DOC NUMBER: **569-DB07-PRO-400-002**	CLIENT NUMBER: **PRD-MEC-CLC-002**
CLIENT: **TAKEDA**	
PROJECT **BURITI EPCMV**	

CHILLED WATER DISTRIBUTION SYSTEM FOR HVAC – CALCULATION REPORT

0	23JUL2021	ISSUED FOR CONSTRUCTION	JRM	LFF	MSS
D	16APR2021	90% DD ISSUE	JRM	CCO	MSS
C	16OCT2020	FINAL BD ISSUE	MPA	LFF	MSS
B	28AUG2020	90% BD ISSUE	MPA	LFF	MSS
A	09JUL2020	50% BD ISSUE	MPA	LFF	MSS
RE	DATE	DESCRIPTION	EXEC	CHECK	APPROV

1. REVISION HISTORY 3
2. PURPOSE 3
3. REFERENCE 3
4. BASIC DATA AND PREMISES 4
5. CALCULATION 4
5.1 BUILDING 7A 4
5.2 BUILDING 7B 10
5.3 PRIMARY PUMPS AND CHILLERS 16
6. RESULTS 19
6.1 VISUAL REPORT 19
6.2 OUTPUT 19
7. PUMPS SELECTED 20

1. REVISION HISTORY

Rev	Reason For Change
A	50% BD ISSUE
B	90% BD ISSUE
C	FINAL BD ISSUE
D	AIR HANDLING UNITS FLOWRATES AND DIAMETERS HAVE BEEN UPDATED. AS WELL AS CALCULATIONS AND EQUIPMENT, ALL DATA WERE UPDATED ACCORDING TO HVAC EQUIPMENT LIST
0	ANSWERING TAKEDA COMMENTS – SUBMITAL 193.0 AIR HANDLING UNIT'S FLOWRATES AND DIAMETERS HAVE BEEN UPDATED. AS WELL AS CALCULATIONS AND EQUIPMENT, ALL DATA WERE UPDATED ACCORDING TO HVAC EQUIPMENT LIST.

2. PURPOSE

This document aims to establish the main characteristics for sizing the Chilled Water Distribution System for HVAC, building 7A – Final Drug Product and Building 7B – Bulk Drug Substance, intended to Buriti Project, located at Hemobrás' site in Goiana - Pernambuco state, Brazil.

3. REFERENCE

The following documents were used as reference:

Item	Number	Title
01	-	EQUIPMENT LIST - CHILLED WATER PLANT STEAM
03	PRD-HVC-LIS-004	LIST OF EQUIPMENT
04	7A-M-0-5-21	DRUG PRODUCT – AFD – AHU-7A-01
05	7A-M-0-5-22	DRUG PRODUCT – AFD – AHU-7A-02
06	7A-M-0-5-23	DRUG PRODUCT – AFD – AHU-7A-03
07	7A-M-0-5-24	DRUG PRODUCT – AFD – AHU-7A-04
08	7A-M-0-5-25	DRUG PRODUCT – AFD – AHU-7A-05
09	7A-M-0-5-26	DRUG PRODUCT – AFD – AHU-7A-06
10	7A-M-0-5-28	DRUG PRODUCT – AFD – DOAS-7A-01
11	7A-M-0-5-29	DRUG PRODUCT – AFD – FCU's
12	7B-M-0-5-21	DRUG SUBSTANCE – AFD – AHU-7B-01
13	7B-M-0-5-22	DRUG SUBSTANCE – AFD – AHU-7B-02
14	7B-M-0-5-23	DRUG SUBSTANCE – AFD – AHU-7B-03
15	7B-M-0-5-24	DRUG SUBSTANCE – AFD – AHU-7B-04
16	7B-M-0-5-25	DRUG SUBSTANCE – AFD – AHU-7B-05
17	7B-M-0-5-26	DRUG SUBSTANCE – AFD – AHU-7B-06
18	7B-M-0-5-27	DRUG SUBSTANCE – AFD – AHU-7B-07
19	7B-M-0-5-28	DRUG SUBSTANCE – AFD – AHU-7B-08
20	7B-M-0-5-29	DRUG SUBSTANCE – AFD – AHU-7B-09

Item	Number	Title
21	7B-M-0-5-31	DRUG SUBSTANCE – AFD – DOAS-7B-01
22	7B-M-0-5-32	DRUG SUBSTANCE – AFD – FCU's

4. BASIC DATA AND PREMISES

The Chilled Water Distribution System for HVAC supplies the building 7A and 7B and this system includes primary pumps (two in operation and one stand by) and secondary pumps with variable speed for each building (one in operation and the other stand by).

For system sizing, the following conditions were considered:

- DESIGN CONDITION – Sizing Criterion for chillers, lines, valves, and pumps - 100% of the capacity of all HVAC´s equipment and an oversizing of 0.9%, where the excess of flowrate is diverted to balancing valves (Building 7A and Building 7B).

- MAXIMUM OPERATING CONDITION –90% of the capacity of all HVAC´s equipment operating at the same time.

- MINIMUM OPERATING CONDITION – 70% of the Air Handling Units (AHU) and Fan Coils Units (FCU) capacities, plus 50% of the Dedicated Outdoor Air Systems (DOAS) capacities operating at the same time.

It was considered the installation of 3 chillers with nominal capacity of 530 TR each one, being 2 chillers operating and 1 as stand-by.

It was estimated an available pressure drop of 0.5 bar for each HVAC equipment and for evaporators.

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

Motorized pressure independent balancing and control valves with on off control were used for diameters of ¾". For diameters from 1", were used the same valves with modulating control.

5. CALCULATION

5.1 BUILDING 7A

5.1.1 Flow rates Required

The Chilled Water Distribution System for HVAC has the following consumers in the Building 7A:

- Design Condition

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m^3/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7A-01	Y	18.98	316.33	18,979.89	
Air handling unit	AHU-7A-02	Y	10.43	173.83	10,429.94	
Air handling unit	AHU-7A-03	Y	15.77	262.83	15,769.91	

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7A-04	Y	16.58	276.30	16,578.05	
Air handling unit	AHU-7A-05	Y	14.80	246.67	14,799.91	
Air handling unit	AHU-7A-06	Y	20.41	340.17	20,409.88	
Air handling unit dedicated outdoor air	DOAS-7A-01 (1/2)	Y	37.27	621.10	37,265.48	
	DOAS-7A-01 (2/2)	Y	35.80	596.74	35,804.09	
Fan Coil Unit	FCU-A1026-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1026-2	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1026-3	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1027-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1027-2	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1027-3	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1030-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A1041-1	Y	6.48	108.00	6,479.96	
Fan Coil Unit	FCU-A1041-2	Y	6.48	108.00	6,479.96	
Fan Coil Unit	FCU-A1043-1	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-A1043-2	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-A1043-3	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-A1043-4	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-A2024-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A3302-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-A3003-1	Y	5.48	91.25	5,474.97	
Fan Coil Unit	FCU-A3003-2	Y	5.48	91.25	5,474.97	
TOTAL EQUIPMENT		**-**	**214.25**	**3,570.87**	**214,250.87**	
Recirculation (BV)		Y	9.75	162.50	9,749.94	*1*
TOTAL		-	**224.0**	**3,733.4**	**224,000.8**	***3***

Notes:

1. Flowrate through bypasses.
2. Canceled.
3. Total flowrate for Secondary Pump – Design Condition.

- Maximum Operating Condition

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7A-01	Y	17.08	284.70	17081.90	
Air handling unit	AHU-7A-02	Y	9.39	156.45	9386.94	
Air handling unit	AHU-7A-03	Y	14.19	236.55	14192.91	
Air handling unit	AHU-7A-04	Y	14.92	248.67	14920.25	
Air handling unit	AHU-7A-05	Y	13.32	222.00	13319.92	
Air handling unit	AHU-7A-06	Y	18.37	306.15	18368.89	
Air handling unit dedicated outdoor air	DOAS-7A-01 (1/2)	Y	33.54	558.99	33538.93	
	DOAS-7A-01 (2/2)	Y	32.22	537.06	32223.68	
Fan Coil Unit	FCU-A1026-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1026-2	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1026-3	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1027-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1027-2	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1027-3	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1030-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A1041-1	Y	5.83	97.20	5831.97	
Fan Coil Unit	FCU-A1041-2	Y	5.83	97.20	5831.97	
Fan Coil Unit	FCU-A1043-1	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-A1043-2	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-A1043-3	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-A1043-4	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-A2024-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A3302-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-A3003-1	Y	4.93	82.13	4927.47	
Fan Coil Unit	FCU-A3003-2	Y	4.93	82.13	4927.47	
TOTAL EQUIPMENT		**-**	**192.83**	**3213.78**	**192825.78**	
Recirculation (BV)		Y	9.75	162.50	9749.94	*1*
TOTAL		-	**202.6**	**3376.3**	**202575.7**	*2*

Notes:
1. Flowrate through bypasses.
2. Total flowrate for Secondary Pump – Maximum Operating Condition

- Minimum Operating Condition

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7A-01	Y	13.29	221.43	13285.92	
Air handling unit	AHU-7A-02	Y	7.30	121.68	7300.96	
Air handling unit	AHU-7A-03	Y	11.04	183.98	11038.93	
Air handling unit	AHU-7A-04	Y	11.60	193.41	11604.64	
Air handling unit	AHU-7A-05	Y	10.36	172.67	10359.94	
Air handling unit	AHU-7A-06	Y	14.29	238.12	14286.91	
Air handling unit dedicated outdoor air	DOAS-7A-01 (1/2)	Y	18.63	310.55	18632.74	
	DOAS-7A-01 (2/2)	Y	17.90	298.37	17902.04	
Fan Coil Unit	FCU-A1026-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1026-2	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1026-3	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1027-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1027-2	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1027-3	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1030-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A1041-1	Y	4.54	75.60	4535.97	
Fan Coil Unit	FCU-A1041-2	Y	4.54	75.60	4535.97	
Fan Coil Unit	FCU-A1043-1	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-A1043-2	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-A1043-3	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-A1043-4	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-A2024-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A3302-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-A3003-1	Y	3.83	63.88	3832.48	
Fan Coil Unit	FCU-A3003-2	Y	3.83	63.88	3832.48	
TOTAL EQUIPMENT		**-**	**135.36**	**2256.04**	**135361.69**	
Recirculation (BV)		Y	9.75	162.50	9749.94	*1*
TOTAL		-	**145.1**	**2418.5**	**145111.6**	***2***

Notes:
1. Flowrate through bypasses.
2. Total flowrate for Secondary Pump – Minimum Operating Condition

The Design Condition peak load for Building 7A is 1,499,756.1 kcal/h (496.0 TR).

5.1.2 Secondary pumps

Based on the conditions above, the secondary pumps for Building 7A (P-CH-7A-4/ P-CH-7A-5) were sized for the following conditions:

Design Condition – Flowrate = 224.0 m³/h

Maximum Operating Condition = 202.6 m³/h

Minimum Operating Condition = 145.1 m³/h

There are 2 secondary pumps, where one is operating and the other in stand-by. They are controlled by the differential pressure transmitter PDIT-9600234 maintaining constant the pressure drop of 1.29 bar at the main distribution header.

This instrument is installed at a distance of 2/3 of the main distribution pipe total length, to guarantee a good control.

The results of the pumps calculated are indicated in Item 7 of this document.

5.1.3 Flow rates required for 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 9.75 m³/h for chilled water recirculation. This flow rate will be guaranteed by using 6 manual static balancing valves in the by-pass as below:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(bar)	(bar)	(bar)	(Calculated)
126	BV-960010	1.75	29.17	1.7	1.0	0.7	2.4
203	BV-9600210	1.60	26.66	2.8	1.8	1.0	1.9
229	BV-9600182	1.60	26.66	2.9	2.1	0.9	2.0
242	BV-9600219	1.60	26.66	3.0	2.0	1.0	1.9
254	BV-9600184	1.60	26.66	3.0	2.0	1.0	1.9
302	BV-9600235	1.60	26.66	2.7	2.0	0.7	2.2
TOTAL		**9.75**	**162.5**	**-**	**-**	**-**	**-**

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:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
297	BV-9600234	5.5	91.5	1.7	1.6	0.03	36.6
1000	BV-9600210	5.5	91.5	1.8	1.8	0.03	36.6

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
1001	BV-9600183	27.7	461.6	1.7	1.7	0.03	184.9

c) Balancing valves at the pump discharge

Static balancing valves were considered at the pump discharge, as shown in the table below:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
102	BV-960004	224.00	3733.3	2.0	1.8	0.2	595.4
x107	BV-960053	224.00	3733.3	2.0	1.8	0.2	595.4

d) Temperature Control Valves

Motorized pressure independent balancing and control valves with on off control were used for diameters of ¾". For diameters starting in 1", were used the same valves with modulating control.

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
209	TV-9600213	1.30	21.61	1.5	1.0	0.5	2.1
212	TV-9600215	1.30	21.61	1.9	1.4	0.5	2.2
215	TV-9600217	1.30	21.61	2.3	1.8	0.5	2.2
218	TV-960004	16.59	276.44	1.3	0.7	0.7	23.7
221	TV-960005	14.81	246.79	1.3	0.6	0.7	20.0
238	TV-9600225	1.30	21.61	2.4	1.8	0.6	2.0
247	TV-9600221	6.48	108.05	2.5	2.1	0.4	2.0
250	TV-9600223	6.48	108.05	2.5	2.0	0.5	1.9
259	TV-960020	2.16	36.02	2.5	2.0	0.5	11.3
262	TV-9600187	2.16	36.02	2.5	2.0	0.5	11.1
265	TV-9600191	2.16	36.02	2.4	2.0	0.4	1.9
268	TV-9600193	2.16	36.02	2.4	2.0	0.4	3.5
271	TV-9600227	5.48	91.29	1.2	0.4	0.8	3.7
274	TV-9600229	5.48	91.29	1.2	0.4	0.8	3.9
277	TV-960003	15.78	262.96	1.4	0.6	0.8	4.1
280	TV-9600231	1.30	21.61	1.9	1.3	0.6	6.9
283	TV-960001	18.99	316.49	1.4	0.6	0.8	6.9
286	TV-9600233	1.30	21.61	1.2	0.4	0.8	20.4
289	TV-960006	20.42	340.33	1.3	0.7	0.7	1.9

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
292	TV-960027	37.28	621.39	1.3	0.7	0.7	25.3
295	TV-9600331	35.82	597.03	1.3	0.7	0.6	1.7
309	TV-9600237	1.30	21.61	1.4	1.2	0.2	28.7
312	TV-9600239	1.30	21.61	1.8	1.6	0.2	53.3
315	TV-9600241	1.30	21.61	2.2	2.0	0.2	51.4
318	TV-960002	10.44	173.92	1.3	0.7	0.6	2.2

5.2 BUILDING 7B

5.2.1 Flow rates Required

The Chilled Water Distribution System for HVAC has the following consumers in the Building 7B:

- Design Condition

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7B-01	Y	7.38	123.00	7,380	
Air handling unit	AHU-7B-02	Y	24.43	407.17	24,430	
Air handling unit	AHU-7B-03	Y	20.98	349.67	20,980	
Air handling unit	AHU-7B-04	Y	15.97	266.22	15,973.01	
Air handling unit	AHU-7B-05	Y	6.41	106.89	6,413.41	
Air handling unit	AHU-7B-06	Y	2.92	48.67	2,919.98	
Air handling unit	AHU-7B-07	Y	2.66	44.37	2,662.17	
Air handling unit	AHU-7B-08	Y	9.08	151.26	9,075.58	
Air handling unit	AHU-7B-09	Y	18.06	301.00	18,059.89	
Air handling unit dedicated outdoor air	DOAS-7B-01 (1/2)	Y	40.48	674.65	40,478.46	
	DOAS-7B-01 (2/2)	Y	38.89	648.19	38,891.07	
Fan Coil Unit	FCU-B1014-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1014-2	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1014-3	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1014-4	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1015-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1015-2	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1015-3	Y	1.30	21.60	1,295.99	

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Fan Coil Unit	FCU-B1029-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1031-1	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-B1031-2	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-B1031-3	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-B1031-4	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-B1031-5	Y	2.16	36.00	2,159.99	
Fan Coil Unit	FCU-B1032-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1032-2	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1032-3	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B1033-1	Y	6.71	111.83	6,709.96	
Fan Coil Unit	FCU-B1033-2	Y	6.71	111.83	6,709.96	
Fan Coil Unit	FCU-B3010-1	Y	1.30	21.60	1,295.99	
Fan Coil Unit	FCU-B3011-1	Y	5.98	99.67	5,979.96	
Fan Coil Unit	FCU-B3011-2	Y	5.98	99.67	5,979.96	
Fan Coil Unit	FCU-B1034-1	Y	0.46	7.67	460.00	
TOTAL EQUIPMENT		**-**	**239.46**	**3,990.94**	**239,454.93**	
Recirculation (BV)		Y	17.54	292.33	17,539.89	*1*
TOTAL		**-**	**257.0**	**4,283.3**	**256,994.8**	***3***

Notes:
1. Flowrate through bypasses.
2. Canceled.
3. Total flowrate for Secondary Pump – Design Condition

- Maximum Operating Condition

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7B-01	Y	6.64	110.70	6641.96	
Air handling unit	AHU-7B-02	Y	21.99	366.45	21986.87	
Air handling unit	AHU-7B-03	Y	18.88	314.70	18881.89	
Air handling unit	AHU-7B-04	Y	14.38	239.60	14375.71	
Air handling unit	AHU-7B-05	Y	5.77	96.20	5772.07	
Air handling unit	AHU-7B-06	Y	2.63	43.80	2627.98	
Air handling unit	AHU-7B-07	Y	2.40	39.93	2395.95	
Air handling unit	AHU-7B-08	Y	8.17	136.13	8168.02	
Air handling unit	AHU-7B-09	Y	16.25	270.90	16253.90	

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m^3/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit dedicated outdoor air	DOAS-7B-01 (1/2)	Y	36.43	607.18	36430.61	
	DOAS-7B-01 (2/2)	Y	35.00	583.37	35001.96	
Fan Coil Unit	FCU-B1014-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1014-2	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1014-3	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1014-4	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1015-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1015-2	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1015-3	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1029-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1031-1	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-B1031-2	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-B1031-3	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-B1031-4	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-B1031-5	Y	1.94	32.40	1943.99	
Fan Coil Unit	FCU-B1032-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1032-2	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1032-3	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B1033-1	Y	6.04	100.65	6038.96	
Fan Coil Unit	FCU-B1033-2	Y	6.04	100.65	6038.96	
Fan Coil Unit	FCU-B3010-1	Y	1.17	19.44	1166.39	
Fan Coil Unit	FCU-B3011-1	Y	5.38	89.70	5381.97	
Fan Coil Unit	FCU-B3011-2	Y	5.38	89.70	5381.97	
Fan Coil Unit	FCU-B1034-1	Y	0.41	6.90	414.00	
TOTAL EQUIPMENT		**-**	**215.51**	**3591.85**	**215509.44**	
Recirculation (BV)		Y	17.54	292.33	17539.89	*1*
TOTAL		**-**	**233.1**	**3884.2**	**233049.3**	***2***

Notes:

1. Flowrate through bypasses.
2. Total flowrate for Secondary Pump – Maximum Operating Condition

- Minimum Operating Condition

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m^3/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
Air handling unit	AHU-7B-01	Y	5.17	86.10	5165.97	
Air handling unit	AHU-7B-02	Y	17.10	285.02	17100.90	
Air handling unit	AHU-7B-03	Y	14.69	244.77	14685.91	
Air handling unit	AHU-7B-04	Y	11.18	186.35	11181.11	
Air handling unit	AHU-7B-05	Y	4.49	74.82	4489.38	
Air handling unit	AHU-7B-06	Y	2.04	34.07	2043.99	
Air handling unit	AHU-7B-07	Y	1.86	31.06	1863.52	
Air handling unit	AHU-7B-08	Y	6.35	105.88	6352.90	
Air handling unit	AHU-7B-09	Y	12.64	210.70	12641.92	
Air handling unit dedicated outdoor air	DOAS-7B-01 (1/2)	Y	20.24	337.32	20239.23	
	DOAS-7B-01 (2/2)	Y	19.45	324.09	19445.53	
Fan Coil Unit	FCU-B1014-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1014-2	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1014-3	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1014-4	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1015-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1015-2	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1015-3	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1029-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1031-1	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-B1031-2	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-B1031-3	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-B1031-4	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-B1031-5	Y	1.51	25.20	1511.99	
Fan Coil Unit	FCU-B1032-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1032-2	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1032-3	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B1033-1	Y	4.70	78.28	4696.97	
Fan Coil Unit	FCU-B1033-2	Y	4.70	78.28	4696.97	
Fan Coil Unit	FCU-B3010-1	Y	0.91	15.12	907.19	
Fan Coil Unit	FCU-B3011-1	Y	4.19	69.77	4185.97	
Fan Coil Unit	FCU-B3011-2	Y	4.19	69.77	4185.97	
Fan Coil Unit	FCU-B1034-1	Y	0.32	5.37	322.00	

EQUIPMENT	TAG	DIVERSITY (Y/N)	FLOWRATE (m³/h)	FLOWRATE (lpm)	FLOWRATE (kg/h)	NOTES
TOTAL EQUIPMENT		**-**	**151.75**	**2529.09**	**151744.55**	
Recirculation (BV)		Y	17.54	292.33	17539.89	*1*
TOTAL		**-**	**169.3**	**2821.4**	**169284.4**	***2***

Notes:
1. Flowrate through bypasses.
2. Total flowrate for Secondary Pump – Minimum Operating Condition.

The Design Condition peak load for Building 7B is 1,676,184.5 kcal/h (554.3 TR).

5.2.2 Secondary pumps

Based on the conditions above, the secondary pumps for Building 7B (P-CH-7B-6/ P-CH-7B-7) were sized for the following conditions:

Design Condition – Flowrate = 257.0 m³/h

Maximum Operating Condition = 233.1 m³/h

Minimum Operating Condition = 169.3 m³/h

There are 2 secondary pumps, where one is operating and the other in stand-by. They are controlled by the differential pressure transmitter PDIT-960008 maintaining constant the pressure drop of 1.61 bar at the main distribution header.

This instrument is installed at a distance of 2/3 of the main distribution pipe total length, to guarantee a good control. The results of the pumps calculated are indicated in Item 7 of this document.

5.2.3 Flow rates required for 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 17.54 m³/h for chilled water recirculation. This flow rate will be guaranteed by using 8 manual balancing valves in the by-pass as below:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
528	BV-960011	2.10	34.99	2.1	1.0	1.1	2.3
628	BV-9600251	2.10	34.99	3.1	2.2	0.8	2.6
647	BV-9600171	2.10	34.99	3.3	2.4	0.9	2.6
659	BV-9600173	2.10	34.99	3.3	2.4	0.9	2.5
684	BV-9600269	2.85	47.50	3.2	2.5	0.7	3.9
708	BV-9600259	2.10	34.99	3.3	2.3	1.0	2.4
727	BV-9600279	2.10	34.99	2.0	0.9	1.1	2.3

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
753	BV-9600291	2.10	34.99	3.1	2.3	0.8	2.7
TOTAL		**17.54**	**292.4**	**-**	**-**	**-**	**-**

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

Throughout the system, 6 static balancing valves in the distribution headers were considered to guarantee the correct water distribution, as shown in the table below:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
624	BV-9600250	5.99	99.8	2.05	2.02	0.03	40.0
642	BV-9600170	40.31	671.8	2.01	1.98	0.03	269.2
653	BV-9600172	28.33	472.2	3.34	3.31	0.03	189.2
678	BV-9600268	8.49	141.6	3.32	3.29	0.03	56.7
724	BV-9600278	14.06	234.3	1.98	1.95	0.03	93.9
749	BV-9600290	5.99	99.8	1.92	1.89	0.03	40.0

c) Balancing valves at the pump discharge

Static balancing valves were considered at the pump discharge, as shown in the table below:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(bar)	(bar)	(bar)	(Calculated)
502	BV-960007	257.00	4283.3	2.8	2.4	0.4	445.1
x507	BV-960056	257.00	4283.3	2.8	2.4	0.4	445.1

d) Temperature Control Valves

Motorized pressure independent balancing and control valves with on off control were used for diameters of ¾". For diameters starting in 1", were used the same valves with modulating control.

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(bar)	(bar)	(bar)	(Calculated)
601	TV-960012	24.44	407.36	2.0	0.6	1.4	24.0
604	TV-960013	20.99	349.84	1.9	0.6	1.3	21.4
607	TV-960018	9.08	151.33	2.0	0.6	1.4	8.9
610	TV-960019	18.07	301.15	1.9	0.6	1.3	18.2
613	TV-960017	2.66	44.39	1.9	0.6	1.3	2.7

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(bar)	(bar)	(bar)	(Calculated)
616	TV-960028	40.50	674.97	1.9	0.8	1.1	44.6
619	TV-9600337	38.91	648.50	1.9	0.8	1.1	42.9
622	TV-960014	15.98	266.35	1.8	0.8	1.0	18.2
634	TV-9600253	1.30	21.61	1.8	1.4	0.4	2.5
637	TV-9600255	1.30	21.61	2.1	1.8	0.3	2.6
640	TV-9600257	1.30	21.61	2.5	2.2	0.3	2.7
667	TV-960021	2.16	36.02	2.8	2.2	0.6	3.3
670	TV-9600175	2.16	36.02	2.8	2.3	0.5	3.4
673	TV-9600265	6.71	111.89	2.8	2.4	0.5	11.5
676	TV-9600267	6.71	111.89	2.8	2.4	0.4	12.1
692	TV-9600299	0.46	7.67	2.8	2.4	0.5	0.8
695	TV-9600271	1.30	21.61	2.8	2.4	0.3	2.6
698	TV-9600273	1.30	21.61	2.7	2.5	0.3	3.0
701	TV-9600275	1.30	21.61	2.7	2.5	0.2	3.3
704	TV-9600277	1.30	21.61	2.7	2.5	0.2	3.5
713	TV-9600261	2.16	36.02	2.7	2.3	0.4	4.0
716	TV-9600263	1.30	21.61	2.8	2.3	0.4	2.3
719	TV-9600179	2.16	36.02	2.8	2.4	0.4	3.8
722	TV-9600181	2.16	36.02	2.8	2.4	0.4	4.0
732	TV-9600281	5.98	99.72	1.5	0.9	0.6	8.8
735	TV-9600283	5.98	99.72	1.5	0.9	0.6	8.9
738	TV-960011	7.38	123.06	1.7	1.0	0.7	10.2
741	TV-9600287	1.30	21.61	1.5	0.8	0.7	1.8
744	TV-960016	2.92	48.69	1.7	1.0	0.7	4.2
747	TV-960015	6.42	106.94	1.6	1.0	0.6	9.5
759	TV-9600293	1.30	21.61	1.8	1.5	0.3	2.7
762	TV-9600295	1.30	21.61	2.1	1.9	0.3	2.9
765	TV-9600297	1.30	21.61	2.5	2.3	0.2	3.0

5.3 PRIMARY PUMPS AND CHILLERS

5.3.1 Primary Pumps

There are 3 primary pumps and 3 chillers, where two are operating and the other in stand-by.

Based on the secondary pump's calculation, the primary pumps were sized for the following conditions:

Design Condition – Total Flowrate = 224.0 + 257.0 =476.0 m³/h

Design Condition for each pump = 240.5 m³/h.

The design and operating conditions for this pump is shown in item 7 of this document.

The primary pumps operate at a fixed speed. When the flow rate of the secondary pumps reduces, the pressure transmitter PIT-960059 opens the bypass valve PV-960059, recirculating the excess flow rate through the primary pump and the chiller.

The PIT-960059 is installed at the secondary pumps suction. The pressure set point for this instrument is 0.5 barG. If this value changes, the Pressure Controller opens or closes the bypass valve PV-960059.

The bypass valve PV-960059 has the following operating conditions:

a) Design Condition

Flowrate from Secondary Pumps = 224.0 + 257.0 = 481.0 m³/h

Flowrate from Primary Pumps = 240.5 x 2 = 481 m³/h

Flowrate PV-960059 = 0.0 m³/h (valve is closed)

ITEM	VALVE	FLOWRATE (m³/h)	ΔP (bar)	CV (Calculated)
X75	PV-960059	0.0	N/A	N/A

b) Maximum Operating Condition

Flowrate from Secondary Pumps = 202.6 + 233.1 = 435.7 m³/h

Flowrate from Primary Pumps = 240.5 x 2 = 481 m³/h

Flowrate PV-960059 = 45.3 m³/h

ITEM	VALVE	FLOWRATE (m³/h)	ΔP (bar)	CV (Calculated)
75	PV-960059	45.3	0.2	105.3

c) Minimum Operating Condition

Flowrate from Secondary Pumps = 145.1 + 169.3 = 314.4 m³/h

Flowrate from Primary Pumps = 240.5 x 2 = 481 m³/h

Flowrate PV-960059 = 166.6 m³/h

ITEM	VALVE	FLOWRATE (m³/h)	ΔP (bar)	CV (Calculated)
75	PV-960059	166.6	0.1	556.6

5.3.2 Flow rates required for Balancing Valves

At the outlet of each chiller there is a static balancing valve with the following condition:

ITEM	VALVE	FLOWRATE		P in	P out	ΔP	CV
		(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
2	BV-960001	241.3	4022.4	0.7	0.5	0.2	578.0
x4	BV-960002	238.9	3981.9	0.7	0.5	0.2	630.1
6	BV-960003	239.7	3994.9	0.7	0.5	0.2	630.1

5.3.3 Chiller Capacity

According to calculations carried out, the chiller shall be sized for the following Design Condition:

7A - DESIGN CONDITION	FLOWRATE		THERMAL CAPACITY		TEMPERATURE	
	m³/h	kg/h	kcal/h	TR	Tin	Tout
EQUIPMENT	214.25	214,250.9	1,499,756.1	496.0	5.5	12.5
BALANCING VALVES	9.75	9,749.9	0.0	0.0	5.5	5.5
TOTAL	**224.0**	**224,000.8**	**1,499,756.1**	**496.0**	**5.5**	**12.2**

7B - DESIGN CONDITION	FLOWRATE		THERMAL CAPACITY		TEMPERATURE	
	m³/h	kg/h	kcal/h	TR	Tin	Tout
EQUIPMENT	239.46	239,454.9	1,676,184.5	554.3	5.5	12.5
BALANCING VALVES	17.54	17,539.9	0.0	0.0	5.5	5.5
TOTAL	**257.0**	**256,994.8**	**1,676,184.5**	**554.3**	**5.5**	**12.0**

CHILLER	FLOWRATE		THERMAL CAPACITY		TEMPERATURE	
	m³/h	kg/h	kcal/h	TR	Tin	Tout
CH-7A-1	240.50	240,497.8	1,587,970.3	525.1	5.5	12.1
CH-7A-2 (Stand-by)	240.50	240,497.8	1,587,970.3	525.1	5.5	12.1
CH-7A-3	240.50	240,497.8	1,587,970.3	525.1	5.5	12.1
TOTAL	**481.00**	**480,995.6**	**3,175,940.6**	**1,050.2**	**5.5**	**12.1**

The Chilled Water Distribution System was sized based on the flowrates and diversity indicated above, using the software FATHOM version 10.0 and the PIDs 7A-M-0-5-43, 7A-M-0-5-44, 7A-M-0-5-54, 7A-M-0-5-55, 7A-M-0-5-56, 7B-M-0-5-43, 7B-M-0-5-55, 7B-M-0-5-56, 7B-M-0-5-57 and 7B-M-0-5-58, for this system were elaborated based on these calculations.

6. RESULTS

6.1 VISUAL REPORT

- Design Condition
- Maximum Operating Condition
- Minimum Operating Condition

Visual Report - Design Condition.p

Visual Report - Operation Conditio

Visual Report - Minimum Condition

6.2 OUTPUT

- Design Condition
- Maximum Operating Condition
- Minimum Operating Condition

Output - Design Condition.pdf

Output - Operation Condition.pdf

Output - Minimum Condition.pdf

7. PUMPS SELECTED

a) DESIGN CONDITION

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	P Static Suction (barG)	P Static Disc. (barG)	dP (bar)
59	Show ...	P-CH-7A-1	240,8	17,07	15,01	82,71	18,15	100,0	14,64	0,4271	2,052	1,674
X61	Show ...	P-CH-7A-2 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A
63	Show ...	P-CH-7A-3	240,6	17,08	15,00	82,69	18,14	100,0	14,64	0,4269	2,052	1,674
101	Show ...	P-CH-7A-4	224,0	17,51	14,33	79,00	18,14	100,0	16,42	0,5986	2,256	1,718
X106	Show ...	P-CH-7A-5 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A
501	Show ...	P-CH-7B-6	257,0	25,92	24,33	81,00	30,04	100,0	16,17	0,5712	3,064	2,542
X506	Show ...	P-CH-7B-7 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A

P-PCH-7A-1/ 2/ 3 - The pump head will be rounded to 20 mlc.

P-PCH-7A-4/ 5 - The pump head will be rounded to 20 mlc.

P-CH-7B-6/ 7 - The pump head will be rounded to 26 mlc.

b) MAXIMUM OPERATING CONDITION

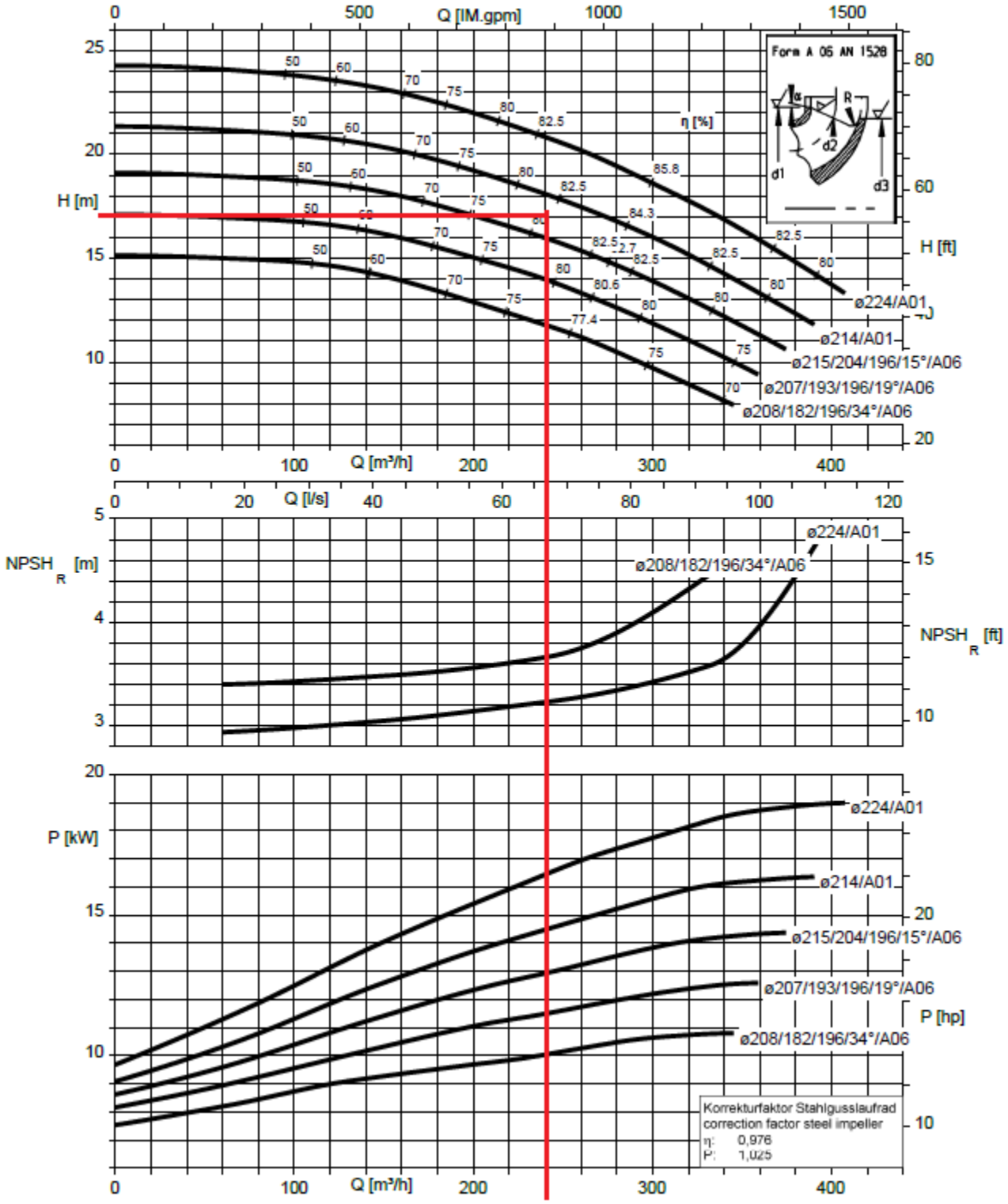
Jct	Results Diagram	Name	Vol. Flow (m3/hr)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	P Static Suction (barG)	P Static Disc. (barG)	dP (bar)
59	Show ...	P-CH-7A-1	240,8	17,07	15,01	82,71	18,15	100,0	14,64	0,4271	2,052	1,674
X61	Show ...	P-CH-7A-2 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A
63	Show ...	P-CH-7A-3	240,6	17,08	15,00	82,69	18,14	100,0	14,64	0,4269	2,052	1,674
101	Show ...	P-CH-7A-4	224,0	17,51	14,33	79,00	18,14	100,0	16,42	0,5986	2,256	1,718
X106	Show ...	P-CH-7A-5 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A
501	Show ...	P-CH-7B-6	257,0	25,92	24,33	81,00	30,04	100,0	16,17	0,5712	3,064	2,542
X506	Show ...	P-CH-7B-7 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A

c) MINIMUM OPERATING CONDITION

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	dH (meters)	Ideal Power (hp)	Overall Efficiency (Percent)	Overall Power (hp)	Speed (Percent)	NPSHA (meters)	P Static Suction (barG)	P Static Disc. (barG)	dP (bar)
59	Show ...	P-CH-7A-1	240,8	17,08	15,012	82,71	18,15	100,00	14,76	0,4384	2,063	1,674
X61	Show ...	P-CH-7A-2 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
63	Show ...	P-CH-7A-3	243,1	17,00	15,093	82,87	18,21	100,00	14,87	0,4461	2,064	1,667
101	Show ...	P-CH-7A-4	145,7	13,66	7,269	70,50	10,31	85,20	17,02	0,6614	1,947	1,340
X106	Show ...	P-CH-7A-5 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A
501	Show ...	P-CH-7B-6	171,5	19,47	12,198	75,59	16,14	83,80	16,90	0,6481	2,509	1,910
X506	Show ...	P-CH-7B-7 (Stand by)	0,0	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

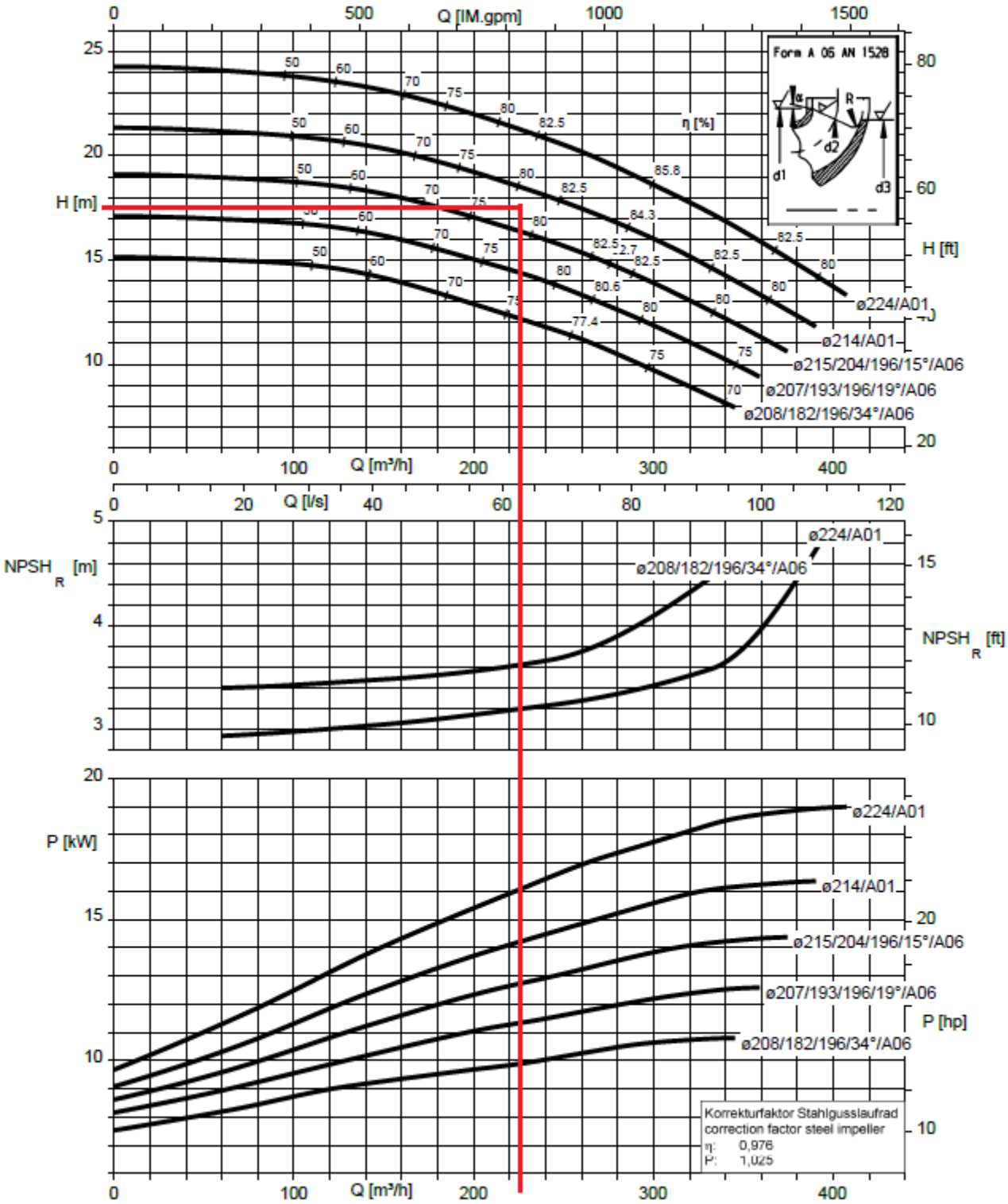
- Primary Pumps (P-CH-7A-1, P-CH-7A-2 and P-CH-7A-3)

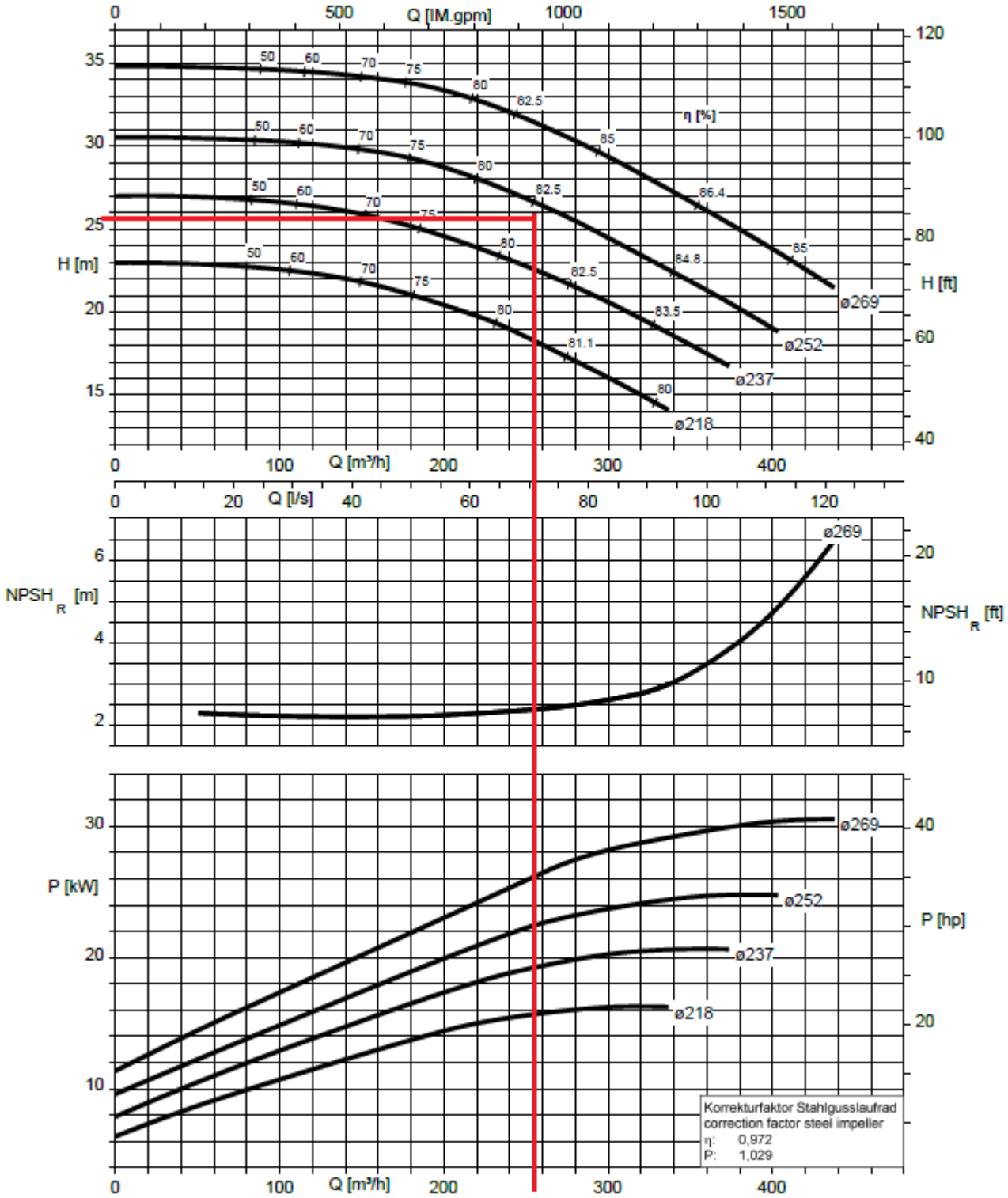
  Meganorm 150-125-200, 1750 rpm



- Secondary Pump Building 7A (P-CH-7A-4 and P-CH-7A-5)

  Meganorm 150-125-200, 1750 rpm



- Secondary Pump Building 7B (P-CH-7B-6 and P-CH-7B-7)

  Meganorm 150-125-250, 1750 rpm