DOC NUMBER: **569-DB7B-PRO-400-003**	CLIENT NUMBER: **PRD-MEC-CLC-010**
CLIENT: **TAKEDA**	
PROJECT **BURITI EPCMV PROJECT**	

COOLING WATER SYSTEM CALCULATION

REV	DATE	DESCRIPTION	EXEC	CHECK	APPROV
0	30JUL2021	ISSUED FOR CONSTRUCTION	JRM	LFF	MSS
D	14MAY2021	90% DD ISSUE	JRM	CCO	MSS
C	16OCT2020	FINAL BD ISSUE	MPA	LFF	MSS
B	28AUG202	90% BD ISSUE	MPA	LFF	MSS
A	28AUG202	90% BD ISSUE	MPA	LFF	MSS

1. REVISION HISTORY

Rev	Reason for Change
A	90% BD ISSUE
B	90% BD ISSUE
C	FINAL BD ISSUE
D	FLOWRATES AND DIAMETERS HAVE BEEN UPDATED. AS WELL AS CALCULATIONS AND EQUIPMENT, ALL DATA WERE UPDATED ACCORDING DETAILMENT DESIGN.
0	ANSWERING TAKEDA COMMENTS – SUBMITAL 247.0

2. PURPOSE

This document aims to establish the main characteristics for sizing the Cooling Water System for Building 7B (Bulk Drug Substance – BDS), 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
1	7B-M-0-5-45	Chilled Glycol Generation System
2	7B-M-0-5-81	Compressed Air Generation System
3	7B-Z-0-2-76	Bio-Kill System, BKS-7501

4. BASIC DATA AND PREMISES

The Cooling Water System supplies the Building 7B and this system includes 2 Cooling Towers (2 are operating in parallel or 1 is operating and the other is shutted down - in case of maintenance) primary pumps (1 in operation and 1 stand by) all with variable speed.

For system sizing, the following conditions were considered:

- DESIGN CONDITION – Sizing Criterion for Cooling Towers - 100% of the capacity of all equipment and an oversizing of 20%. – 1 Cooling Towers operating and 1 stand-by (maintenance).
- MAXIMUM OPERATING CONDITION – 100% of the capacity of all equipment operating at the same time – 1 Cooling Towers operating and 1 stand-by (maintenance – higher pressure drop of the system).
- MINIMUM OPERATING CONDITION – 100% of the capacity of all equipment operating at the same time – 2 Cooling Towers operating at the same time (minimum pressure drop of the system).

This system supplies 2 Process Chillers (1 operating and the other stand-by), 1 Bio-Kill Cooler and 2 Air Compressors.

The pressure drop required for the cooling water is 0.197 bar, according to the tower manufacturer's information.

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

The chemical dosing is carried out directly in the cooling towers basin.

5. CALCULATION

5.1 Thermal load

The Cooling Water System has the following consumers in the Building 7B for the Maximum Operating Condition:

Item	Equipment	Tag	Diversity	Volumetric Flowrate		Mass Flowrate	Temp Inicial	Temp Final
				(m³/h)	(lpm)	(kg/h)	(°C)	(°C)
1	Process Chiller	P-CH-7B-1	Y	202.2	3,370.0	201,251.0	31.5	37.0
2	Process Chiller (stand-by)	P-CH-7B-2	N	-	-	-	31.5	37.0
3	Bio-Kill Outlet Cooler	TC-7501	Y	12.3	205.0	12,242.3	31.5	37.0
4	Compressor	COMP-7B-1	Y	7.2	120.0	7,166.2	31.5	41.5
5	Compressor	COMP-7B-2	Y	7.2	120.0	7,166.2	31.5	31.5
TOTAL				**228.9**	**3,815.0**	**227,825.7**	**31.5**	**37.00**

Notes:
1. Compressor – stand-by the cooling water is kept recirculating without thermal load.

Maximum Thermal Load Required = 1,253,042 kcal/h

Design Condition: Based on the Maximum Operating Condition, the manufacturer have selected 2 cooling towers operating at the same time, but in case of maintenance, each cooling tower has capacity to operate with the same required thermal load.

Cooling Towers Selected:

Cooling Tower	Flowrate m³/h	Flowrate (lpm)	Thermal Load kcal/h
1	260.0	4,333.3	1,428,505
2	520.0	8,666.7	2,857,010

Each cooling tower has the thermal load of 1,428,505 kcal/h, with a flow rate of 260 m³/h.

At the maximum operating condition, the thermal load required is 1,253,042 kcal/h, with a flow rate of 228.9 m³/h.

For design condition, the total flow rate is 260 m³/h. The flow rate in excess (31.1 m³/h) is diverted to tie-in (future expansion).

5.2 Pumps

The pumps were sized for the Design Condition, Maximum Operating Condition and Minimum Operating Condition, according to the tables shown below.

a) Design Condition – 1 Cooling Tower and 1 Pump are operating at the same time.

EQUIPMENT	TAG	DIVERSITY (Y/N)	SIMULT. FLOWRATE (m^3/h)	SIMULT. FLOWRATE (lpm)	SIMULT. FLOWRATE (kg/h)	NOTES
Process Chiller	P-CH-7B-1	Y	202.2	3,370.0	201,251.0	
Process Chiller (stand-by)	P-CH-7B-2	N	-	-	-	
Bio-Kill Outlet Cooler	TC-7501	Y	12.3	205.0	12,242.3	
Compressor	COMP-7B-1	Y	7.2	120.0	7,166.2	
Compressor	COMP-7B-2	Y	7.2	120.0	7,166.2	
Tie-in	-	Y	31.1	518.3	30,953.9	
TOTAL		**-**	**260.0**	**4,333.3**	**258,779.6**	

b) Maximum Operating Condition – 1 Cooling Tower and 1 Pump are operating at the same time without the future expansion. See table below:

EQUIPMENT	TAG	DIVERSITY (Y/N)	SIMULT. FLOWRATE (m^3/h)	SIMULT. FLOWRATE (lpm)	SIMULT. FLOWRATE (kg/h)	NOTES
Process Chiller	P-CH-7B-1	Y	202.2	3,370.0	201,251.0	
Process Chiller (stand-by)	P-CH-7B-2	N	-	-	-	
Bio-Kill Outlet Cooler	TC-7501	Y	12.3	205.0	12,242.3	
Compressor	COMP-7B-1	Y	7.2	120.0	7,166.2	
Compressor	COMP-7B-2	Y	7.2	120.0	7,166.2	
Tie-in	-	N	-	-	-	
TOTAL		**-**	**228.9**	**3,815.0**	**227,825.7**	

Notes:
1. 1 Cooling Towers operating and 1 stand-by (maintenance).

c) Minimum Operating Condition

For Minimum Operating Condition, 1 pump is operating with 2 cooling towers (minimum pressure drop of the system) and without the future expansion.

EQUIPMENT	TAG	DIVERSITY (Y/N)	SIMULT. FLOWRATE (m³/h)	SIMULT. FLOWRATE (lpm)	SIMULT. FLOWRATE (kg/h)	NOTES
Process Chiller	P-CH-7B-1	Y	202.2	3,370.0	201,251.0	
Process Chiller (stand-by)	P-CH-7B-2	N	-	-	-	
Bio-Kill Outlet Cooler	TC-7501	Y	12.3	205.0	12,242.3	
Compressor	COMP-7B-1	Y	7.2	120.0	7,166.2	
Compressor	COMP-7B-2	Y	7.2	120.0	7,166.2	
Tie-in	-	N	-	-	-	
TOTAL		**-**	**228.9**	**3,815.0**	**227,825.7**	

Notes:
1. 2 Cooling Towers operating at the same time.

5.3 Balancing Valves

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

a) Static Balancing valves at the pump discharge

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

ITEM	VALVE	PUMP	FLOWRATE (m³/h)	FLOWRATE (LPM)	P in (barG)	P out (barG)	ΔP (bar)	CV (Calculated)
15	BV-940006	P-C-7B-1	260.0	4,333.6	2.8	2.6	0.16	751.5
x18	BV-940008	P-C-7B-2	260.0	4,333.6	2.8	2.6	0.16	751.5

b) Static Balancing valves at the cooling water return (inlet of each tower)

Static balancing valves were considered at the inlet of each Tower, as shown in the table below:

ITEM	VALVE	PUMP	FLOWRATE (m³/h)	FLOWRATE (LPM)	P in (barG)	P out (barG)	ΔP (bar)	CV (Calculated)
58	BV-940012	CT-7B-1	260.4	4,340.7	0.4	0.3	0.12	866.7
x60	BV-940013	CT-7B-2	260.4	4,340.7	0.4	0.3	0.12	866.7

c) Static Balancing valves at the inlet/ outlet of Equipment

Static balancing valves were considered for each Equipment, as shown in the table below:

ITEM	VALVE	PUMP	FLOWRATE		P in	P out	ΔP	CV
			(m³/h)	(LPM)	(barG)	(barG)	(bar)	(Calculated)
107	BV-980014	PCH-7B-1	202.6	3,376.4	1.6	1.0	0.62	296.9
x110	BV-980016	PCH-7B-2	202.6	3,376.4	1.6	1.0	0.62	296.8
203	BV-8400117	COMP-7B-1	7.2	120.0	3.5	3.5	0.03	45.8
206	BV-8400118	COMP-7B-2	7.2	120.1	3.5	3.5	0.03	48.0
211	BV-940015	TC-7501	12.3	205.0	3.9	3.5	0.34	24.3

The Cooling Water System was sized based on flowrate and diversity indicated above, using the software Fathom version 10.0 and PID 7B-M-0-5-42 for this system was elaborated based on these calculations.

6. RESULTS

6.1 VISUAL REPORT

Design Condition

Visual Report - Design Condition.p

Maximum Operating Condition

Visual Report - Maximum Operating

Minimum Operating Condition

Visual Report - Minimum Operating

6.2 OUTPUT

Design Condition

Output - Design Condition.pdf

Maximum Operating Condition

Output - Maximum Operating Conditio

Minimum Operating Condition

Output - Minimum Operating Conditio

6.3 PUMPS SELECTED

a) DESIGN CONDITION

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	dH (meters)	Ideal Power (kcal/hr)	Overall Efficiency (Percent)	Overall Power (kcal/hr)	Speed (Percent)	NPSHA (meters)	P Static Suction (barG)	P Static Disc. (barG)	dP (bar)
14	Show ...	P-C-7B-1	260,0	30,77	18.652	82,50	22.609	100,0	10,28	0,02635	2,966	3,003
X17	Show ...	P-C-7A-2 (Stand-by)	0,0	N/A	N/A	N/A	N/A	0,0	N/A	N/A	N/A	N/A

P-C-7B-1/2 – The pump head will be rounded to 31 mlc.

b) MAXIMUM OPERATING CONDITION

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	dH (meters)	Ideal Power (kcal/hr)	Overall Efficiency (Percent)	Overall Power (kcal/hr)	Speed (Percent)	NPSHA (meters)	P Static Suction (barG)	P Static Disc. (barG)	dP (bar)
14	Show ...	P-C-7B-1	228,9	29,71	15.857	80,97	19.583	97,02	10,48	0,04843	2,888	2,900
X17	Show ...	P-C-7A-2 (Stand-by)	0,0	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

c) MINIMUM OPERATING CONDITION

Jct	Results Diagram	Name	Vol. Flow (m3/hr)	dH (meters)	Ideal Power (kcal/hr)	Overall Efficiency (Percent)	Overall Power (kcal/hr)	Speed (Percent)	NPSHA (meters)	P Static Suction (barG)	P Static Disc. (barG)	dP (bar)
14	Show ...	P-C-7B-1	228,9	29,73	15.867	80,96	19.598	97,05	10,48	0,04843	2,890	2,902
X17	Show ...	P-C-7A-2 (Stand-by)	0,0	N/A	N/A	N/A	N/A	0,00	N/A	N/A	N/A	N/A

Pumps (P-C-7B-1 and P-C-7B-2)

Meganorm 150-125-250, 1750 rpm