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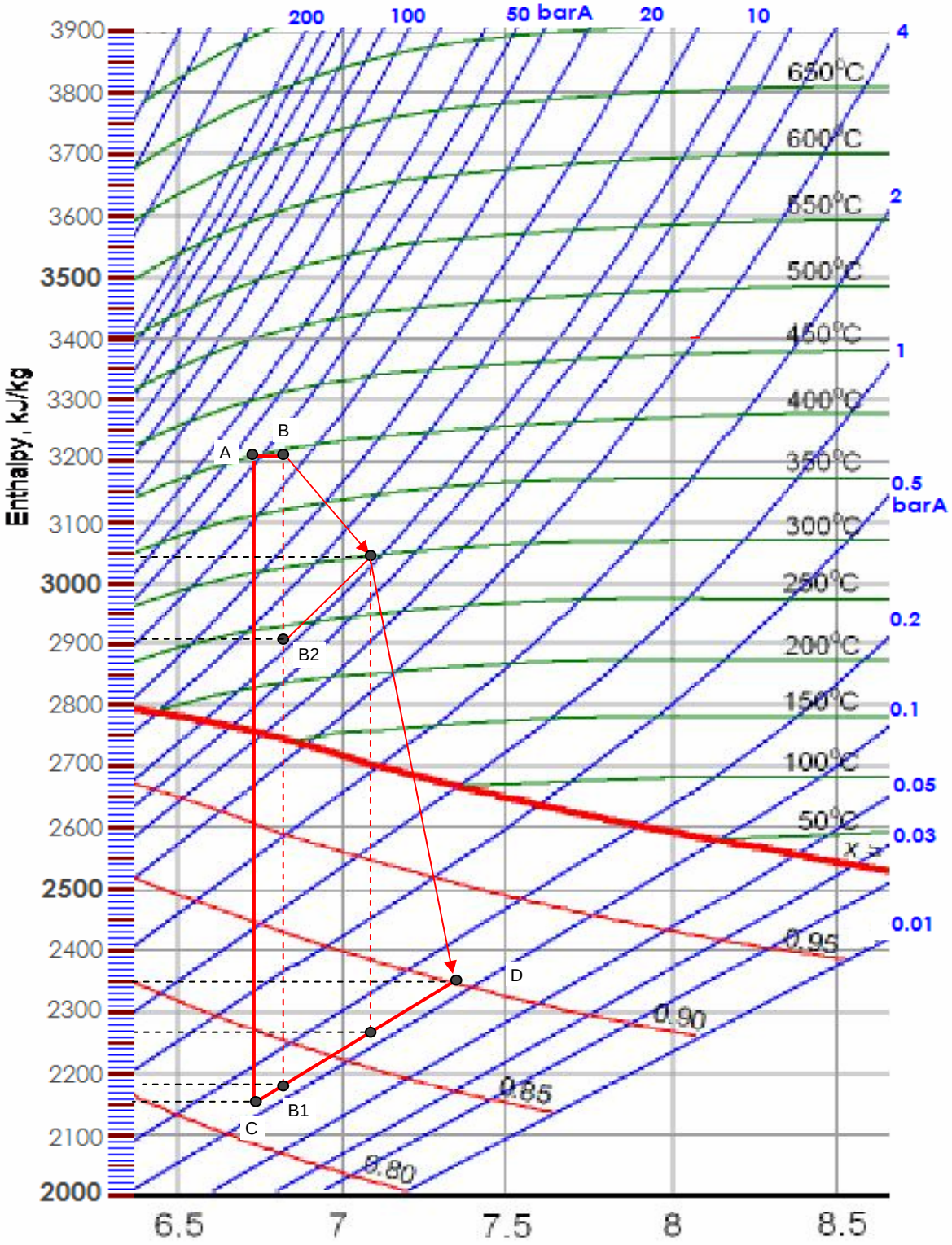
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1					
2	Turbine type		CURTIS+REACTION		
3			Control stage : Curtis		
4			CONDENSING TURBINE		
5	REQUIRED CONDITION				
6					
7	P	kW	7000		
8	N	RPM	7500		
9	pi	bar A	42		
10	ti	C	400		
11	po	bar A	0.12		
12					
13	STEAM DATA				
14					
15	hi	kJ/kg	3210		See steam Mollier diagram, point A.
16	hos	kJ/kg	2155		See steam Mollier diagram, point B
17	Δhs	kJ/kg	1055		= hi - hos
18	Governor valve factor		0.97		Multi valve 0.97, single valve 0.93
19	Δhs'	kJ/kg	1023.4		= Gov. vlv. Factor x Δhs (equation 11)
20	hos'	kJ/kg	2186.7		See diagram, point D
21	pi'	bar A	40		
22	ti'	C	395		
23	vi'	m^3/kg	0.074		See steam table at pi' and ti'
24					
25	CALCULATION				
26					
27	*Control Stage*				
28	Nominal diameter, D	mm	550		See figure 9. At required speed, select D
29	Peripheral velocity, U	m/s	216.4		Equation 1
30	Best head, $\Delta h'_{IMP}$	kJ/kg	304.3		Eq. 4 at μ_S = 6.5 for Curtis and = 2 for Rateau
31	hos'_{IMP}	kJ/kg	2905.7		=hi - $\Delta h'_{IMP}$
32	po_{IMP}	bar A	11.0		Point B2 where po_{IMP} approx. = 0.3 x pi'
33	Head coefficient, μ_S		6.5		
34	Efficiency, η_{05}		0.71		Figure 12
35	Entrance area factor, A		34		
36	Trial error of control stage power	kW	1755		First trial appr. about 0.2 of total power
37	l x ε	mm	32.148		Equation 15
38	Nozzle height, l		70		Select l so that ε within the range below
39	ε		0.459		0.015-0.45 weld/half circle, max. $\approx$ 0.8
40	Efficiency factor FI		1.00		Figure 13
41	Efficiency factor Fe		0.987		Equation in figure 13
42	Efficiency, η_{IMP}		0.70		= η_{05} x F_l x Fε

No.	Designation		Quantity		Note and additional information
1	Δhe	kJ/kg	213.2		= η_1 x Δh_{IMP}
2	he_{IMP}	kJ/kg	2996.8		Than make steam process in Mollier diagr.
3	Exhaust temperature, to	C	300		See steam Mollier diagram
4	Exhaust specific volume, vo	m^3/kg	0.236		See steam table
5	P_{LOSS}	kW	47.92		Equation 5
6					
7	*Reaction Stages*				
8	Reaction stage power	kW	5245.0		
9	hi	kJ/kg	2996.8		
10	hos	kJ/kg	2265		
11	Δhs_R	kJ/kg	731.83		
12	Pitch diameter, D	mm	600		See fig. 11, at required speed, select pitch
13	Base diameter	mm	500		and base diameter
14	Average blade height, l	mm	100		
15	D/l		6		
16	S/l		0.40		=0.2 LP blade,=0.4 MP and =0.6 HP
17	Calculated number of stages		14		Eq. 12a (integer number)
18	Peripheral velocity, U	m/s	236.0		
19	Steam velocity, C	m/s	323.2		
20	Velocity ratio, U/C		0.73		
21	Δhs_{RSTG}	kJ/kg	52.3		
22	η_R		0.89		
23	Δhe_R	kJ/kg	647.67		
24	he_R	kJ/kg	2349.2		
25	X		0.900		
26	Wet enthalpy	kJ/kg	2700.0		
27	Wet eficiency, η_{WET}		0.973		
28	Mechanical efficiency, η_m		0.980		
29	Turbine efficiency, η		0.84		= η_R x η_m x η_{WET}
30					
31	*Trial result*				
32					
33	Mass flow for contrl stage	ton/hr	30.45		Trial power of control stage until mass flow for
34	Mass flow for reaction stages	ton/hr	30.59		control stage and reaction stages is almost
35					equal
36					


Enthalpy, kJ/kg
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
6.5
7
7.5
8
8.5
200
100
50 barA
20
10
4
2
1
0.5 barA
0.2
0.1
0.05
0.03
0.01
650°C
600°C
550°C
500°C
450°C
400°C
350°C
300°C
250°C
200°C
150°C
100°C
50°C
x =
0.95
0.90
0.85
0.80
A
B
B2
B1
C
D

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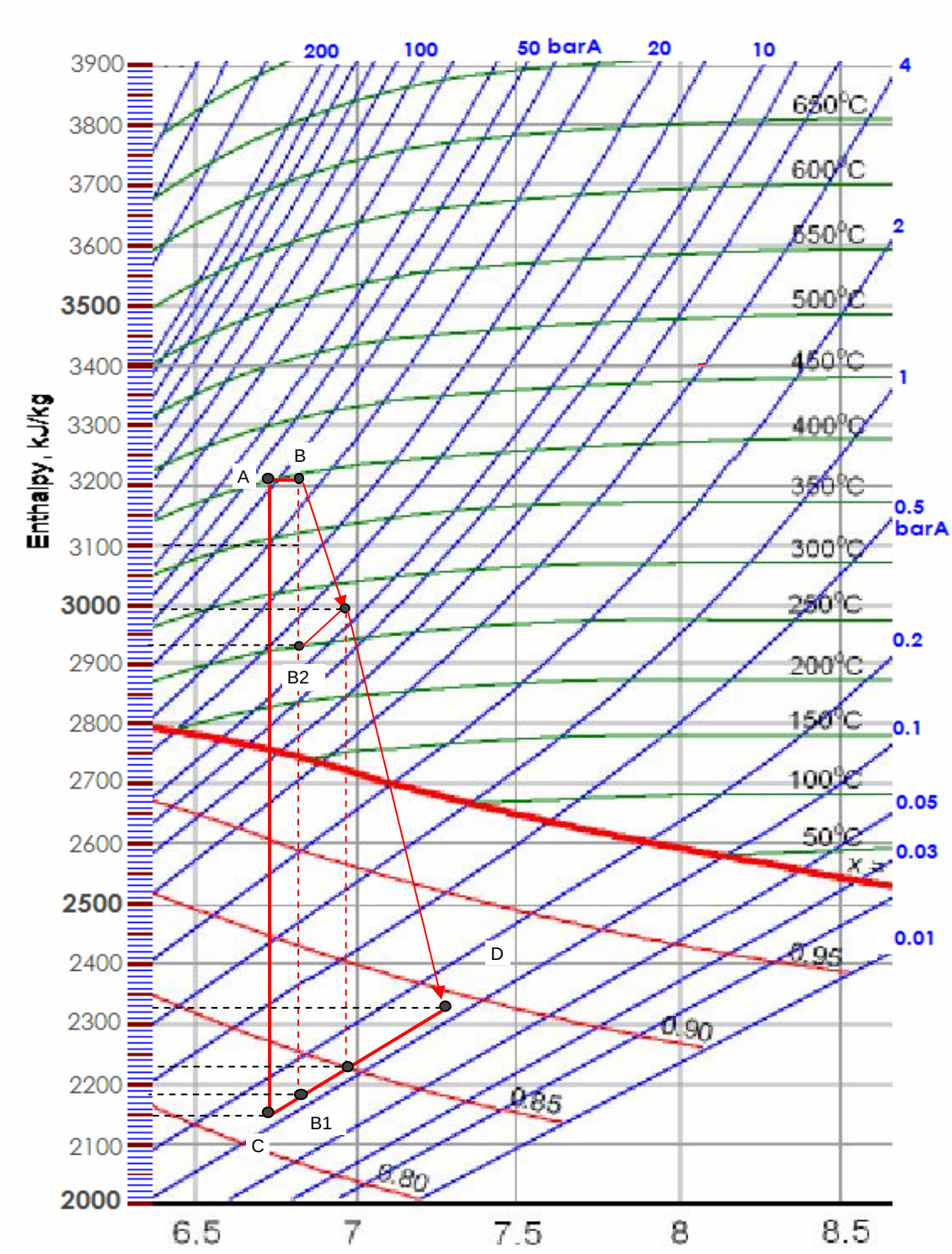
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1					
2	Turbine type		RATEAU+REACTION		
3			Control stage : Rateau		
4			CONDENSING TURBINE		
5	REQUIRED CONDITION				
6					
7	P	kW	12000		
8	N	RPM	6000		
9	pi	bar A	42		
10	ti	C	400		
11	po	bar A	0.12		
12					
13	STEAM DATA				
14	hi	kJ/kg	3210		See steam Mollier diagram, point A.
15	hos	kJ/kg	2240		See steam Mollier diagram, point B
16	Δhs	kJ/kg	970		= hi - hos
17	Governor valve factor		0.97		Multi valve 0.97, single valve 0.93
18	Δhs'	kJ/kg	940.9		= Gov. vlv. Factor x Δhs (equation 11)
19	hos'	kJ/kg	2269.1		See diagram, point D
20	pi'	bar A	40		
21	ti'	C	395		
22	vi'	m^3/kg	0.074		See steam table at pi' and ti'
23					
24	CALCULATION				
25	*Control Stage*				
26	Nominal diameter, D	mm	600		See figure 9. At required speed, select D
27	Peripheral velocity, U	m/s	188.8		Equation 1
28	po_{IMP}	bar A	12.0		Point B2 where po_{IMP} approx. = 0.3 x pi'
29	hos'_{IMP}	kJ/kg	2930.0		=hi - $\Delta h'_{IMP}$
30	$\Delta h'_{IMP}$	kJ/kg	280.0		Eq. 4 at μ_S = 6.5 for Curtis and = 2 for Rateau
31	Number of stage, z		3		
32	Head coefficient, μ_S		2.6		
33	Efficiency, η_{05}		0.80		
34	Entrance area factor, A		34		
35	Trial error of control stage power	kW	2830		First trial appr. about 0.2 of total power
36	l x ε	mm	4.738		Equation 15, P_{STG} and Δh_{STG} each row
37	Nozzle height, l		25		Select l so that ε within the range below
38	ε		0.190		0.015-0.45 weld/half circle, max. ≈ 0.8
39	Efficiency factor Fl		0.97		Figure 13
40	Efficiency factor Fe		0.945		Equation in figure 13
41	Efficiency, η_{IMP}		0.73		= η_{05} x F_l x Fε

No.	Designation		Quantity		Note and additional information
1	Δhe	kJ/kg	205.5		= η_{IMP}x $\Delta h'_{IMP}$
2	he_{IMP}	kJ/kg	3004.5		Than make steam process in Mollier diagr.
3	Exhaust temperature, to	C	280		See steam Mollier diagram
4	Exhaust specific volume, vo	m^3/kg	0.206		See steam table
5	P_{LOSS}	kW	22.81		Equation 5
6					
7	*Reaction Stages*				
8	Reaction stage power	kW	9170.0		
9	hi	kJ/kg	3004.5		
10	hos	kJ/kg	2230		
11	Δhs_R	kJ/kg	774.49		
12	Pitch diameter, D	mm	600		See fig. 11, at required speed, select pitch
13	Base diameter	mm	500		and base diameter
14	Average blade height, l	mm	100		
15	D/l		6		
16	S/l		0.40		=0.2 LP blade,=0.4 MP and =0.6 HP
17	Calculated number of stages		23		Eq. 12a (integer number)
18	Peripheral velocity, U	m/s	188.8		
19	Steam velocity, C	m/s	259.4		
20	Velocity ratio, U/C		0.73		
21	Δhs_{RSTG}	kJ/kg	33.7		
22	η_R		0.89		
23	Δhe_R	kJ/kg	685.42		
24	he_R	kJ/kg	2319.1		
25	X		0.890		
26	Wet enthalpy	kJ/kg	2720.0		
27	Wet eficiency, η_{WET}		0.968		
28	Mechanical efficiency, η_m		0.995		
29	Turbine efficiency, η		0.85		= η_R x η_m x η_{WET}
30					
31	*Trial result*				
32					
33	Mass flow for contrl stage	ton/hr	49.97		Trial power of contro stage until mass flow for
34	Mass flow for reaction stages	ton/hr	50.01		control stage and reaction stages is almost
35					equal
36					


200
100
50 barA
20
10
4
2
1
0.5 barA
0.2
0.1
0.05
0.03
0.01
650°C
600°C
550°C
500°C
450°C
400°C
350°C
300°C
250°C
200°C
150°C
100°C
50°C
x =
0.95
0.90
0.85
0.80
Enthalpy, kJ/kg
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
6.5
7
7.5
8
8.5
A
B
B2
B1
C
D