

Design Calculations

The equipment and basins of Waste Water Circuit are designed and sized according the information given by Big River Steel (BRS). The design calculations are explained in the next sections.

2.1 WB 1.1 BASIN AND WP 1.X PUMPS.

The following information has been used to size the WB 1.1 basin and WP 1.X pumps:

Table 1. Water streams collected in WB 1.1 basin.

Line	Consumers	Flow (m ³ /h)		Temperature (°C)		Pressure (bar)		Frequency
		Avg	Peak	Return	Supply	Return	Supply	
WC1.1.1	General purpose (with oily contents)	1	50	amb	-	≥ 2	-	In case of leakages, fire alarm, accidents or cleaning works
WC1.1.2	WW 1– Alkaline concentrates (oily contaminated waste water)	1	30	85	-	> 4	-	Every 2 month. Total quantity if all tanks are empty is 30 m ³ .
WC1.1.3	Waste emulsion / Spent emulsion	0	150 - 200	amb	-	-	-	In case of drain of emulsion tanks

Note 1: The estimated concentration of oil in rolling emulsion WW 1 is 5 – 7 g/L (line WC 1.1.2).

Note 2: The waste emulsion/spent emulsion (line WC 1.1.3) will be coming from the draining and empty of the emulsion tanks. There will be 2 tanks of 250 m³ and 1 tank of 65 m³. The drainage of these tanks will be done by service pumps at 150 – 200 m³/h as maximum flow. Two tanks will be not drained at the same time.

Note 3: All the information indicated in this table has been given by BRS.

The WB 1.1 basin has been designed to take the total drain volume when the 250 m³-volume emulsion tank and cleaning section 30 m³-volume tanks (line WC1.1.2) are drained. The volume

basin will be enough to take the waste water coming from the streams indicated before. It will have the next dimensions:

Table 2. Dimensions of WB 1.1 basin.

Volume (m ³)	300
Height (mm)	3400
Water surface height (mm)	2500
Length (mm)	15700
Width (mm)	7600

The WP1.X pump is selected according the following operating conditions:

Table 3. WP 1.X pumps.

Flowrate (m ³ /h)	20
Pressure (bar)	1.5

After receiving alkaline concentrate water (line WC 1.1.2) and waste emulsion/spent emulsion (WC 1.1.3), WP 1.X pumps take 13 – 14 hours to send waste water to DAF 1, assuming that the discharge happens at the same time. The discharge frequency of the oily waste water will be less than 14 hours. Therefore, there is enough time to adjust pH, break oil in water emulsion and sent water phase to DAF 1 working at 20 m³/h.

2.2 OIL MASS FLOW

Based on the information exposed in previous section, the oil amount received in WB 1.1 basin is estimated as follow in the table below. It is considered an oil concentration of 5 – 7 mg/L for the oily waste water lines, taking 7 mg/L for the calculation.

Table 4. Oil amount.

Line	Flow (m ³ /h)	Discharge volume (m ³)	Oil concentration supposed (g/L)	Oil discharged volume (L)	Oil flow mass (L/h)
WC1.1.1	10	-	57	-	78
WC1.1.2	30	30	7	233	233
WC1.1.3	200	250	7	1944	1556

If the streams WC 1.1.2 and WC 1.1.3 drain at the same time to WB 1.1 basin, oil discharge estimated will be 2177 liters.

It is considered that one third of the oil amount will be removed in the WB 1.1 basin. The oil removal capacity of the selected oil skimmer is 390 L/h. According this, the oil will be removed

from the surface basin in 2 hours. A storage tank WOT 1 of 4000 liters is selected to store the oil.

The remaining oil will be removed in the dissolved air flotation equipment DAF 1 and in the thickener WST 1. It will be stored in oil tank WOT 2 whose capacity will be 4000 liters.

The oil tanks have been selected to have a high capacity of storage.

2.3 WB 1.2 CHROMIUM REACTION TANK:

The following information has been used to size the WB 1.2 basin:

Table 5. Water stream collected in WB 1.2 basin.

Line	Consumers	Flow (m ³ /h)		Temperature (°C)		Pressure (bar)		Frequency
		Avg	Peak	Return	Supply	Return	Supply	
WC1.2	WW4 – Chromate contamina- ted water	-	5	40	-	> 3	-	Estimated amount 1 – 2 m ³ per month

Note 1: Volume per cleaning cycle is 0.2 m³. The estimated amount is 1 – 2 m³ per month. The total amount depends on number of campaigns and number of tank draining. The drain has hexavalent chromium content.

Note 2: All the information indicated in this table has been given by BRS.

The reaction redox for converting the hexavalent chromium to trivalent form will be carry out in the WB 1.2 tank. It will be always required to maintain a remaining reaction volume with the adequate operating conditions to ensure the redox process is carrying out when chromate contaminated water arrives to WB 1.2 tank. It works like a semi-batch stirred tank reactor.

The WB1.2 tank is sized to collect the volume drained per month, to maintain the required reaction volume and to guarantee the enough reaction time to convert all chromium to trivalent form. It will have the next dimensions:

Table 6. Dimensions of WB 1.2 tank.

Volume (m ³)	4
Diameter (mm)	2000
Height (mm)	2000
Water surface height (mm)	1300

2.4 WB 2 BASIN AND WSP 2.X PUMPS:

The following information has been used to size the WB 2 basin and WSP 2.X pumps:

Table 7. Water streams coming collected in WB 2 basin.

Line	Consumers	Flow (m ³ /h)		Temperature (°C)		Pressure (bar)		Frequency
		Avg	Peak	Return	Supply	Return	Supply	
WC2.1	Draining of EM system & fume exhaust system	0	20	amb	-	≥ 2,5	-	It varies depending on the production and on the weather
WC2.2	Sump pits	0	2	≤ 85	-	≤ 15	-	
WC2.3	Sump pits	0	20	amb	-	-	-	
WC2.4	WW3 - Zn/Al contaminated water	-	20	50	-	> 4	-	It varies depending on production

Note 1: WW3 has zinc and aluminum content expecting as maximum 2 g/L of zinc and 7 mg/L of aluminum and a non-indicated concentration of suspended solids.

Note 2: All the information indicated in this table has been given by BRS.

Additionally, the WB 2 basin receives the next streams coming from WTP or from other stages of Waste Water Circuit:

Table 8. Additional water streams to WB 2 basin.

Line	Consumers	Flow (m ³ /h)		Temperature (°C)	Pressure (bar)	Frequency
		Avg	Peak			
W1	NCW & CW circuits drain / blowdown	31.7	75 / 150	30 (max)	≤ 1,5 bar	-
NO3.2.3	NCW Cold Mill Blowdown	15.7	27	35 (max)	≤ 1,5 bar	-
NFL3.2	Cold Mill Ring Filters Backwash	7	80	35 (max)	≤ 5,5 bar	Once a hour
W1.1	DAF treated water	-	20	-	Atmospheric pressure	It depends on oily waste discharge

Line	Consumers	Flow (m ³ /h)		Temperature (°C)	Pressure (bar)	Frequency
		Avg	Peak			
W1.2	Treated chromate water	2 m ³ /month	2	-	Atmospheric pressure	Once or twice a month
WD1.1	Overflow / drain WB1	80	155	35	Atmospheric pressure	If basin is drained
WD3	Drain WB 3	60	120	35	Atmospheric pressure	If basin is drained
WD4.1	Drain WB 4	80	150	35	Atmospheric pressure	If basin is drained
ND3	Drain NB 3	180	350	35	Atmospheric pressure	If basin is drained

Note 1: The drain and blowdown peak flow (75 / 150 m³/h) corresponds to one pump group working (DWP 1.X, CWP 1.X or LWP 1.X). In normal conditions, one pump will work pumping 75 m³/h. The cooling tower basins could be drained due to cleaning annual maintenance and a high water volume has to be discharged. In this situation, the selected pump and standby pump could be working together pumping 150 m³/h in order to evacuate faster the waste water drained.

The average flow

Note 2: The peak flow of WD1.1, WD3, WD4.1 and NB3 drain corresponds to the discharge flow when the basin is full and the water surface is at high level. The average flow is calculated based on the volume basin and the total time of discharge until total empty.

Note 3: Line W1 transfers waste water to the basin WB2 from the following lines:

- Line DW1: blowdown and drain from Contact Water Circuit for Degasser (drawing Russula 019854).
- Line CW1: blowdown and drain from Contact Water Circuit for HSM (drawing Russula 019857).
- Line LW1: blowdown and drain from Laminar Water Circuit (drawing Russula 019858).

It is not considered the drain lines in the Table 8 for sizing the WB2 basin and WSP 2.X pumps due to it will be not a frequent situation.

The blowdown from each cooling circuit is estimated based on recirculating water, inlet and outlet temperatures and water quality requirements. The estimation of makeup consumption and blowdown can be found in Annex 6. To do this estimation should be considered the following points:

- Non-contact circuit blowdown is reused for contact water circuit.

- It is considered the well water as makeup water. Well water quality was sent by BRS (Annex 5, Fluid List SMS).
- The use of scaling and corrosion inhibitors and biocides is required.
- It was considered cooling water qualities different from those recommended by SMS due to, as indicated by themselves, it is possible applying an adequate water treatment using scaling and corrosion inhibitors and biocides. It is indicated below the non-contact and contact water quality considered:

Table 9. Cooling water quality.

Parameter	Non-contact water circuit	Contact water circuit
Temperature	50 as maximum	50 as maximum
pH	8,5	8,5
Total hardness	109	220
Calcium hardness	86	173
Magnesium hardness	23	47
Alkalinity M	390	780
Iron	0,4	0,8
Chlorides	19	38
Sulphates	145	290
Silica	28	56
Total dissolved solids	712	1423
Langelier Saturation Index	1,5	2,1

The parameter values were established evaluating the Langelier Saturation Index. This index determines the water scaling and corrosion potential according the following values determined by Carrier (1965):

Table 10. Langelier saturation index values.

LSI Values	Indication
-2 < LSI < -0,5	Serious corrosion
-0,5 < LSI < 0	Slightly corrosion but non-scale forming
LSI = 0	Balanced but pitting corrosion possible
0 < LSI < 0,5	Slightly scale forming and corrosive
0,5 < LSI < 2	Scale forming but non corrosive

According these values, the cooling water will have scaling tendency but not corrosive. The scaling inhibitors supplied by chemical manufacturers can avoid the scaling of salts working at the qualities indicated in the Table 9.

Therefore, according to the streams indicated in the Table 7 and 8, the average flow received in Waste Water Circuit is estimated as follow:

Table 11. Average treatment flow for Waste Water Circuit.

Line	Consumers	Flow (m ³ /h)		Frequency
		Average	Peak	
WC2.1	Draining of EM system & fume exhaust system	0	20	No exact information about it. It depends on the production
WC2.2	Sump pits	0	2	
WC2.3	Sump pits	0	20	
WC2.4	WW3 - Zn/Al contaminated water	-	20	
W1	NCW & CW circuits drain / blowdown	31.7	75 / 150	Once every hour
NO 3.2.3	NCW Cold Mill Blowdown	15.7	27	Once a hour
NFL 3.2	Cold Mill Ring filters Backwash	7	80	Once a hour
W1.1	DAF treated water	-	20	-
W1.2	Treated chromate water	-	5	Once or twice a month

Note 1: The discharge frequency assumed for WC2.1, WC2.2, WC2.3 and WC2.4 lines is 20 minutes discharging during 1 hour.

$$\begin{aligned}
 &\text{Average flow} \\
 &= \left(\frac{20 + 2 + 20 + 20}{3} \right) + 31,7(W1) + 15,7(NO3.2.3) + 20(W1.1) \\
 &\quad + 7(NFL3.2) = 95 \frac{m^3}{h}
 \end{aligned}$$

The average water flowrate to be treated in Waste Water Circuit is 95 m³/h.

Therefore, the WB 2 basin is sized according the following dimensions considering a buffer volume to store water in case of need.

Table 12. Dimensions of WB 2 basin.

Volume (m ³)	150
Height (mm)	4500
Water surface height (mm)	2200
Length (mm)	10100
Width (mm)	6700

The WSP2.X pump is selected according the following operating conditions:

Table 13. WSP 2.X pumps.

Flowrate (m ³ /h)	100
Pressure (bar)	1,5

If it would need, the selected pump can work at 130 m³/h at 1.1 bar.

2.5 WST 1 THICKENER:

The design parameters applied for the calculation of the thickener are indicated below:

Table 14. Design parameters of thickener WST 1.

Parameter	Value	Units
Hydraulic residence time	> 2,5	h
Settling velocity	< 1	m/h

The water flow at the WST thickener 1 is 100 m³/h receiving waste water from WB 2 basin. When filter backwashing is running, the flow sent to thickener is 180 m³/h, 100 m³/h from WB 2 basin and 80 m³/h from filter backwashing. This is the worst case and it is taken as reference for the thickener design. The dimensional requirements for WST 1 thickener are indicated below:

Table 15. Minimum requirements for thickener WST 1.

Parameter	Value	Units
Volume	450	m ³
Surface	180	m ²
Diameter	15100	mm

According this, the thickener selected will have the following dimensions:

Table 16. Dimensions of thickener WST 1.

Parameter	Value	Units
Diameter	16000	mm
Water surface height since top of the sludge cone	2500	mm
Volume	552	m ³
Surface	201	m ²

The settled sludge will be continuously pumping to WSPF 1 press plate filter by the WSP 4.1 sludge pump. When the press plate filter is full, it is opened and the dewatering sludge is stored in a container until it is collected by others to reclamation.

In case of any stop for maintenance in the dewatering sludge system, the thickener has a sludge storage volume of 127 m³.

2.6 WB 4 AERATION BASIN AND WB 3 BASIN:

The design parameters applied for the calculation of the aeration basin are indicated below:

Table 17. Design parameters of WB 4 aeration basin.

Parameter	Value	Units
Hydraulic residence time	> 30	min
Minimum height of water surface	2000	mm

The WB 4 aeration basin is sized according the following dimensions:

Table 18. Dimensions of WB 3 aeration basin.

Volume (m ³)	75
Height (mm)	3400
Water surface height (mm)	2500
Length (mm)	7500
Width (mm)	4000

The aeration system will be one of these options:

- A fine bubble diffusers installed in the bottom of the WB 4 basin. The air supply is given by a blower.
- An agitation system taking the air by Ventury effect.

2.7 WSF 1 SAND FILTRATION:

The design parameters applied for the calculation of the sand filtration are indicated below:

Table 19. Design parameters of WSF 1 sand filtration.

Parameter	Value	Units
Filtration velocity	< 11	m/h
Backwash velocity	< 30	m/h

According the filtration velocity, the minimum surface for sand filters WSF 1 is 9.1 m². The sand filters selected should have the following basic characteristics:

Table 20. Technical characteristics of sand filters WSF 1.

Parameter	Value	Units
Number of filters	3	-
Diameter of each filter	2000	mm
Unitary surface	3.14	m ²
Total surface	9.42	m ²
Maximum backwash flow	94	m ³ /h

2.8 WP 4.1 SLUDGE PUMP AND PRESS PLATE FILTER WSPF 1:

The dewatering sludge system is designed considering waste water has maximum total suspended solids of 300 mg/L. The estimation of the produced sludge is exposed in the table below:

Table 21. Dewatering sludge production.

Initial data	Value	Units
Average total suspended solids	300	mg/L
Treated water total suspended solids	20	mg/L
Water flow to thickener	100	m ³ /h
Max. solid dryness of dewatered sludge	50	%
Dewatered sludge density	2500	Kg/m ³
Calculated values		
Suspended solids mass flow	28	Kg SS/h
Suspended solids mass flow	672	Kg SS/day
Dewatered sludge production	1344	Kg/day
Dewatered sludge daily volume	538	Liters/day

The dewatered sludge production has been estimated in 538 liters/day. Therefore, the capacity of press plate filter selected will be 800 liters of dewatered sludge.

WP 4.1 sludge pump is sized according the recommendations of press plate filter supplier.