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CLIENT: **TAKEDA/BAXALTA**	
PROJECT **BURITI EPCMV PROJECT**	

CHILLED WATER SYSTEM (PROCESS) CALCULATION REPORT

0	21SEP2021	ISSUED FOR CONSTRUCTION	MPA	LFF	MSS
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1. REVISION HISTORY

Rev	Reason For Change
A	90% BD ISSUE
B	FINAL BD ISSUE
C	FLOWRATES AND DIAMETERS HAVE BEEN UPDATED AS WELL AS CALCULATIONS AND EQUIPMENT. ALL DATA WERE UPDATED ACCORDING TO IPS INFORMATION.
D	FLOWRATES AND DIAMETERS HAVE BEEN UPDATED AS WELL AS CALCULATIONS. ALL DATA WERE UPDATED ACCORDING TO IPS INFORMATION. EQUIPMENT TC-6404 WAS ADDED.
0	ISSUED FOR CONSTRUCTION

2. PURPOSE

This document aims to establish the main characteristics for sizing the Chilled Water System for Building 7A (Final Drug Product), intended to Takeda unit - Buriti Project, located at Hemobrás site in Goiana - Pernambuco state. Brazil.

3. REFERENCE

The following documents were used as reference:

Item	Number	Title
1	-	B07A Process Equipment List
2	7A-M-4-5-40	Drug product - Chilled Water Generation Diagram
3	7A-M-0-5-45	Chilled Water Generation System - Process
4	7A-M-0-5-46	Chilled Water Distribution System – Process (1/2)
5	7A-M-0-5-53	Chilled Water Distribution System – Process (2/2)
6	-	FDP-Plant Utility Summary_DD Internal Progress
7	7A-Z-0-2-01	PID - Buffer Prep
8	7A-Z-0-2-02	PID - Formulation
9	7A-Z-0-2-04	PID – Filling Line, LE-1100 (WASH, DEPY, FILL, LYO, CAP)
10	7A-Z-0-2-05	PID – Decontamination Autoclave, AT-9002
11	7A-Z-0-2-06	PID - Autoclave, AT-9001
12	7A-Z-0-2-08	PID - LYO N°1, LYO-1105
13	7A-Z-0-2-09	PID - LYO N°2, LYO-1106
14	7A-Z-0-2-10	PID – Formulation Area Temp Control Unit, SK-3903-TCU
15	7A-Z-0-2-24	PID - WFI Still, MES-6401
16	7A-Z-0-2-26	PID - Hot WFI Distribution
17	7A-Z-0-2-27	PID - Clean Steam Generator, CSG-6501
18	7A-Z-0-2-28	PID - Clean Steam Distribution

4. BASIC DATA AND PREMISES

The Chilled Water/Glycol System consists of 2 primary pumps (one operating and the other stand-by), 2 process chillers (one operating and the other stand-by), 2 secondary pumps (one operating and the other stand-by).

At first, the system will operate with chilled water, keeping a temperature of 5 °C. If this temperature will not be sufficient to keep the process working correctly, the installation shall be prepared to operate with Propylene Glycol, with a temperature of 1 °C.

The system was calculated with the glycol properties (as shown below) because if it is needed in the future, the pump will operate since it is equipped with a frequency inverter.

Glycol Properties:

Density = 1015 kg/m³

Viscosity = 2.6 centipoise

Vapor Pressure = 0.00964 bar

The Chilled Water System was sized based on flowrate and diversity, using the software Fathom version 10.0. The PIDs 7A-M-0-5-45 (generation), 7A-M-0-5-46 and 7A-M-0-5-53 (distribution) for this system were elaborated based on these calculations.

For this system were elaborated the following conditions:

- Design Condition – Sizing Criterion for chillers, lines, valves and pumps to define the Nominal Capacity of each equipment simultaneity of the process equipment and an oversizing of 18.4 % (Thermal Load), where the excess of flow rate is diverted to a future expansion (tie-in).

- Maximum Operating Condition – The same simultaneity of the Design Condition without oversizing.

- Intermediate Operating Condition – Equipment out of the diversity in the Maximum Operating Condition.

- Minimum Operating Condition – the process equipment without consumption. The secondary pump operates only for the chilled water recirculation (minimum flowrate).

It was considered the installation of 2 chillers with nominal capacity of 150 TR each one, where 1 chiller is operating and the other as stand-by.

It was estimated an available pressure drop of 1.0 bar for each process equipment and valve control (considering Propylene Glycol mass flowrate).

It was estimated an available pressure drop of 1.0 bar for the chiller for design condition (considering Propylene Glycol mass flowrate).

To guarantee a balancing and a good distribution, static balancing valves were considered throughout the system as indicated in the PID´s.

5. CALCULATION

5.1 CHILLED WATER (5 °C)

5.1.1 Flowrate

The Chilled Water System has the following consumers in the Building 7A (this study was carried out with its diversity based on the document - Plant Utility Summary):

- Design Condition

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
TE-1102	Depyrogenation Tunnel	Y	84.5	5.1	5073.0	118325.0	29837.3	
LYO-1105	Lyo nº1	Y	224.3	13.5	13458.9	237600.0	59914.2	
LYO-1106	Lyo nº2	N	0	0	0	0	0	
MES-6401	WFI Still	Y	243.6	14.6	14616.0	342144.0	86276.4	
CSG-6501	Clean Steam Generator w/Sample cooler	Y	25.4	1.5	1522.5	35640.0	8987.1	
TC-6402	Point of Use Cooler to Wash Sink	Y	121.8	7.3	7308.0	171072.0	43138.2	
TC-6403	Point of Use Cooler to Buffer Prep	N	0	0	0	0	0	
TC-6404	Point of Use Cooler to Clean Equipment	N	0	0	0	0	0	
AT-9002	Autoclave	Y	169.5	10.2	10170.3	238075.0	60033.9	
AT-9001	Autoclave	Y	169.5	10.2	10170.3	238075.0	60033.9	
UP-3802	Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
UP-3803	Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
UP-3901	Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
UP-3902	Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
TCU-3903	Formulation Vessel TCU	Y	38.6	2.3	2314.2	44966.0	11338.8	
TC-6501	Sample Cooler	N	0	0	0	0	0	
TC-6502	Sample Cooler	N	0	0	0	0	0	
TOTAL EQUIPMENT		**-**	**1231.5**	**73.9**	**73890.0**	**1462013.0**	**368667.0**	
Recirculation (BV)		Y	318.3	19.1	19100	-	-	1
Tie-in (Future Expansion)		Y	349.5	21	20967	336816	84933	2
TOTAL		**-**	**1899.3**	**114.0**	**113957.0**	**1798829.0**	**453600.0**	3

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Oversizing of 18.4 % (see item 4).
3. Total flow rate for Primary and Secondary Pump – Design Condition (Attachment 6.1.1).

- Maximum Operating Condition

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m^3/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
TE-1102	Depyrogenation Tunnel	Y	84.5	5.1	5073.0	118325.0	29837.3	
LYO-1105	Lyo nº1	Y	224.3	13.5	13458.9	237600.0	59914.2	
LYO-1106	Lyo nº2	N	0	0	0	0	0	
MES-6401	WFI Still	Y	243.6	14.6	14616.0	342144.0	86276.4	
CSG-6501	Clean Steam Generator w/Sample cooler	Y	25.4	1.5	1522.5	35640.0	8987.1	
TC-6402	Point of Use Cooler to Wash Sink	Y	121.8	7.3	7308.0	171072.0	43138.2	
TC-6403	Point of Use Cooler to Buffer Prep	N	0	0	0	0	0	
TC-6404	Point of Use Cooler to Clean Equipment	N	0	0	0	0	0	
AT-9002	Autoclave	Y	169.5	10.2	10170.3	238075.0	60033.9	
AT-9001	Autoclave	Y	169.5	10.2	10170.3	238075.0	60033.9	
UP-3802	Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
UP-3803	Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
UP-3901	Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
UP-3902	Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	Y	38.6	2.3	2314.2	9029.0	2276.8	
TCU-3903	Formulation Vessel TCU	Y	38.6	2.3	2314.2	44966.0	11338.8	
TC-6501	Sample Cooler	N	0	0	0	0	0	
TC-6502	Sample Cooler	N	0	0	0	0	0	
TOTAL		**-**	**1231.5**	**73.9**	**73890.0**	**1462013.0**	**368667.0**	
Recirculation (BV)		Y	317.4	19.0	19041	-	-	1
Tie-in (Future Expansion)		N	-	-	-	-	-	
TOTAL		**-**	**1548.9**	**92.9**	**92931.0**	**1462013.0**	**368667.0**	2

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Total flow rate for Primary and Secondary Pump – Maximum Condition (Attachment 6.1.2).

- Intermediate Operating Condition

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
TE-1102	Depyrogenation Tunnel	N	0	0	0	0	0	
LYO-1105	Lyo nº1	N	0	0	0	0	0	
LYO-1106	Lyo nº2	Y	224.3	13.5	13458.9	237600.0	59914.2	
MES-6401	WFI Still	N	0	0	0	0	0	
CSG-6501	Clean Steam Generator w/Sample cooler	N	0	0	0	0	0	
TC-6402	Point of Use Cooler to Wash Sink	N	0	0	0	0	0	
TC-6403	Point of Use Cooler to Buffer Prep	Y	121.8	7.3	7308.0	171072.0	43138.2	
TC-6404	Point of Use Cooler to Clean Equipment	Y	121.8	7.3	7308.0	171072.0	43138.2	
AT-9002	Autoclave	N	0	0	0	0	0	
AT-9001	Autoclave	N	0	0	0	0	0	
UP-3802	Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	N	0	0	0	0	0	
UP-3803	Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	N	0	0	0	0	0	
UP-3901	Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	N	0	0	0	0	0	
UP-3902	Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	N	0	0	0	0	0	
TCU-3903	Formulation Vessel TCU	N	0	0	0	0	0	
TC-6501	Sample Cooler	Y	7.1	0.4	426.3	38841.0	9794.3	
TC-6502	Sample Cooler	Y	7.1	0.4	426.3	38841.0	9794.3	
TOTAL		**-**	**482.1**	**28.9**	**28927.5**	**657426.0**	**165779.2**	
Recirculation (BV)		Y	312.1	18.7	18726.3	-	-	1
Tie-in (Future Expansion)		N	-	-	-	-	-	
TOTAL		**-**	**794.2**	**47.7**	**47653.8**	**657426.0**	**165779.2**	2

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Total flow rate for Primary and Secondary Pump – Intermediate Condition (Attachment 6.1.3).

- Minimum Operating Condition

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
TE-1102	Depyrogenation Tunnel	N	0	0	0	0	0	

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
LYO-1105	Lyo nº1	N	0	0	0	0	0	
LYO-1106	Lyo nº2	N	0	0	0	0	0	
MES-6401	WFI Still	N	0	0	0	0	0	
CSG-6501	Clean Steam Generator w/Sample cooler	N	0	0	0	0	0	
TC-6402	Point of Use Cooler to Wash Sink	N	0	0	0	0	0	
TC-6403	Point of Use Cooler to Buffer Prep	N	0	0	0	0	0	
TC-6404	Point of Use Cooler to Clean Equipment	N	0	0	0	0	0	
AT-9002	Autoclave	N	0	0	0	0	0	
AT-9001	Autoclave	N	0	0	0	0	0	
UP-3802	Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	N	0	0	0	0	0	
UP-3803	Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	N	0	0	0	0	0	
UP-3901	Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	N	0	0	0	0	0	
UP-3902	Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	N	0	0	0	0	0	
TCU-3903	Formulation Vessel TCU	N	0	0	0	0	0	
TC-6501	Sample Cooler	N	0	0	0	0	0	
TC-6502	Sample Cooler	N	0	0	0	0	0	
TOTAL		**-**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
Recirculation (BV)		Y	315.5	18.9	18930	-	-	1
Tie-in (Future Expansion)		N	-	-	-	-	-	
TOTAL		**-**	**315.5**	**18.9**	**18930.0**	**0.0**	**0.0**	2

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Total flow rate for Primary and Secondary Pump – Minimum Condition (Attachment 6.1.4).

5.1.2 Balancing Valves

To ensure the correct flow distribution in the installation, the following balancing valves were installed.

a) By-pass at the end of the header distribution

It was considered 19.1 m³/h for chilled water recirculation in the system. This flowrate will be guaranteed by using of 5 static balancing valves in the by-pass as shown below:

Valve	Flowrate (m^3/h)	dP (bar)	Cv
BV-9800165	3.0	1.51	2.8
BV-9800164	3.0	1.47	2.9
BV-9800180	3.0	1.55	2.8
BV-9800186	3.0	1.47	2.9
BV-9800163	7.1	1.16	7.6
TOTAL	**19.1**	-	-

The total flowrate of 19.1 m^3/h in these valves represents the pump's minimum flowrate, as it can be seen in the pump curve (item 7). The pump can operate in the minimum flowrate, where all the process equipment don´t need chilled water and the flowrate required is only for the chilled water recirculation.

b) Balancing valves installed at the beginning of the distribution headers

Throughout the system, 3 static balancing valves in the distribution headers were considered to guarantee the correct water distribution, as shown in the table below:

Valve	Flowrate (m^3/h)	dP (bar)	Cv
BV-9800160	39.0	0.04	219.7
BV-9800162	35.7	0.09	138.7
BV-9800161	18.3	0.05	98.3
TOTAL	**93.0**	-	-

c) Balancing valves at the process equipment inlet

Static Balancing valves were considered as shown in the table below:

Equipment	Valve	Flowrate (m^3/h)	dP (bar)	Cv
TE-1102	BV-9800169	5.1	0.60	7.6
LYO-1105	BV-9800171	13.5	0.53	21.4
LYO-1106	BV-9800173	13.5	0.36	26.1
AT-9001	BV-9800177	10.2	0.45	17.5
TC-6402	BV-9800179	7.3	0.44	12.7
UP-3901	BV-9800185	2.3	0.40	4.2
UP-3902	BV-9800183	2.3	0.38	4.3
UP-3802	BV-9800189	2.3	0.32	4.7
UP-3803	BV-9800226	2.3	0.30	4.9
TC-6403	BV-9800193	7.3	0.21	18.5
AT-9002	BV-9800167	10.2	0.39	19.0
TC-6501	BV-9800232	0.4	0.32	0.9
TCU-3903	BV-9800195	2.3	0.09	9.1
CSG-6501	BV-9800199	1.5	0.14	4.6
TC-6502	BV-9800234	0.4	0.27	0.9

Equipment	Valve	Flowrate (m^3/h)	dP (bar)	Cv
MES-6401	BV-980091	14.6	0.15	43.4
TC-6404	BV-9800237	7.3	0.26	16.6

d) Balancing valves at the chillers´s outlet

Static balancing valves were considered after the chiller, as shown in the table below:

Valve	Flowrate (m^3/h)	dP (bar)	Cv
BV-980080	114.0	0.22	279.8
BV-980083	114.0	0.22	279.8

5.1.3 Process Equipment

The table below shows the information of the inlet pressures standardized as requested by IPS, the actual inlet pressure in each process equipment and the total DP of 1.0 bar in the equipment and in the temperature control valve.

Floor	Equipment	P in Equip. (barG)	Pressure in the PID (barG)	dP Equipment (bar)	dP Temp. Control Valves (barG)	Balancing Valve	dP Balancing Valve (bar)	dP Total
First	TE-1102	2.10	2.5	0.5	0.5	BV-9800169	0.60	1.60
	LYO-1105	2.14	2.5	0.5	0.5	BV-9800171	0.53	1.53
	LYO-1106	2.07	2.5	0.5	0.5	BV-9800173	0.35	1.35
	AT-9001	2.18	2.5	0.5	0.5	BV-9800177	0.45	1.45
	TC-6402	2.19	2.5	0.5	0.5	BV-9800179	0.44	1.44
	UP-3901	2.26	2.5	0.5	0.5	BV-9800185	0.40	1.40
	UP-3902	2.27	2.5	0.5	0.5	BV-9800183	0.38	1.38
	UP-3802	2.30	2.5	0.5	0.5	BV-9800189	0.32	1.32
	UP-3803	2.31	2.5	0.5	0.5	BV-9800226	0.30	1.30
	TC-6403	2.20	2.5	0.5	0.5	BV-9800193	0.18	1.18
	AT-9002	2.16	2.5	0.5	0.5	BV-9800167	0.39	1.39
Ground	TC-6501	2.41	3.5	0.5	0.5	BV-9800232	0.37	1.37
	TCU-3903	3.14	3.5	0.5	0.5	BV-9800195	0.09	1.09
	CSG-6501	3.11	3.5	0.5	0.5	BV-9800199	0.14	1.14
	TC-6502	2.41	3.5	0.5	0.5	BV-9800234	0.36	1.36
	MES-6401	3.12	3.5	0.5	0.5	BV-980091	0.15	1.15
	TC-6404	2.92	3.5	0.5	0.5	BV-9800237	0.26	1.26

5.1.4 Pump Capacity

The Chilled Water System has 2 primary centrifugal pumps, one operating (P-PCH-7A-1) and the other stand-by (P-PCH-7A-2) and 2 secondary centrifugal pumps, one operating (P-PCH-7A-3) and the other stand-by (P-PCH-7A-4).

The flowrate required for the primary and secondary pumps at design condition with the balancing valves, an oversizing of 18.7 % and the equipment is:

BV flowrate (m³/h)	19.1
Equipment flowrate (m³/h)	73.9
Tie-in (m³/h)	21.0
TOTAL	**114.0**

The flowrate required for the primary and secondary pumps at maximum operate condition with the balancing valves, and the equipment is:

BV flowrate (m³/h)	19.1
Equipment flowrate (m³/h)	73.9
TOTAL	**92.9**

The primary pumps will be operated with a fixed speed with a maximum operating flowrate of 92.94 m³/h and design condition of 114.0 m³/h. The excess of flowrate for the minimum operating condition of the secondary pump will be directed to supply the chiller through the buffer tank where overflow will occur from the cold side to the hot side of the tank.
Only the Secondary pumps will be operated with minimum and maximum flowrate. These pumps will be controlled by the differential pressure transmitter PDIT-9800163 keeping constant the differential pressure of 1.38 bar (see table below). This instrument will be installed at 2/3 of the main distribution pipe total length.

The minimum operating condition is shown in item 7.

Study	Simulation (file) (1)	Junction Number (3)	Secondary Pump Flowrate (m³/h)	P in supply (barG)	P in return (barG)	dP (bar)
Design flowrate	Design_CW_5°C_Visual Report	60 and 61	114.0	2.89	1.51	1.38
	Design_CW_5°C _Output					
Maximum flowrate	Maximum_CW_5°C_Visual Report	60 and 61	92.9	2.88	1.49	1.38
	Maximum_CW_5°C_Output					
Intermediate flowrate	Intermediate_CW_5°C_Visual Report	60 and 61	47.7	2.77	1.39	1.38
	Intermediate_CW_5°C_Output					
Minimum flowrate (all equipment closed)	Minimum_CW_5°C_Visual Report	60 and 61	18.9 (2)	2.72	1.34	1.38
	Minimum_CW_5°C_Output					

(1) The simulations are shown in Attachment 6.3.1.

(2) Item 7.

(3) The junction number can be seen in the Visual Report attachment.

Based on that, the primary and secondary pumps will have the following condition:

- Design condition

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	114,0	113.980	1,660	16,93	7,048	81,81	8,615	98,71	10,78	N/A	0,04080	1,701
X379	Show ...	P-PCH-7A-2	0,0	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	114,0	113.957	2,043	20,83	8,670	76,59	11,320	100,00	11,17	N/A	0,07655	2,119
X400	Show ...	P-PCH-7A-4	0,0	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

P-PCH-7A-1/2 - The pump head will be rounded to 18 mlc (considering the air separator pressure drop).

P-PCH-7A-3/4 - The pump head will be rounded to 21 mlc.

The curves of the selected pumps are shown in Attachment 7.

- Maximum Operating condition

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	92,94	92.924	1,153	11,76	3,990	82,03	4,864	81,87	11,06	N/A	0,07291	1,226
X379	Show ...	P-PCH-7A-2	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	92,94	92.944	1,996	20,35	6,908	76,84	8,990	94,80	11,33	N/A	0,09680	2,092
X400	Show ...	P-PCH-7A-4	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

- Intermediate Operating condition

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	92,94	92.924	1,153	11,76	3,990	82,03	4,864	81,87	11,06	N/A	0,07291	1,226
X379	Show ...	P-PCH-7A-2	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	47,73	47.733	1,671	17,04	2,971	67,67	4,391	81,58	11,56	N/A	0,12651	1,798
X400	Show ...	P-PCH-7A-4	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

- Minimum Operating condition (item 7)

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	92,94	92.924	1,153	11,76	3,990	82,03	4,864	81,87	11,06	N/A	0,07291	1,226
X379	Show ...	P-PCH-7A-2	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	18,93	18.929	1,561	15,91	1,100	48,50	2,268	77,64	11,63	N/A	0,13557	1,696
X400	Show ...	P-PCH-7A-4	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

5.1.5 Chiller Capacity

According to item 5.1.1, the Simultaneous Peak Load is 368,667.0 kcal/h and it is equivalent to 122 TR. This is the maximum operating condition for the chillers.

The Nominal Capacity of each Chiller is 150 TR, so they have an oversizing of 18.7 % (28 TR).

At the Design and Maximum Operating Conditions, the inlet temperature for the process equipment's is 5.0 ºC and the outlet temperature (return to Chiller) is 9.0 ºC.

At the Intermediate Operating Condition, the inlet temperature for the process equipment's is 5.0 ºC and the outlet temperature (return to Chiller) is 8.2 ºC.

At the Minimum Operating Condition, the inlet temperature for the process equipment's and the outlet temperature (return to Chiller) is 5.0 ºC, because at this condition, all equipment's are closed, and the recirculation has no thermal load.

According to recommendation of Chiller´s supplier, the minimum stabilization time is 2 minutes. For that reason, it was adopted the residence time of 3 minutes, guaranteeing the thermal load when the chiller shuts down.

5.1.6 Buffer Tank

For the selection of the tank, an additional of 18.4 % (21.0 m³/h diverted to a future expansion) was considered in the equipment flowrate, thus:

$$73.9 + 21.0 + 19.1 \cong 114.0\, m^3/h$$

The Buffer tank is divided in 2 sides (side cold and side hot) and it was sized based on the residence time of 3 minutes for each side (minimum time required to stabilize the chiller in the event of a temporary shortages of electric energy supply).

Flowrate = 114 m³/h

Volume for each side = 6.0 m³

Total Useful volume = 12.0 m³

According to recommendation of Chiller´s supplier (Trane), the minimum stabilization time is 2 minutes. For that reason, it was adopted the residence time of 3 minutes, guaranteeing the thermal load when the chiller shuts down.

5.2 CHILLED PROPYLENE GLYCOL (1 °C)

5.2.1 Flowrate

The Chilled Propylene Glycol System has the following consumers in the Building 7A (this study was carried out with its diversity based on the document - Plant Utility Summary):

- Design Condition

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m^3/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
TE-1102	Depyrogenation Tunnel	Y	83.3	5.0	5073.0	118325.0	29837.3	
LYO-1105	Lyo nº1	Y	221.0	13.3	13458.9	237600.0	59914.2	
LYO-1106	Lyo nº2	N	0	0	0	0	0	
MES-6401	WFI Still	Y	240.0	14.4	14616.0	342144.0	86276.4	
CSG-6501	Clean Steam Generator w/Sample cooler	Y	25.0	1.5	1522.5	35640.0	8987.1	
TC-6402	Point of Use Cooler to Wash Sink	Y	120.0	7.2	7308.0	171072.0	43138.2	
TC-6403	Point of Use Cooler to Buffer Prep	N	0	0	0	0	0	
TC-6404	Point of Use Cooler to Clean Equipment	N	0	0	0	0	0	
AT-9002	Autoclave	Y	167.0	10.0	10170.3	238075.0	60033.9	
AT-9001	Autoclave	Y	167.0	10.0	10170.3	238075.0	60033.9	
UP-3802	Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
UP-3803	Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
UP-3901	Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
UP-3902	Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
TCU-3903	Formulation Vessel TCU	Y	38.0	2.3	2314.2	44966.0	11338.8	
TC-6501	Sample Cooler	N	0	0	0	0	0	
TC-6502	Sample Cooler	N	0	0	0	0	0	
TOTAL EQUIPMENT		**-**	**1213.3**	**72.8**	**73890.0**	**1462013.0**	**368667.0**	
Recirculation (BV)		Y	313.6	18.8	19100	-	-	1
Tie-in (Future Expansion)		Y	344.3	20.7	20967	336816	84933	2
TOTAL		**-**	**1871.2**	**112.3**	**113957.0**	**1798829.0**	**453600.0**	3

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Oversizing of 18.4 % (see item 4).

3. Total flow rate for Primary and Secondary Pump – Design Condition (Attachment 6.2.1).

- Maximum Operating Condition

TAG	Equipment	Diversity (Y/N)	Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
TE-1102	Depyrogenation Tunnel	Y	83.3	5.0	5073.0	118325.0	29837.3	
LYO-1105	Lyo nº1	Y	221.0	13.3	13458.9	237600.0	59914.2	
LYO-1106	Lyo nº2	N	0	0	0	0	0	
MES-6401	WFI Still	Y	240.0	14.4	14616.0	342144.0	86276.4	
CSG-6501	Clean Steam Generator w/Sample cooler	Y	25.0	1.5	1522.5	35640.0	8987.1	
TC-6402	Point of Use Cooler to Wash Sink	Y	120.0	7.2	7308.0	171072.0	43138.2	
TC-6403	Point of Use Cooler to Buffer Prep	N	0	0	0	0	0	
TC-6404	Point of Use Cooler to Clean Equipment	N	0	0	0	0	0	
AT-9002	Autoclave	Y	167.0	10.0	10170.3	238075.0	60033.9	
AT-9001	Autoclave	Y	167.0	10.0	10170.3	238075.0	60033.9	
UP-3802	Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
UP-3803	Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
UP-3901	Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
UP-3902	Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	Y	38.0	2.3	2314.2	9029.0	2276.8	
TCU-3903	Formulation Vessel TCU	Y	38.0	2.3	2314.2	44966.0	11338.8	
TC-6501	Sample Cooler	N	0	0	0	0	0	
TC-6502	Sample Cooler	N	0	0	0	0	0	
TOTAL EQUIPMENT		**-**	**1213.3**	**72.8**	**73890.0**	**1462013.0**	**368667.0**	
Recirculation (BV)		Y	313.6	18.8	19095.2	-	-	1
Tie-in (Future Expansion)		N	-	-	-	-	-	
TOTAL		**-**	**1526.9**	**91.6**	**92985.2**	**1462013.0**	**368667.0**	2

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Total flow rate for Primary and Secondary Pump – Design Condition (Attachment 6.2.2).

- Intermediate Operating Condition

Equipment	TAG	Diversity (Y/N)	Simult. Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
Depyrogenation Tunnel	TE-1102	N	0	0	0	0	0	
Lyo nº1	LYO-1105	N	0	0	0	0	0	
Lyo nº2	LYO-1106	Y	221.0	13.3	13458.9	237600.0	59875.2	
WFI Still	MES-6401	N	0	0	0	0	0	
Clean Steam Generator w/Sample cooler	CSG-6501	N	0	0	0	0	0	
Point of Use Cooler to Wash Sink	TC-6402	N	0	0	0	0	0	
Point of Use Cooler to Buffer Prep	TC-6403	Y	120.0	7.2	7308.0	171072.0	43110.1	
Point of Use Cooler to Clean Equipment	TC-6404	Y	120.0	7.2	7308.0	171072.0	43110.1	
Autoclave	AT-9002	N	0	0	0	0	0	
Autoclave	AT-9001	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	UP-3802	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	UP-3803	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	UP-3901	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	UP-3902	N	0	0	0	0	0	
Formulation Vessel TCU	TCU-3903	N	0	0	0	0	0	
Sample Cooler	TC-6501	Y	7.0	0.4	426.3	9030.0	2275.6	
Sample Cooler	TC-6502	Y	7.0	0.4	426.3	9031.0	2275.8	
TOTAL EQUIPMENT		**-**	**475.0**	**28.5**	**28927.5**	**597805.0**	**150646.9**	
Recirculation (BV)		Y	308.5	18.5	18787.4	-	-	1
Tie-in (Future Expansion)		N	-	-	-	-	-	
TOTAL		**-**	**783.5**	**47.0**	**47714.9**	**597805.0**	**150646.9**	2

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Total flow rate for Primary and Secondary Pump – Design Condition (Attachment 6.2.3).

- Minimum Operating Condition

Equipment	Equipment	Diversity (Y/N)	Simult. Flowrate (LPM)	Chilled Water Volum Flowrate (m³/h)	Simult. Flowrate (kg/h)	Simult. Peak Load (BTU/h)	Simult. Peak Load (kcal/h)	Notes
Depyrogenation Tunnel	TE-1102	N	0	0	0	0	0	
Lyo nº1	LYO-1105	N	0	0	0	0	0	
Lyo nº2	LYO-1106	N	0	0	0	0	0	
WFI Still	MES-6401	N	0	0	0	0	0	
Clean Steam Generator w/Sample cooler	CSG-6501	N	0	0	0	0	0	
Point of Use Cooler to Wash Sink	TC-6402	N	0	0	0	0	0	
Point of Use Cooler to Buffer Prep	TC-6403	N	0	0	0	0	0	
Point of Use Cooler to Clean Equipment	TC-6404	N	0	0	0	0	0	
Autoclave	AT-9002	N	0	0	0	0	0	
Autoclave	AT-9001	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 2 (Maint.)	UP-3802	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 3 (Maint.)	UP-3803	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 4 (Maint.)	UP-3901	N	0	0	0	0	0	
Utility Panel for 50L Formulation Vessel No. 5 (Maint.)	UP-3902	N	0	0	0	0	0	
Formulation Vessel TCU	TCU-3903	N	0	0	0	0	0	
Sample Cooler	TC-6501	N	0	0	0	0	0	
Sample Cooler	TC-6502	N	0	0	0	0	0	
TOTAL EQUIPMENT		**-**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
Recirculation (BV)		Y	312.0	18.7	19000	-	-	1
Tie-in (Future Expansion)		N	-	-	-	-	-	
TOTAL		**-**	**312.0**	**18.7**	**18999.8**	**0.0**	**0.0**	2

Notes:

1. Flow rate through bypasses, guaranteed by using of 5 balancing valves.
2. Total flow rate for Primary and Secondary Pump – Design Condition (Attachment 6.2.4).

5.2.2 Balancing Valves

To ensure the correct flow distribution in the installation, the following balancing valves were installed.

a) By-pass at the end of the header distribution

It was considered 18.8 m³/h for chilled water recirculation in the system. This flowrate will be guaranteed by using 5 static balancing valves in the by-pass as shown below:

Valve	Flowrate (m³/h)	dP (bar)	Cv
BV-9800165	2.96	1.52	2.8
BV-9800164	2.96	1.47	2.8
BV-9800180	2.96	1.56	2.8
BV-9800186	2.96	1.48	2.8
BV-9800163	7.00	1.15	7.6
TOTAL	**18.8**	-	-

The total flowrate of 18.8 m³/h in these valves represents the pump's minimum flowrate, as it can be seen in the pump curve (item 7). The pump can operate in the minimum flowrate, where all the process equipment don´t need chilled water and the flowrate required is only for the chilled water recirculation.

b) Balancing valves installed at the beginning of the distribution headers

Throughout the system, 3 static balancing valves in the distribution headers were considered to guarantee the correct water distribution, as shown in the table below:

Valve	Flowrate (m³/h)	dP (bar)	Cv
BV-9800160	38.4	0.04	219.7
BV-9800162	35.2	0.09	138.7
BV-9800161	18.0	0.05	98.3
TOTAL	**91.6**	-	-

c) Balancing valves at the process equipment inlet

Static Balancing valves were considered as shown in the table below:

Equipment	Valve	Flowrate (m³/h)	dP (bar)	Cv
TE-1102	BV-9800169	5.0	0.61	7.5
LYO-1105	BV-9800171	13.3	0.54	21.1
LYO-1106	BV-9800173	13.3	0.36	25.9
AT-9001	BV-9800177	10.0	0.45	17.3
TC-6402	BV-9800179	7.2	0.44	12.7
UP-3901	BV-9800185	2.3	0.40	4.2
UP-3902	BV-9800183	2.3	0.38	4.3
UP-3802	BV-9800189	2.3	0.32	4.7
UP-3803	BV-9800226	2.3	0.30	4.9
TC-6403	BV-9800193	7.2	0.20	18.8
AT-9002	BV-9800167	10.0	0.38	18.8
TC-6501	BV-9800232	0.4	0.32	0.9

Equipment	Valve	Flowrate (m^3/h)	dP (bar)	Cv
TCU-3903	BV-9800195	2.3	0.07	10.3
CSG-6501	BV-9800199	1.5	0.12	5.0
TC-6502	BV-9800234	0.4	0.27	0.9
MES-6401	BV-980091	14.4	0.14	45.2
TC-6404	BV-9800237	7.2	0.25	16.9

d) Balancing valves at the chillers´s outlet

Static balancing valves were considered after the chiller, as shown in the table below:

Valve	Flowrate (m^3/h)	dP (bar)	Cv
BV-980080	112.3	0.22	279.8
BV-980083	112.3	0.22	279.8

5.2.3 Process Equipment

The table below shows the information of the inlet pressures standardized as requested by IPS, the actual inlet pressure in each process equipment and the total DP of 1.0 bar in the equipment and in the temperature control valve.

Floor	Equipment	P in Equip. (barG)	Pressure in the PID (barG)	dP Equipment (bar)	dP Temp. Control Valves (barG)	Balancing Valve	dP Balancing Valve (bar)	dP Total
First	TE-1102	2.12	2.5	0.5	0.5	BV-9800169	0.61	1.61
	LYO-1105	2.16	2.5	0.5	0.5	BV-9800171	0.54	1.54
	LYO-1106	2.11	2.5	0.5	0.5	BV-9800173	0.36	1.36
	AT-9001	2.20	2.5	0.5	0.5	BV-9800177	0.45	1.45
	TC-6402	2.22	2.5	0.5	0.5	BV-9800179	0.44	1.44
	UP-3901	2.28	2.5	0.5	0.5	BV-9800185	0.40	1.40
	UP-3902	2.29	2.5	0.5	0.5	BV-9800183	0.38	1.38
	UP-3802	2.33	2.5	0.5	0.5	BV-9800189	0.32	1.32
	UP-3803	2.34	2.5	0.5	0.5	BV-9800226	0.30	1.30
	TC-6403	2.23	2.5	0.5	0.5	BV-9800193	0.20	1.20
	AT-9002	2.19	2.5	0.5	0.5	BV-9800167	0.38	1.38
Ground	TC-6501	2.47	3.5	0.5	0.5	BV-9800232	0.32	1.32
	TCU-3903	3.18	3.5	0.5	0.5	BV-9800195	0.07	1.07
	CSG-6501	3.16	3.5	0.5	0.5	BV-9800199	0.12	1.12
	TC-6502	2.50	3.5	0.5	0.5	BV-9800234	0.27	1.27
	MES-6401	3.16	3.5	0.5	0.5	BV-980091	0.14	1.14
	TC-6404	2.86	3.5	0.5	0.5	BV-9800237	0.25	1.25

5.2.4 Pump Capacity

The Chilled Water System has 2 primary centrifugal pumps, one operating (P-PCH-7A-1) and the other stand-by (P-PCH-7A-2) and 2 secondary centrifugal pumps, one operating (P-PCH-7A-3) and the other stand-by (P-PCH-7A-4).

The flowrate required for the primary and secondary pumps at design condition with the balancing valves, an oversizing of 18.7 % and the equipment is:

BV flowrate (m³/h)	18.8
Equipment flowrate (m³/h)	72.8
Tie-in (m³/h)	20.7
TOTAL	**112.3**

The flowrate required for the primary and secondary pumps at maximum operate condition with the balancing valves, and the equipment is:

BV flowrate (m³/h)	18.8
Equipment flowrate (m³/h)	72.8
TOTAL	**91.6**

The primary pumps will be operated with a fixed speed with a maximum operating flowrate of 91.6 m³/h and design condition of 112.3 m³/h. The excess of flowrate for the minimum operating condition of the secondary pump will be directed to supply the chiller through the buffer tank where overflow will occur from the cold side to the hot side of the tank.
Only the Secondary pumps will be operated with minimum and maximum flowrate. These pumps will be controlled by the differential pressure transmitter PDIT-9800163 keeping constant the differential pressure of 1.38 bar (see table below). This instrument will be installed at 2/3 of the main distribution pipe total length.

The minimum operating condition is shown in item 7.

Study	Simulation (file) (1)	Junction Number (3)	Secondary Pump Flowrate (m³/h)	P in supply (barG)	P in return (barG)	dP (bar)
Design flowrate	Design_GLY_1°C_Visual Report	60 and 61	112.3	2.92	1.54	1.38
	Design_GLY_1°C_Output					
Maximum flowrate	Maximum_GLY_1°C_Visual Report	60 and 61	91.6	2.90	1.52	1.38
	Maximum_GLY_1°C_Output					
Intermediate flowrate	Intermediate_GLY_1°C_Visual Report	60 and 61	47.0	2.79	1.41	1.38
	Intermediate_GLY_1°C_Output					
Minimum flowrate (all equipment closed)	Minimum_GLY_1°C_Visual Report	60 and 61	18.7 (2)	2.74	1.36	1.38
	Minimum_GLY_1°C_Output					

(1) The simulations are shown in Attachment 6.3.2.

(2) Item 7.

(3) The junction number can be seen in the Visual Report attachment.

Based on that, the primary and secondary pumps will have the following condition:

- Design condition

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	112,3	113.985	1,159	11,65	4,849	78,23	6,198	85,56	N/A	N/A	0,04304	1,202
X379	Show ...	P-PCH-7A-2	0,0	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	112,3	113.957	2,057	20,66	8,599	76,66	11,217	99,32	N/A	N/A	0,07912	2,136
X400	Show ...	P-PCH-7A-4	0,0	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

- Maximum Operating condition

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	92,94	94.334	0,8414	8,453	2,913	79,07	3,684	72,29	N/A	N/A	0,07308	0,9145
X379	Show ...	P-PCH-7A-2	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	91,63	93.003	2,0100	20,193	6,859	76,79	8,933	94,26	N/A	N/A	0,09912	2,1091
X400	Show ...	P-PCH-7A-4	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

- Intermediate Operating condition

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	92,94	94.334	0,8414	8,453	2,913	79,07	3,684	72,29	N/A	N/A	0,07308	0,9145
X379	Show ...	P-PCH-7A-2	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	47,10	47.803	1,6810	16,888	2,949	67,46	4,371	81,18	N/A	N/A	0,12860	1,8096
X400	Show ...	P-PCH-7A-4	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

- Minimum Operating condition (item 7)

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	Mass Flow (kg/hr)	dP (bar)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	NPSHR (meters)	P Static Suction (barG)	P Static Disc. (barG)
378	Show ...	P-PCH-7A-1	92,94	94.334	0,8414	8,453	2,913	79,07	3,684	72,29	N/A	N/A	0,07308	0,9145
X379	Show ...	P-PCH-7A-2	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
399	Show ...	P-PCH-7A-3	18,72	18.998	1,5649	15,722	1,091	46,39	2,351	77,24	N/A	N/A	0,13762	1,7025
X400	Show ...	P-PCH-7A-4	0,00	0	N/A	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

5.2.5 Chiller Capacity

According to item 5.1.1, the Simultaneous Peak Load is 368,667.0 kcal/h and it is equivalent to 122 TR. This is the maximum operating condition for the chillers.

The Nominal Capacity of each Chiller is 150 TR, so they have an oversizing of 18.4 % (28 TR).

At the Design and Maximum Operating Conditions, the inlet temperature for the process equipment's is 1.0 ºC and the outlet temperature (return to Chiller) is 5.0 ºC.

At the Intermediate Operating Condition, the inlet temperature for the process equipment's is 1.0 ºC and the outlet temperature (return to Chiller) is 4.5 ºC.

At the Minimum Operating Condition, the inlet temperature for the process equipment's and the outlet temperature (return to Chiller) is 1.0 ºC, because at this condition, all equipment's are closed, and the recirculation has no thermal load.

According to recommendation of Chiller´s supplier, the minimum stabilization time is 2 minutes. For that reason, it was adopted the residence time of 3 minutes, guaranteeing the thermal load when the chiller shuts down.

5.2.6 Buffer Tank

For the selection of the tank, an additional of 18.4 % (20.7 m³/h diverted to a future expansion) was considered in the equipment flowrate, thus:

$$72.8 + 20.7 + 18.8 \cong 112.3\, m^3/h$$

The Buffer tank is divided in 2 sides (side cold and side hot) and it was sized based on the residence time of 3 minutes for each side (minimum time required to stabilize the chiller in the event of a temporary shortages of electric energy supply).

Flowrate = 112.3 m³/h

Volume for each side = 6.0 m³

Total Useful volume = 12.0 m³

According to recommendation of Chiller´s supplier (Trane), the minimum stabilization time is 2 minutes. For that reason, it was adopted the residence time of 3minutes, guaranteeing the thermal load when the chiller shuts down.

6. ATTACHMENTS

6.1 SCHEMATICS FOR CHILLED WATER (5°C)

6.1.1 Design Condition

Schematic_Design_CW.pdf

6.1.2 Maximum Operating Condition

Schematic_Max_CW.pdf

6.1.3 Intermediate Operating Condition

Schematic_Interm_CW.pdf

6.1.4 Minimum Operating Condition

Schematic_Min_CW.pdf

6.2 SCHEMATICS FOR CHILLED PROPYLENE GLYCOL (1°C)

6.2.1 Design Condition

Schematic_Design_GLY.pdf

6.2.2 Maximum Operating Condition

Schematic_Max_GLY.pdf

6.2.3 Intermediate Operating Condition

Schematic_Interm_GLY.pdf

6.2.4 Minimum Operating Condition

Schematic_Min_GLY.pdf

6.3 RESULTS

6.3.1 Chilled Water (5 °C)

- Design Condition

Output Design CW.pdf

Visual Report Design CW.pdf

Output Design CW 2.pdf

Visual Report Design CW 2.pdf

Output Design Interm CW.pdf

Visual Report Design Interm CW.p

- Maximum Operating Condition

Output Max CW.pdf

Visual Report Max CW.pdf

- Intermediate Operating Condition

Output Interm CW.pdf

Visual Report Interm CW.pdf

- Minimum Operating Condition

Output Min CW.pdf

Visual Report Min CW.pdf

6.3.2 Chilled propylene glycol (1 °C)

- Design Condition

Output Design GLY.pdf

Visual Report Design GLY.pdf

Output Design GLY 2.pdf

Visual Report Design GLY 2.pdf

Output Design Interm GLY.pdf

Visual Report Design Interm GLY.p

- Maximum Operating Condition

Visual Report Max GLY.pdf

Output Max GLY.pdf

- Intermediate Operating Condition

Output Interm GLY.pdf

Visual Report Interm GLY.pdf

- Minimum Operating Condition

Output Min GLY.pdf

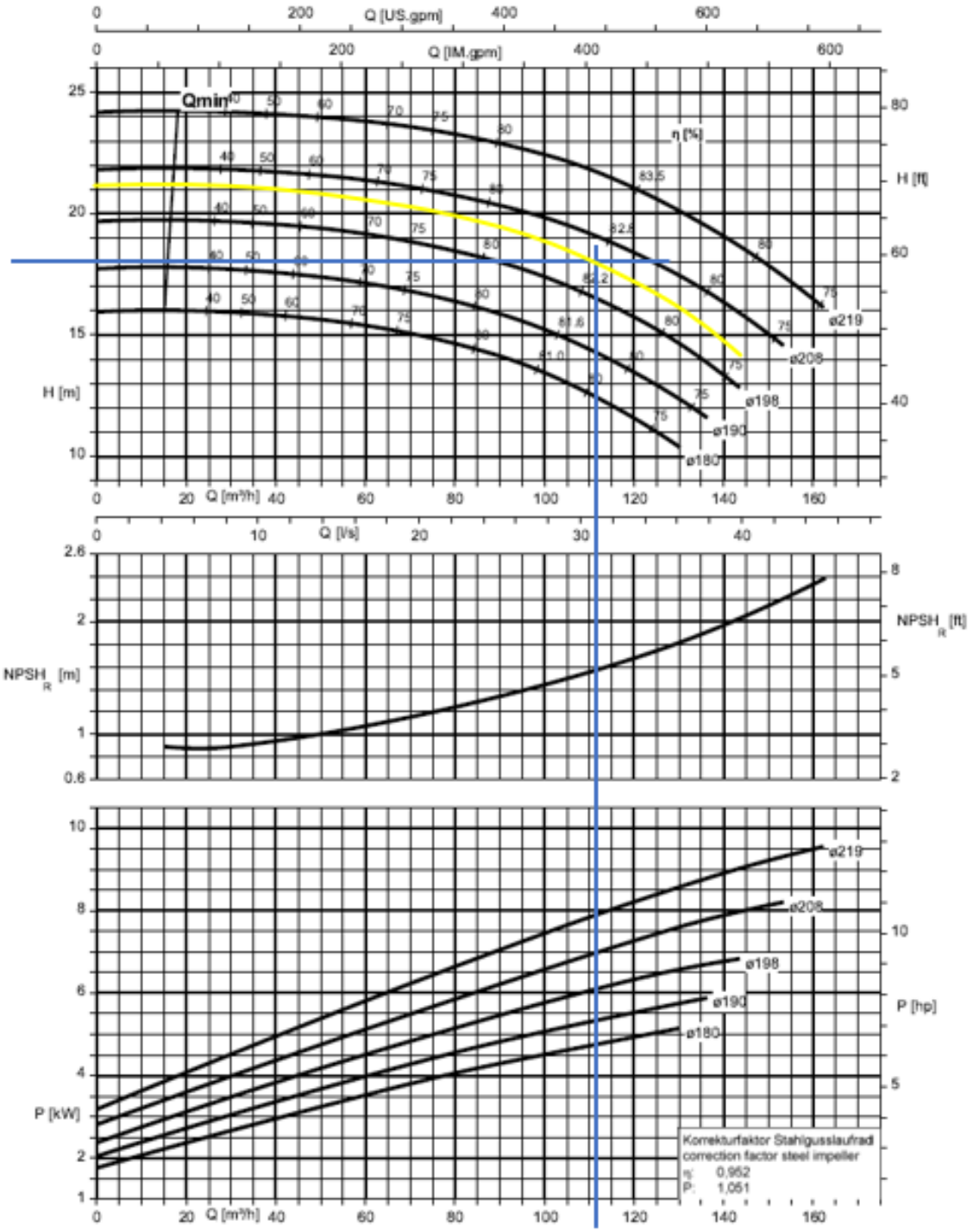
Visual Report Min GLY.pdf

7. PUMPS SELECTED

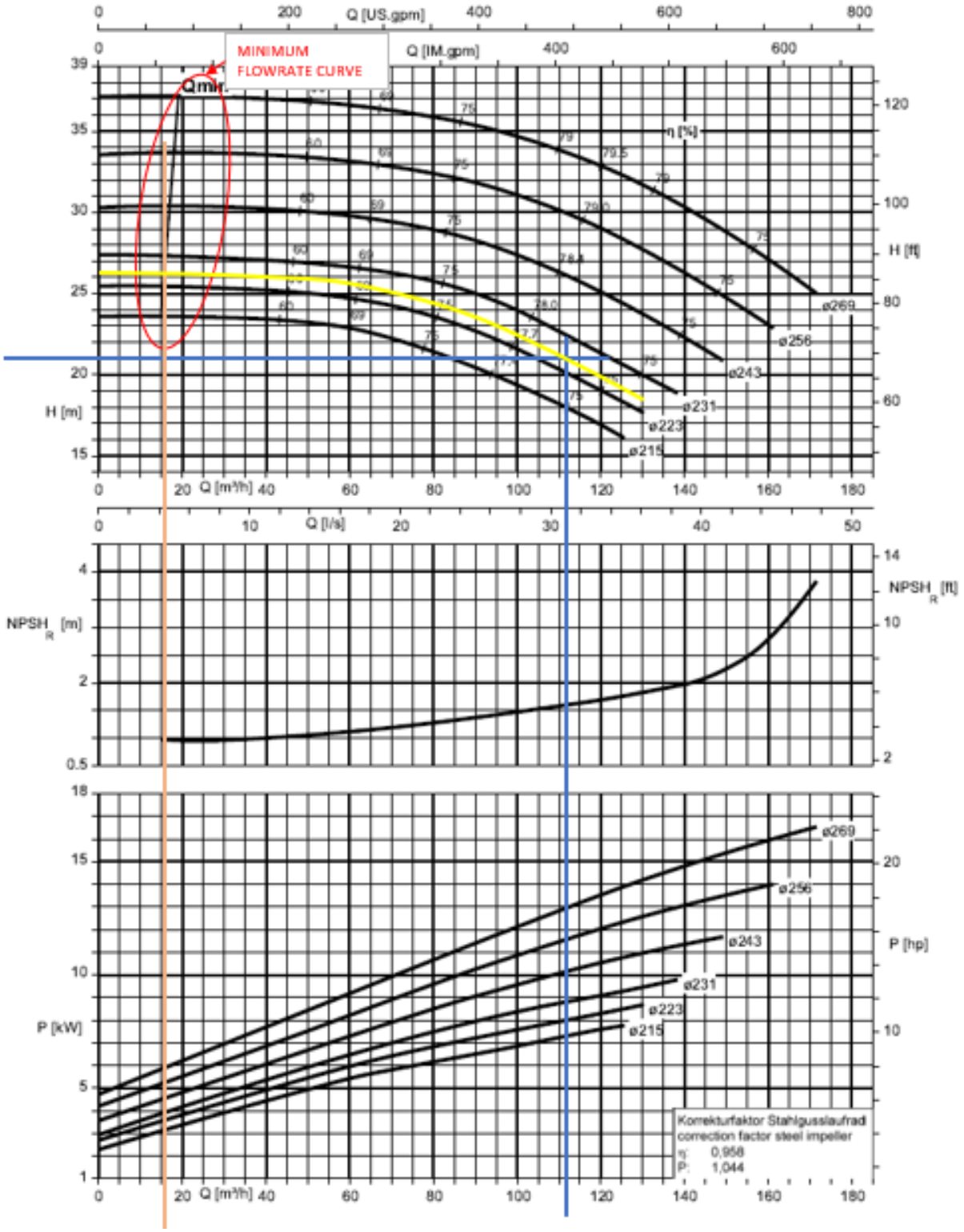
Primary pump – P-PCH-7A-1 / P-PCH-7A-2

Model selected – Meganorm 1750 rpm – 125-080-200.

Meganorm 125-080-200, n = 1.750 rpm



Secondary pump - P-PCH-7A-3 / P-PCH-7A-4

Model selected – Meganorm 1750 rpm – 125-080-250.

Meganorm 125-080-250, n = 1.750 rpm