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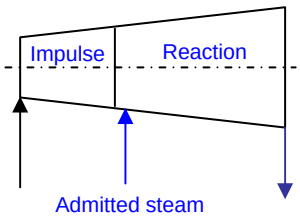
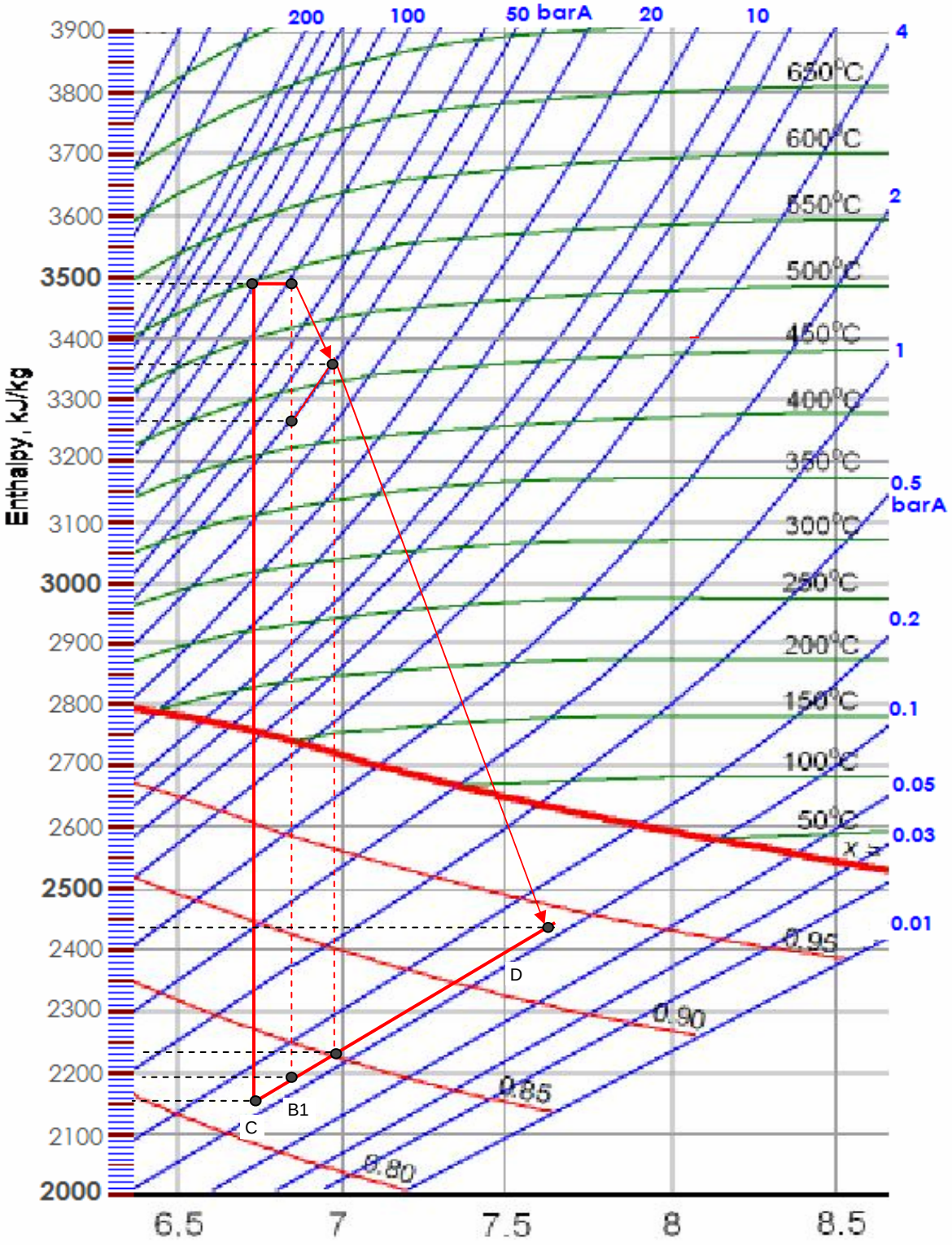
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1			ADMISSION TURBINE		
2	Turbine type		CURTIS+REACTION		
3			Control stage : Curtis		
4			CONDENSING TURBINE		
5	REQUIRED CONDITION				
6					
7	P	kW	5500		
8	N	RPM	7000		
9	pi	bar A	100		
10	ti	C	550		
11	Admitted pressure	bar A	40		
12	Admitted steam mass flow	ton/hr	5		
13	po	bar A	0.12		
14					
15	STEAM DATA				
16					
17	hi	kJ/kg	3490		See steam Mollier diagram, point A.
18	hos	kJ/kg	2155		See steam Mollier diagram, point B
19	Δhs	kJ/kg	1335		= hi - hos
20	Governor valve factor		0.97		Multi valve 0.97, single valve 0.93
21	Δhs'	kJ/kg	1295.0		= Gov. vlv. Factor x Δhs (equation 11)
22	hos'	kJ/kg	2195.1		See diagram, point D
23	pi'	bar A	80		
24	ti'	C	540		
25	vi'	m^3/kg	0.0444		See steam table at pi' and ti'
26					
27	CALCULATION				
28					
29	*Control Stage*				
30	po_{IMP}	bar A	40		
31	hos'_{IMP}	kJ/kg	3265		
32	Head, $\Delta h'_{IMP}$	kJ/kg	225		
33	Calc. diameter at best eff.	mm	506.75		
34	Selected dia., D	mm	500.0		
35	Peripheral velocity, U	m/s	183.6		Equation 1
36	Head coefficient, μ_S		6.7		
37	hos'_{IMP}	kJ/kg	3265.0		=hi - $\Delta h'_{IMP}$
38	Efficiency, η_{05}		0.71		Figure 12
39	Entrance area factor, A		34		
40	Trial error of control stage power	kW	440		
41	l x ε	mm	0.474		Equation 15
42	Nozzle height, l		25		Select l so that ε within the range below
43	ε		0.019		0.015 - 0.45 for welded, min. 0.07 reaming
44	Efficiency factor Fl		0.93		Figure 13
45	Efficiency factor Fe		0.793		Equation in figure 13
46	Efficiency, η_{IMP}		0.52		= η_{05} x F_l x $F\varepsilon$



No.	Designation		Quantity		Note and additional information
1	Δhe_{IMP}	kJ/kg	117.6		= η_1 x Δh_{IMP}
2	he_{IMP}	kJ/kg	3372.4		Than make steam process in Mollier diagr.
3	Exhaust temperature, to	C	470		See steam Mollier diagram
4	Exhaust specific volume, vo	m^3/kg	0.0825		See steam table
5	P_{LOSS}	kW	50.67		Equation 5
6					
7	*Reaction Stages*				
8	Reaction stage power	kW	5060.0		
9	hi	kJ/kg	3372.4		
10	hos'	kJ/kg	2235		
11	Δhs_R	kJ/kg	1137.44		
12	Pitch diameter, D	mm	720		See fig. 11, at required speed, select pitch
13	Base diameter	mm	630		and base diameter
14	Average blade height, l	mm	90		
15	D/l		8		
16	S/l		0.40		=0.2 LP blade,=0.4 MP and =0.6 HP
17	Calculated number of stages		17		Eq. 12a (integer number)
18	Peripheral velocity, U	m/s	264.3		
19	Steam velocity, C	m/s	365.6		
20	Velocity ratio, U/C		0.72		
21	Δhs_{RSTG}	kJ/kg	66.9		
22	η_R		0.83		
23	Δhe_R	kJ/kg	938.38		
24	he_R	kJ/kg	2434.1		
25	X		0.940		
26	Wet enthapy	kJ/kg	2720.0		
27	Wet eficiency, η_{WET}		0.991		
28	Mechanical efficiency, η_m		0.978		
29	Turbine efficiency, η		0.80		= η_R x η_m x η_{WET}
30	Required steam mass flow	ton/hr	20.02		
31	*Trial result*				
32					
33	Mass flow for control stage	ton/hr	15.03		Trial power of control stage until mass flow for
34	Mass flow for reaction stages	ton/hr	15.02		control stage and reaction stages minus adm.
35	minus admision steam				flow is almost 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
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
Enthalpy, kJ/kg
6.5
7
7.5
8
8.5
B1
C
D

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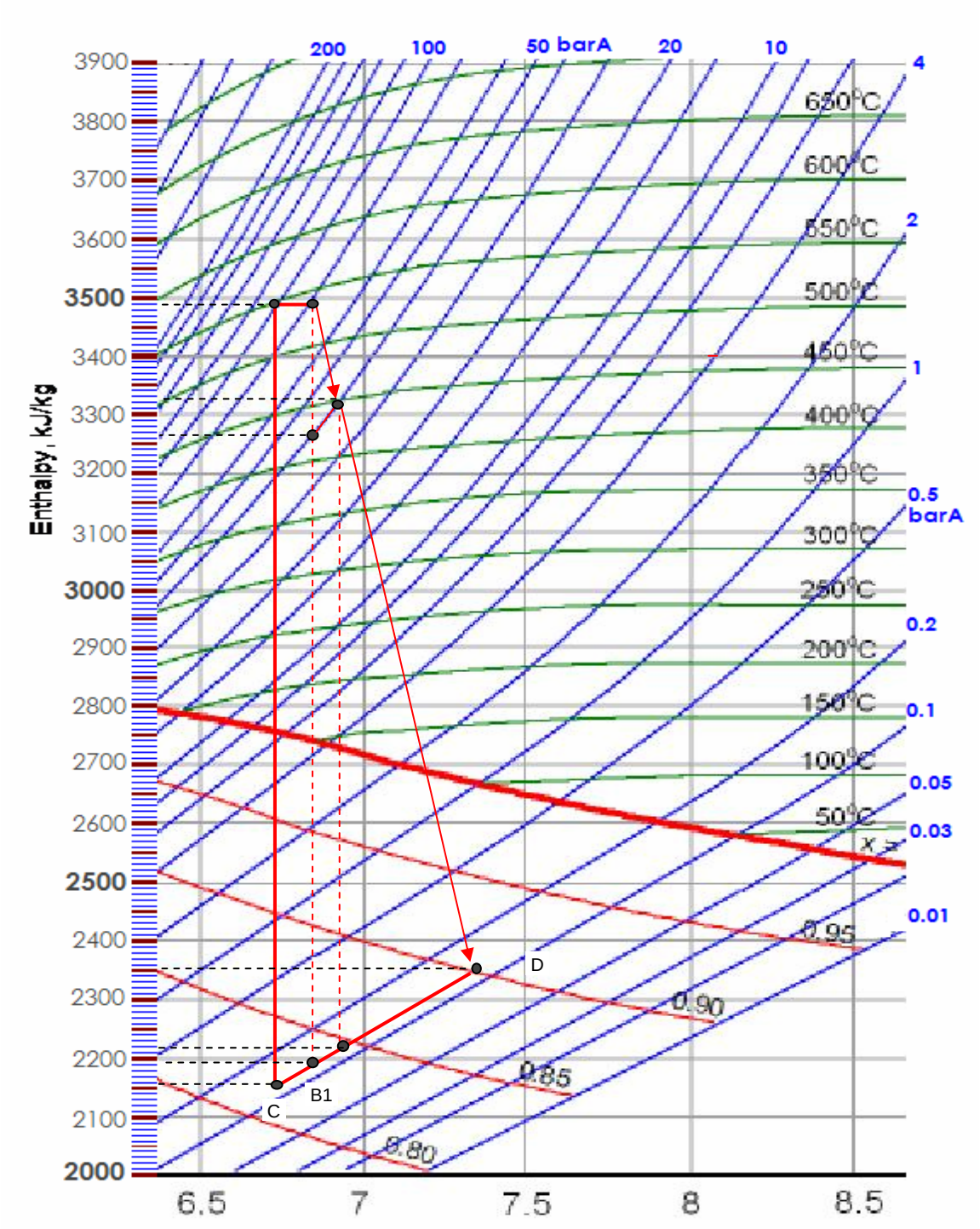
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1			ADMISSION TURBINE		
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	100		
10	ti	C	550		
11	Admitted pressure		40		
12	Admitted steam mass flow	ton/hr	10		
13	po	bar A	0.12		
14					
15	STEAM DATA				
16	hi	kJ/kg	3490		See steam Mollier diagram, point A.
17	hos	kJ/kg	2155		See steam Mollier diagram, point B
18	Δhs	kJ/kg	1335		= hi - hos
19	Governor valve factor		0.97		Multi valve 0.97, single valve 0.93
20	Δhs'	kJ/kg	1294.95		= Gov. vlv. Factor x Δhs (equation 11)
21	hos'	kJ/kg	2195.05		See diagram, point D
22	pi'	bar A	80		
23	ti'	C	540		
24	vi'	m^3/kg	0.0444		See steam table at pi' and ti'
25					
26	CALCULATION				
27	*Control Stage*				
28	po_{IMP}	bar A	40		
29	hos'_{IMP}	kJ/kg	3265		
30	Head, $\Delta h'_{IMP}$	kJ/kg	225		
31	Selected dia., D	mm	700		
32	Peripheral velocity, U	m/s	220.3		Equation 1
33	Number of stage, z		2		
34	Head coefficient, μ_S		2.3		
35	Efficiency, η_{05}		0.82		
36	Entrance area factor, A		34		
37	Trial error of control stage power	kW	1250		
38	l x ε	mm	1.197		Equation 15
39	Nozzle height, l		25		Select l so that ε within the range below
40	ε		0.048		0.015 - 0.45 for welded, min. 0.07 reaming
41	Efficiency factor Fl		0.97		Figure 13
42	Efficiency factor Fe		0.900		Equation in figure 13
43	Efficiency, η_{IMP}		0.713		= η_{05} x F_l x $F\varepsilon$
44	Δhe_{IMP}	kJ/kg	160.5		= η_{IMP}x $\Delta h'_{IMP}$
45					

No.	Designation		Quantity		Note and additional information
1	he_{IMP}	kJ/kg	3329.5		Than make steam process in Mollier diagr.
2	Exhaust temperature, to	C	450		See steam Mollier diagram
3	Exhaust specific volume, vo	m^3/kg	0.08		See steam table
4	P_{LOSS}	kW	127.70		Equation 5
5					
6	*Reaction Stages*				
7	Reaction stage power	kW	10750.0		
8	hi	kJ/kg	3329.5		
9	hos'	kJ/kg	2220		
10	Δhs_R	kJ/kg	1109.52		
11	Pitch diameter, D	mm	750		See fig. 11, at required speed, select pitch
12	Base diameter	mm	630		and base diameter
13	Average blade height, l	mm	120		
14	D/l		6		
15	S/l		0.40		=0.2 LP blade,=0.4 MP and =0.6 HP
16	Calculated number of stages		21		Eq. 12a (integer number)
17	Peripheral velocity, U	m/s	236.0		
18	Steam velocity, C	m/s	324.9		
19	Velocity ratio, U/C		0.73		
20	Δhs_{RSTG}	kJ/kg	52.8		
21	η_R		0.880		
22	$\Delta he_R'$	kJ/kg	976.38		
23	he_R	kJ/kg	2353.1		
24	X		0.925		
	Wet enthalpy	kJ/kg	2720.0		
25	Wet eficiency, η_{WET}		0.986		
26	Mechanical efficiency, η_m		0.995		
27	Turbine efficiency, η		0.86		= η_R x η_m x η_{WET}
28	Required steam mass flow	ton/hr	40.40		
29	*Trial result*				
30					
31	Mass flow for control stage	ton/hr	30.91		Trial power of control stage until mass flow for
32	Mass flow for reaction stages	ton/hr	30.40		control stage and reaction stages minus adm.
33	minus admision steam				flow is almost equal
34					


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
D
B1
C