	42			57,700	114,150
Auxiliary Boiler							
Electrical Power Equipment							
Pumps	8,710	3,090	42			138,700	274,500
Tanks + Auxiliary Heat Exchangers							
District Heater(s)							
Station/Instrument Air Compressors	8,090	345	42			22,580	39,860
Bridge Crane(s)	7,200	307	42			20,080	35,450
Reciprocating Engine Genset(s)	8,230	351	42			22,970	40,550
2. Assembly & Wiring	**4,576,000**	**95,300**	**42**			**8,579,000**	**14,055,000**
Switchgear	31,380	2,290	42	25,500	5	127,500	235,450
Motor Control Centers	69,200	4,310	42	2,880	87	250,200	456,500
Feeders	1,067,000	28,320	42	14,110	160	2,257,000	3,796,000
Medium/Low Voltage Cable Bus	2,333,000	31,750	42	39,000	94	3,666,000	5,733,000
Cable Tray	357,200	7,530	42	673,600	1	673,600	1,105,000
General Plant Instrumentation	177,950	3,190	42	1,370	227	311,800	502,400
Generator to Step-up Transformer Bus	40,790	725	42	71,200	1	71,200	114,650
Transformers	148,200	7,900	42	47,990	10	479,900	864,400
Circuit Breakers	127,600	4,530	42	26,500	12	317,950	551,400
Miscellaneous	224,000	4,750	42	423,650	1	423,650	695,500
3. User-defined						**0**	**0**

	Area	Cost/Unit Area	Ref. Cost	Est. Cost
VI Buildings (USD)			18,861,000	31,357,000
1. Boiler House and Turbine Hall	9496	1800.89	17,101,000	28,430,000
2. Administration, Control Room, Machine Shop / Warehouse	1486.5	1150.46	1,710,000	2,843,000
3. Water Treatment System	23.43	1200.48	28,130	46,760
4. Guard House	18.58	1200.48	22,310	37,080
5. Fuel Barn				
6. User-defined			0	0

	Material	Labor Hours	Labor Rate	Unit Cost	Quantity	Ref. Cost	Est. Cost
VII Engineering & Plant Startup (USD)						56,261,000	57,134,000
1. Engineering						46,077,000	46,077,000
2. Start-Up	2,911,000	79,850	91.07	10,183,000		10,183,000	11,057,000
3. User-defined						0	0

	Ref. Cost	Est. Cost
VIII Soft & Miscellaneous Costs (USD)		
1. Contractor's Soft Costs	**136,215,000**	**224,948,000**
Contingency:	41,212,000	72,154,000
Labor	25,624,000	51,889,000
Specialized Equipment	7,770,000	10,101,000
Other Equipment	1,973,000	2,566,000
Commodity	5,845,000	7,599,000
Profit:	62,724,000	106,312,000
Labor	34,165,000	69,185,000
Specialized Equipment	19,425,000	25,252,000
Other Equipment	3,289,000	4,276,000
Commodity	5,845,000	7,599,000
Permits, Licenses, Fees, Miscellaneous	0	0
Bonds and Insurance	8,069,000	11,621,000
Spare Parts & Materials	0	0
Contractor's Fee	24,208,000	34,862,000
2. Owner's Soft Costs	**188,632,000**	**277,402,000**
Permits, Licenses, Fees, Miscellaneous	18,863,000	27,740,000
Land Cost	0	0
Utility Connection Cost	0	0
Legal & Financial Costs	18,863,000	27,740,000
Escalation and Interest During Construction	141,474,000	208,051,000
Spare Parts & Materials	0	0
Project Administration & Developer's Fee	9,432,000	13,870,000
3. Total of all user-defined costs displayed on each account	**0**	**0**

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
CO2 Capture Plant (USD)				0	0
1. CO2 Capture					
Absorbers					
Strippers					
CO2 compressors and dehydrators					
Heat exchangers					
Pumps					
Piping					
Electrical & Controls					
Engineering & Design					
Miscellaneous					
Approximate shipping to typical US site					
2. User-defined				0	0

	Item Cost	Unit Cost	Quantity	Ref. Cost	Est. Cost
Desalination Plant (USD)				0	0
1. Desalination					
MSF System					
- Evaporators					
- Brine Heater					
- Deaerator					
- Pumps					
- Piping					
- Electrical & Controls					
- Intake System & Distillate Delivery					
- Engineering & Design					
- Platform/ladder/walkway					
- Miscellaneous					
RO System					
- Intake & Outfall					
- Pre-treatment System					
- Pumps					
- Energy Recovery Device					
- RO Membrane Assembly					
- Post-treatment System					
- Miscellaneous					
Approximate shipping to typical US site					
2. User-defined				0	0

Estimated Site Plan Data		
1. Site Plot Plan		
Length	430	m
Width	400	m
Area	17.17	hectare
2. Boiler House and Turbine Hall		
Area	9,500	m^2
3. Switchyard		
Length	117	m
Width	74.9	m
Area	8,770	m^2
4. Water Treatment Facility		
Length	6.8	m
Width	3.4	m
Area	23.43	m^2
5. Administration, Shop & Warehouse Building		
Length	35.2	m
Width	14.1	m
Area	1,490	m^2
Number of Floors	3	
6. Road		
Length	851	m
Width	7.6	m
Area	6,490	m^2
7. Parking Lot		
Number of Parking Spaces	16	
Total Width	48.8	m
Depth of Parking Space	6.1	m
Total Area	297	m^2
8. Walkways		
Area	8,580	m^2
9. Guard House		
Area	18.58	m^2

Estimated Piping Data	ID x No.	Nom. D [mm]	Length [m]	Schedule	Material	Fittings	M [t/h]	Design Flow	Design Vel. [m/s]
1. High Pressure Steam Piping									
BLR to HPT	HP0 x 1	457.2	172.5	Custom	TP347HFG	8	1918.4	6.682 m^3/s	41.26 m/s
HP Bypass	HPBP x 1	457.2	43.59	Custom	TP347HFG	3	1918.4	6.682 m^3/s	41.26 m/s
2. Cold Reheat Steam Piping									
Cold Reheat	CRH0 x 1	730.3	181.1	Custom	P-22	8	1740.2	20.04 m^3/s	48.71 m/s
3. Hot Reheat Steam Piping									
Hot Reheat	HRH0 x 1	812.8	189.9	Custom	TP347HFG	8	1740.2	31.09 m^3/s	61.05 m/s
IP Bypass	IPBP x 1	812.8	43.59	Custom	TP347HFG	3	1740.2	31.09 m^3/s	61.05 m/s
4. FWH Heating Steam Piping									
FWH 1 Heating	FWHHS1 x 1	762	10.67	10	A-106	4	59.99	55.51 m^3/s	133 m/s
FWH 2 Heating	FWHHS2 x 1	609.6	21.34	40	A-106	6	66.09	24.23 m^3/s	97.29 m/s
FWH 3 Heating	FWHHS3 x 1	457.2	32	40	A-106	7	70.11	12.98 m^3/s	94.24 m/s
FWH 4 Heating	FWHHS4 x 1	406.4	42.67	40	A-106	9	73.38	7.521 m^3/s	67.93 m/s
Deaerator (FWH 5) Heating	FWHHS5 x 1	406.4	103	40	A-106	19	76.74	4.794 m^3/s	43.07 m/s
FWH 6 Heating	FWHHS6 x 2	203.2	37.19	40	P-11	8	32.89	1.308 m^3/s	40.97 m/s
FWH 8 Heating	FWHHS8 x 2	203.2	47.85	60	P-22	10	66.21	0.7624 m^3/s	24.78 m/s
FWH 9 Heating	FWHHS9 x 2	203.2	53.04	60	P-91	11	61.58	1.482 m^3/s	48.9 m/s
5. Other Steam & Heating Piping									
FPT Main Steam	FPTMS1 x 1	609.6	71.02	40	A-106	9	147.3	15.1 m^3/s	59.5 m/s
FPT Exhaust (to condenser)	FPTX1 x 1	3048	46.63	20	A-106	5	147.3	567.5 m^3/s	82.48 m/s
6. Feedwater Piping									
FWH 1 Exit Feedwater	FWFW1 x 1	508	23.47	20	A-106	2	1245.5	21303 lpm	1.891 m/s
FWH 2 Exit Feedwater	FWFW2 x 1	609.6	24.99	20	A-106	2	1520.3	26517 lpm	1.614 m/s
FWH 3 Exit Feedwater	FWFW3 x 1	609.6	22.25	20	A-106	2	1520.3	27152 lpm	1.652 m/s
FWH 4 Exit Feedwater	FWFW4 x 1	609.6	103	20	A-106	11	1520.3	27918 lpm	1.699 m/s
Deaerator (FWH 5) Exit Feedwater	FWFW5 x 1	609.6	103	20	A-106	11	1918.4	36418 lpm	2.214 m/s
FWH 6 Exit Feedwater	FWFW6 x 2	412.8	16.76	Custom	A-106	2	959.2	18517 lpm	2.307 m/s
FWH 7 Exit Feedwater	FWFW7 x 2	425.5	14.94	Custom	A-106	2	959.2	19362 lpm	2.27 m/s
FWH 8 Exit Feedwater	FWFW8 x 2	431.8	17.68	Custom	A-106	2	959.2	20379 lpm	2.319 m/s
FWH 9 Exit Feedwater	FWFW9 x 2	438.2	7.62	Custom	A-106	2	959.2	20699 lpm	2.288 m/s
Feedwater to Boiler	FW3 x 1	622.3	176.5	Custom	A-106	14	1918.4	41397 lpm	2.269 m/s
Condensate	FW1 x 1	457.2	300.8	20	A-106	14	1245.5	20969 lpm	2.284 m/s
7. Circulating Water Piping									
8. Auxiliary Cooling Water Piping									
CW for ST+Generator Lube Oil	CW7 x 1	203.2	174.3	40	A-106	20	169.7	2836.3 lpm	1.465 m/s
CW for ST Generator	CW8 x 1	254	174.3	40	A-106	16	355.1	5933 lpm	1.944 m/s
9. Other Water Piping									
Makeup from Water Treatment System	FW2 x 1	63.5	358.4	40	A-106	14	22.89	381.9 lpm	2.061 m/s
10. Raw Water Piping									
Raw Water	RW0 x 1	88.9	713.9	40	A-106	118	22.89	382.2 lpm	0.9987 m/s
11. Service Water Piping									
Service Water	SW0 x 1	76.2	1226.5	40	A-106	303	NA	NA	0.9541 m/s
12. Fuel Gas Piping									
13. Fuel Oil Piping									
14. Service Air Piping									
Service Air	SERVA x 1	50.8	919.9	40	A-106	228	NA	NA	31.1 m/s
15. Vacuum Air Piping									
Condenser Air Removal	CAR0 x 1	203.2	197.2	80	A-106	50	NA	NA	25.73 m/s
16. Ammonia Piping									
17. Boiler & Equipment Drain Piping									
FWH 1 Drain	FWDW1 x 1	254	32.31	40	A-106	4	274.8	4710 lpm	1.535 m/s
FWH 2 Drain	FWDW2 x 1	203.2	32.31	40	A-106	4	209.6	3601 lpm	1.859 m/s
FWH 3 Drain	FWDW3 x 1	152.4	31.39	40	A-106	4	143.5	2514.7 lpm	2.249 m/s
FWH 4 Drain	FWDW4 x 1	127	28.35	40	A-106	4	73.38	1317.5 lpm	1.701 m/s
FWH 6 Drain	FWDW6 x 2	203.2	89.92	40	A-106	4	160.7	3105 lpm	1.604 m/s
FWH 7 Drain	FWDW7 x 2	152.4	21.03	40	A-106	4	127.8	2549.8 lpm	2.28 m/s
FWH 8 Drain	FWDW8 x 2	127	21.64	80	A-106	4	66.21	1391.9 lpm	1.976 m/s
Small Drains	BEDR1 x 36	101.6	151.8	40	A-106	17	NA	NA	0.3452 m/s
Medium Drains	BEDR2 x 22	152.4	151.8	40	A-106	17	NA	NA	0.1521 m/s
Large Drains	BEDR3 x 14	254	151.8	40	A-106	17	NA	NA	0.0557 m/s
18. Boiler Blowdown Piping									
19. Steam Blowoff Piping									
Steam Blowoff Piping	STBL x 2	457.2	25.3	40	A-106	9	NA	NA	2.248 m/s
20. Fire Protection Piping									
Main Fire Protection	FP0 x 1	508	1073.2	20	A-106	90	1362	22712 lpm	2.016 m/s

Estimated Piping Data	ID x No.	Nom. D [mm]	Length [m]	Schedule	Material	Fittings	M [t/h]	Design Flow	Design Vel. [m/s]
Miscellaneous Fire Protection	FP1 x 1	406.4	1073.2	20	A-106	90	681	11356 lpm	1.58 m/s

Estimated Pump Data		
Number of Units	1	
Boiler Feed Pump		
Pump type	Multistage centrifugal	
Drive type	Variable RPM	
Number per Boiler	1 - 100%	
Nameplate (unrounded) mass flow	2131.5	t/h
Nameplate (unrounded) head	3155	m
Nameplate volume flow	41640	lpm
Nameplate head	3170	m H2O
Pump shaft speed	3000	RPM
Shaft power	34000	hp
Pump isentropic efficiency	75	%
Pump mechanical efficiency	97	%
Baseplate length (each)	12.77	m
Baseplate width (each)	3.802	m
Pump weight (each)	91905	kg
Turbine weight (each)	79152	kg
Boiler Feed Booster Pump		
Pump type	Vertical canned	
Drive type	Fixed RPM	
Number per Boiler	1 - 100%	
Nameplate (unrounded) mass flow	2131.5	t/h
Nameplate (unrounded) head	81.81	m
Nameplate volume flow	41640	lpm
Nameplate head	83.82	m H2O
Pump shaft speed	600	RPM
Shaft power	800	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.804	m
Baseplate width (each)	1.804	m
Pump weight (each)	2102.7	kg
Motor weight (each)	2068.3	kg
Condenser C.W. Pump (P4)		
Number of Pumps per ST	None	
Condensate Forwarding Pump		
Pump type	Vertical canned	
Drive type	Fixed RPM	
Number per ST	2 - 100%	
Nameplate (unrounded) mass flow	1383.9	t/h
Nameplate (unrounded) head	237.6	m
Nameplate volume flow	24605	lpm
Nameplate head	243.8	m H2O
Pump shaft speed	750	RPM
Shaft power	1500	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	2.077	m
Baseplate width (each)	2.077	m
Pump weight (each)	3965	kg
Motor weight (each)	3411	kg
Condenser Vacuum Pump (P7)		
Number of Pumps per ST	None	
Fuel Oil Unloading Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	111.5	t/h
Nameplate (unrounded) head	45.81	m
Nameplate volume flow	2271.2	lpm
Nameplate head	53.34	m H2O
Pump shaft speed	3000	RPM
Shaft power	23	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.389	m
Baseplate width (each)	0.4881	m
Pump weight (each)	247	kg
Motor weight (each)	122.5	kg
Fuel Oil Forwarding Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	2 - 100%	
Nameplate (unrounded) mass flow	41.48	t/h
Nameplate (unrounded) head	38.17	m
Nameplate volume flow	851.7	lpm
Nameplate head	45.72	m H2O

Estimated Pump Data		
Pump shaft speed	3000	RPM
Shaft power	7	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.074	m
Baseplate width (each)	0.375	m
Pump weight (each)	129.2	kg
Motor weight (each)	49.54	kg
Aux Cooling Water Pump (closed loop) (P10)		
Number of Pumps per Plant	None	
Treated Water Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	22.89	t/h
Nameplate (unrounded) head	57.55	m
Nameplate volume flow	416.4	lpm
Nameplate head	60.96	m H2O
Pump shaft speed	3000	RPM
Shaft power	6	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.032	m
Baseplate width (each)	0.3598	m
Pump weight (each)	116.7	kg
Motor weight (each)	41.18	kg
Diesel Fire Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	3 - 100%	
Nameplate (unrounded) mass flow	449.1	t/h
Nameplate (unrounded) head	70.44	m
Nameplate volume flow	7571	lpm
Nameplate head	76.2	m H2O
Pump shaft speed	3000	RPM
Shaft power	140	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	2.071	m
Baseplate width (each)	0.7358	m
Pump weight (each)	1692.9	kg
Electric Fire Pump (P13)		
Number of Pumps per Plant	None	
Jockey Fire Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	10.25	t/h
Nameplate (unrounded) head	30.54	m
Nameplate volume flow	170.3	lpm
Nameplate head	38.1	m H2O
Pump shaft speed	3000	RPM
Shaft power	1.5	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	0.753	m
Baseplate width (each)	0.2604	m
Pump weight (each)	52.71	kg
Motor weight (each)	15.19	kg
ST+Generator Lube Oil Coolant Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per ST+Generator Lube Oil	2 - 100%	
Nameplate (unrounded) mass flow	169.7	t/h
Nameplate (unrounded) head	30.54	m
Nameplate volume flow	3028	lpm
Nameplate head	38.1	m H2O
Pump shaft speed	3000	RPM
Shaft power	23	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.393	m
Baseplate width (each)	0.4897	m
Pump weight (each)	249	kg
Motor weight (each)	133.1	kg
ST Generator Coolant Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	

Estimated Pump Data		
Number per ST Generator	2 - 100%	
Nameplate (unrounded) mass flow	355.1	t/h
Nameplate (unrounded) head	30.54	m
Nameplate volume flow	6624	lpm
Nameplate head	38.1	m H2O
Pump shaft speed	1500	RPM
Shaft power	50	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.638	m
Baseplate width (each)	0.5782	m
Pump weight (each)	374.5	kg
Motor weight (each)	235.5	kg
Demin Water Pump		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	2 - 100%	
Nameplate (unrounded) mass flow	22.89	t/h
Nameplate (unrounded) head	55.24	m
Nameplate volume flow	416.4	lpm
Nameplate head	60.96	m H2O
Pump shaft speed	3000	RPM
Shaft power	6	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	1.023	m
Baseplate width (each)	0.3565	m
Pump weight (each)	114.1	kg
Motor weight (each)	39.9	kg
Raw Water Pump 1		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	22.89	t/h
Nameplate (unrounded) head	46.04	m
Nameplate volume flow	416.4	lpm
Nameplate head	53.34	m H2O
Pump shaft speed	3000	RPM
Shaft power	4.75	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	0.9825	m
Baseplate width (each)	0.3422	m
Pump weight (each)	103.1	kg
Motor weight (each)	34.65	kg
Raw Water Pump 2		
Pump type	Single stage centrifugal	
Drive type	Fixed RPM	
Number per Plant	1 - 100%	
Nameplate (unrounded) mass flow	22.89	t/h
Nameplate (unrounded) head	46.04	m
Nameplate volume flow	416.4	lpm
Nameplate head	53.34	m H2O
Pump shaft speed	3000	RPM
Shaft power	4.75	hp
Pump isentropic efficiency	85	%
Pump mechanical efficiency	97	%
Baseplate length (each)	0.9825	m
Baseplate width (each)	0.3422	m
Pump weight (each)	103.1	kg
Motor weight (each)	34.65	kg
Raw Water Pump 3 (P28)		
Number of Pumps per Plant	None	
District Heating Pump (P29)		
Number of Pumps per DHC	None	
Aux Cooling Water Pump (open loop) (P30)		
Number of Pumps per Plant	None	
FGD Slurry Pump (P31)		
Number of Pumps per FGD	None	
Startup Boiler Feed Pump		
Pump type	Multistage centrifugal	
Drive type	Fixed RPM	
Number per Boiler	1 - 100%	
Nameplate (unrounded) mass flow	532.9	t/h
Nameplate (unrounded) head	3335	m
Nameplate volume flow	10410	lpm
Nameplate head	3353	m H2O

Estimated Pump Data		
Pump shaft speed	3000	RPM
Shaft power	9000	hp
Pump isentropic efficiency	75	%
Pump mechanical efficiency	97	%
Baseplate length (each)	5.147	m
Baseplate width (each)	1.874	m
Pump weight (each)	24282	kg
Motor weight (each)	20235	kg

Estimated Electric Load Data	Number in plant	Nameplate kW (each)	Nominal kW Operating	Nominal kW Standby	Nominal kWe Operating	Nominal kWe Standby	Voltage	Heat Balance Aux. kWe
1. Pump Motors								
Boiler Feed Booster Pump	1	597	597	0	600	0	6600 V	583.9
Condensate Forwarding Pump	2	1,120	1,120	1,120	1,200	1,200	6600 V	1096.9
Fuel Oil Unloading Pump	1	15.66	0	15.66	0	19	415 V	0
Fuel Oil Forwarding Pump	2	4.847	4.847	4.847	6	6	415 V	6
Treated Water Pump	1	3.729	3.729	0	5	0	415 V	5
Jockey Fire Pump	1	1.119	1.119	0	1.25	0	415 V	1.25
ST+Generator Lube Oil Coolant Pump	2	17.15	17.15	17.15	19	19	415 V	19
ST Generator Coolant Pump	2	37.29	37.29	37.29	40	40	415 V	40
Demin Water Pump	2	3.729	3.729	3.729	4.75	4.75	415 V	4.75
Raw Water Pump 1	1	3.169	3.169	0	4	0	415 V	4
Raw Water Pump 2	1	3.169	3.169	0	4	0	415 V	4
Startup Boiler Feed Pump	1	6,710	0	6,710	0	7,000	6600 V	0
FWH 1 Drain Water Pump	3	130	261	130	260	130	415 V	205.9
2. Auxiliary Cooling Fan Motors								
ST+Generator Lube Oil Fin Fan Cooler Fan	3	48.47	145	0	165	0	415 V	165
ST Generator Fin Fan Cooler Fan	6	48.47	291	0	330	0	415 V	330
3. Air Cooled Condenser Fan Motors								
Air Cooled Condenser Fan	64	130	8,350	0	7,680	0	415 V	7014
4. Air Compressor Motors								
Station Air Compressor	5	205	1,030	0	1,120	0	6600 V	1025.3
5. Water Treatment System Motors								
Misc. Water Treatment Auxiliary Loads	18	52.2	313	626	330	660	415 V	271.5
6. Bridge Crane Motors								
ST bridge crane hoist motor	1	89.48	0	89.48	0	100	415 V	0
ST bridge crane bridge motor	2	6.338	0	12.68	0	15	415 V	0
ST bridge crane trolley motor	2	5.966	0	11.93	0	14	415 V	0
7. Boiler Fans								
Boiler Forced Draft Fan	3	746	2,240	0	2,400	0	6600 V	1924.1
Boiler Induced Draft Fan	3	1,040	3,130	0	3,300	0	6600 V	2668.7
Primary Air Fan	3	671	2,010	0	2,100	0	6600 V	1436.7
8. Pollution Control								
Electrostatic Precipitator	1	2,050	2,050	0	2,000	0	6600 V	1613.1
Ash Handling	3	522	1,040	522	1,100	550	6600 V	856.5
9. Fuel Delivery Motors								
Fuel Handling	7	746	5,220	0	5,600	0	6600 V	4439
10. ST Auxiliary Loads								
ST Lube Oil Pumps	2	1,300	1,300	1,300	1,300	1,300	6600 V	1018.1
Misc. ST Aux Loads	18	18.64	336	0	360	0	415 V	356.4
11. Miscellaneous Plant Loads								
HVAC Loads	1	112	112	0	120	0	415 V	120
Lighting Loads	1	298	298	0	275	0	415 V	275
Misc. Plant Aux Loads 1	8	205	1,230	410	1,200	400	6600 V	1187.8
Misc. Plant Aux Loads 2	9	55.93	503	0	540	0	415 V	509.1
Total Plant Motors & Loads	**180**		**42,450**	**14,770**	**32,070**	**11,460**		**27180.7**
Total 6600 V Motors & Loads					21,920	10,450		
Total 415 V Motors & Loads					10,140	1,010		

Estimated Main Electrical Data		
1. Steam Turbine Step-up Transformer		
Count	1	
Nominal Rating	792	MVA
Cooling	OA/FA/FA	
Configuration	Circuit Breaker Connected	
High-side Voltage	500	kV
Low-side Voltage	20	kV
Length	27.92	m
Width	9.306	m
Weight	627,400	kg
Unit Mechanical Installation hours	6,290	hours
Unit Electrical Installation hours	6,290	hours
Unit Reference Cost	9,857,000	USD
2. Medium Voltage Step-down Transformer		
Count	2	
Nominal Rating	17.99	MVA
High-side Voltage	20	kV
Low-side Voltage	6.6	kV
Length	2.406	m
Width	1.925	m
Weight	11,870	kg
Unit Mechanical Installation hours	298	hours
Unit Electrical Installation hours	298	hours
Unit Reference Cost	276,400	USD
3. Low Voltage Step-down Transformer		
Count	7	
Nominal Rating	1.77	MVA
High-side Voltage	20	kV
Low-side Voltage	0.415	kV
Length	2.198	m
Width	1.758	m
Weight	5,740	kg
Unit Mechanical Installation hours	144	hours
Unit Electrical Installation hours	144	hours
Unit Reference Cost	123,150	USD
4. Steam Turbine Generator Circuit Breaker		
Count	1	
Voltage	20	kV
Amperage	22,860	Amps
Unit Mechanical Installation hours	319	hours
Unit Electrical Installation hours	638	hours
Unit Reference Cost	3,095,000	USD
5. Utility Interconnect Circuit Breaker		
Count	1	
Voltage	500	kV
Amperage	859	Amps
Unit Mechanical Installation hours	182	hours
Unit Electrical Installation hours	364	hours
Unit Reference Cost	960,800	USD
6. Auxiliary Bus Feeder Circuit Breaker		
Count	1	
Voltage	20	kV
Amperage	1,400	Amps
Unit Mechanical Installation hours	159	hours
Unit Electrical Installation hours	317	hours
Unit Reference Cost	38,350	USD
7. Medium Voltage Circuit Breaker		
Count	2	
Voltage	6.6	kV
Amperage	1,570	Amps
Unit Mechanical Installation hours	163	hours
Unit Electrical Installation hours	327	hours
Unit Reference Cost	43,220	USD
8. Low Voltage Circuit Breaker		
Count	7	
Voltage	0.415	kV
Amperage	2,460	Amps
Unit Mechanical Installation hours	183	hours
Unit Electrical Installation hours	366	hours
Unit Reference Cost	120,600	USD
9. Generator to Step-up Transformer Bus		
Steam Turbine Generator Bus Type	Isolated phase bus	
Number generators	1	
Length (per generator)	73.63	m
Mechanical installation hours (per generator)	1,450	hours
Electrical installation hours (per generator)	725	hours

Estimated Main Electrical Data		
Reference Cost (per generator)	4,477,000	USD
10. Plant Buswork		
Low Voltage		
Total length (all runs)	14,550	m
Total Electrical Installation hours	26,450	hours
Total Reference Equipment Cost	1,918,000	USD
Medium Voltage		
Total length (all runs)	5,560	m
Total Electrical Installation hours	5,310	hours
Total Reference Equipment Cost	258,300	USD
11. Switch Gear		
Low Voltage		
Number sections in plant	0	
Medium Voltage		
Number sections in plant	5	
Total weight	8,870	kg
Total Mechanical Installation hours	687	hours
Total Electrical Installation hours	2,290	hours
Total Reference Equipment Cost	1,171,000	USD
12. Motor Control Centers		
Low Voltage		
Number sections in plant	67	
Total number of starters	123	
Total load on all starters	11,300	kW
Total weight	30,390	kg
Total Mechanical Installation hours	829	hours
Total Electrical Installation hours	2,760	hours
Total Reference Equipment cost	709,800	USD
Medium Voltage		
Number sections in plant	20	
Total number of starters	37	
Total load on all starters	28,430	kW
Total weight	28,070	kg
Total Mechanical Installation hours	464	hours
Total Electrical Installation hours	1,550	hours
Total Reference Equipment cost	1,872,000	USD
13. Motor & Load Feeders		
Low Voltage		
Number runs in plant	123	
Total length (all runs)	11,040	m
Total Electrical Installation hours	23,580	hours
Total Reference Equipment Cost	815,100	USD
Medium Voltage		
Number runs in plant	37	
Total length (all runs)	2,640	m
Total Electrical Installation hours	4,740	hours
Total Reference Equipment Cost	180,500	USD
14. Cable Tray		
Total length (all runs)	4,020	m
Total Mechanical Installation hours	21,520	hours
Total Electrical Installation hours	7,530	hours
Total Reference Equipment Cost	357,200	USD
15. General Plant Instrumentation		
Instrument Count	69.19	
Total Electrical Installation hours	3,190	hours
Total Reference Equipment Cost	371,250	USD

Estimated Tank Data	Number	Volume [l]	Diameter [m]	Height [m]
Fuel Oil	1	2,781,000	17.9	11
Demineralized Water	1	394,800	8.2	7.5
Raw Water	1	394,800	8.2	7.5
Neutralized Water	1	197,400	5.8	7.4
Acid Storage	1	23,690	2.4	5.1
Caustic Storage	1	23,690	2.4	5.1
Fire Protection	1	2,725,000	17.8	11

Estimated Water Treatment System Data		
1. Clarifier-Reactivator	**None**	
2. Pressure Filter	**None**	
3. Softener	**1 Twin Unit**	
Design Flow (8 hr continuous operation running one unit)	269	lpm
Exchange Capacity (each)	72,000	ppm per min.
Weight (twin unit)	33,820	kg
Cost (twin unit), Reference Basis	411,400	USD
4. Reverse Osmosis System	**None**	
5. Two-Bed Demineralizer	**1 Train**	
Design Flow (each)	269	lpm
Weight (each)	2,400	kg
Cost (each), Reference Basis	907,900	USD

Estimated Boiler Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
1. Boiler System Summary		
Boiler Type	Conventional, Two Pass	
Overall Length	40.95	m
Overall Width	18.99	m
Overall Height	67.41	m
Total Weight (wet)	14,128,000	kg
Total Weight (dry)	13,936,000	kg
Includes:		
- Furnace incl. burners & waterwall		
- Pulverizers & feeders		
- Boiler casing & refractory		
- Convective HX incl. waterwall		
- Desuperheaters and controls		
- Air & flue gas ducts		
- Burner piping & fittings		
- Soot blowers		
- Structural steel incl. walkways & ladders		
- Rotary air heater		
- Fans		
- Miscellaneous		
Overall Heat Transfer Surface Area	86,400	m^2
- Water Wall effective projected surface	5,270	m^2
- Economiser	48,090	m^2
- Superheater (convective & radiant)	13,380	m^2
- Reheater (convective & radiant)	19,680	m^2
Total Number of Tubes (in convective elements)	11,060	
Total Boiler Cost, Reference Basis	183,772,000	USD
Includes:		
- Furnace (incl. radiant platens)		
- Convective Elements (incl. interconnecting piping)		
- Additional Waterwall		
- Soot Blowers		
- Desuperheaters and Controls		
- Air and Flue Gas Ducts		
- Coal Pulverisers and Feeders		
- FD Fan, PA Fan, ID Fan		
- Supporting Steel Structure, Ladders, Walkways		
- Rotary Air Heater		
2. Furnace		
Furnace height (including hopper height if it exists)	67.41	m
Furnace width	18.99	m
Furnace depth	18.61	m
Aperture height	18.99	m
Hopper height	11.17	m
Furnace volume	21,850	m^3
Furnace effective projected radiant surface	7,160	m^2
Water wall effective projected surface	5,270	m^2
Radiant superheater	1,880	m^2
3. Horizontal Pass		
Height (tube length)	18.99	m
Width (boiler width)	18.99	m
Depth (duct length)	3.368	m
Gas flow frontal area	361	m^2
4. Second Vertical Downward Pass		
Height (duct length)	6.604	m
Width (boiler width)	18.99	m
Depth (tube length)	18.62	m
Gas flow frontal area	354	m^2
5. Rotary Air Heater		
Matrix heat transfer surface	46,770	m^2
Total flow cross section area	57.54	m^2
Total frontal surface	97.24	m^2
- Gas surface	50	%
- Secondary air surface	45.62	%
- Primary air surface	4.384	%
Unit height	6.035	m
Unit side dimension	12.73	m
Unit foot area	162	m^2

Estimated Steam Turbine Data		
Number of Units	1	
Displayed quantities in this table are on a per unit basis		
1. Steam Turbine Description		
Nameplate Capacity	791.9	MVA
Power Factor	0.9	
Steam Turbine Type	Condensing, Reheat	
Nameplate Throttle Pressure	289.8	bar
Nameplate Throttle Temperature	604	C
Nameplate Throttle Massflow	1918.4	t/h
Exhaust End Type	Down Draft	
Number of LPT Exhaust Annuli	2	
Last Stage Bucket Length	947.3	mm
Last Stage Pitch Diameter	2734.1	mm
Number of Ports	12	
Number of Auto-Extraction Ports	0	
2. Estimated Weights, Dimensions & Cost		
Steam Turbine Length	37.33	m
Steam Turbine Width	5.89	m
Steam Turbine Weight	888,300	kg
Generator Length (Including Exciter)	15.94	m
Generator Width	4.392	m
Generator Weight	620,300	kg
Overall ST and Generator Length	53.28	m
Overall ST and Generator Width	5.89	m
Overall ST and Generator Weight	1,509,000	kg
Equipment Cost per Unit, Reference Basis	82,605,000	USD
Foundation Length	58.1	m
Foundation Width	7.068	m
Foundation Concrete per Unit	2187.6	m^3

Estimated Feedwater Heater Data		
Number of Units	1	
Displayed quantities in this table are on a per unit basis		
FWH 1-P		
Feedwater heater configuration: Includes condensing section only		
Nameplate steam pressure	0.4673	bar
Shell material	Carbon Steel	
Shell length	18.41	m
Shell inner diameter	1.559	m
Shell wall thickness	7.938	mm
Tube sheet thickness	63.5	mm
Nameplate water pressure	21.15	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	564	
Number of passes	2	
Number of tubes in heater	1128	
Tube length per pass	18.41	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	1.245	mm
Tube pitch	30.48	mm
Total heat transfer area (outside tubes)	1,240	m^2
Tube weight, dry	11,690	kg
Overall length	20.8	m
Overall outer diameter	1.6	m
Heater total dry weight	23,670	kg
Heater total operating (wet) weight	31,210	kg
FWH 2-D		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	1.314	bar
Shell material	Carbon Steel	
Shell length	19.54	m
Shell inner diameter	1.684	m
Shell wall thickness	9.525	mm
Tube sheet thickness	63.5	mm
Nameplate water pressure	19.34	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	701	
Number of passes	2	
Number of tubes in heater	1402	
Tube length per pass	19.54	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	1.245	mm
Tube pitch	29.53	mm
Total heat transfer area (outside tubes)	1,640	m^2
Tube weight, dry	15,410	kg
Overall length	22.2	m
Overall outer diameter	1.7	m
Heater total dry weight	32,470	kg
Heater total operating (wet) weight	42,100	kg
FWH 3-D		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	3.151	bar
Shell material	Carbon Steel	
Shell length	17.1	m
Shell inner diameter	1.592	m
Shell wall thickness	9.525	mm
Tube sheet thickness	57.15	mm
Nameplate water pressure	17.59	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	716	
Number of passes	2	
Number of tubes in heater	1432	
Tube length per pass	17.1	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	1.245	mm
Tube pitch	27.62	mm
Total heat transfer area (outside tubes)	1,470	m^2
Tube weight, dry	13,780	kg
Overall length	19.6	m
Overall outer diameter	1.6	m
Heater total dry weight	27,560	kg
Heater total operating (wet) weight	35,780	kg

Estimated Feedwater Heater Data		
FWH 4-D		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	6.667	bar
Shell material	Carbon Steel	
Shell length	15.25	m
Shell inner diameter	1.613	m
Shell wall thickness	9.525	mm
Tube sheet thickness	47.62	mm
Nameplate water pressure	16.14	bar
Tube material	Stainless Steel (304)	
Number of tubes per pass	735	
Number of passes	2	
Number of tubes in heater	1470	
Tube length per pass	15.25	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	1.245	mm
Tube pitch	27.62	mm
Total heat transfer area (outside tubes)	1,340	m^2
Tube weight, dry	12,610	kg
Overall length	17.8	m
Overall outer diameter	1.6	m
Heater total dry weight	24,730	kg
Heater total operating (wet) weight	32,280	kg
FWH 5-DA		
DA type	HH	
Nameplate feedwater exit flow	1918369	kg/hr
Total storage volume	255609	l
Total storage capacity	7	Min
Number of units	1	
Overall height	7.963	m
Overall length	18.75	m
Storage tank		
-Thickness	25.4	mm
-Outside diameter	4.572	m
-Total length	18.75	m
Heater		
-Thickness	15.88	mm
-Outside diameter	2.781	m
-Total length	16.94	m
Dry weight	85179	kg
Operating weight	331370	kg
Flooded weight	419388	kg
Structure weight	93420	kg
FWH 6-D (6A, 6B)		
Feedwater heater configuration: Includes desuperheating section, condensing section, drain cooler		
Nameplate steam pressure	22.24	bar
Shell material	Carbon Steel	
Shell length	11.65	m
Shell inner diameter	1.989	m
Shell wall thickness	25.4	mm
Tube sheet thickness	340	mm
Nameplate water pressure	309	bar
Tube material	Carbon Steel	
Number of tubes per pass	821	
Number of passes	2	
Number of tubes in heater	1642	
Tube length per pass	11.65	m
Tube outer diameter (O.D.)	22.22	mm
Tube wall thickness	3.81	mm
Tube pitch	32.23	mm
Total heat transfer area (outside tubes)	1,340	m^2
Tube weight, dry	35,000	kg
Overall length	14.7	m
Overall outer diameter	2	m
Heater total dry weight	93,400	kg
Heater total operating (wet) weight	98,700	kg
FWH 7-D (7A, 7B)		
Feedwater heater configuration: Includes condensing section, drain cooler		
Nameplate steam pressure	41.42	bar
Shell material	Carbon Steel	
Shell length	10.04	m
Shell inner diameter	1.928	m
Shell wall thickness	50.8	mm

Estimated Feedwater Heater Data		
Tube sheet thickness	368	mm
Nameplate water pressure	308	bar
Tube material	Carbon Steel	
Number of tubes per pass	1211	
Number of passes	2	
Number of tubes in heater	2422	
Tube length per pass	10.04	m
Tube outer diameter (O.D.)	19.05	mm
Tube wall thickness	3.404	mm
Tube pitch	25.72	mm
Total heat transfer area (outside tubes)	1,460	m^2
Tube weight, dry	34,240	kg
Overall length	13.2	m
Overall outer diameter	2	m
Heater total dry weight	102,250	kg
Heater total operating (wet) weight	106,800	kg
FWH 8-D (8A, 8B)		
Feedwater heater configuration: Includes desuperheating section, condensing section, drain cooler		
Nameplate steam pressure	62.42	bar
Shell material	Carbon Steel	
Shell length	12.2	m
Shell inner diameter	2.075	m
Shell wall thickness	76.2	mm
Tube sheet thickness	305	mm
Nameplate water pressure	307	bar
Tube material	Carbon Steel	
Number of tubes per pass	893	
Number of passes	2	
Number of tubes in heater	1786	
Tube length per pass	12.2	m
Tube outer diameter (O.D.)	22.22	mm
Tube wall thickness	3.81	mm
Tube pitch	32.23	mm
Total heat transfer area (outside tubes)	1,520	m^2
Tube weight, dry	39,540	kg
Overall length	15.5	m
Overall outer diameter	2.2	m
Heater total dry weight	142,750	kg
Heater total operating (wet) weight	148,400	kg
FWH 9-S (9A, 9B)		
Feedwater heater configuration: Shell heating with vapor only fluid		
Please Note:		
Design based on condensing FWH methods - may be less accurate for single-phase fluid in shell		
Nameplate steam pressure	41.42	bar
Shell material	Carbon Steel	
Shell length	2.902	m
Shell inner diameter	1.466	m
Shell wall thickness	38.1	mm
Tube sheet thickness	279	mm
Nameplate water pressure	307	bar
Tube material	Carbon Steel	
Number of tubes per pass	1029	
Number of passes	1	
Number of tubes in heater	1029	
Tube length per pass	2.902	m
Tube outer diameter (O.D.)	22.22	mm
Tube wall thickness	4.191	mm
Tube pitch	30	mm
Total heat transfer area (outside tubes)	209	m^2
Tube weight, dry	6,630	kg
Overall length	6.5	m
Overall outer diameter	1.5	m
Heater total dry weight	40,550	kg
Heater total operating (wet) weight	42,090	kg

Estimated Air Cooled Condenser Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
Dry air-cooled condenser		
Total number of cells	64	
- Number of bays	8	
- Number of cells per bay	8	
1. Overall Dimensions		
Length	104.9	m
Width	104.9	m
Plot area	10994	m^2
2. Cell Dimensions		
Width	13.11	m
Height	36.3	m
Fan deck height	26.53	m
Steam duct outer diameter	3.298	m
Steam duct thickness	10.65	mm
Weight	140583	kg
3. Fan Design (per fan)		
Flow coefficient	0.16	
Static pressure rise coefficient	0.054	
Tip diameter	10.12	m
Hub diameter	1.366	m
RPM	96.93	
Tip speed	51.36	m/s
Static pressure drop at design point	0.8245	millibar
Dynamic pressure at design point	0.3911	millibar
Total fan DP at design point	1.216	millibar
Design volume flow	648.7	m^3/s
Electricity consumption at design point	109.6	kW

Estimated Cooling Tower Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		

Estimated Flue Gas Treatment Data		
Number of Units	**1**	
Displayed quantities in this table are on a per unit basis		
ESP		
Design collection efficiency	99.5	%
Design inlet temperature	137.8	C
Design flue gas mass flow	2,650	t/h
Design flue gas volume flow	3,098,000	m^3/hr
Design flue gas velocity	1.372	m/s
Overall Dimensions		
Number of chambers	3	
Number of fields	4	
Total length	30.74	m
Total width	70.68	m
Total height	20.57	m
Total weight	1,961,000	kg
Collecting Plates		
Design specific collecting area (SCA)	89.78	m^2 / m^3/s
Total collection surface area	77,250	m^2
Number of plates per chamber	64	
Collecting plates height	10.97	m
Collecting plates spacing	304.8	mm
Collecting plates bundle width per chamber	19.2	m
Collecting plates depth per field	4.656	m
Collecting length	18.62	m
Aspect ratio (Collecting length / Plate height)	1.697	
2. Stack		
Type	Concrete	
Concrete Shell Diameter at Base Level	17.77	m
Concrete Shell Diameter at Top Level	14.21	m
Steel Liner Diameter	7.714	m
Height	155.4	m
Total Reference Cost (Installation included)	11,294,000	USD

Estimated Desalination Plant Data: MSF System		
Multi-Stage Flash Desalination		
1. General		
Number of units	1	
Number of stages per unit	21	
Number of stages in heat recovery section (HGS)	0	
Number of stages in heat rejection section (HRS)	0	
Nominal desalinated water flow per unit	0	t/h
Nominal desalinated water flow per unit (MIGD)	0	MIGD
Nominal desalinated water flow per unit (m^3/day)	0	m^3/day
2. Overall dimensions and total weight (per unit, excluding seawater supply circuit)		
Length	0	m
Width	0	m
Height	0	m
Dry weight	0	tonne
3. Brine heater (per unit)		
Tube material	CuNi 70-30	
Heat transfer area	3,747	m^2
Tube outside diameter	38.1	mm
Tube wall thickness	1	mm
Tube length	15.24	m
Number of tubes	2054	
4. Evaporator (per unit)		
Length	0	m
Width	0	m
Height	0	m
Dry weight	0	tonne
HGS Stage Condensers		
- Tube material	CuNi 90-10	
- Heat transfer area per stage	3747	m^2
- HGS total heat transfer area	0	m^2
- Tube outside diameter	38.1	mm
- Tube wall thickness	1	mm
- Tube length	15.24	m
- Number of tubes per stage	2054	
HRS Stage Condensers		
- Tube material	Titanium	
- Heat transfer area per stage	3122	m^2
- HRS total heat transfer area	0	m^2
- Tube outside diameter	31.75	mm
- Tube wall thickness	0.7	mm
- Tube length	15.24	m
- Number of tubes per stage	2054	

Estimated Desalination Plant Data: MED System		
Multi-Effect Distillation		
1. General		
Number of units	0	
Number of effects per unit	8	
System configuration	MED only	
First effect heating steam saturation temperature	-17.78	C
Top brine temperature	-17.78	C
Final effect temperature	-17.78	C
Nameplate capacity	0	t/h
Nameplate capacity (MIGD)	0	MIGD
Nameplate capacity (m^3/day)	0	m^3/day
2. Evaporator island (per unit, incl. main condenser)		
Total heat transfer area	0	m^2
Length	0	m
Width	0	m
Height	0	m
Dry weight	0	tonne
Operating weight	0	tonne
3. Evaporators (per unit)		
Total heat transfer area	0	m^2
Number of effects	8	
Heat transfer area per effect	0	m^2
Number of tubes per effect	0	
Tube outside diameter	0	mm
Tube wall thickness	0	mm
Tube length	0	m
Tube material	Titanium	
Tube dry weight per effect	0	tonne
Total shell length of all effects	0	m
Shell outside diameter	0	m
Shell wall thickness	0	mm
Total tube dry weight	0	tonne
Total dry weight	0	tonne
Total operating weight	0	tonne
Total flooding weight	0	tonne
4. Main condenser (per unit)		
Overall length	0	m
Overall width	0	m
Overall height	0	m
Heat transfer area	0	m^2
Number of tubes	0	
Number of passes	0	
Tube outside diameter	0	mm
Tube wall thickness	0	mm
Tube length	0	m
Tube material	Titanium	
Tube dry weight	0	tonne
Total dry weight	0	tonne
Total operating weight	0	tonne

Estimated Desalination Plant Data: RO System		
Reverse Osmosis Desalination		
1. Nameplate Data		
Total number of RO trains in plant	0	
Desalinated water flow	0	t/h
Desalinated water flow (MIGD)	0	MIGD
Desalinated water flow (m^3/day)	0	m^3/day
Inlet water flow	0	t/h
Inlet water salinity	0	%
Water recovery ratio	40	%
Membrane feed pressure	0	bar
Total power consumption	0	kW

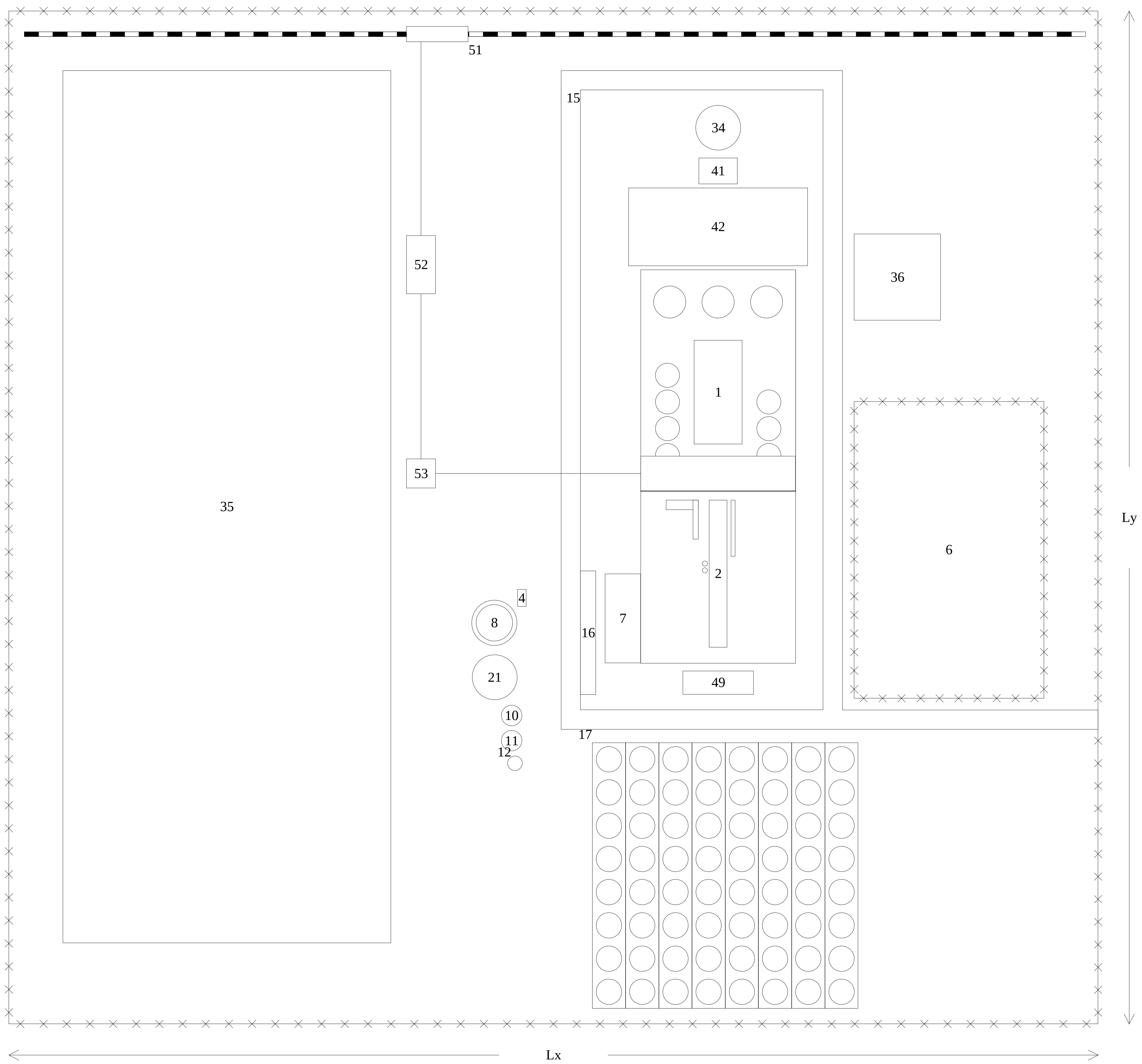
Estimated Miscellaneous Equipment Data		
1. Air Compressor		
Number of Air Compressors in plant	5 - 100%	
Capacity (each)	1529.1	m^3/h
Motor Power (each)	205	kW
Weight (each)	7,070	kg
Installation Labor (each)	230	Labor Hours
Equipment Cost, Reference Basis, (each)	156,400	USD
Foundation Concrete (each)	12.03	m^3
Foundation Labor (each)	450	Labor Hours
2. Auxiliary Boiler	**None**	
3. Emergency Generator		
Number of Generators	1	
Generator Set Type	Medium Speed	
Capacity (each)	1,750	kW
Length	9.9	m
Width	2.4	m
Height	3.3	m
Weight	34,750	kg
Installation Labor (each)	195	Labor Hours
Equipment Cost, Reference Basis, (each)	810,700	USD
Foundation Concrete (each)	57.84	m^3
Foundation Labor (each)	1,340	Labor Hours
4. Black Start Generator		
Number of Generators	5	
Generator Set Type	Medium Speed	
Capacity (each)	5,500	kW
Length	12.5	m
Width	2.5	m
Height	3.9	m
Weight	73,050	kg
Installation Labor (each)	195	Labor Hours
Equipment Cost, Reference Basis, (each)	2,548,000	USD
Foundation Concrete (each)	121	m^3
Foundation Labor (each)	2,400	Labor Hours
5. ST+Generator Lube Oil Fin Fan Cooler		
Number of Cells (per plant)	3	
Capacity (each)	822	kW
Fan Power (each)	48.47	kW
Weight (each)	5,080	kg
Length (each)	3.658	m
Width (each)	2.743	m
Installation Labor (each)	45.5	Labor Hours
Equipment Cost, Reference Basis, (each)	79,750	USD
6. ST Generator Fin Fan Cooler		
Number of Cells (per plant)	6	
Capacity (each)	860	kW
Fan Power (each)	48.47	kW
Weight (each)	5,310	kg
Length (each)	3.962	m
Width (each)	2.743	m
Installation Labor (each)	46.8	Labor Hours
Equipment Cost, Reference Basis, (each)	83,050	USD
7. Bridge Crane (for ST)		
Number of Cranes in Plant	1	
Span	38.1	m
Capacity	134	Ton
Crane Weight	286,300	kg
Hoist Motor Power	89.48	kW
Bridge Motors	2 - 6.338	kW
Trolley Motor Power	5.966	kW
Installation Labor	1,530	Labor Hours
Crane & Support Cost, Reference Basis, (each)	1,545,000	USD

Caution! These results are based on a single set of nameplate plant		
performance data applied for user-input number of operating hours per year.		
Annual Electricity Exported	5,260	10^6 kWh
Annual Heat Exported	0	TJ
Annual Fuel Imported	45,510	TJ LHV
Annual Water Imported	0	10^6 l
Annual CO2 Emission	4,210	ktonne
Annual Desal Water Exported	0	MM imperial gal.
Annual Hydrogen Exported	0	TJ LHV
Annual Syngas Exported	0	TJ LHV
Annual CO2 Captured	0	ktonne
Annual Limestone Consumed	0	ktonne
Annual Lime Consumed	0	ktonne
Annual CO2 Capture Solvent Consumed	0	ktonne
Annual Combustion Waste Production	157	ktonne
Annual FGD Waste/Byproducts Production	0	ktonne
Annual Activated Carbon Consumed	0	ktonne
Total Investment	1,664,412,000	USD
Specific Investment	2561.1	USD per kW
Initial Equity	499,324,000	USD
Cumulative Net Cash Flow	7,681,889,000	USD
Internal Rate of Return on Investment (ROI)	13.690	%
Internal Rate of Return on Equity (ROE)	22.547	%
Years for Payback of Equity	5.398	years
Net Present Value	1,013,126,000	USD
Break-even Electricity Price @ Input Fuel Price (i.e. Levelised Cost of Electricity)	0.0443	USD/kWhr
Break-even Fuel LHV Price @ Input Electricity Price	3.768	USD/GJ
Other		
First Year Combustion Waste Disposal Cost	0	USD/tonne
First Year FGD Waste/Byproducts Disposal Cost	0	USD/tonne
First Year Combustion Waste Disposal Expense	0	USD
First Year FGD Waste/Byproducts Disposal Expense	0	USD
First Year Total Other Expense	0	USD

Cash Flow USD	2020 (1)	2021 (2)	2022 (3)	2023 (4)	2024 (5)	2025 (6)	2026 (7)	2027 (8)	2028 (9)	2029 (10)	2030 (11)	2031 (12)	2032 (13)	2033 (14)	2034 (15)	2035 (16)	2036 (17)	2037 (18)	2038 (19)	2039 (20)
Escalators																				
Inflation	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Fuel	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Steam	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Electricity	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Imported Water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desal water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
H2 from syngas	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Reagent	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Activated carbon	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Prices																				
Electricity, USD per kWh	0.065	0.0679	0.071	0.0742	0.0775	0.081	0.0846	0.0885	0.0924	0.0966	0.1009	0.1055	0.1102	0.1152	0.1204	0.1258	0.1315	0.1374	0.1436	0.15
Fuel, USD/GJ	1.37	1.432	1.496	1.563	1.634	1.707	1.784	1.864	1.948	2.036	2.128	2.223	2.323	2.428	2.537	2.651	2.771	2.895	3.026	3.162
Steam, USD/GJ	4.739	4.953	5.175	5.408	5.652	5.906	6.172	6.45	6.74	7.043	7.36	7.691	8.037	8.399	8.777	9.172	9.585	10.02	10.47	10.94
Imported Water, USD/m^3	0.2642	0.2761	0.2885	0.3015	0.315	0.3292	0.344	0.3595	0.3757	0.3926	0.4103	0.4287	0.448	0.4682	0.4892	0.5112	0.5343	0.5583	0.5834	0.6097
CO2 Emission Penalty, USD/tonne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desal water, USD per 1000 imperial gallons	4	4.18	4.368	4.565	4.77	4.985	5.209	5.443	5.688	5.944	6.212	6.491	6.784	7.089	7.408	7.741	8.089	8.454	8.834	9.231
H2 from syngas, USD/GJ	7.583	7.924	8.281	8.653	9.043	9.45	9.875	10.32	10.78	11.27	11.78	12.31	12.86	13.44	14.04	14.68	15.34	16.03	16.75	17.5
Syngas, USD/GJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limestone, USD/tonne	22.05	23.04	24.08	25.16	26.29	27.47	28.71	30	31.35	32.76	34.24	35.78	37.39	39.07	40.83	42.67	44.59	46.59	48.69	50.88
Lime, USD/tonne	88.18	92.15	96.3	100.6	105.2	109.9	114.8	120	125.4	131.1	136.9	143.1	149.6	156.3	163.3	170.7	178.3	186.4	194.8	203.5
Captured CO2, USD/tonne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent, USD/tonne	2204.6	2303.8	2407.5	2515.8	2629.1	2747.4	2871	3000	3135	3276	3424	3578	3739	3907	4083	4267	4459	4659	4869	5088
Activated carbon, USD/tonne	2204.6	2303.8	2407.5	2515.8	2629.1	2747.4	2871	3000	3135	3276	3424	3578	3739	3907	4083	4267	4459	4659	4869	5088
Revenues																				
Electricity	342,165,000	357,563,000	373,653,000	390,467,000	408,038,000	426,400,000	445,588,000	465,639,000	486,593,000	508,490,000	531,372,000	555,284,000	580,271,000	606,384,000	633,671,000	662,186,000	691,984,000	723,124,000	755,664,000	789,669,000
Capacity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Steam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desal water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2 from syngas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syngas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Captured CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	342,165,000	357,563,000	373,653,000	390,467,000	408,038,000	426,400,000	445,588,000	465,639,000	486,593,000	508,490,000	531,372,000	555,284,000	580,271,000	606,384,000	633,671,000	662,186,000	691,984,000	723,124,000	755,664,000	789,669,000
Operating Expenses																				
Fuel	62,351,000	65,157,000	68,089,000	71,153,000	74,355,000	77,701,000	81,197,000	84,851,000	88,669,000	92,660,000	96,829,000	101,187,000	105,740,000	110,498,000	115,471,000	120,667,000	126,097,000	131,771,000	137,701,000	143,898,000
Limestone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imported Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Activated carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inflating O&M	57,580,000	60,171,000	62,879,000	65,708,000	68,665,000	71,755,000	74,984,000	78,358,000	81,884,000	85,569,000	89,420,000	93,444,000	97,649,000	102,043,000	106,635,000	111,433,000	116,448,000	121,688,000	127,164,000	132,886,000
Book Value O&M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Constant O&M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	119,931,000	125,328,000	130,968,000	136,861,000	143,020,000	149,456,000	156,181,000	163,209,000	170,554,000	178,229,000	186,249,000	194,630,000	203,389,000	212,541,000	222,106,000	232,100,000	242,545,000	253,459,000	264,865,000	276,784,000
Operating Income	**222,234,000**	**232,235,000**	**242,685,000**	**253,606,000**	**265,018,000**	**276,944,000**	**289,407,000**	**302,430,000**	**316,039,000**	**330,261,000**	**345,123,000**	**360,653,000**	**376,883,000**	**393,842,000**	**411,565,000**	**430,086,000**	**449,440,000**	**469,664,000**	**490,799,000**	**512,885,000**
-Depreciation	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	99,865,000	0	0	0	0	0
-Deductible Interest Exp	81,556,000	78,311,000	74,838,000	71,122,000	67,146,000	62,892,000	58,340,000	53,470,000	48,258,000	42,682,000	36,715,000	30,331,000	23,499,000	16,190,000	8,369,000	0	0	0	0	0
Pre-Tax Income	**40,813,000**	**54,059,000**	**67,982,000**	**82,619,000**	**98,007,000**	**114,187,000**	**131,202,000**	**149,096,000**	**167,917,000**	**187,715,000**	**208,543,000**	**230,458,000**	**253,519,000**	**277,788,000**	**303,332,000**	**430,086,000**	**449,440,000**	**469,664,000**	**490,799,000**	**512,885,000**
-Tax	14,285,000	18,921,000	23,794,000	28,917,000	34,303,000	39,966,000	45,921,000	52,183,000	58,771,000	65,700,000	72,990,000	80,660,000	88,732,000	97,226,000	106,166,000	150,530,000	157,304,000	164,383,000	171,780,000	179,510,000
-Non-Deductible Interest Exp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Income	**26,529,000**	**35,139,000**	**44,189,000**	**53,702,000**	**63,705,000**	**74,222,000**	**85,281,000**	**96,912,000**	**109,146,000**	**122,015,000**	**135,553,000**	**149,798,000**	**164,787,000**	**180,562,000**	**197,166,000**	**279,556,000**	**292,136,000**	**305,282,000**	**319,020,000**	**333,375,000**
Debt Principal Payment	46,364,000	49,610,000	53,082,000	56,798,000	60,774,000	65,028,000	69,580,000	74,451,000	79,662,000	85,239,000	91,205,000	97,590,000	104,421,000	111,731,000	119,552,000	0	0	0	0	0
Debt Coverage	1.74	1.82	1.9	1.98	2.07	2.16	2.26	2.36	2.47	2.58	2.7	2.82	2.95	3.08	3.22	0.0	0.0	0.0	0.0	0.0
Net Cash Flow	80,029,000	85,393,000	90,971,000	96,769,000	102,795,000	109,058,000	115,566,000	122,326,000	129,348,000	136,641,000	144,212,000	152,073,000	160,231,000	168,696,000	177,479,000	279,556,000	292,136,000	305,282,000	319,020,000	333,375,000
Cumulative Net Cash Flow	**80,029,000**	**165,423,000**	**256,393,000**	**353,162,000**	**455,958,000**	**565,016,000**	**680,582,000**	**802,908,000**	**932,256,000**	**1,068,896,000**	**1,213,109,000**	**1,365,181,000**	**1,525,412,000**	**1,694,108,000**	**1,871,587,000**	**2,151,143,000**	**2,443,278,000**	**2,748,560,000**	**3,067,580,000**	**3,400,955,000**

Cash Flow USD	2040 (21)	2041 (22)	2042 (23)	2043 (24)	2044 (25)	2045 (26)	2046 (27)	2047 (28)	2048 (29)	2049 (30)
Escalators										
Inflation	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Fuel	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Steam	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Electricity	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Imported Water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0
Desal water	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
H2 from syngas	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Reagent	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Activated carbon	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Prices										
Electricity, USD per kWh	0.1568	0.1638	0.1712	0.1789	0.1869	0.1954	0.2041	0.2133	0.2229	0.233
Fuel, USD/GJ	3.304	3.453	3.608	3.77	3.94	4.117	4.303	4.496	4.699	4.91
Steam, USD/GJ	11.43	11.94	12.48	13.04	13.63	14.24	14.88	15.55	16.25	16.99
Imported Water, USD/m^3	0.6371	0.6658	0.6957	0.727	0.7598	0.794	0.8297	0.867	0.906	0.9468
CO2 Emission Penalty, USD/tonne	0	0	0	0	0	0	0	0	0	0
Desal water, USD per 1000 imperial gallons	9.647	10.08	10.53	11.01	11.5	12.02	12.56	13.13	13.72	14.34
H2 from syngas, USD/GJ	18.29	19.11	19.97	20.87	21.81	22.79	23.82	24.89	26.01	27.18
Syngas, USD/GJ	0	0	0	0	0	0	0	0	0	0
Limestone, USD/tonne	53.17	55.56	58.06	60.67	63.41	66.26	69.24	72.36	75.61	79.01
Lime, USD/tonne	212.7	222.2	232.2	242.7	253.6	265	277	289.4	302.4	316.1
Captured CO2, USD/tonne	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent, USD/tonne	5317	5556	5806	6067	6341	6626	6924	7236	7561	7901
Activated carbon, USD/tonne	5317	5556	5806	6067	6341	6626	6924	7236	7561	7901
Revenues										
Electricity	825,204,000	862,339,000	901,144,000	941,695,000	984,072,000	1,028,355,000	1,074,631,000	1,122,989,000	1,173,524,000	1,226,332,000
Capacity	0	0	0	0	0	0	0	0	0	0
Steam	0	0	0	0	0	0	0	0	0	0
Desal water	0	0	0	0	0	0	0	0	0	0
H2 from syngas	0	0	0	0	0	0	0	0	0	0
Syngas	0	0	0	0	0	0	0	0	0	0
Captured CO2	0	0	0	0	0	0	0	0	0	0
TOTAL	825,204,000	862,339,000	901,144,000	941,695,000	984,072,000	1,028,355,000	1,074,631,000	1,122,989,000	1,173,524,000	1,226,332,000
Operating Expenses										
Fuel	150,373,000	157,140,000	164,211,000	171,600,000	179,322,000	187,392,000	195,825,000	204,637,000	213,845,000	223,468,000
Limestone	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0
CO2 capture solvent	0	0	0	0	0	0	0	0	0	0
Imported Water	0	0	0	0	0	0	0	0	0	0
CO2 Emission Penalty	0	0	0	0	0	0	0	0	0	0
Activated carbon	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Inflating O&M	138,866,000	145,115,000	151,645,000	158,470,000	165,601,000	173,053,000	180,840,000	188,978,000	197,482,000	206,369,000
Book Value O&M	0	0	0	0	0	0	0	0	0	0
Constant O&M	0	0	0	0	0	0	0	0	0	0
TOTAL	289,239,000	302,255,000	315,856,000	330,070,000	344,923,000	360,445,000	376,665,000	393,615,000	411,327,000	429,837,000
Operating Income	**535,965,000**	**560,084,000**	**585,287,000**	**611,625,000**	**639,148,000**	**667,910,000**	**697,966,000**	**729,375,000**	**762,196,000**	**796,495,000**
-Depreciation	0	0	0	0	0	0	0	0	0	0
-Deductible Interest Exp	0	0	0	0	0	0	0	0	0	0
Pre-Tax Income	**535,965,000**	**560,084,000**	**585,287,000**	**611,625,000**	**639,148,000**	**667,910,000**	**697,966,000**	**729,375,000**	**762,196,000**	**796,495,000**
-Tax	187,588,000	196,029,000	204,851,000	214,069,000	223,702,000	233,769,000	244,288,000	255,281,000	266,769,000	278,773,000
-Non-Deductible Interest Exp	0	0	0	0	0	0	0	0	0	0
Net Income	**348,377,000**	**364,054,000**	**380,437,000**	**397,556,000**	**415,447,000**	**434,142,000**	**453,678,000**	**474,093,000**	**495,428,000**	**517,722,000**
Debt Principal Payment	0	0	0	0	0	0	0	0	0	0
Debt Coverage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net Cash Flow	348,377,000	364,054,000	380,437,000	397,556,000	415,447,000	434,142,000	453,678,000	474,093,000	495,428,000	517,722,000
Cumulative Net Cash Flow	**3,749,332,000**	**4,113,387,000**	**4,493,823,000**	**4,891,380,000**	**5,306,826,000**	**5,740,968,000**	**6,194,646,000**	**6,668,739,000**	**7,164,167,000**	**7,681,889,000**

FOR QUALITATIVE INDICATION ONLY



Area 17.17 hectare
Lx 430 m
Ly 400 m
1 - Boiler
2 - Steam Turbine
4 - Water Treatment
6 - Switchyard
7 - Administration, Shop & Warehouse
8 - Fuel Oil Tank
10 - Demineralized Water Tank
11 - Raw Water Tank
12 - Neutralized Water Tank
15 - Road
16 - Parking
17 - Air-cooled Condenser
21 - Fire Protection Tank
34 - Stack
35 - Coal Storage Area (lx=129, ly=344)
36 - Combustion Waste Storage Area (lx=34, ly=34)
41 - ID Fan
42 - Electrostatic Precipitators
49 - Transformer
51 - Car Dumper
52 - Reclaiming Hopper
53 - Crusher Building

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Site Plan
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
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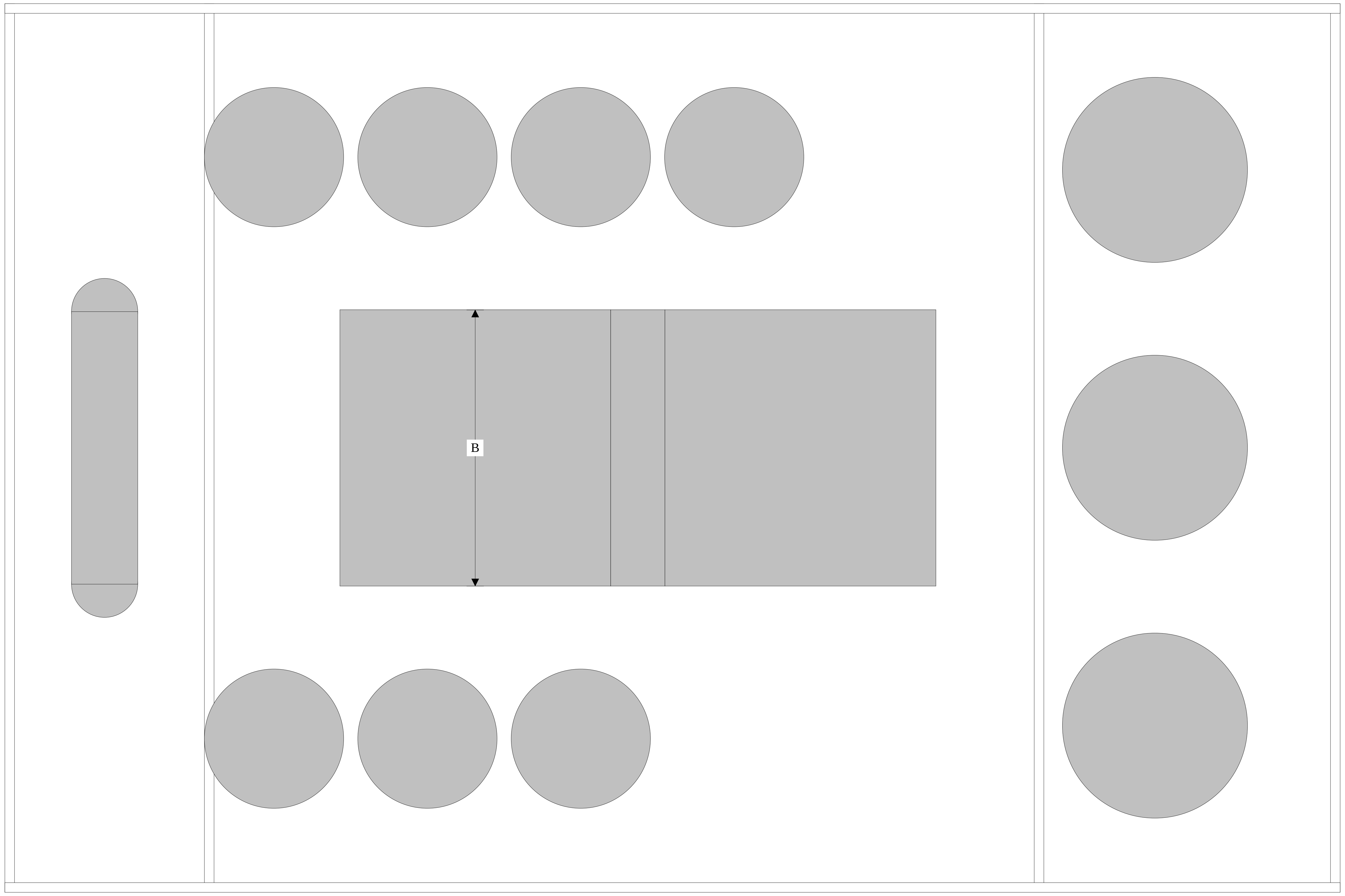
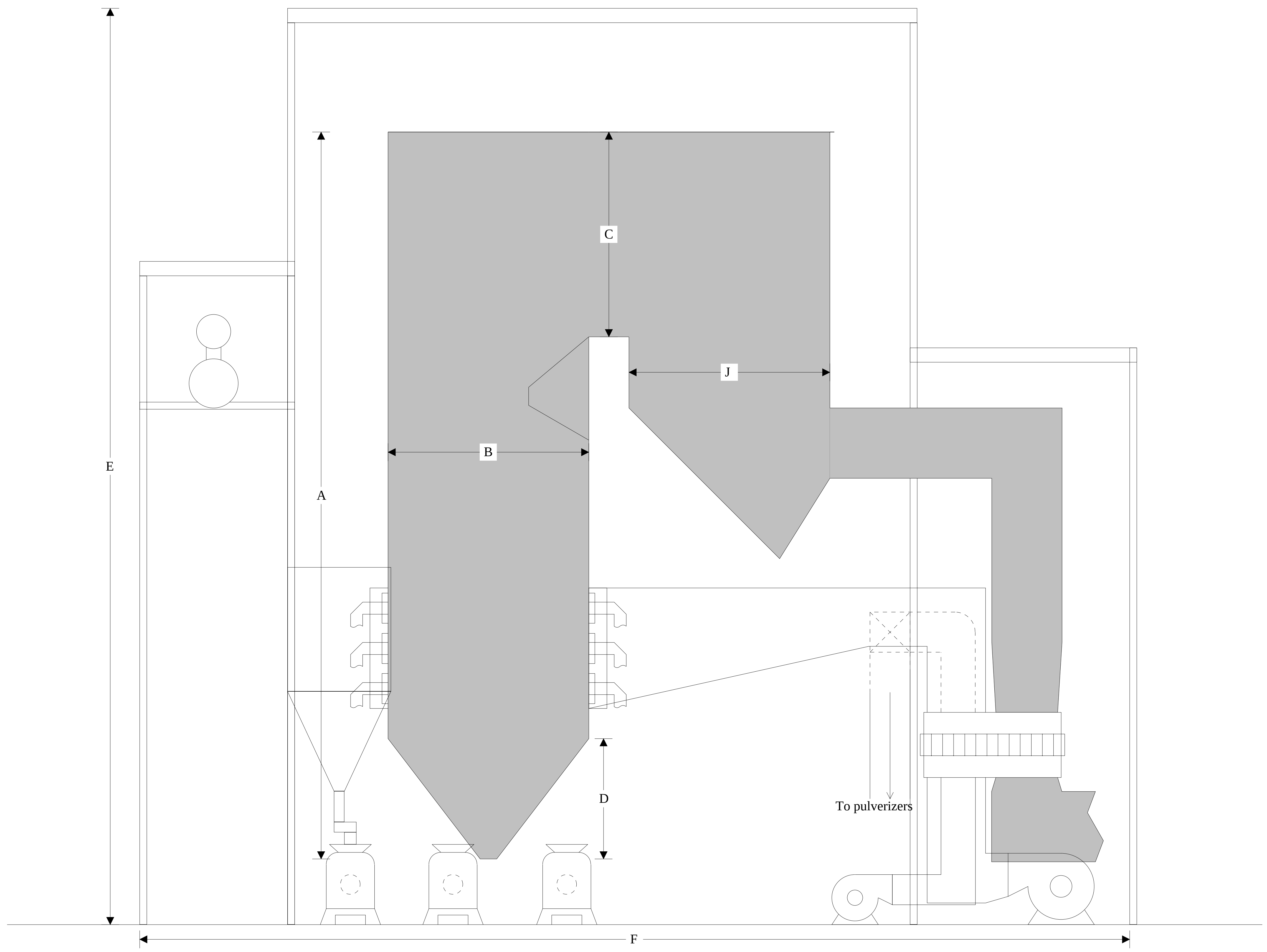
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
-	18.99 m	-	-	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	BOILER PLAN VIEW
Date: 04/21/17	
Drawing No:	

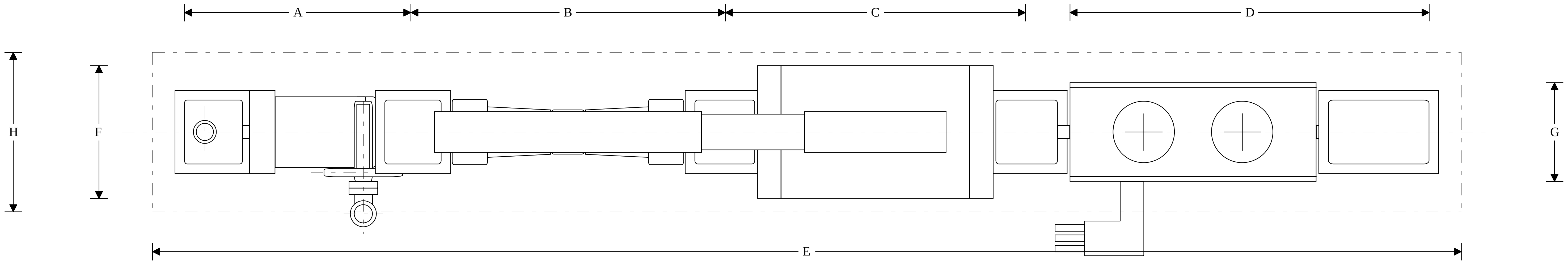
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
67.41 m	18.61 m	18.99 m	11.17 m	84.97 m	91.78 m	-	-	-	18.62 m

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	BOILER
	ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

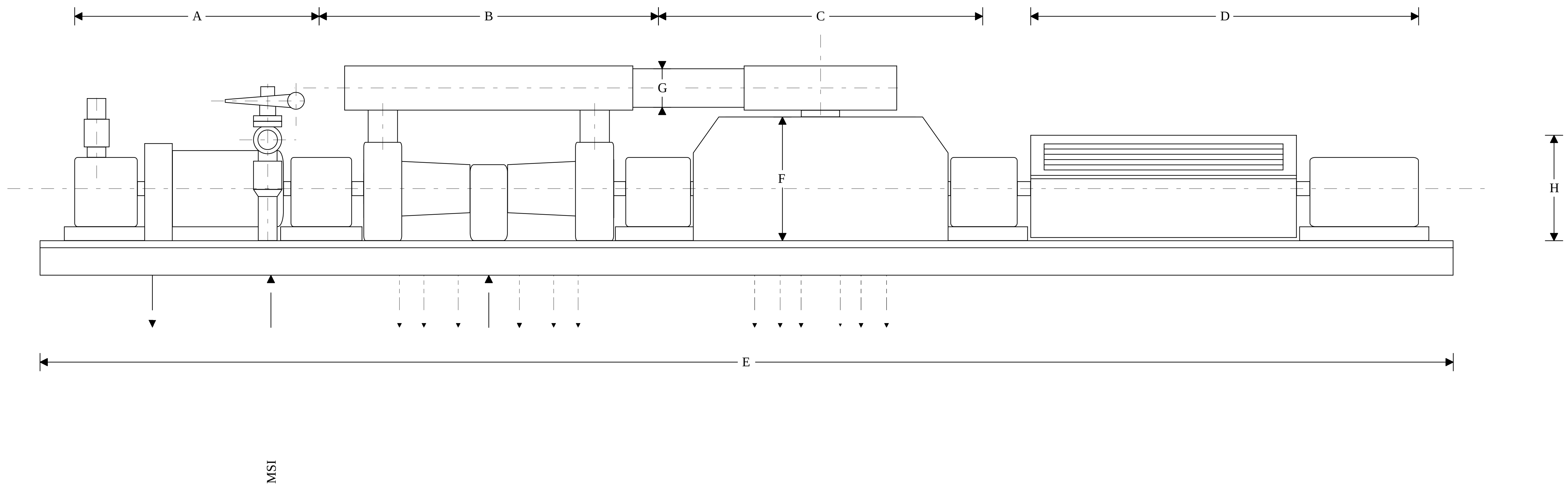


SHAPE, DIMENSIONS & SCALE ARE APPROXIMATE

A	B	C	D	E	F	G	H	I	J
10.05 m	13.95 m	13.33 m	15.94 m	58.1 m	5.89 m	4.392 m	7.068 m	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM TURBINE PACKAGE
	PLAN
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY



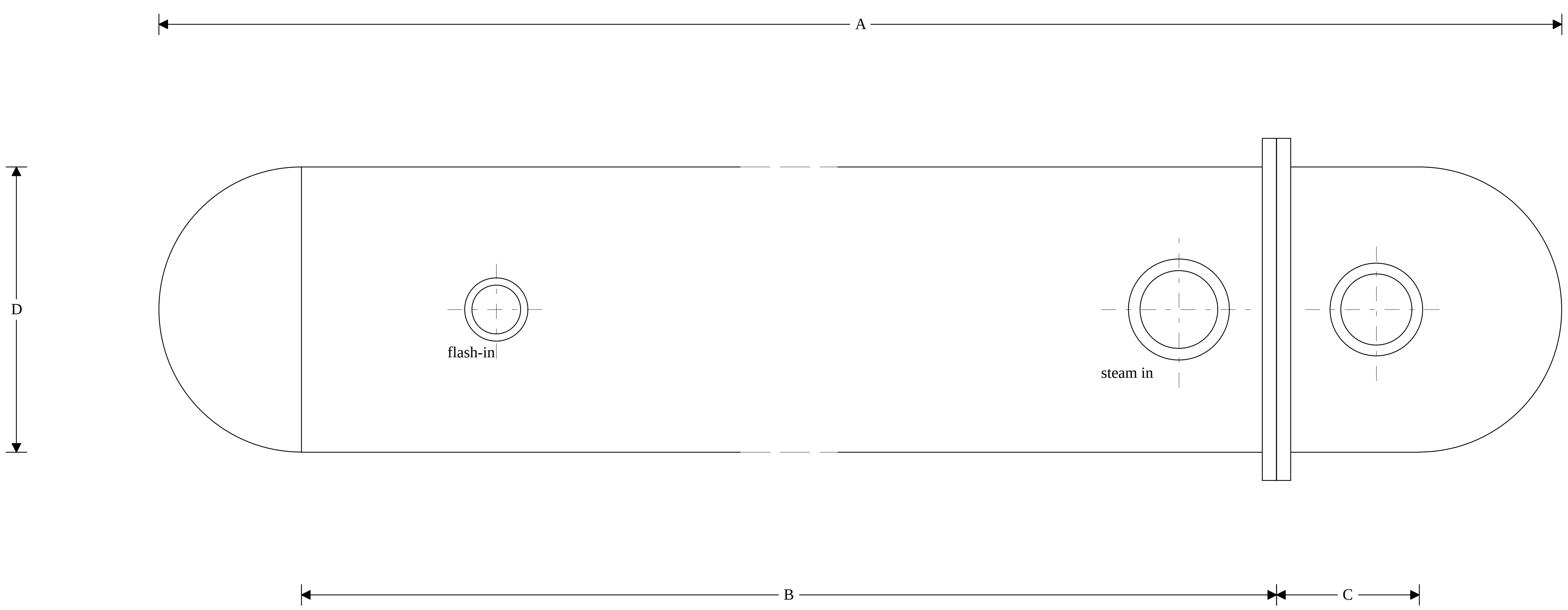
SHAPE, DIMENSIONS & SCALE ARE APPROXIMATE

A	B	C	D	E	F	G	H	I	J
10.05 m	13.95 m	13.33 m	15.94 m	58.1 m	5.083 m	1.587 m	4.334 m	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM TURBINE PACKAGE ELEV
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

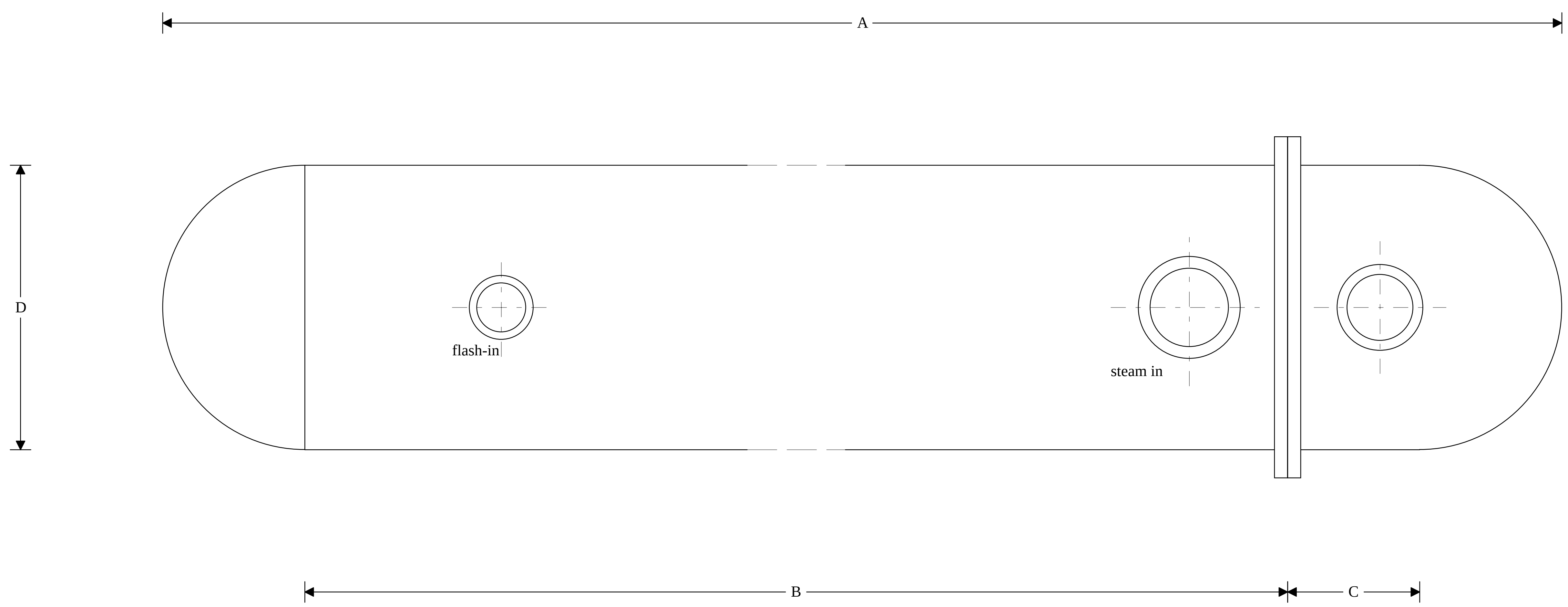


A	B	C	D	E	F	G	H	I	J
20.81 m	18.41 m	0.7642 m	1.575 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 1-P PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

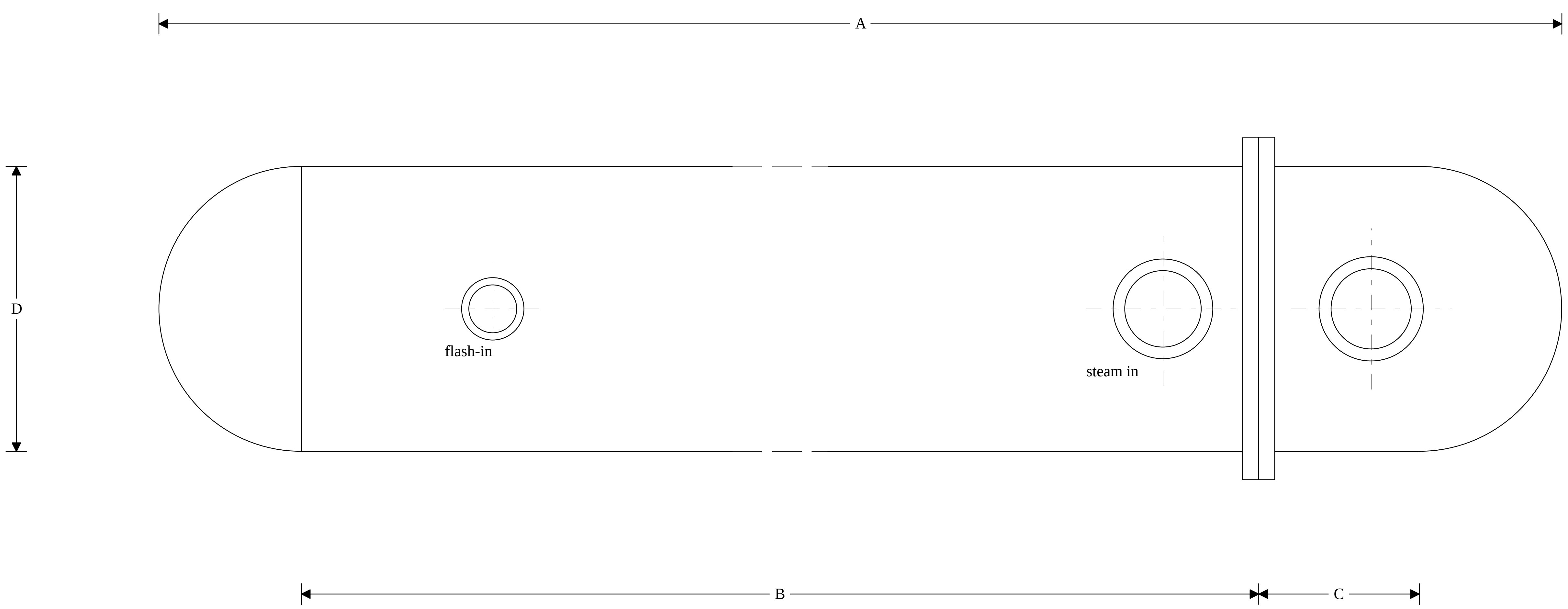


A	B	C	D	E	F	G	H	I	J
22.16 m	19.54 m	0.8511 m	1.703 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 2-D PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

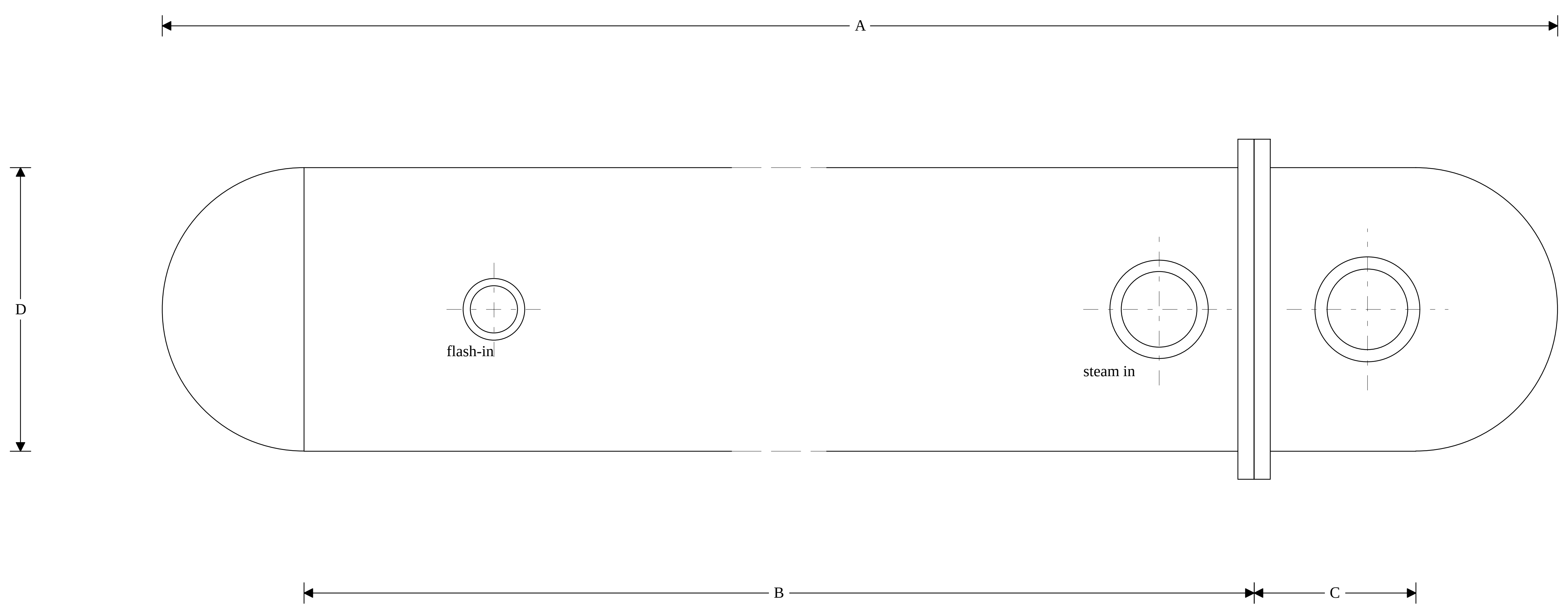
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
19.63 m	17.1 m	0.8594 m	1.611 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 3-D PLAN VIEW
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

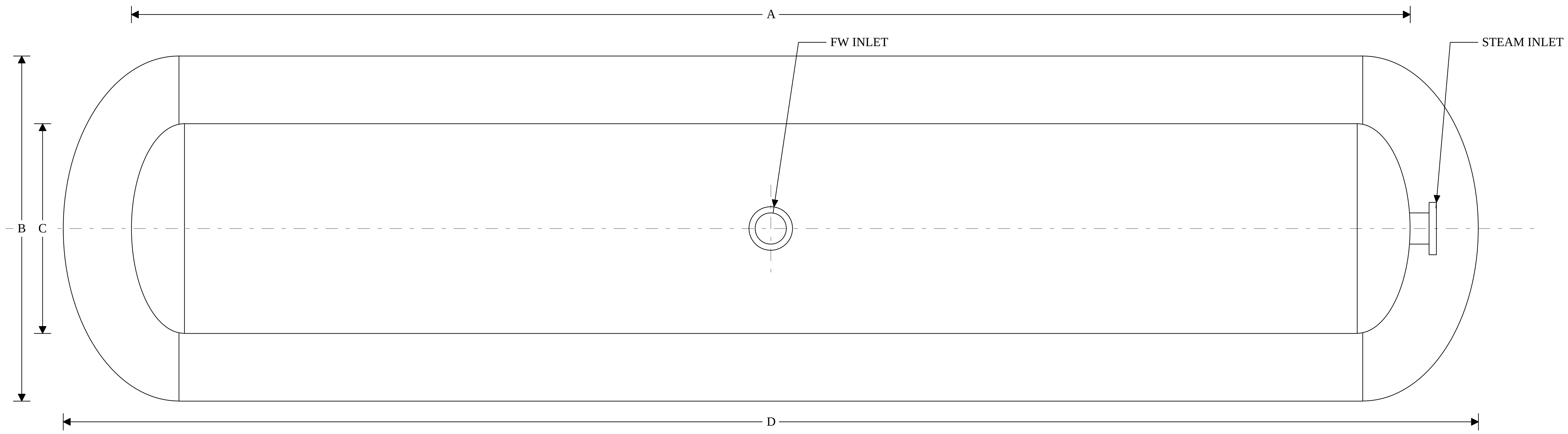


A	B	C	D	E	F	G	H	I	J
17.8 m	15.25 m	0.8696 m	1.632 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 4-D PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

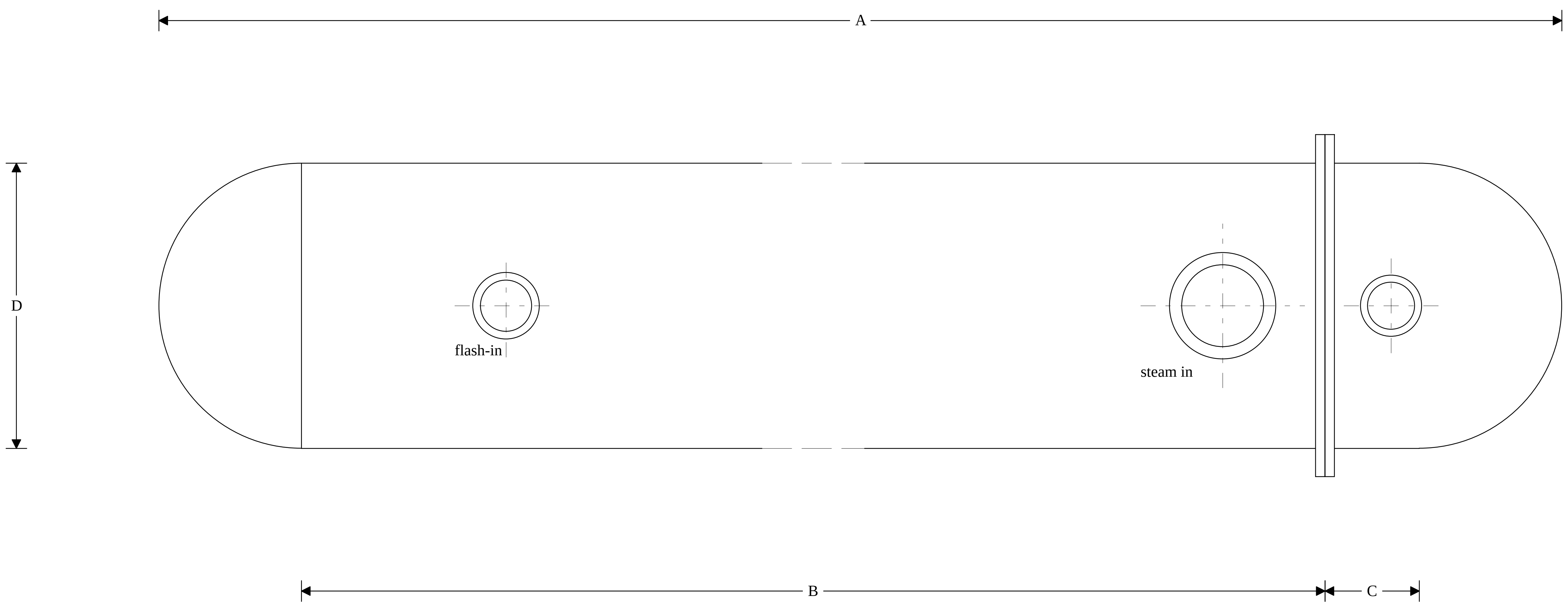


A	B	C	D	E	F	G	H	I	J
16.94 m	4.572 m	2.781 m	18.75 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM HEATED DEAERATOR
	PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

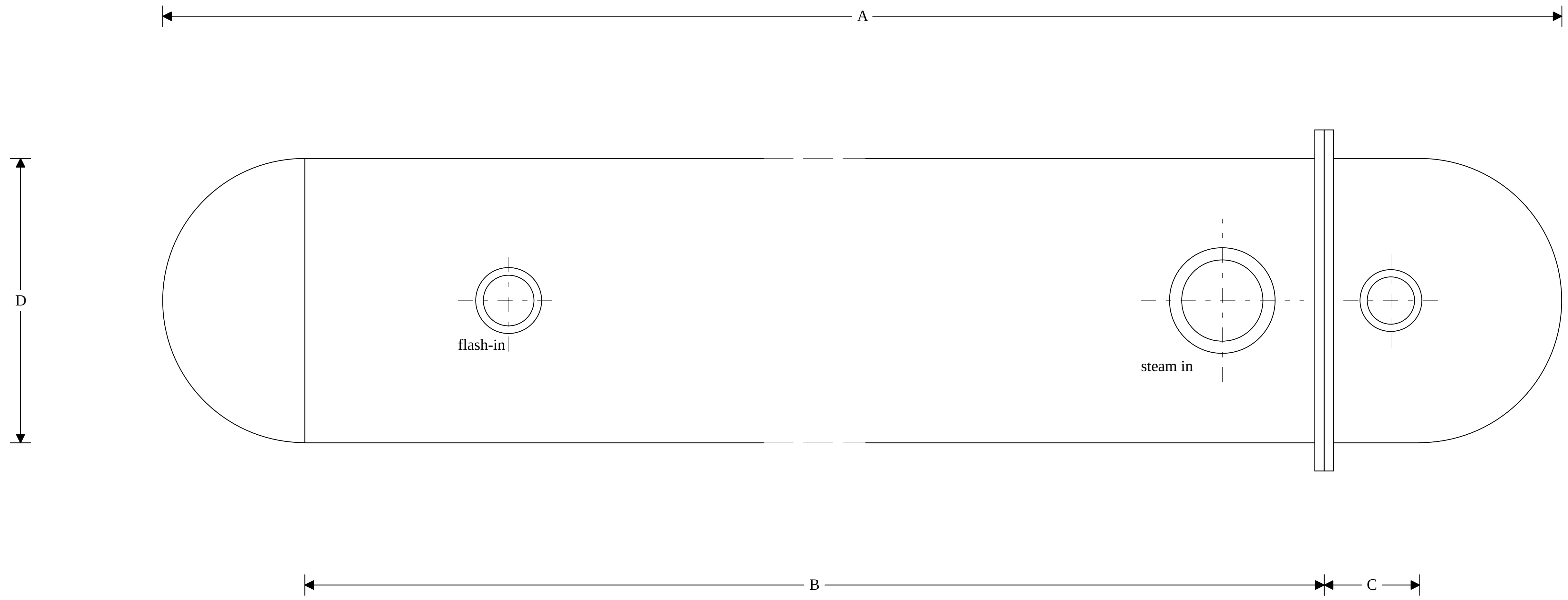


A	B	C	D	E	F	G	H	I	J
14.74 m	11.65 m	0.708 m	2.04 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 6-D (6A, 6B)
	PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

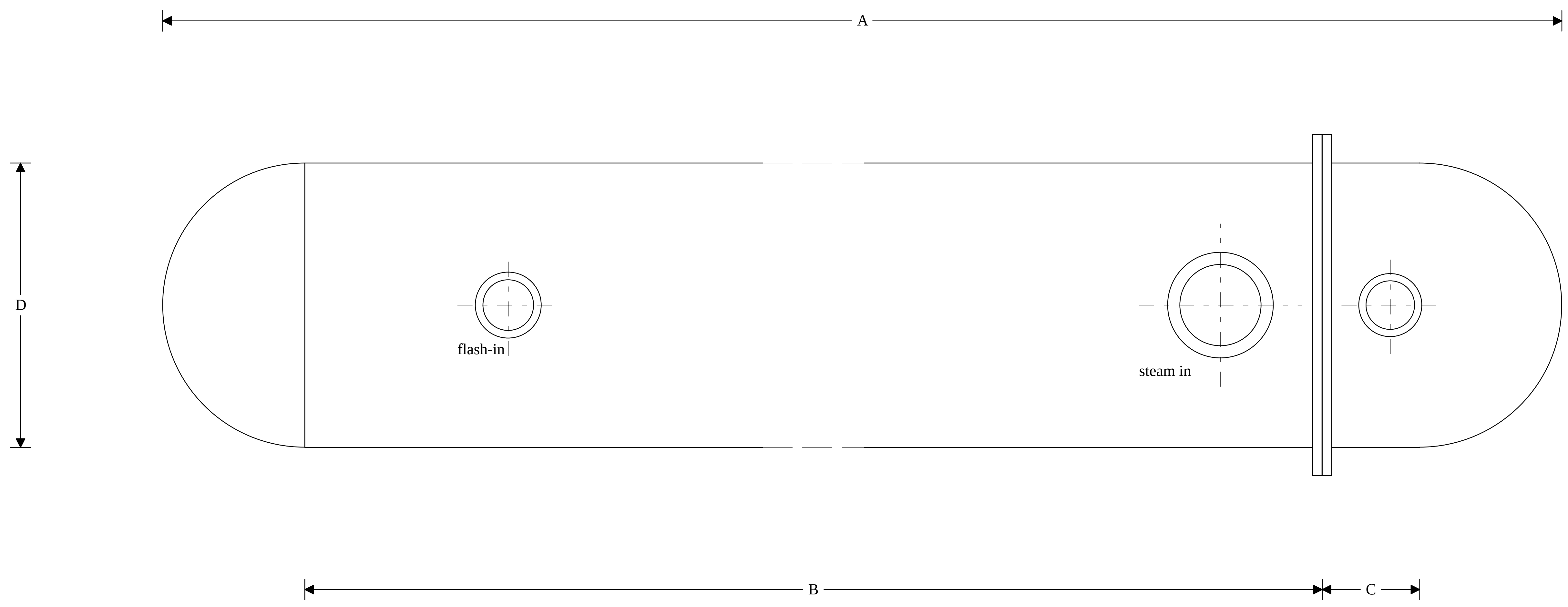


A	B	C	D	E	F	G	H	I	J
13.16 m	10.04 m	0.7181 m	2.03 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 7-D (7A, 7B) PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

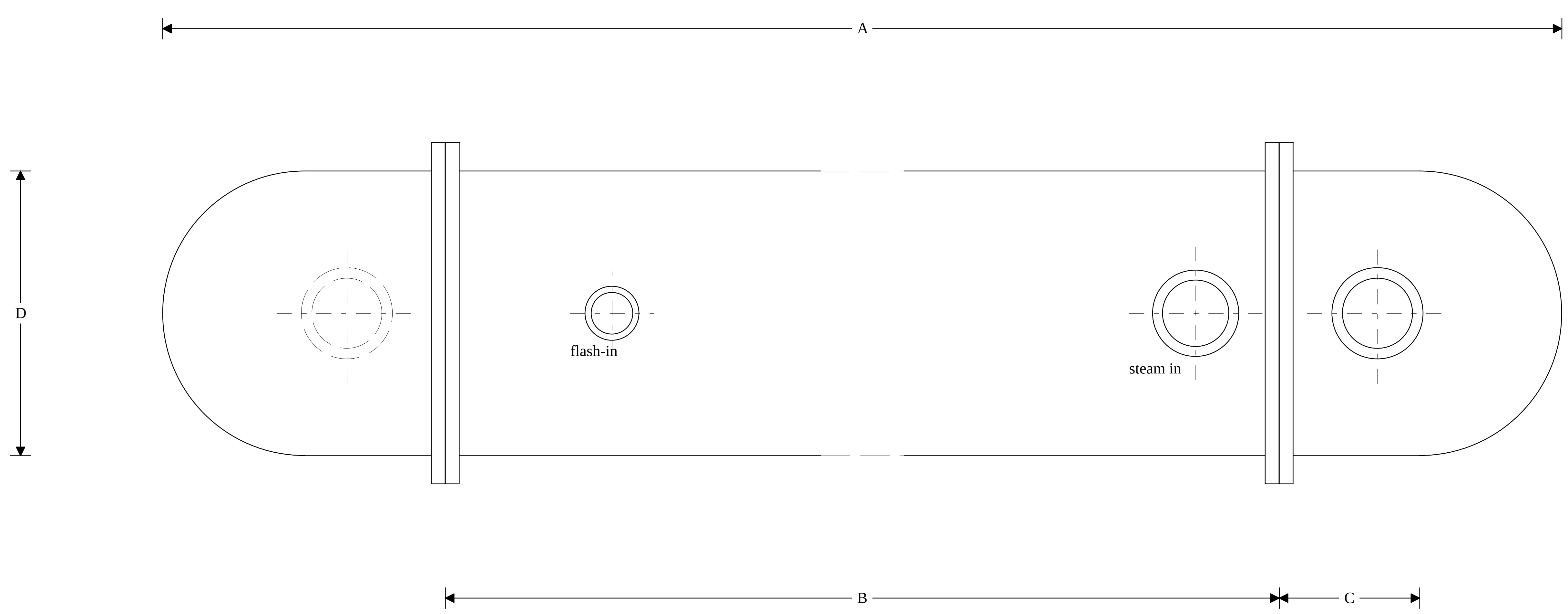
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
15.47 m	12.2 m	0.7343 m	2.227 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 8-D (8A, 8B) PLAN VIEW
Date: 04/21/17	
Drawing No:	

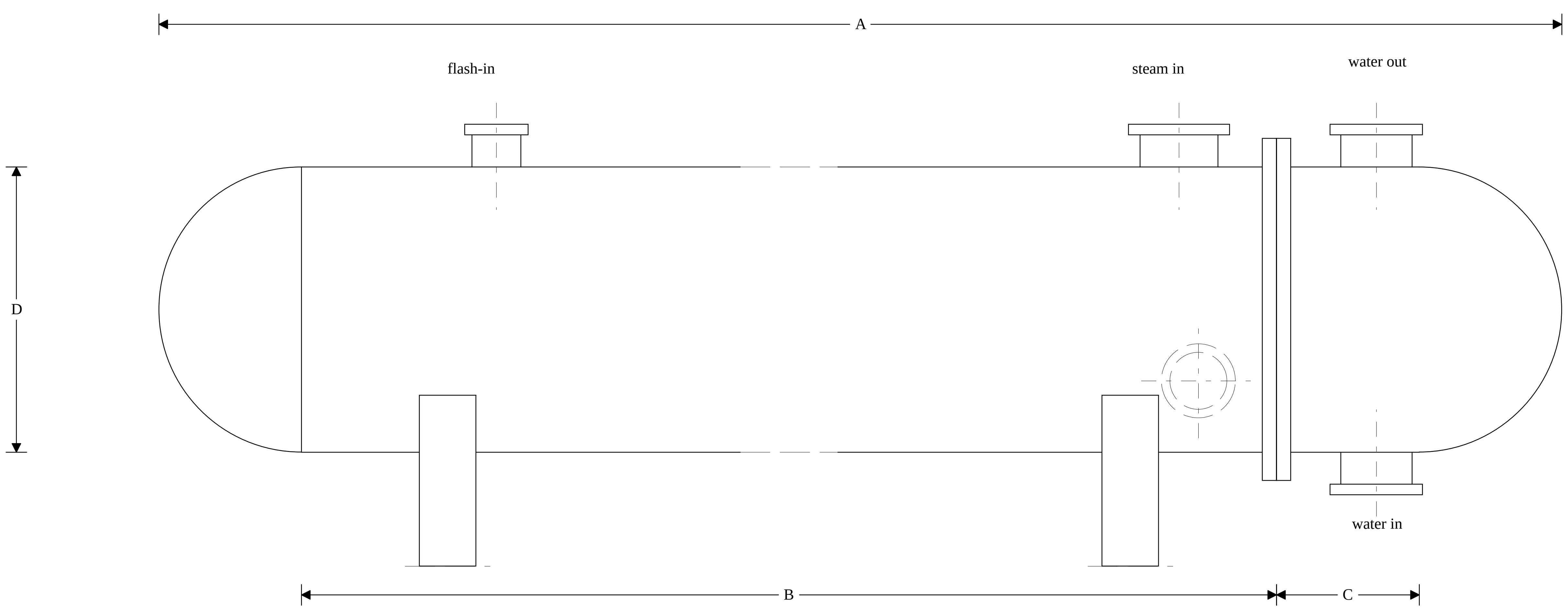
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
6.51 m	2.902 m	0.7534 m	1.542 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 9-S (9A, 9B) PLAN VIEW
Date: 04/21/17	
Drawing No:	

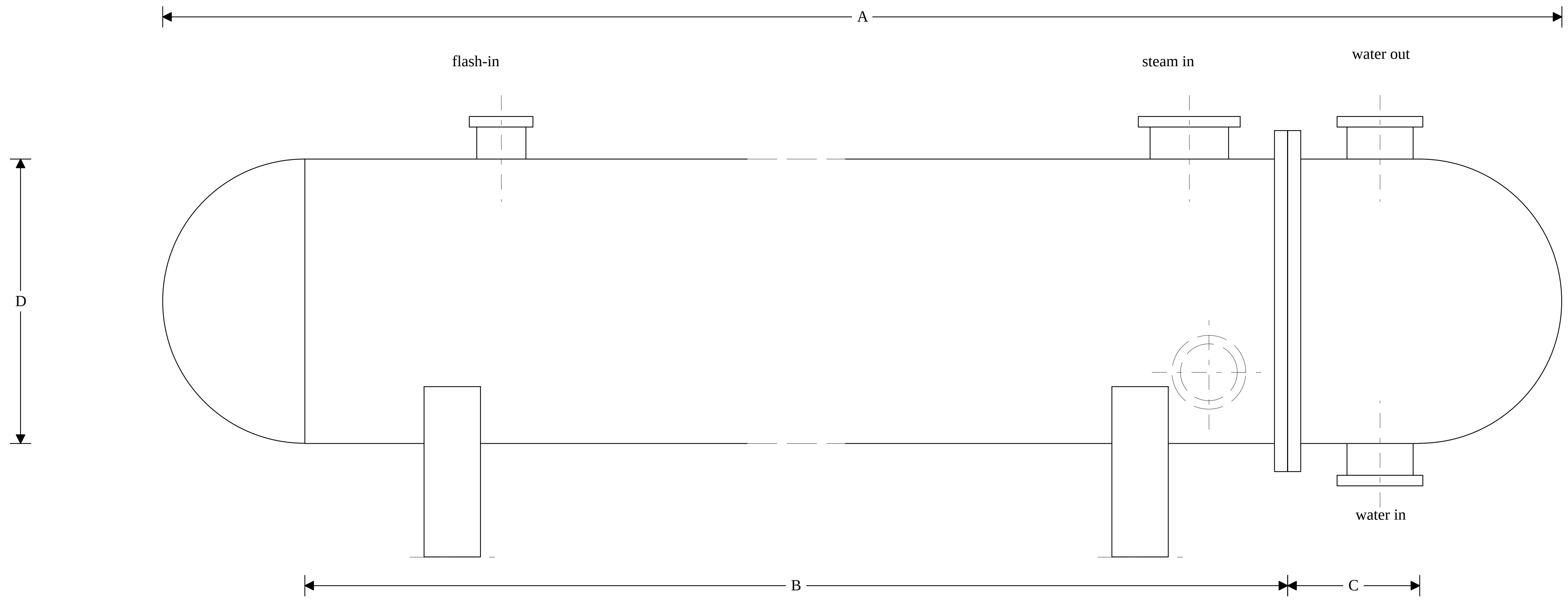
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
20.81 m	18.41 m	0.7642 m	1.575 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 1-P SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

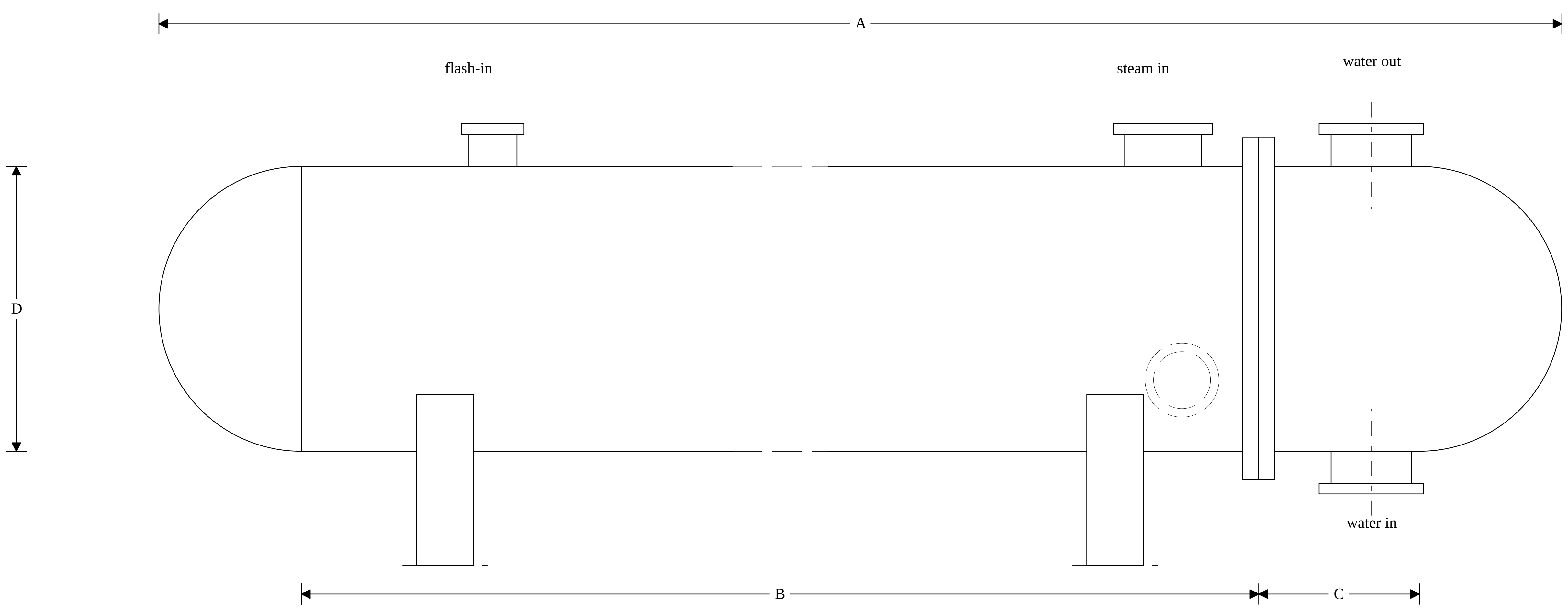


A	B	C	D	E	F	G	H	I	J
22.16 m	19.54 m	0.8511 m	1.703 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 2-D SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

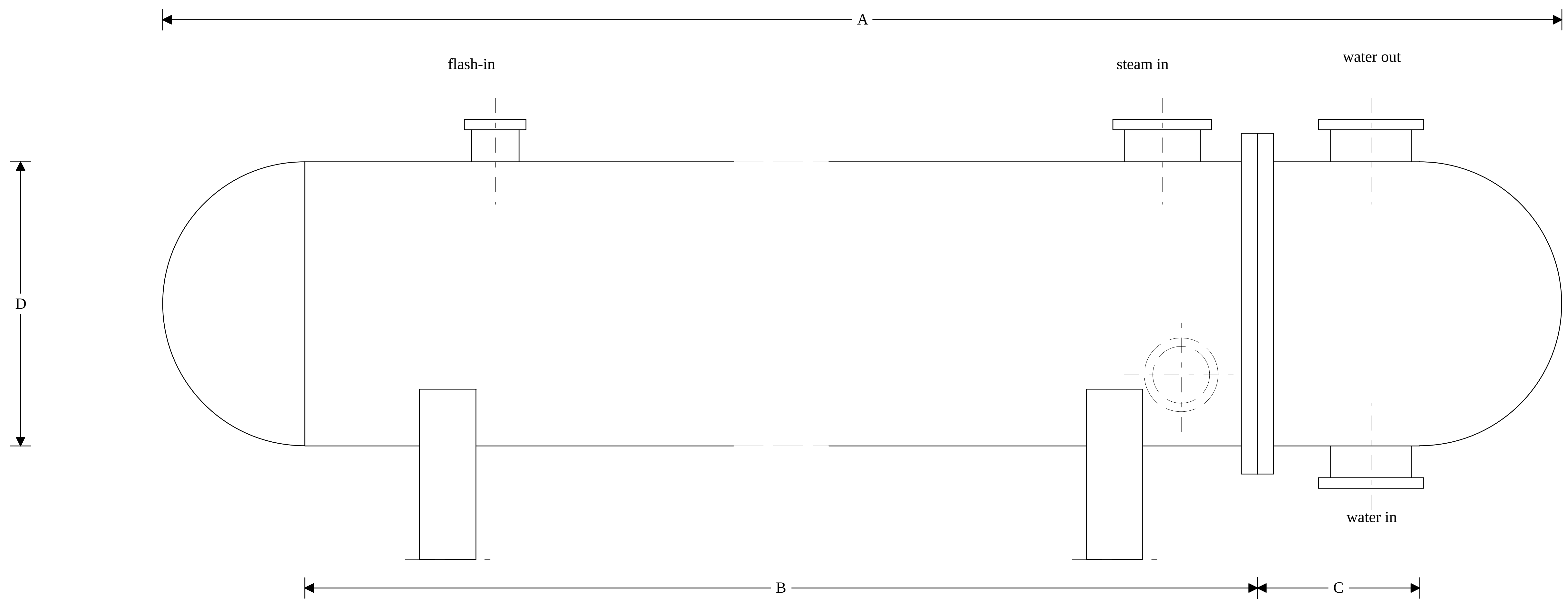


A	B	C	D	E	F	G	H	I	J
19.63 m	17.1 m	0.8594 m	1.611 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 3-D SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

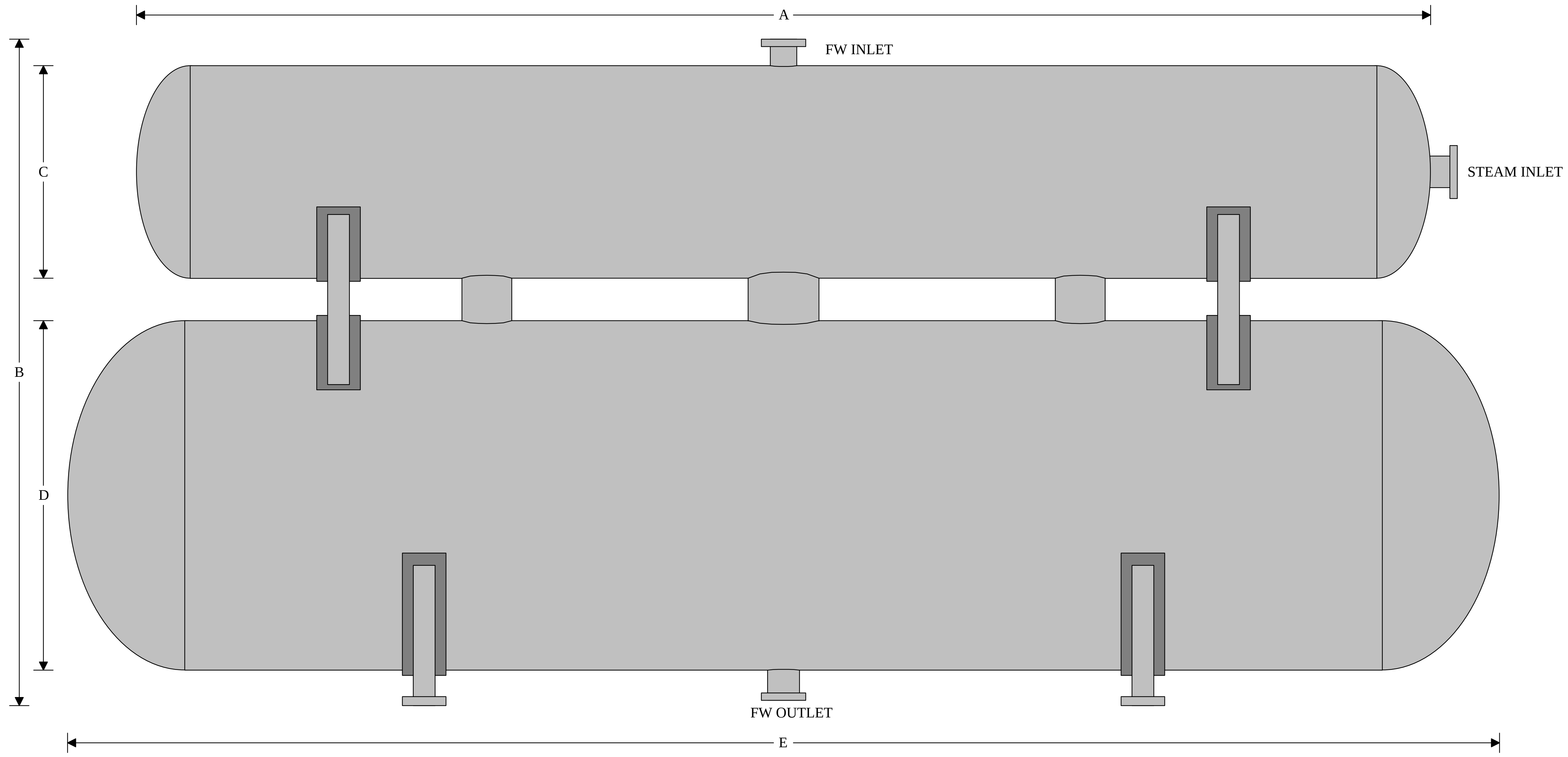
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
17.8 m	15.25 m	0.8696 m	1.632 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 4-D SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

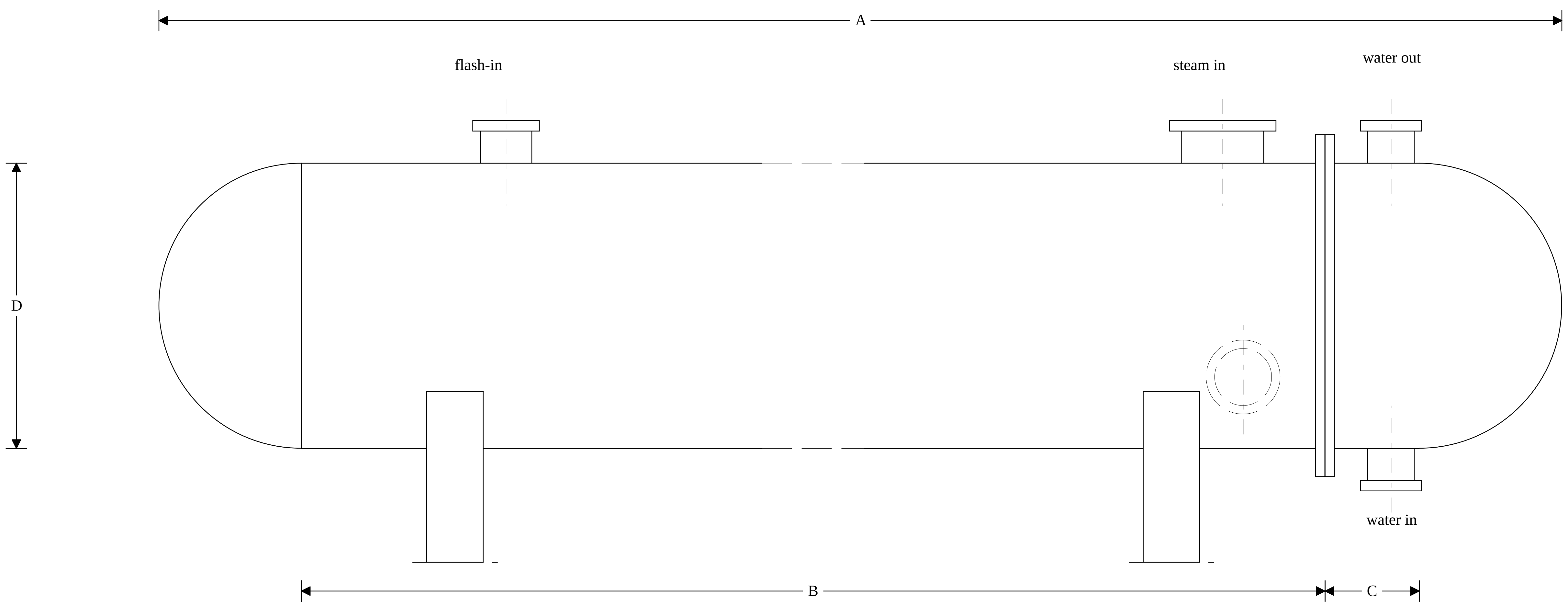
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
16.94 m	7.963 m	2.781 m	4.572 m	18.75 m	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	STEAM HEATED DEAERATOR ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

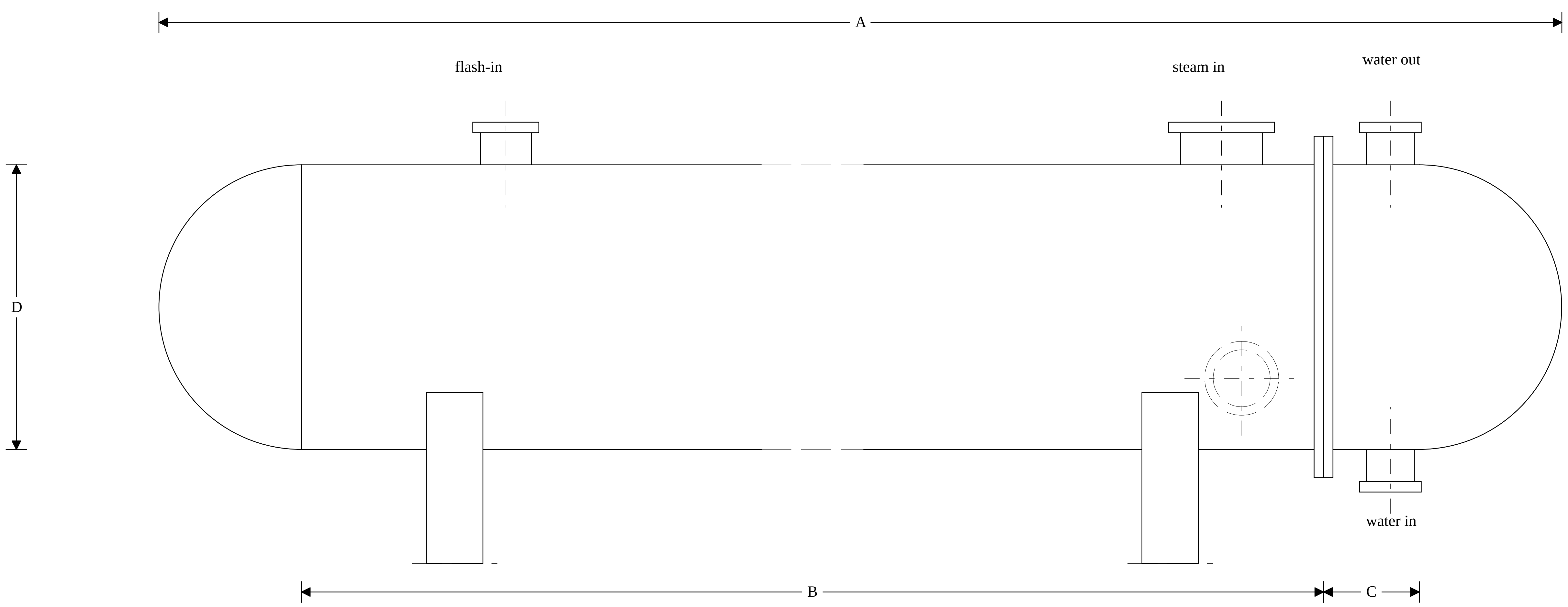


A	B	C	D	E	F	G	H	I	J
14.74 m	11.65 m	0.708 m	2.04 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 6-D (6A, 6B)
	SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

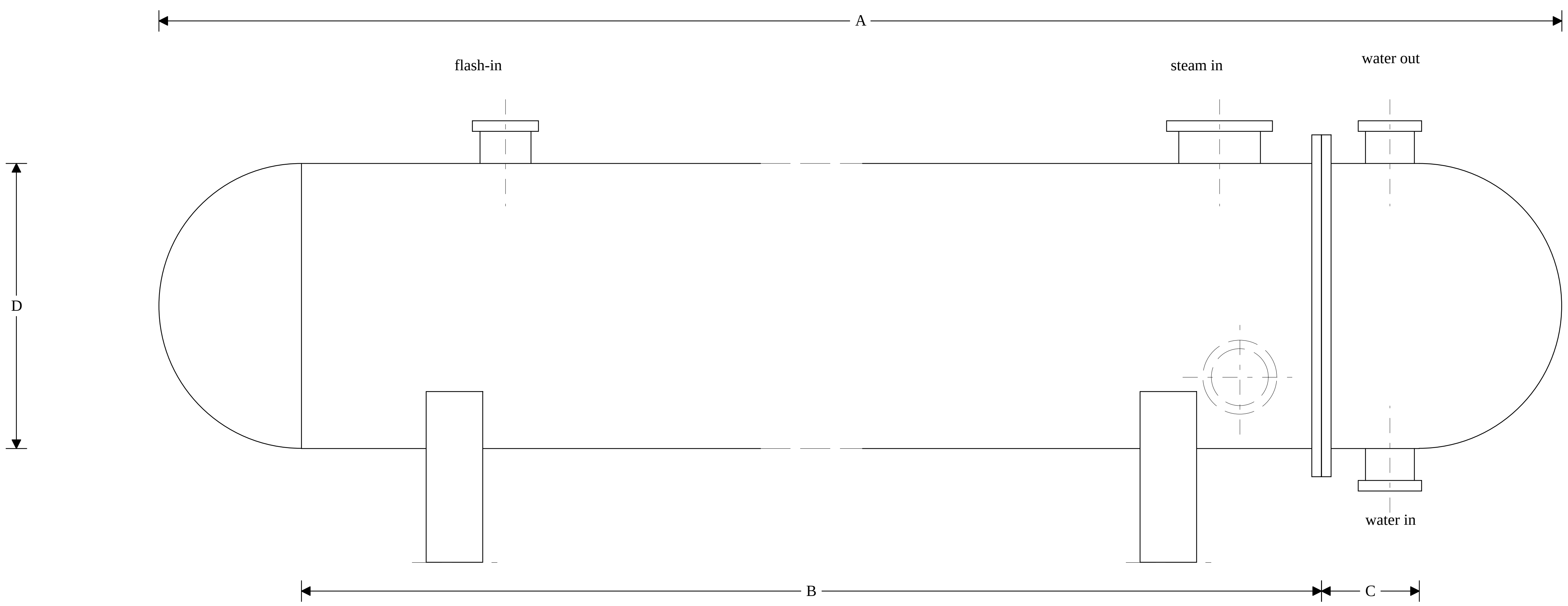
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
13.16 m	10.04 m	0.7181 m	2.03 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 7-D (7A, 7B)
	SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

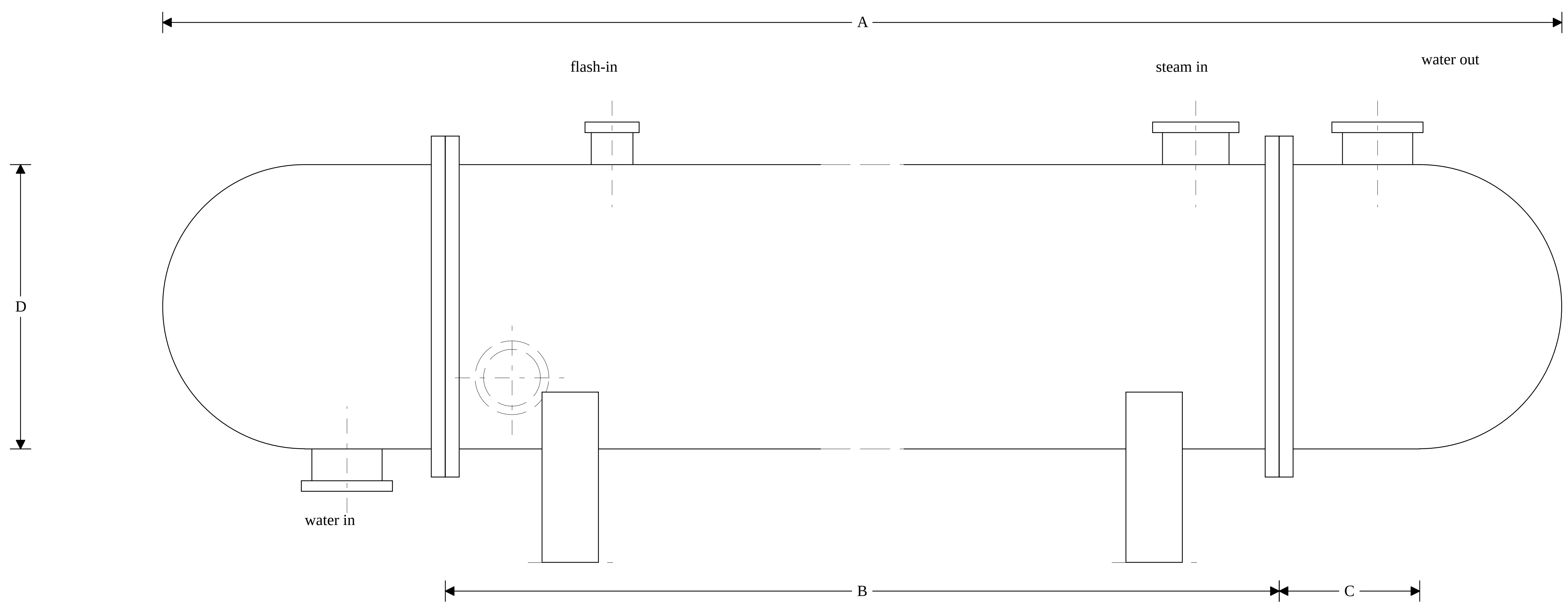


A	B	C	D	E	F	G	H	I	J
15.47 m	12.2 m	0.7343 m	2.227 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 8-D (8A, 8B)
	SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

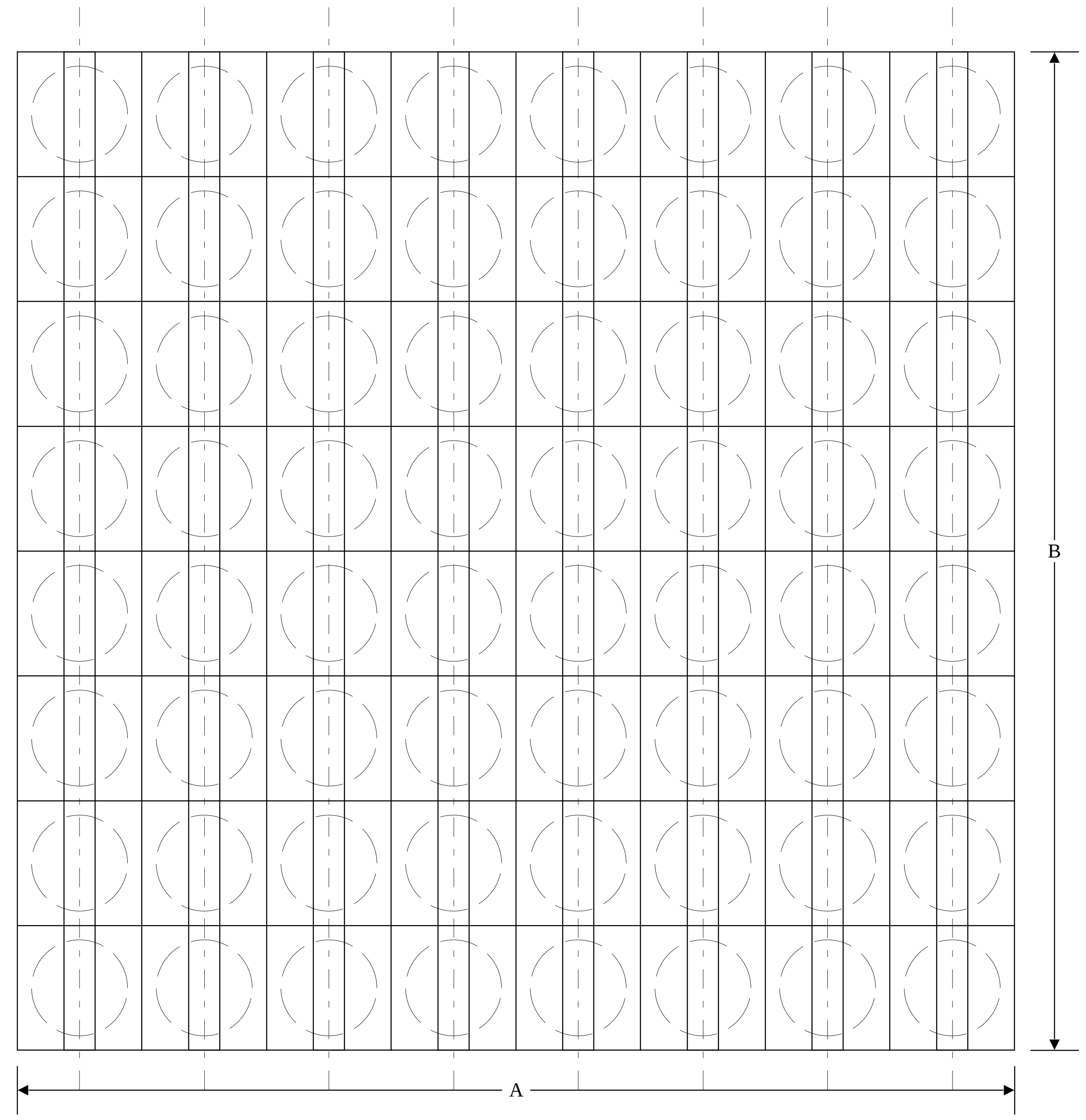
FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I	J
6.51 m	2.902 m	0.7534 m	1.542 m	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH 9-S (9A, 9B) SIDE ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

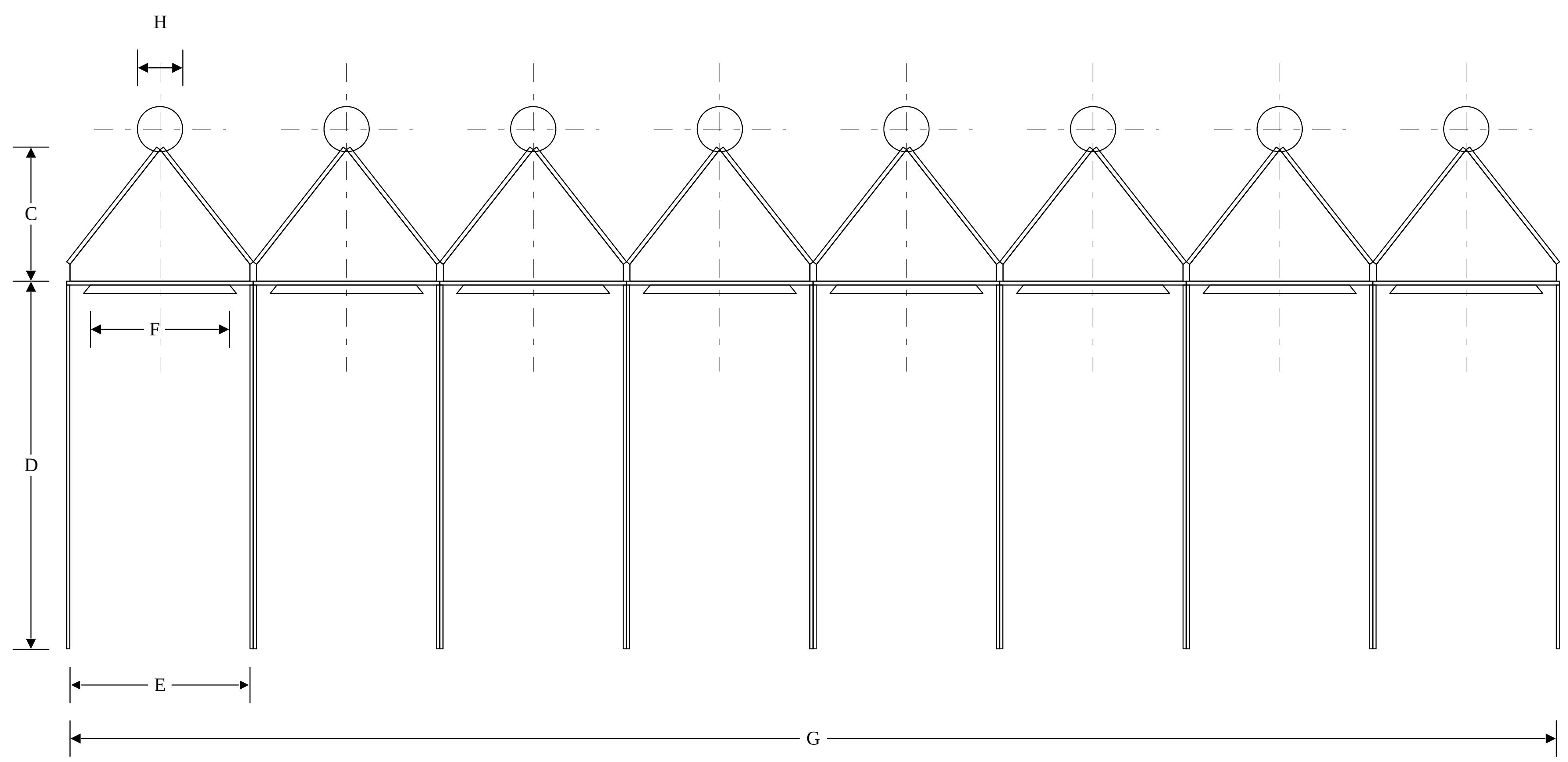


A	B	C	D	E	F	G	H	I	J
104.9 m	104.9 m	-	-	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	DRY AIR-COOLED CONDENSER PLAN
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

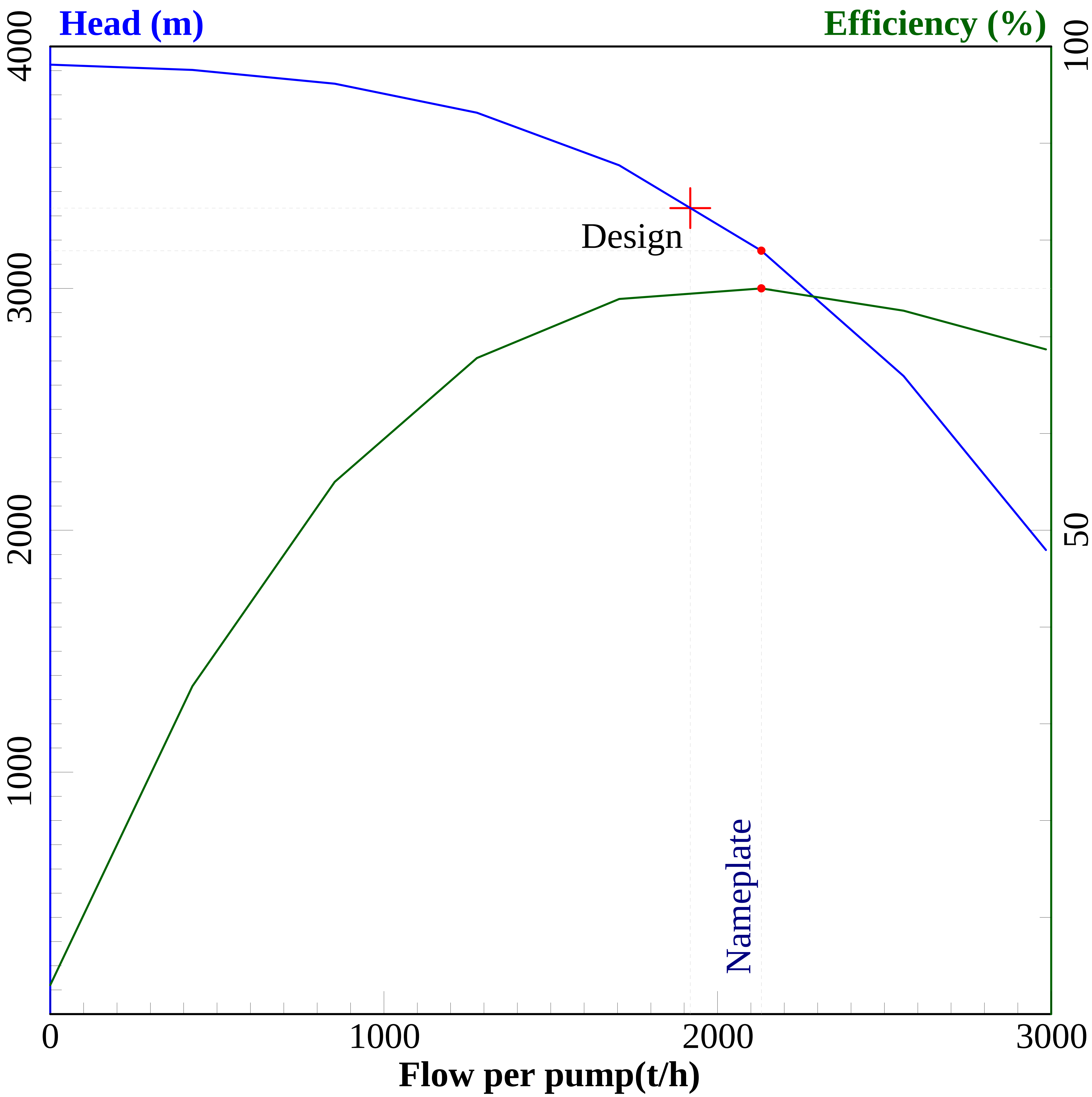


DIMENSION A IS SINGLE CELL LENGTH.
DIMENSION B IS LENGTH PER BAY.
(THERE ARE 8 CELLS PER BAY.)

A	B	C	D	E	F	G	H	I	J
13.11 m	104.9 m	9.768 m	26.53 m	13.11 m	10.12 m	104.9 m	3.298 m	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	DRY AIR-COOLED CONDENSER
	ELEV
Date: 04/21/17	
Drawing No:	

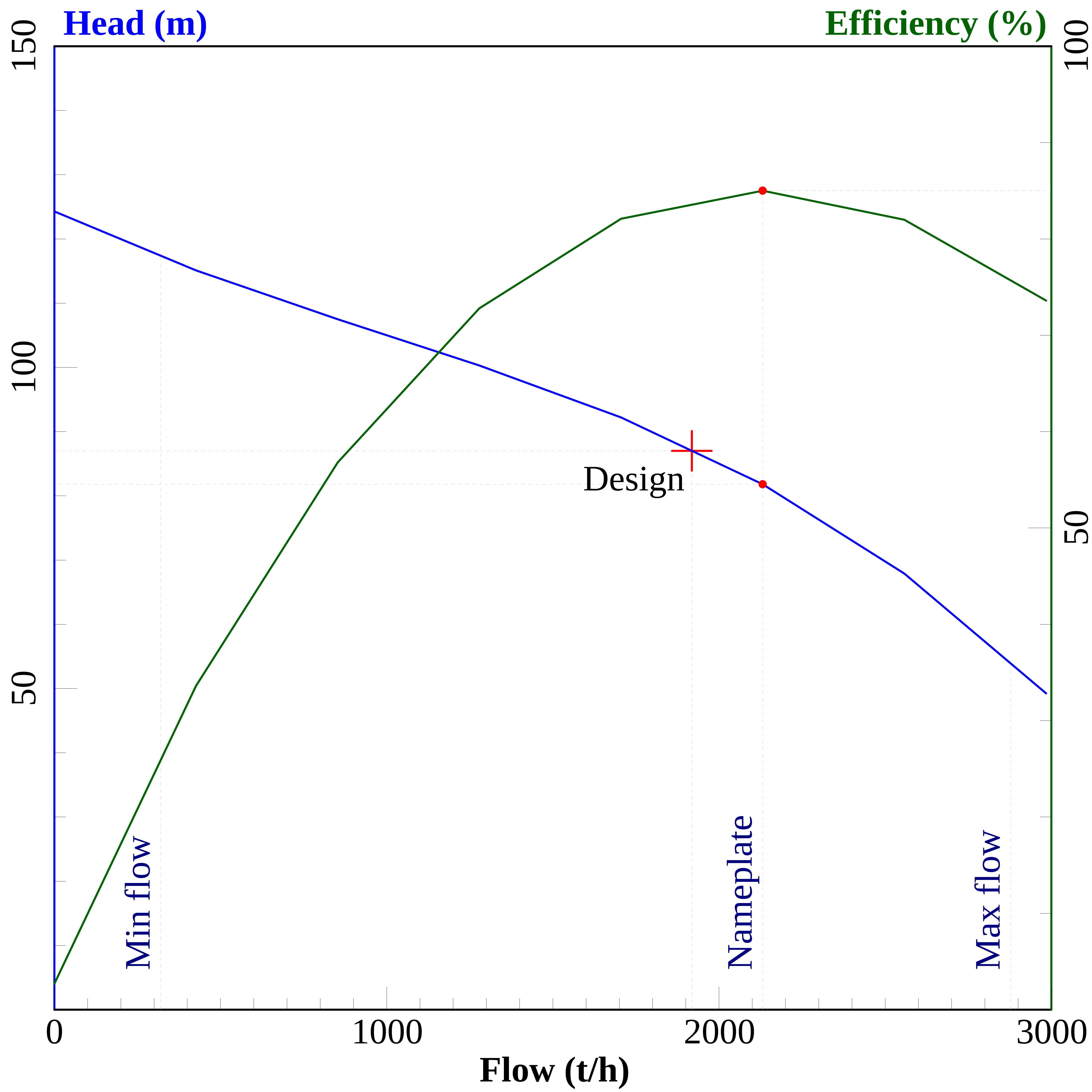
Boiler Feed Pump (P1)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2131.5 t/h
Nameplate head	3155 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	3170 m
Nameplate RPM	3000
Design flow	1918.4 t/h
Design head	3332 m
Design RPM	3000

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Pump (P1)
Date: 04/21/17	
Drawing No:	

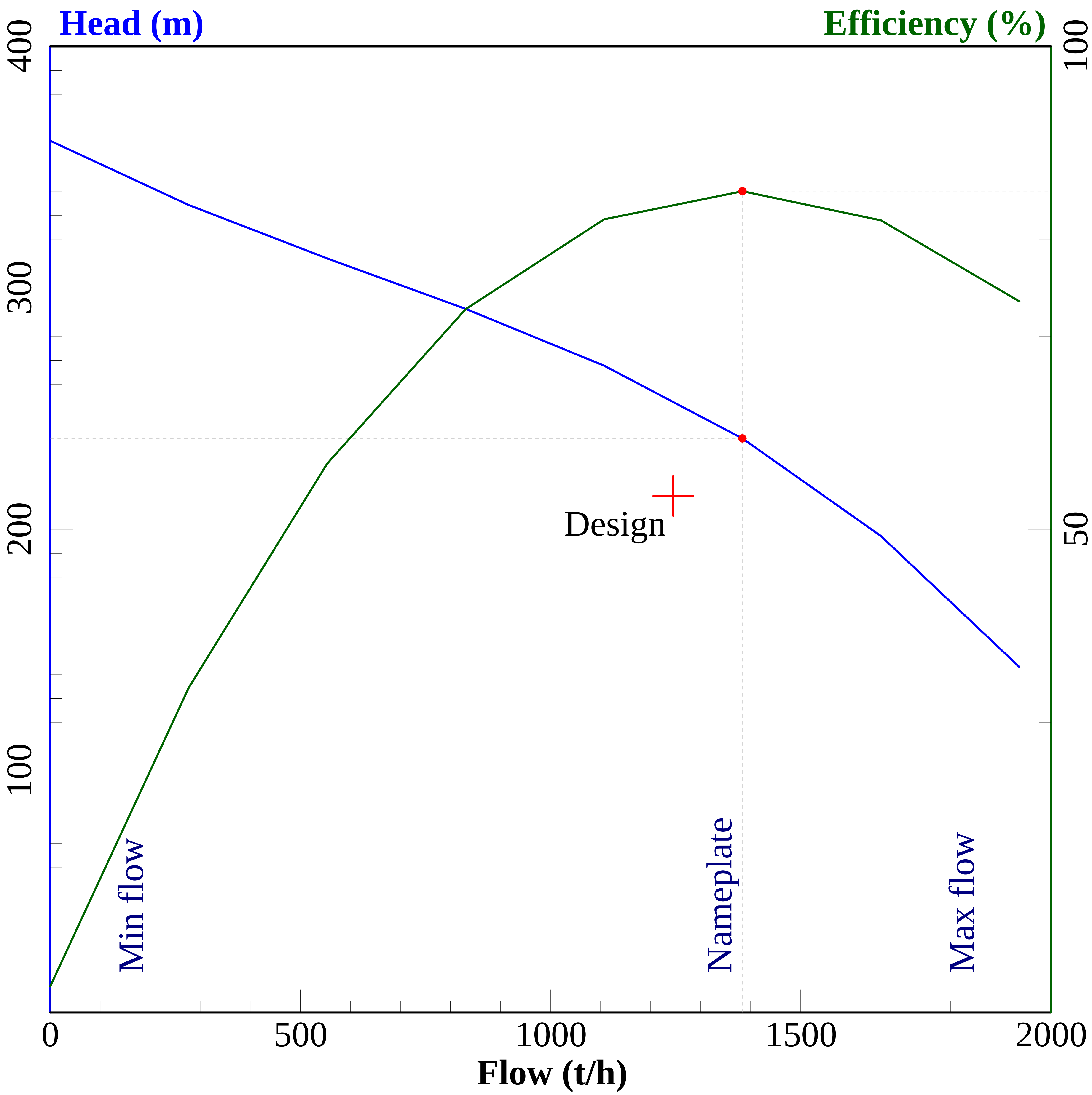
Boiler Feed Booster Pump (P3)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	2131.5 t/h
Nameplate head	81.81 m
Nameplate flow (nominal)	41640 lpm
Nameplate head (nominal)	83.82 m
Nameplate RPM	600
Design flow	1918.4 t/h
Design head	87.01 m
Design RPM	600
Minimum continuous flow	319.7 t/h
Maximum continuous flow	2877.6 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Boiler Feed Booster Pump (P3)
Date: 04/21/17	
Drawing No:	

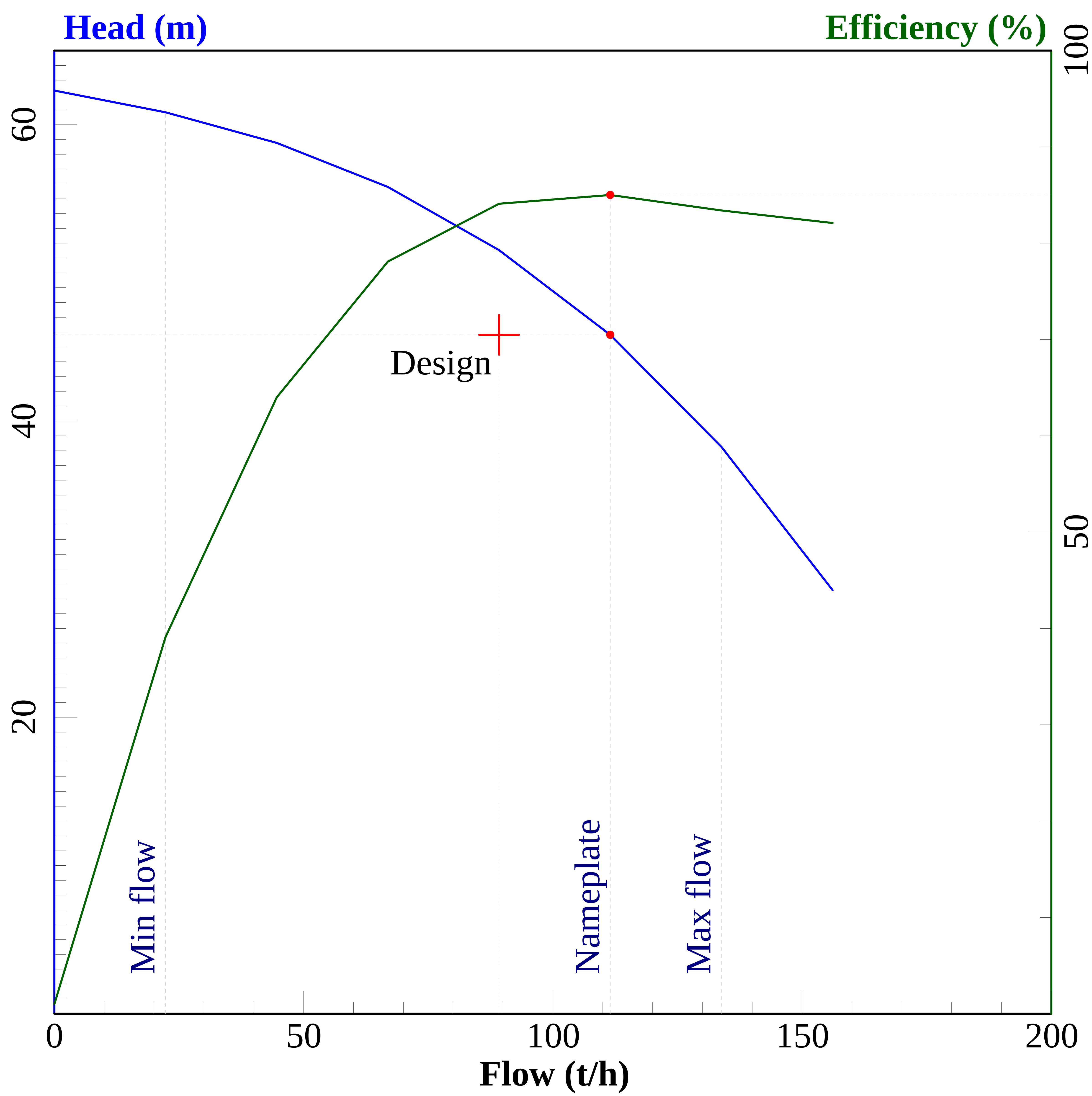
Condensate Forwarding Pump (P6)



No. per ST	2
No. operating per ST	1
Nameplate flow	1383.9 t/h
Nameplate head	237.6 m
Nameplate flow (nominal)	24605 lpm
Nameplate head (nominal)	243.8 m
Nameplate RPM	750
Design flow	1245.5 t/h
Design head	213.9 m
Design RPM	750
Minimum continuous flow	207.6 t/h
Maximum continuous flow	1868.2 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Condensate Forwarding Pump (P6)
Date: 04/21/17	
Drawing No:	

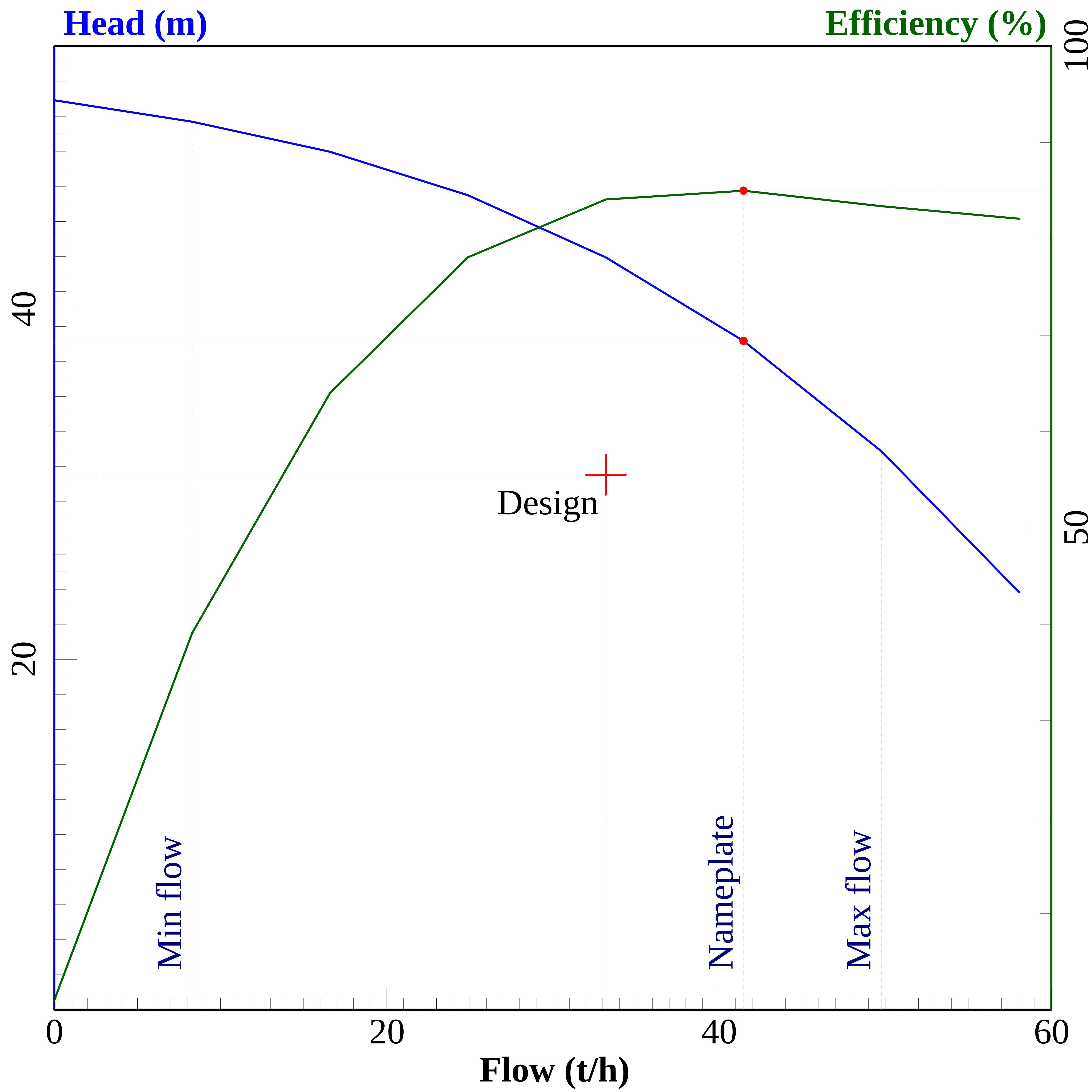
Fuel Oil Unloading Pump (P8)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	111.5 t/h
Nameplate head	45.81 m
Nameplate flow (nominal)	2271.2 lpm
Nameplate head (nominal)	53.34 m
Nameplate RPM	3000
Design flow	89.21 t/h
Design head	45.81 m
Design RPM	3000
Minimum continuous flow	22.3 t/h
Maximum continuous flow	133.8 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Fuel Oil Unloading Pump (P8)
Date: 04/21/17	
Drawing No:	

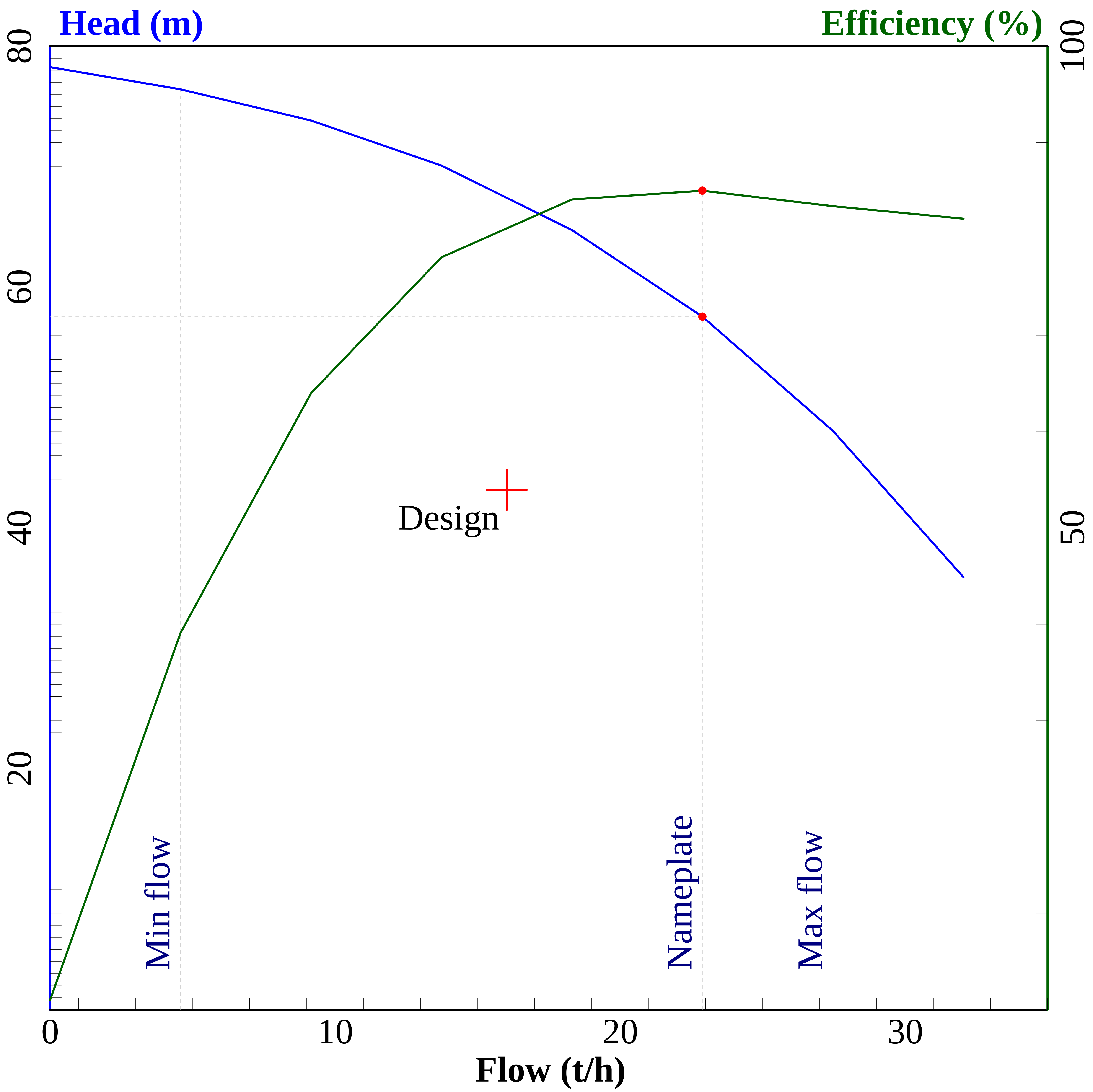
Fuel Oil Forwarding Pump (P9)



No. per Plant	2
No. operating per Plant	1
Nameplate flow	41.48 t/h
Nameplate head	38.17 m
Nameplate flow (nominal)	851.7 lpm
Nameplate head (nominal)	45.72 m
Nameplate RPM	3000
Design flow	33.18 t/h
Design head	30.54 m
Design RPM	3000
Minimum continuous flow	8.296 t/h
Maximum continuous flow	49.78 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Fuel Oil Forwarding Pump (P9)
Date: 04/21/17	
Drawing No:	

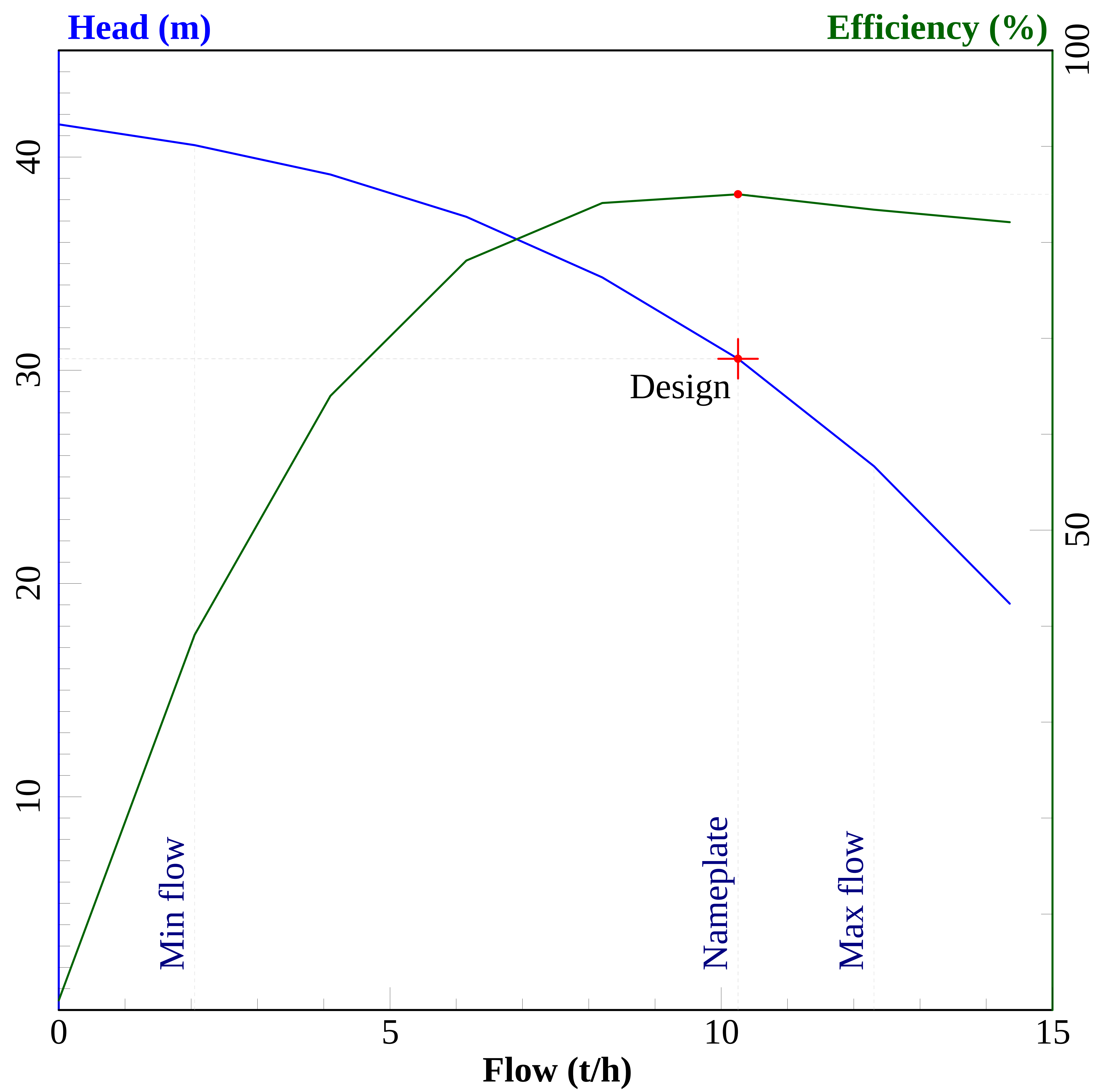
Treated Water Pump (P11)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	22.89 t/h
Nameplate head	57.55 m
Nameplate flow (nominal)	416.4 lpm
Nameplate head (nominal)	60.96 m
Nameplate RPM	3000
Design flow	16.03 t/h
Design head	43.16 m
Design RPM	3000
Minimum continuous flow	4.579 t/h
Maximum continuous flow	27.47 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Treated Water Pump (P11)
Date: 04/21/17	
Drawing No:	

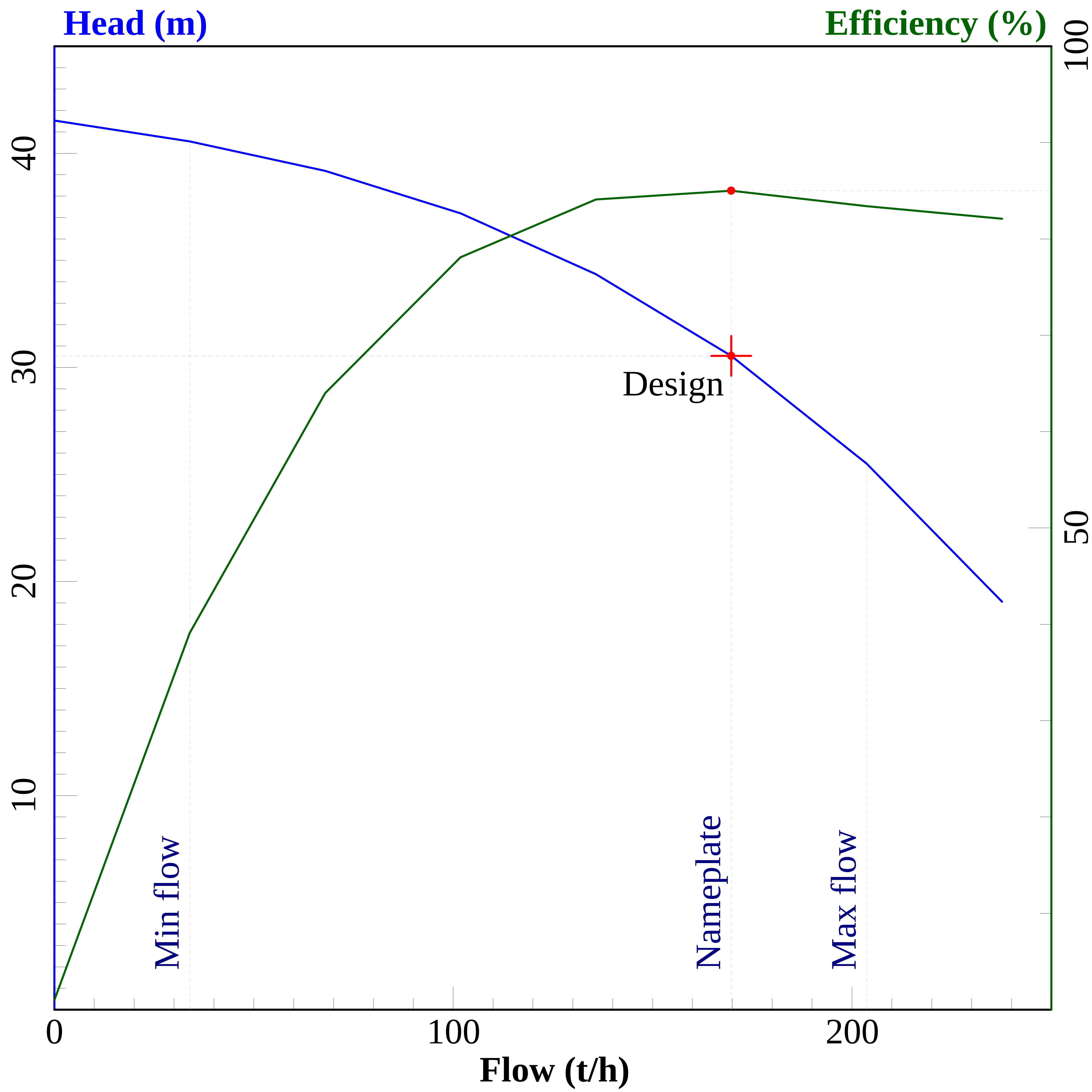
Jockey Fire Pump (P14)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	10.25 t/h
Nameplate head	30.54 m
Nameplate flow (nominal)	170.3 lpm
Nameplate head (nominal)	38.1 m
Nameplate RPM	3000
Design flow	10.25 t/h
Design head	30.54 m
Design RPM	3000
Minimum continuous flow	2.051 t/h
Maximum continuous flow	12.31 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Jockey Fire Pump (P14)
Date: 04/21/17	
Drawing No:	

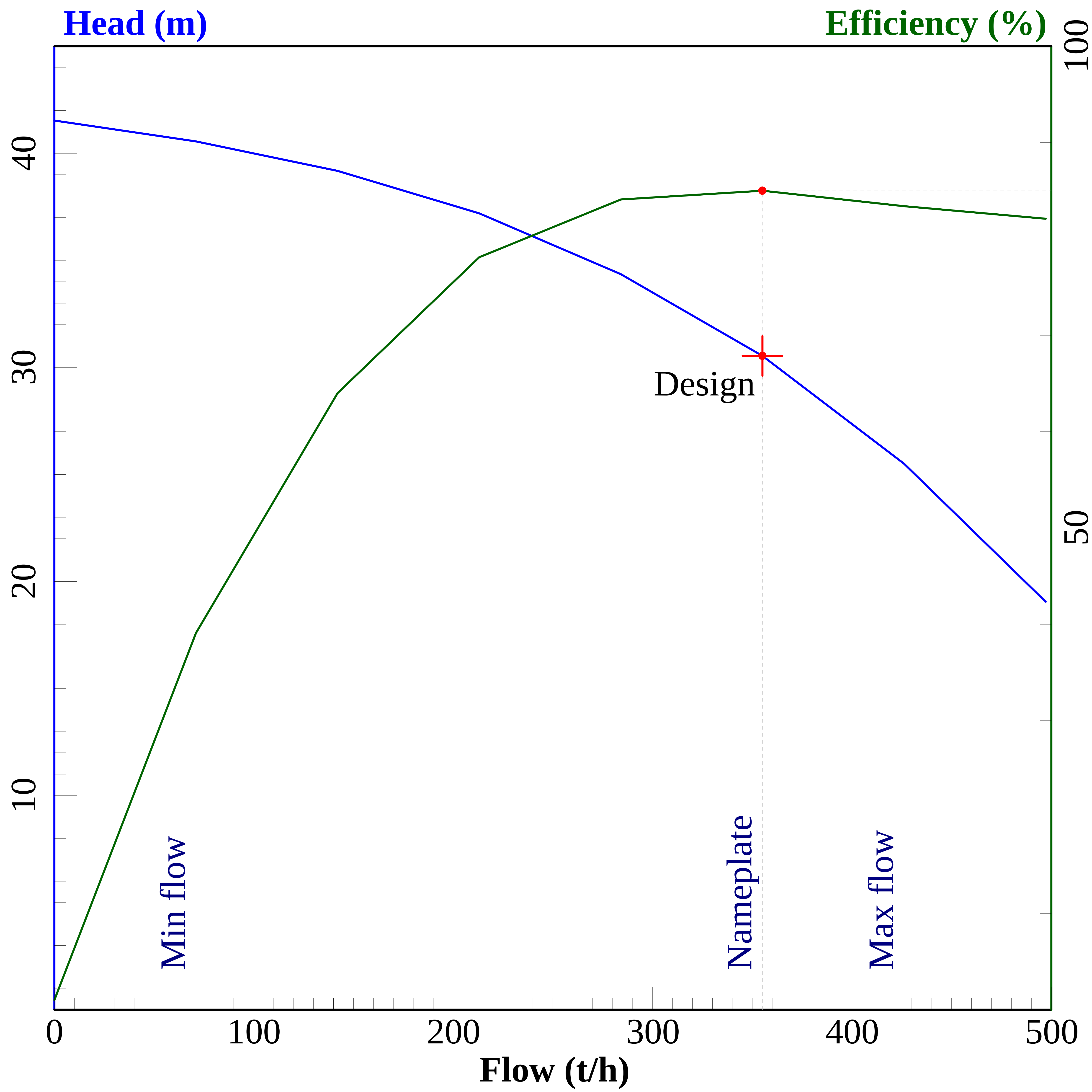
ST+Generator Lube Oil Coolant Pump (P21)



No. per ST+Generator Lube Oi	2
No. operating per ST+Generator	1
Nameplate flow	169.7 t/h
Nameplate head	30.54 m
Nameplate flow (nominal)	3028 lpm
Nameplate head (nominal)	38.1 m
Nameplate RPM	3000
Design flow	169.7 t/h
Design head	30.54 m
Design RPM	3000
Minimum continuous flow	33.95 t/h
Maximum continuous flow	203.7 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ST+Generator Lube Oil Coolant Pump (P21)
Date: 04/21/17	
Drawing No:	

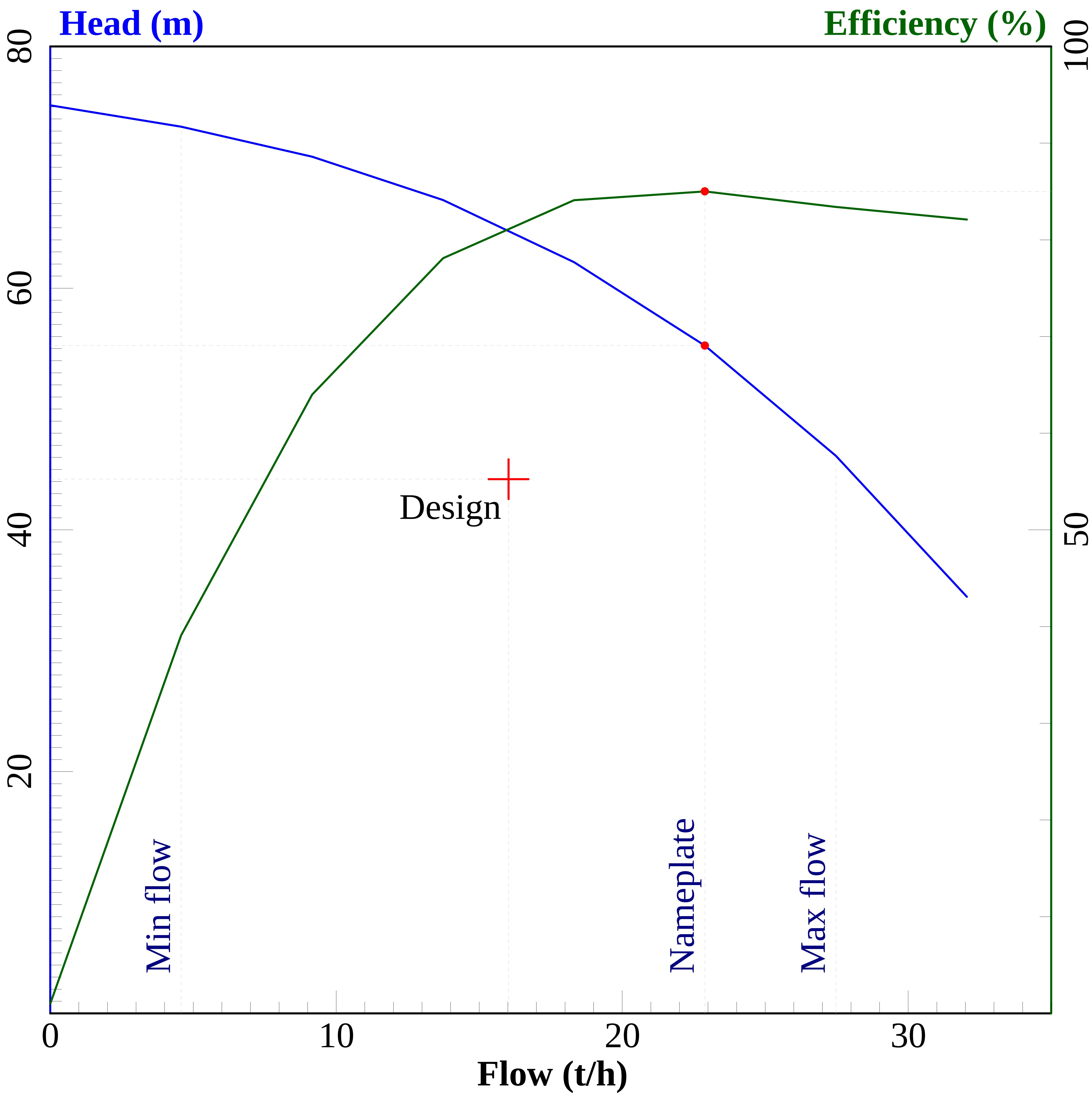
ST Generator Coolant Pump (P22)



No. per ST Generator	2
No. operating per ST Generator	1
Nameplate flow	355.1 t/h
Nameplate head	30.54 m
Nameplate flow (nominal)	6624 lpm
Nameplate head (nominal)	38.1 m
Nameplate RPM	1500
Design flow	355.1 t/h
Design head	30.54 m
Design RPM	1500
Minimum continuous flow	71.02 t/h
Maximum continuous flow	426.1 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ST Generator Coolant Pump (P22)
Date: 04/21/17	
Drawing No:	

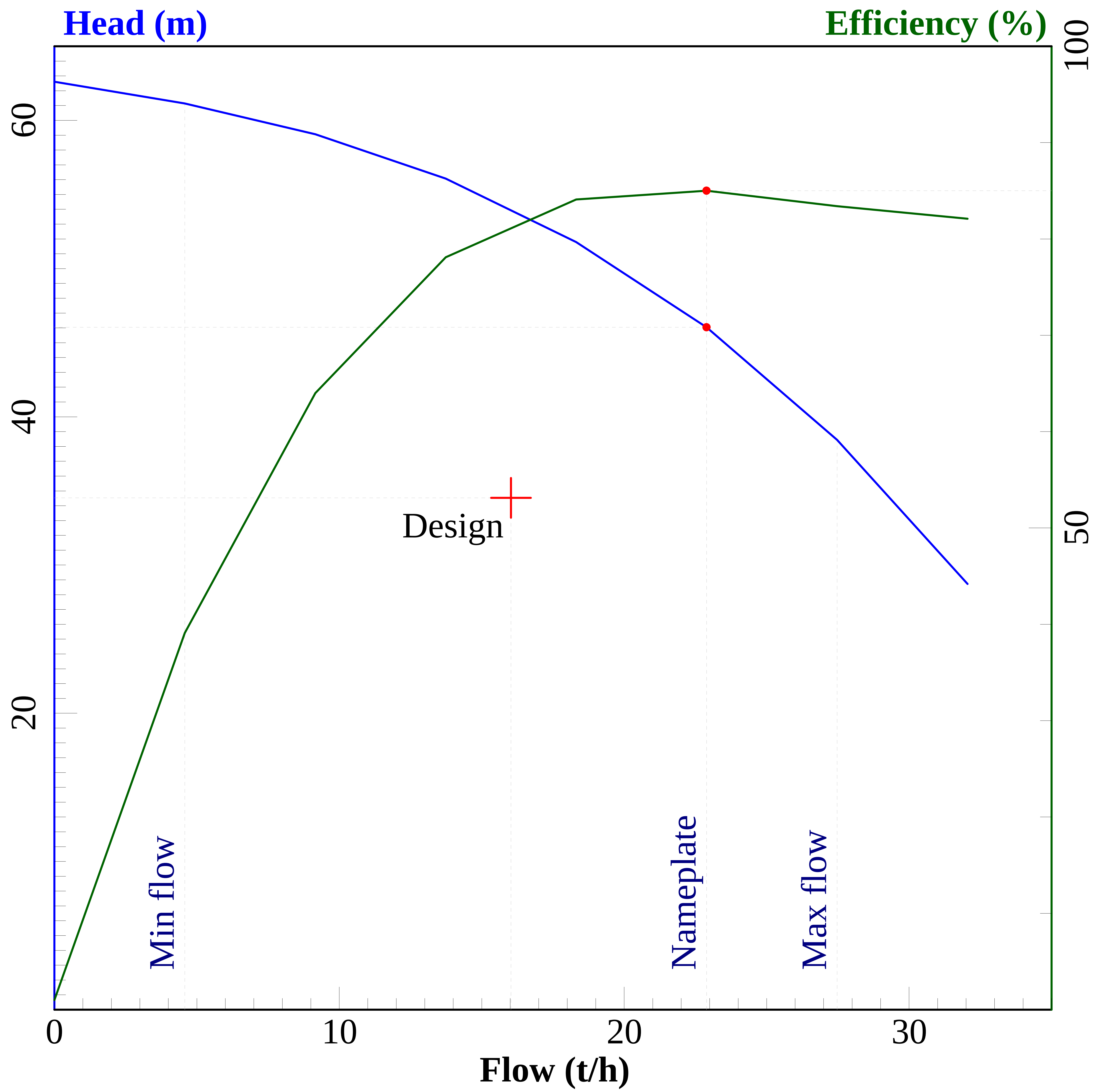
Demin Water Pump (P23)



No. per Plant	2
No. operating per Plant	1
Nameplate flow	22.89 t/h
Nameplate head	55.24 m
Nameplate flow (nominal)	416.4 lpm
Nameplate head (nominal)	60.96 m
Nameplate RPM	3000
Design flow	16.03 t/h
Design head	44.2 m
Design RPM	3000
Minimum continuous flow	4.579 t/h
Maximum continuous flow	27.47 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Demin Water Pump (P23)
Date: 04/21/17	
Drawing No:	

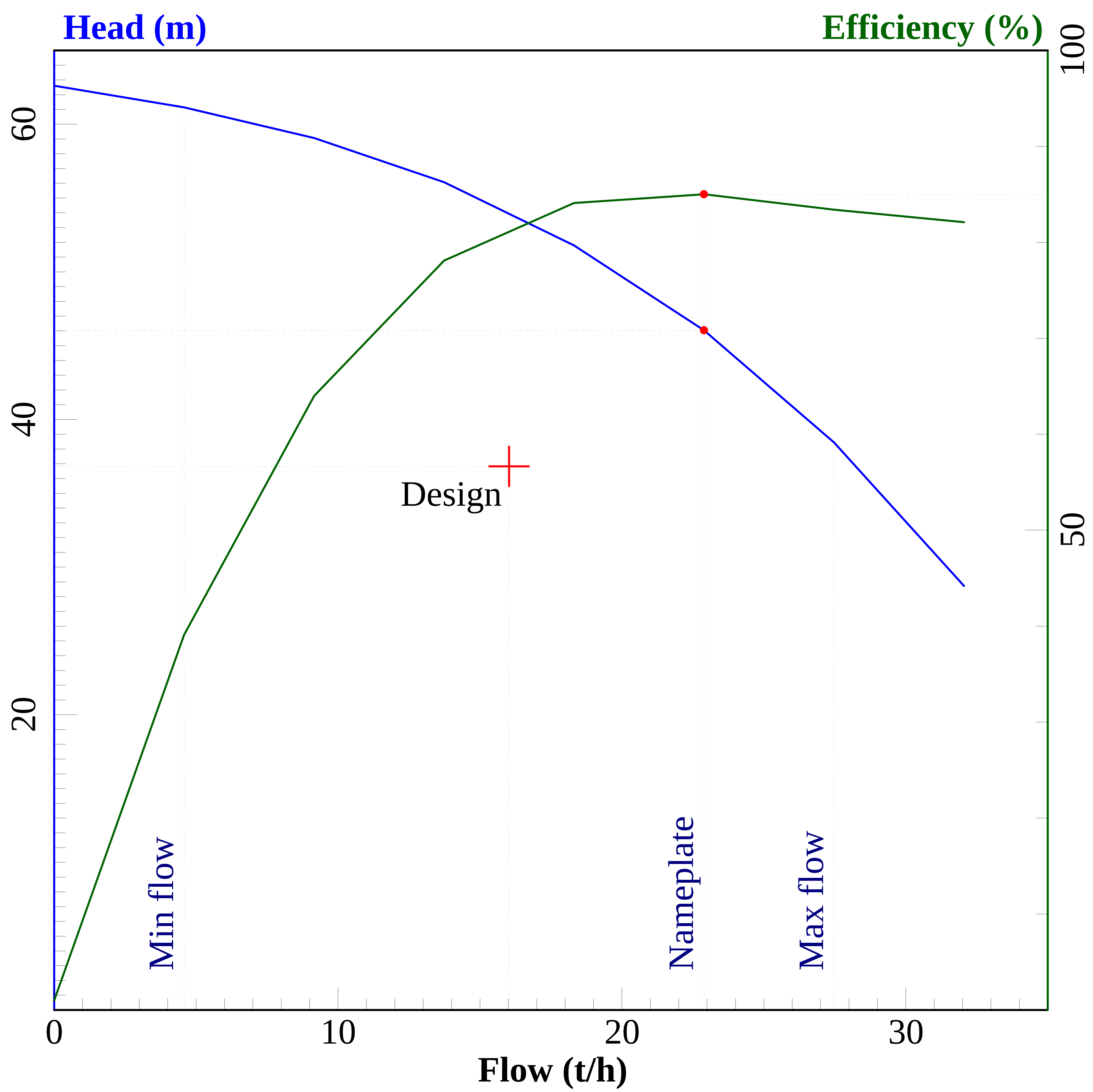
Raw Water Pump 1 (P26)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	22.89 t/h
Nameplate head	46.04 m
Nameplate flow (nominal)	416.4 lpm
Nameplate head (nominal)	53.34 m
Nameplate RPM	3000
Design flow	16.03 t/h
Design head	34.53 m
Design RPM	3000
Minimum continuous flow	4.579 t/h
Maximum continuous flow	27.47 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Raw Water Pump 1 (P26)
Date: 04/21/17	
Drawing No:	

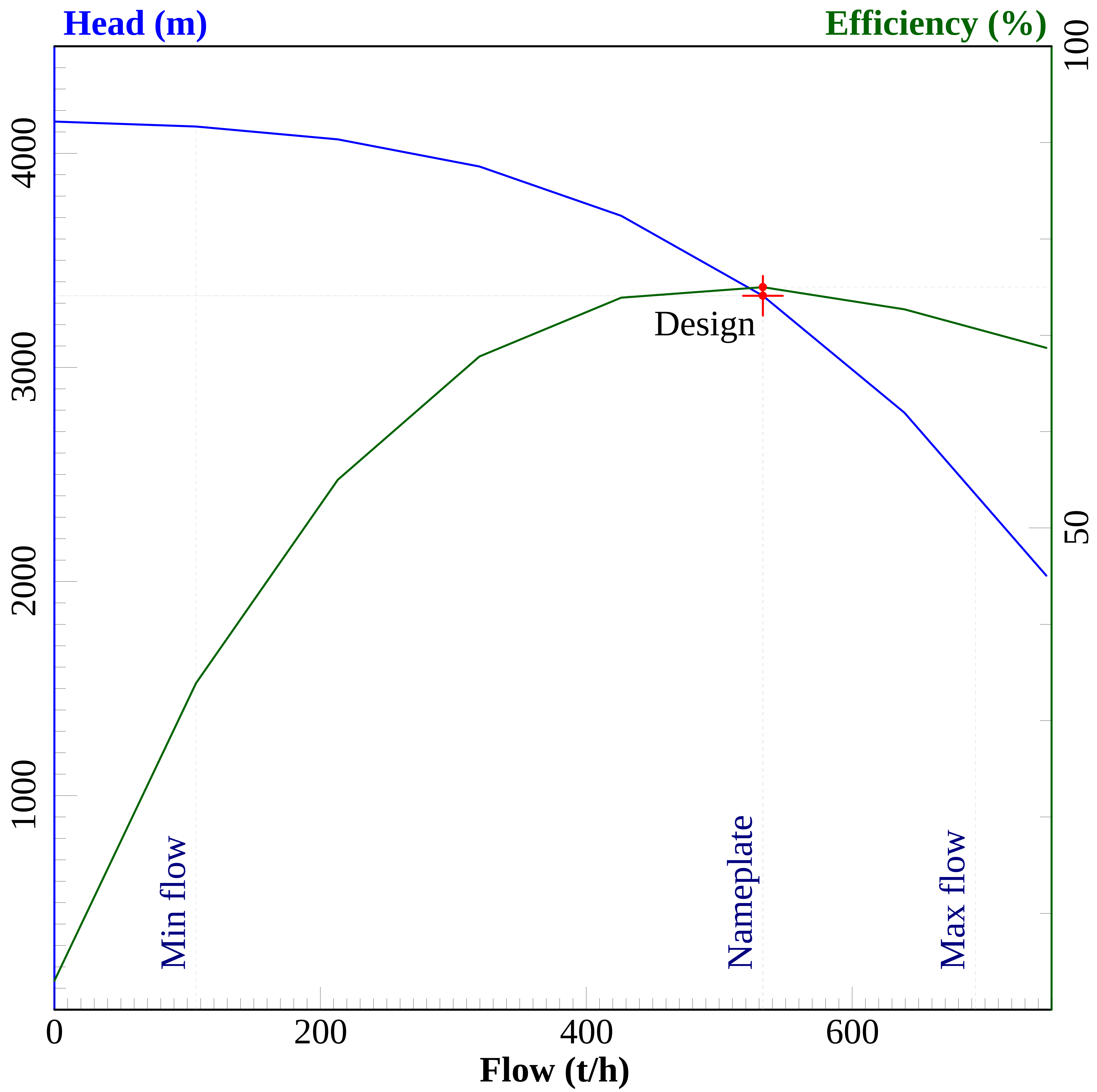
Raw Water Pump 2 (P27)



No. per Plant	1
No. operating per Plant	1
Nameplate flow	22.89 t/h
Nameplate head	46.04 m
Nameplate flow (nominal)	416.4 lpm
Nameplate head (nominal)	53.34 m
Nameplate RPM	3000
Design flow	16.03 t/h
Design head	36.83 m
Design RPM	3000
Minimum continuous flow	4.579 t/h
Maximum continuous flow	27.47 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Raw Water Pump 2 (P27)
Date: 04/21/17	
Drawing No:	

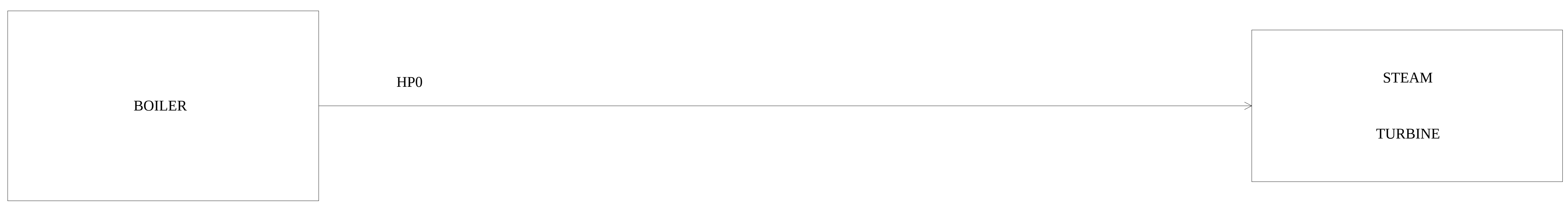
Startup Boiler Feed Pump (P2)



No. per Boiler	1
No. operating per Boiler	1
Nameplate flow	532.9 t/h
Nameplate head	3335 m
Nameplate flow (nominal)	10410 lpm
Nameplate head (nominal)	3353 m
Nameplate RPM	3000
Design flow	532.9 t/h
Design head	3335 m
Design RPM	3000
Minimum continuous flow	106.6 t/h
Maximum continuous flow	692.7 t/h

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Startup Boiler Feed Pump (P2)
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
HP0 x 1	457.2	172.5	Custom	TP347HFG	280.1	606	1918.4	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	HP PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
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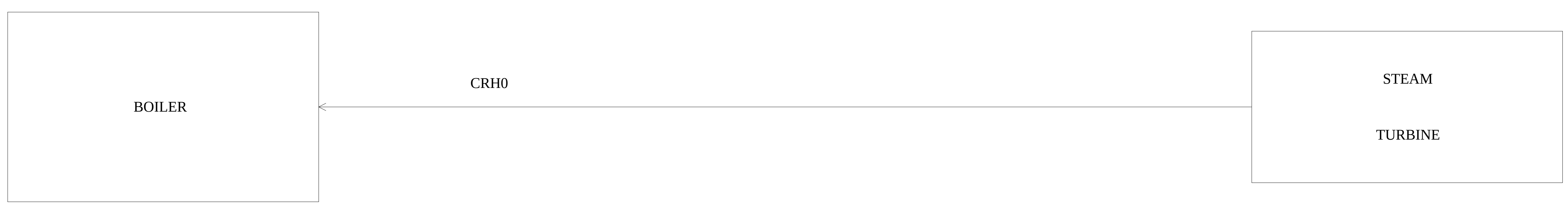
FOR QUALITATIVE INDICATION ONLY

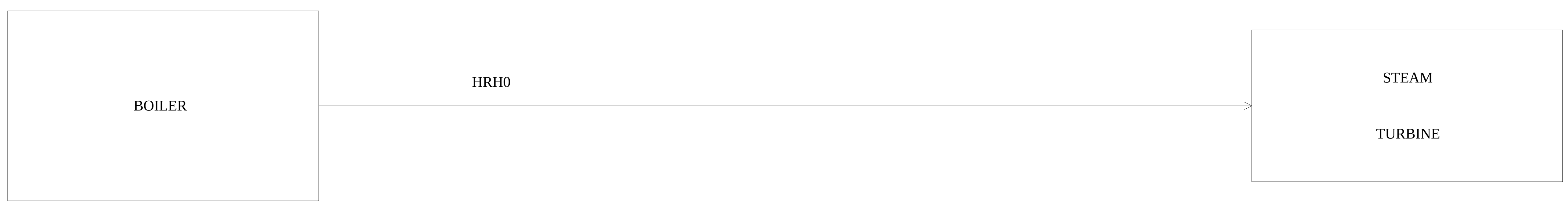


ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
CRH0 x 1	730.3	181.1	Custom	P-22	64.3	374.5	1740.2	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	RH PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

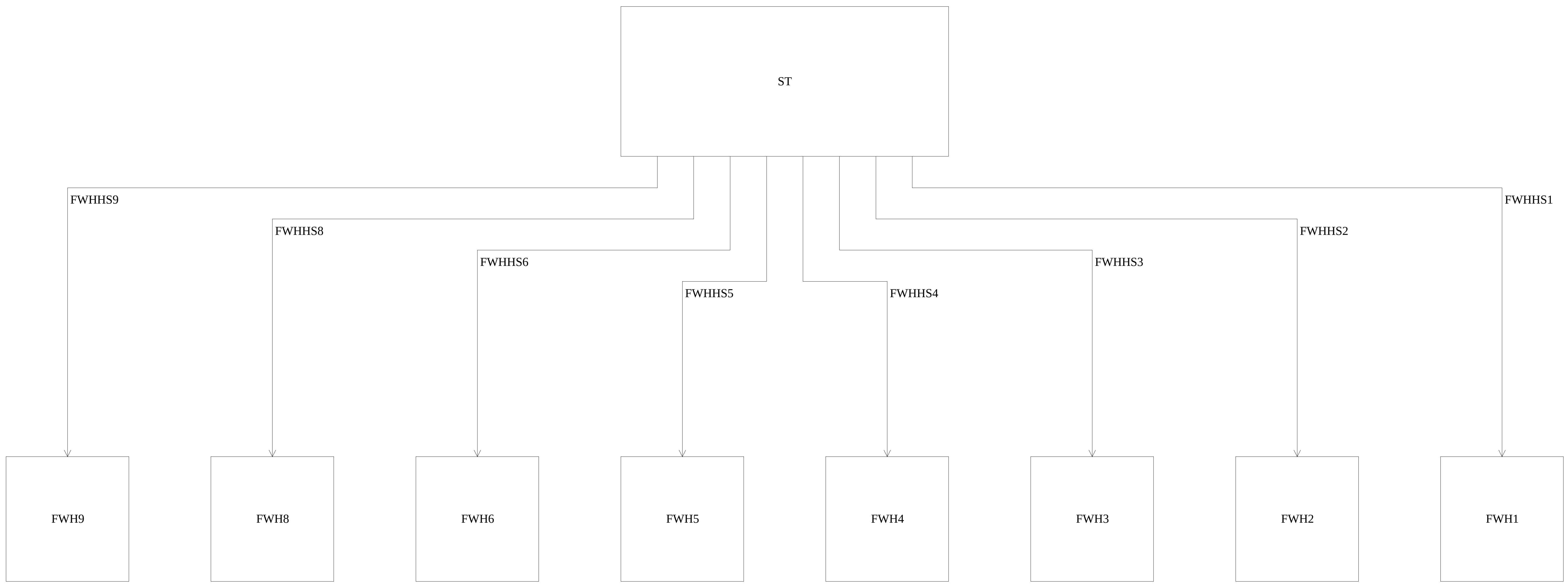
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
HRH0 x 1	812.8	189.9	Custom	TP347HFG	61.2	605.4	1740.2	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	RH PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

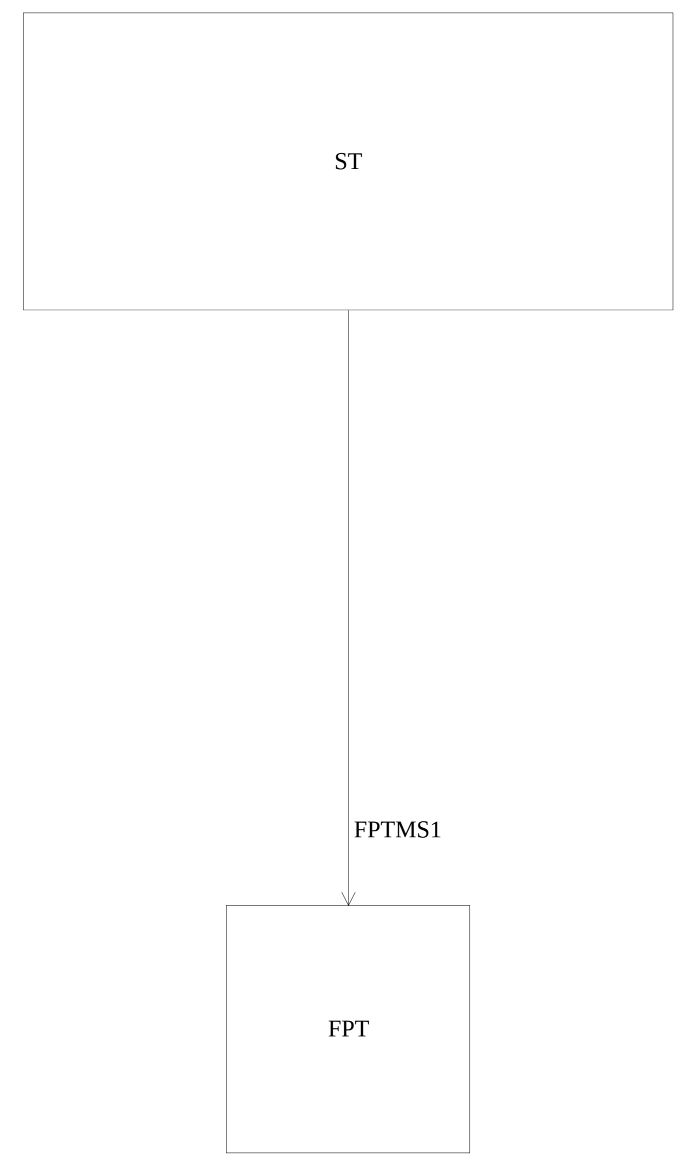
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FWHHS1 x 1	762	10.67	10	A-106	0.4907	80.88	59.99	
FWHHS2 x 1	609.6	21.34	40	A-106	1.38	127.6	66.09	
FWHHS3 x 1	457.2	32	40	A-106	3.309	212.4	70.11	
FWHHS4 x 1	406.4	42.67	40	A-106	7	296.5	73.38	
FWHHS5 x 1	406.4	103	40	A-106	13.04	375.4	76.74	
FWHHS6 x 2	203.2	37.19	40	P-11	22.9	454.3	32.89	
FWHHS8 x 2	203.2	47.85	60	P-22	64.3	374.5	66.21	
FWHHS9 x 2	203.2	53.04	60	P-91	42.67	549.8	61.58	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FWH HEATING STEAM PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

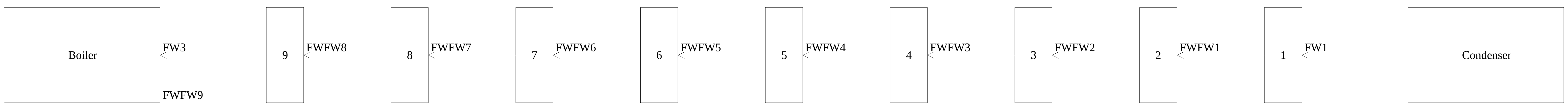
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FPTMS1 x 1	609.6	71.02	40	A-106	7	296.5	147.3	
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	OTHER HEATING STEAM PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

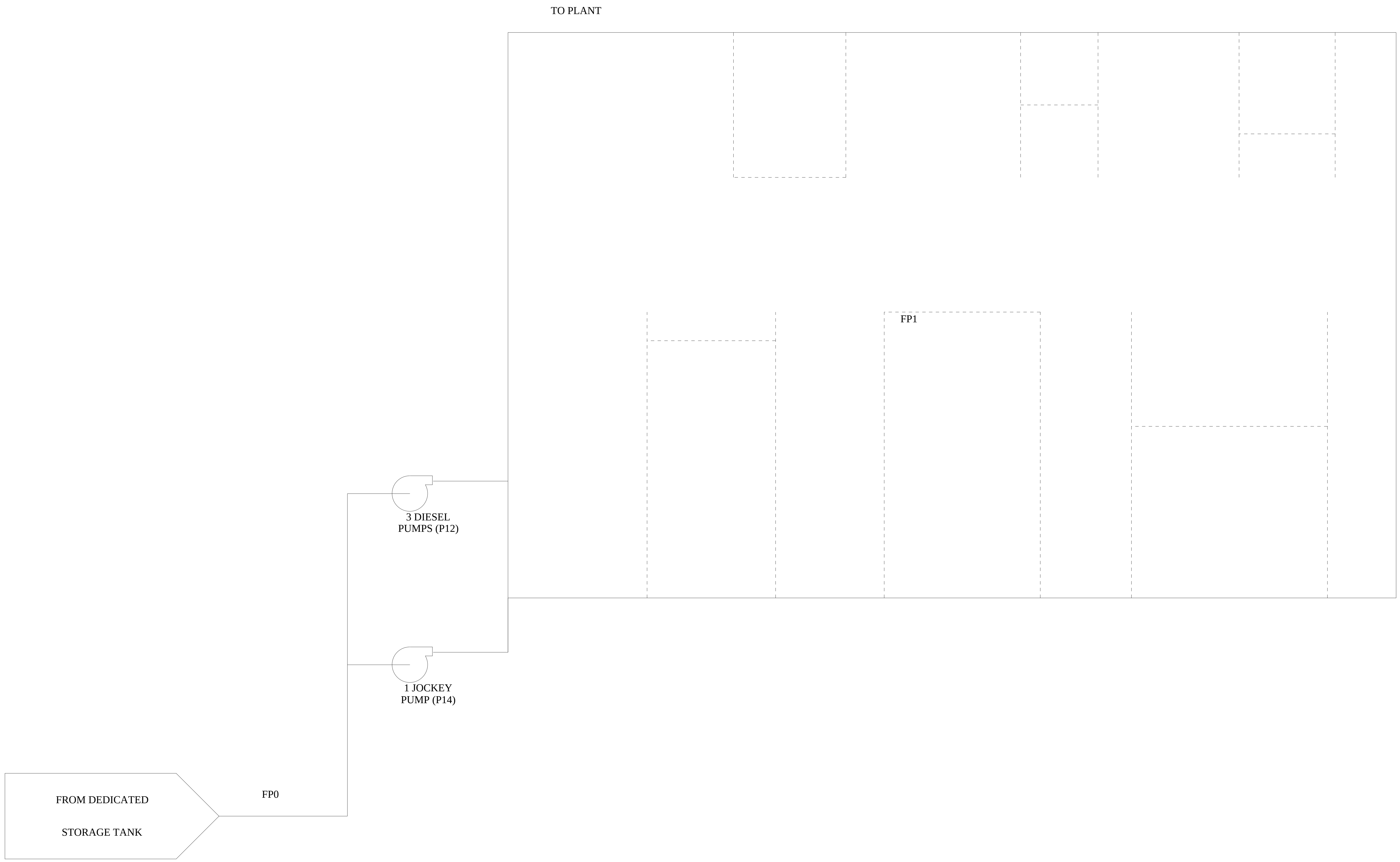
FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FW1 x 1	457.2	300.8	20	A-106	21.15	47.85	1245.5	20969
FWFW1 x 1	508	23.47	20	A-106	19.34	76.9	1245.5	21303
FWFW2 x 1	609.6	24.99	20	A-106	17.59	104.7	1520.3	26517
FWFW3 x 1	609.6	22.25	20	A-106	16.14	132.4	1520.3	27152
FWFW4 x 1	609.6	103	20	A-106	14.9	160.2	1520.3	27918
FWFW5 x 1	609.6	103	20	A-106	12.66	190.4	1918.4	36418
FWFW6 x 2	412.8	16.76	Custom	A-106	308	220.1	959.2	18517
FWFW7 x 2	425.5	14.94	Custom	A-106	307.4	250.7	959.2	19362
FWFW8 x 2	431.8	17.68	Custom	A-106	306.8	279.9	959.2	20379
FWFW9 x 2	438.2	7.62	Custom	A-106	306.7	287.7	959.2	20699
FW3 x 1	622.3	176.5	Custom	A-106	306.7	287.7	1918.4	41397
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FEEDWATER PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY



ID & # OFF	DIAMETER	LENGTH	SCHEDULE	MATERIAL	DESIGN P	DESIGN T	DESIGN M	DESIGN Q
FP0 x 1	508	1073.2	20	A-106	6.895	15	1362	22712
FP1 x 1	406.4	1073.2	20	A-106	6.895	15	681	11356
	mm	m			bar	C	t/h	lpm

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	FIRE PROTECTION PIPING DIAGRAM
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	Electrical One-line Diagram
	DIAGRAM
Date: 04/21/17	
Drawing No:	

FOR QUALITATIVE INDICATION ONLY

D

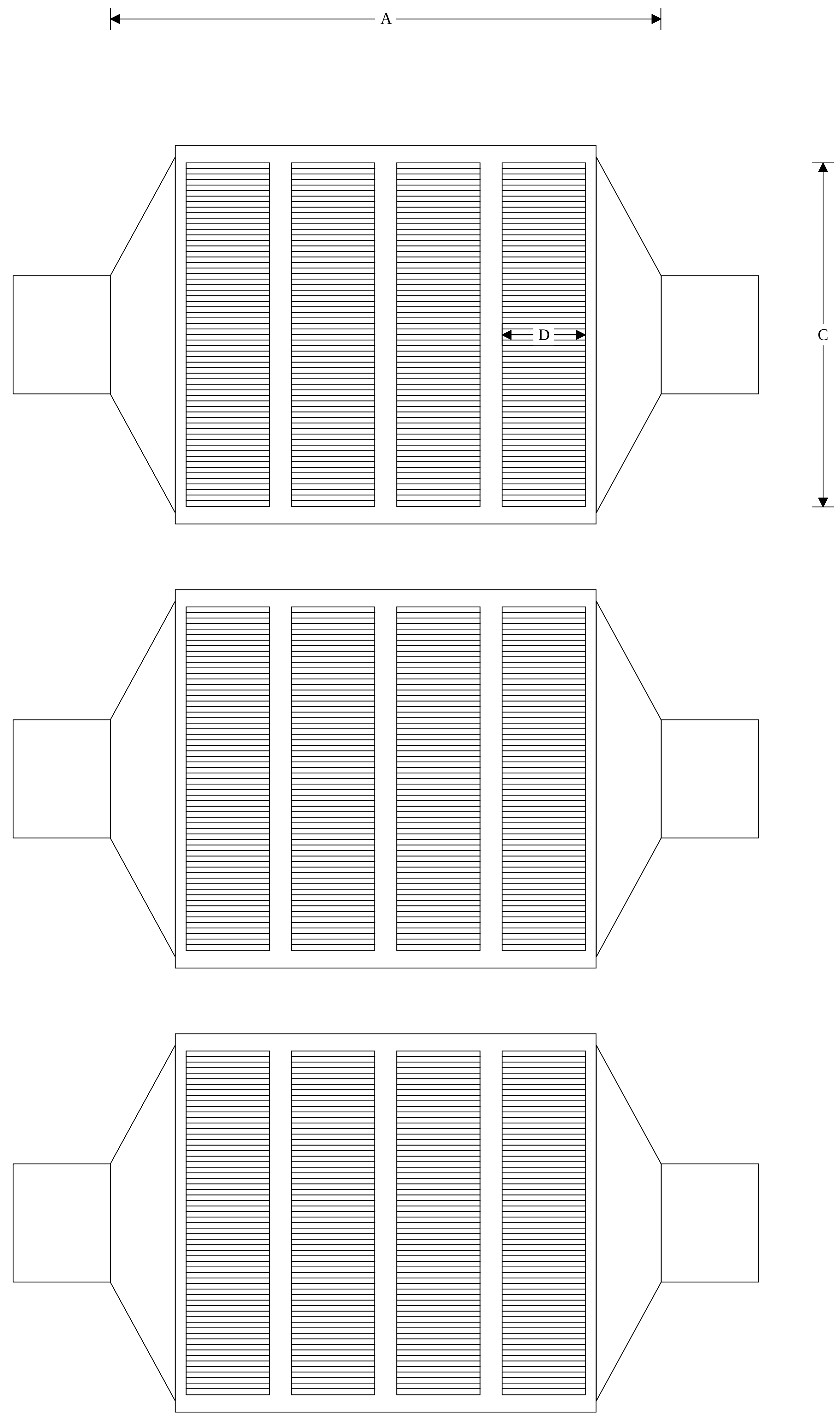
NUMBER OF ABSORBER MODULES = 1

A	B	C	D	E	F	G	H	I
-	-	-	-	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	WFGD
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY

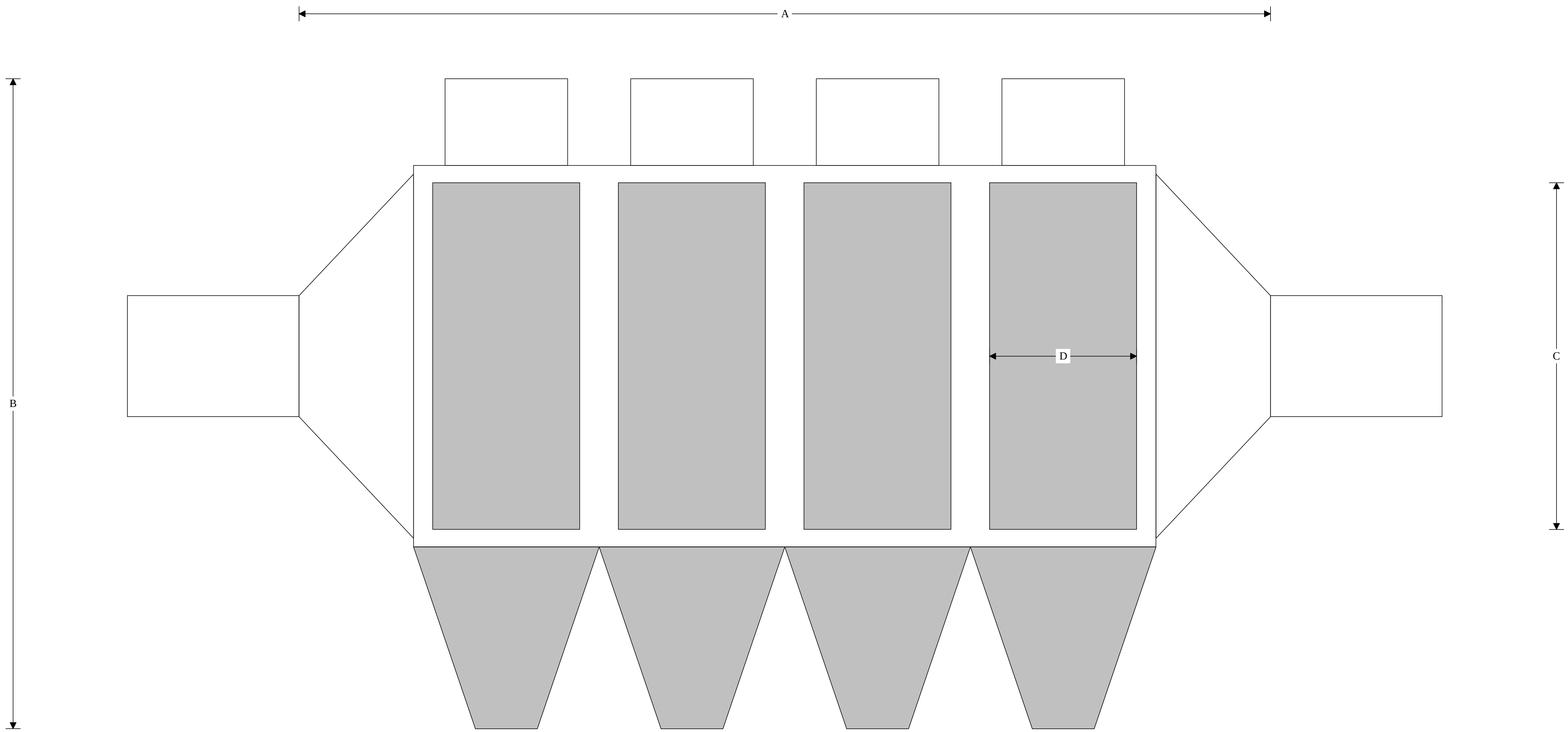


A	B	C	D	E	F	G	H	I
30.74 m	70.68 m	19.2 m	4.656 m	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ESP
	PLAN VIEW
Date: 04/21/17	
Drawing No:	

PEACE/STEAM PRO 26.1 GHD GHD Pty Ltd
File = G:\41\30763\Tech\HELE documentation\Model\USC model_dry cooling.stp

FOR QUALITATIVE INDICATION ONLY



A	B	C	D	E	F	G	H	I
30.74 m	20.57 m	10.97 m	4.656 m	-	-	-	-	-

Thermoflow, Inc.	Company: GHD Pty Ltd
	User: GHD
	ESP ELEVATION VIEW
Date: 04/21/17	
Drawing No:	

Appendix C – Benchmarking Details

Ultra - Super Critical Power Stations (HELE)

GHD compilation of publicly available data and comparison to Thermoflow™ PEACE estimates

Publicly available plant details																	PEACE estimate		
Plant Name	Location	Unit size (MW)	# units	Plant size (MW)	Year of Operation	Reference year for cost	PPI used	PPI in reference year	PPI in 2016	Reported cost in reference year	Reported cost unit	Reported cost escalated using PPI	Exchange rate used	Exch. rate at April 2017 (USD per 1 native currency)	Cost in 2016 USD	USD million/MW	Plant cost (USD million)	USD million/MW	Benchmark project deviation from PEACE
Linkou	Taiwan	800	3	2,400	2016/2017/2021	2011	Taiwan	100	105	$152,500 M	NTD	$160,125 M	New Taiwan $ to USD	0.033	$5,284 M	$2.2	$3,680	1.5	44%
Talin	Taiwan	800	2	1,600	2016/2017	2011	Taiwan	100	105	$119,200 M	NTD	$125,160 M	New Taiwan $ to USD	0.033	$4,130 M	$2.6	$2,510	1.6	65%
Shenao	Taiwan	800	2	1,600	2018/2019	2011	Taiwan	100	105	$108,900 M	NTD	$114,345 M	New Taiwan $ to USD	0.033	$3,773 M	$2.4	$2,510	1.6	50%
Maasvlakte 3	Netherlands	1,100	1	1,100	2015	2012	Netherlands	115	99	$1,200 M	Euro	$1,036 M	Euro to USD	1.06	$1,098 M	$1.0	$1,920	1.7	-43%
Mannheim	Germany	912	1	912	2015	2015	Germany	105	104	$1,200 M	Euro	$1,192 M	Euro to USD	1.06	$1,263 M	$1.4	$1,670	1.8	-24%
Wai Gao Qiao 3	China	1,000	2	2,000	2008	2008	China	93	94	$8,500 M	Yuan	$8,637 M	Yuan to USD	0.15	$1,296 M	$0.6	$2,280	1.1	-43%
Westfalen D and E	Germany	800	2	1,600	2012/2014	2012	Germany	105	104	$2,400 M	Euro	$2,384 M	Euro to USD	1.06	$2,527 M	$1.6	$2,840	1.8	-11%
John W. Turk, Jr.	America	600	1	600	2012/2013	2012	United States	110	104	$1,800 M	USD	$1,695 M	N/A	1	$1,695 M	$2.8	$1,060	1.8	60%
Huaibei Pingshan	China	660	2	1,320	2015/2016	2015	China	90	94	$5,000 M	Yuan	$5,274 M	Yuan to USD	0.15	$791 M	$0.6	$1,630	1.2	-51%
Eemshaven	Netherlands	800	2	1,600	2015	2014	Netherlands	111	99	$2,200 M	Euro	$1,968 M	Euro to USD	1.06	$2,086 M	$1.3	$2,800	1.8	-26%
Safi	Morocco	693	2	1,386	2018	2014	Morocco	110	102	$2,600 M	USD	$2,411 M	N/A	1	$2,411 M	$1.7	$2,000	1.4	21%
Tanjung Bin Energy	Malaysia	1,000	1	1,000	2016	2016	Malaysia	100	100	$1,000 M	Euro	$1,000 M	Euro to USD	1.06	$1,060 M	$1.1	$1,510	1.5	-30%
Chugoku Electric	Malaysia	1,000	2	2,000	2018	2014	Malaysia	112	100	$360,000 M	Yen	$321,429 M	Yen to USD	0.00920	$2,957 M	$1.5	$2,860	1.4	3%
Manjung Unit 4	Malaysia	1,000	1	1,000	2015	2012	Malaysia	113	100	$1,000 M	Euro	$885 M	Euro to USD	1.06	$938 M	$0.9	$1,510	1.5	-38%
Lunen	Germany	820	1	820	2013	2013	Germany	105	104	$1,400 M	Euro	$1,385 M	Euro to USD	1.06	$1,468 M	$1.8	$1,530	1.9	-4%
Moorburg	Germany	820	2	1,640	2014	2014	Germany	105	104	$2,800 M	Euro	$2,779 M	Euro to USD	1.06	$2,945 M	$1.8	$2,900	1.8	2%
Yuhuan	China	1,000	4	4,000	2006/2007	2007	China	94	94	$14,500 M	Yuan	$14,577 M	Yuan to USD	0.15	$2,187 M	$0.5	$4,400	1.1	-50%
Kogan Creek (SC only)	Australia	750	1	750	2007	2007	Australia	88	106	$1,200 M	AUD	$1,445 M	AUD to USD	0.75	$1,084 M	$1.4	$1,330	1.8	-18%
Tanjung Jati B (recently announced, not yet under construction)	Indonesia	1,000	2	2,000	2019/2020	2016	N/A	-	-	$500,000 M	Yen	$500,000 M	Yen to USD	0.00920	$4,600 M	$2.3	$3,130	1.6	47%

GHD

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	D Baptie	P Wootton	*P Wootton*	S Bond	*S Bond*	*1/6/17*
1	D Baptie	P Wootton	*P Wootton*	S Bond	*S Bond*	*2/6/17*
2	D Baptie	P Wootton	P. Wootton	S Bond	P. Wootton	23/6/17

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