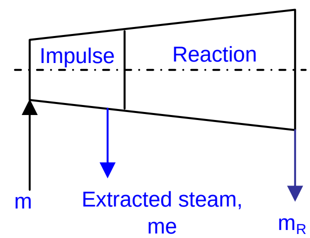
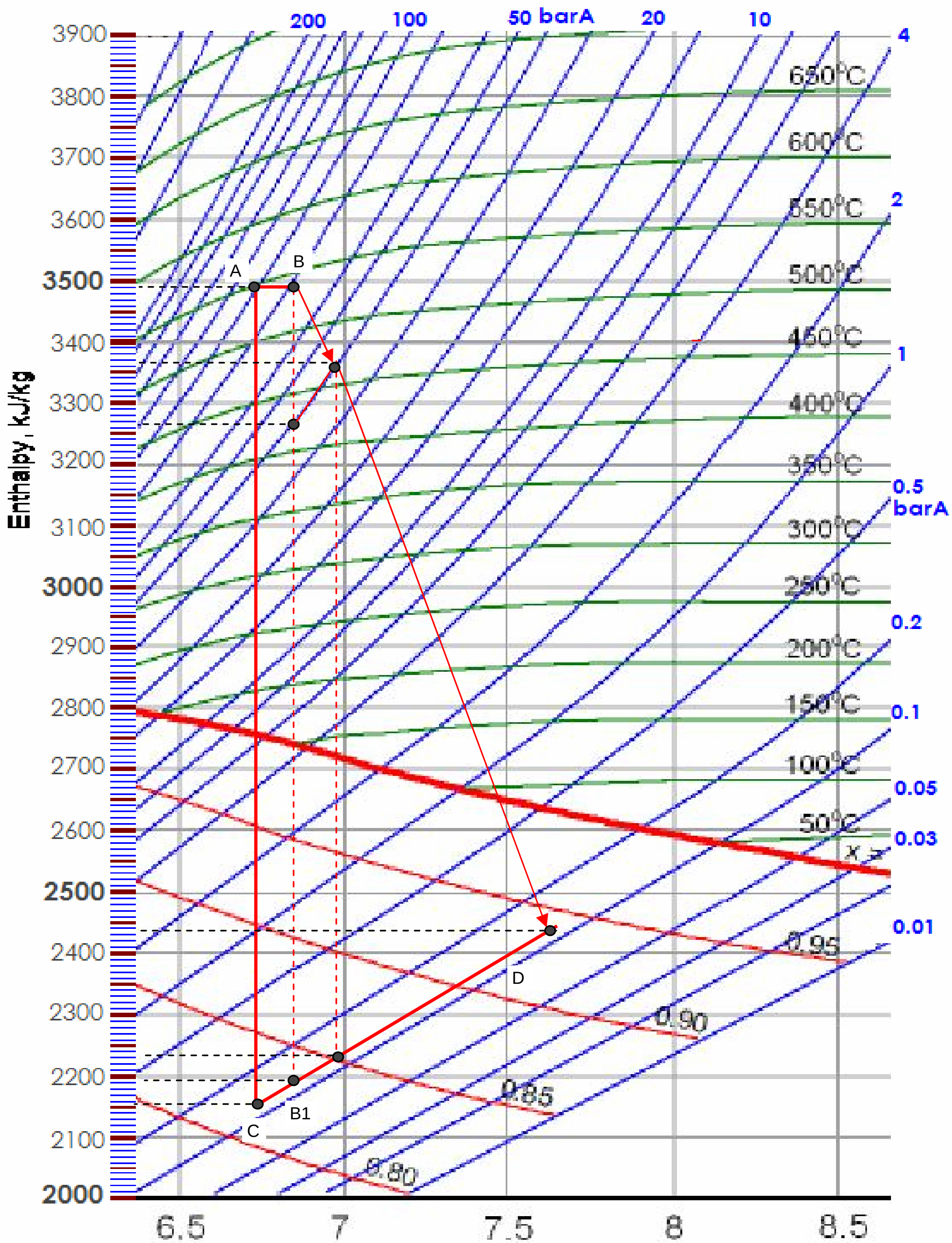
STEAM TURBINE CALCULATION SHEET

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1			EXTRACTION TURBINE		
2	Turbine type		**CURTIS+REACTION**		
3			**Control stage : Curtis**		
4			CONDENSING TURBINE		
5	REQUIRED CONDITION				
6			Normal	Rated	
7	Steam flow available, m	ton/hr	20		
8	N	RPM	7000		
9	pi	bar A	100		
10	ti	C	550		
11	Extracted pressure	bar A	40		
12	Extracted steam mass flow, me	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 C
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 B1
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		See diagram
32	Head, $\Delta h'_{IMP}$	kJ/kg	225		
33	Calc. diameter at best eff.	mm	506.75		Equation in fig. 9
34	Selected dia., D	mm	500.0		Decide D
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		
1	$l \times \varepsilon$	mm	0.967		Equation 15 but replace P by ($\Delta hs' \times m \times \eta_{05}$)
2	Nozzle height, l		25		Select l so that ε within the range below
3	ε		0.039		0.015 - 0.45 for welded, min. 0.07 reaming
4	Efficiency factor Fl		0.93		Figure 13
5	Efficiency factor Fe		0.804		Equation in figure 13
6	Efficiency, η_{IMP}		0.53		$= \eta_{05} \times F_l \times F\varepsilon$

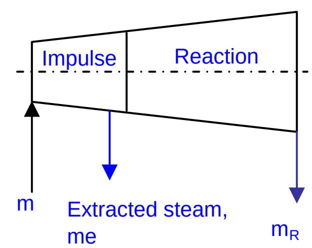


No.	Designation		Quantity		Note and additional information
1	Δhe_{IMP}	kJ/kg	119.3		$= \eta_1 \times \Delta h_{IMP}$
2	he_{IMP}	kJ/kg	3370.7		Than make steam process in Mollier diagr.
3	Exhaust temperature, to	C	470		See steam Mollier diagram
4	Exhaust specific volume, vo	m^3/kg	0.0825		See steam table
5	P_{LOSS}	kW	50.48		Equation 5
6	Control stage power, P_{IMP}	kW	612.2		
7	*Reaction Stages*				
8	Reaction stage steam flow, m_R	ton/hr	15.0		= m-me
9	hi	kJ/kg	3370.7		
10	hos'	kJ/kg	2235		
11	Δhs_R	kJ/kg	1135.71		
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	365.4		
20	Velocity ratio, U/C		0.72		
21	Δhs_{RSTG}	kJ/kg	66.8		
22	η_R		0.83		
23	Δhe_R	kJ/kg	936.96		
24	he_R	kJ/kg	2433.7		
25	Vapor fraction, X		0.940		
26	Wet enthalpy	kJ/kg	2720.0		
27	Wet eficiency, η_{WET}		0.991		Equation 7.
28	Reaction stages efficiency, η		0.82		$= \eta_R \times \eta_{WET}$
29	Reaction stages power, P_R	kW	3868.2		$= m_R \times \Delta hs_R \times \eta$
30	Reaction + impulse power	kW	4480.465		$= P_R + P_{IMP}$
31	Mechanical efficiency, η_m		0.974		
32					
33	BHP	kW	4364.7		$= (P_R + P_{IMP}) \times \eta_m$
34					
35					
36					
37					
38					


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
0.95
0.90
0.85
0.80
A
B
B1
C
D

STEAM CONSUMPTION

No.	Designation		Quantity		Note and additional information
1			EXTRACTION TURBINE		
2	Turbine type		**RATEAU+REACTION**		
3			**Control stage : Rateau**		
4			CONDENSING TURBINE		
5	REQUIRED CONDITION				
6					
7	Steam flow available, m	ton/hr	45		
8	N	RPM	6000		
9	pi	bar A	100		
10	ti	C	550		
11	Extracted pressure	bar A	40		
12	Extracted steam mass flow, me	ton/hr	5		
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 C
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 B1
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		Fig. 10, near cross poit N and red dot line
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		
1	l x ε	mm	2.199		Equation 15
2	Nozzle height, l		25		Select l so that ε within the range below
3	ε		0.088		0.015 - 0.45 for welded, min. 0.07 reaming
4	Efficiency factor Fl		0.97		Figure 13
5	Efficiency factor Fe		0.914		Equation in figure 13
6	Efficiency, η_{IMP}		0.724		= η_{05} x F_l x $F\varepsilon$
7	Δhe_{IMP}	kJ/kg	163.0		= η_{IMP} x $\Delta h'_{IMP}$
8					



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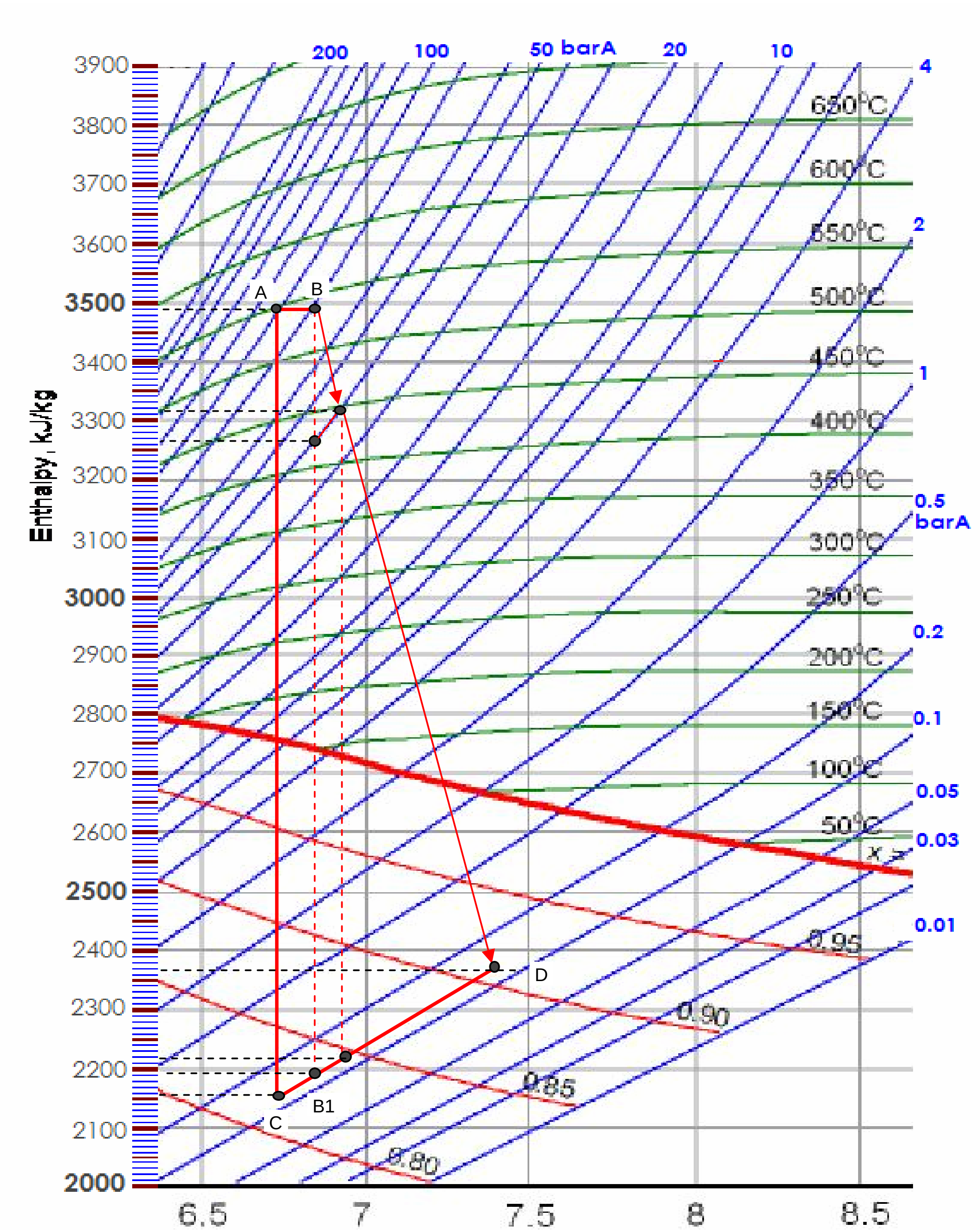
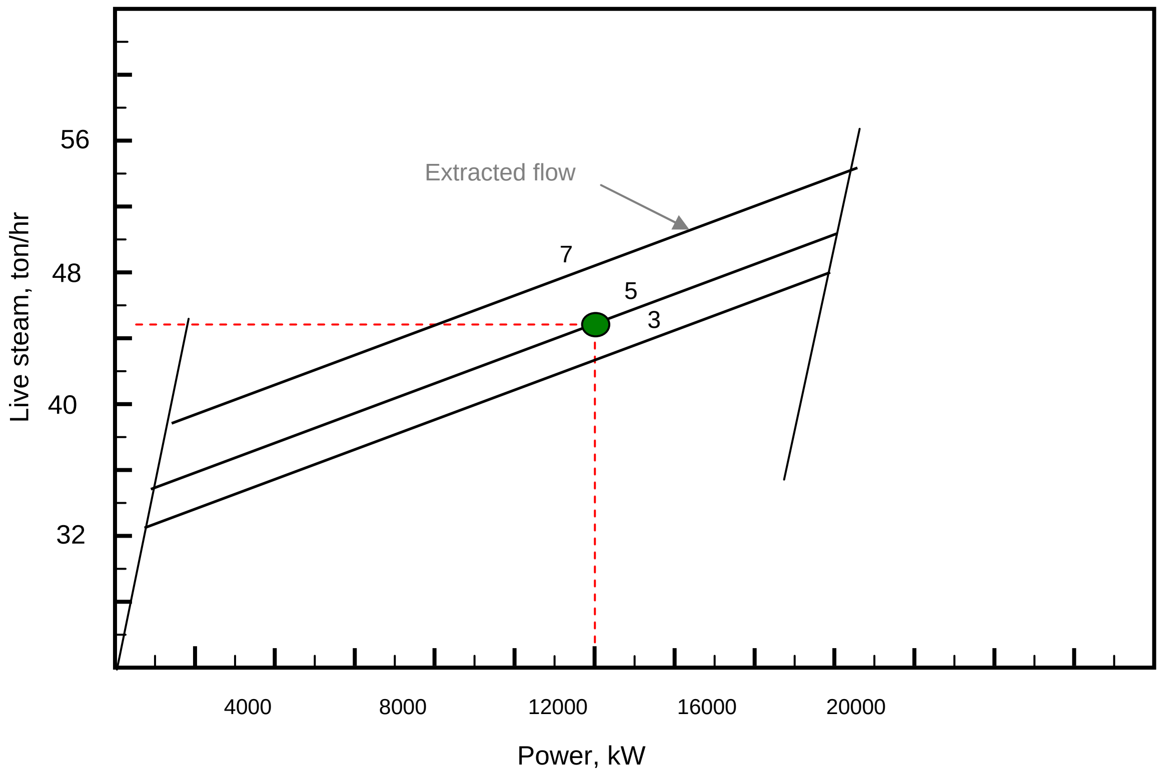
STEAM TURBINE CALCULATION SHEET

No.	Designation		Quantity		Note and additional information
1	he_{IMP}	kJ/kg	3327.0		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	123.01		Equation 5
5	Control stage power, P_{IMP}	kW	1914.0		
6	*Reaction Stages*				
7	Reaction stage steam flow, m_R	ton/hr	40.0		
8	hi	kJ/kg	3327.0		
9	hos'	kJ/kg	2220		
10	Δhs_R	kJ/kg	1107.04		
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	324.5		
19	Velocity ratio, U/C		0.73		
20	Δhs_{RSTG}	kJ/kg	52.7		
21	η_R		0.875		
22	$\Delta he_R'$	kJ/kg	968.66		
23	he_R	kJ/kg	2358.4		Point D
24	X		0.910		
25	Wet enthalpy	kJ/kg	2730		
26	Wet eficiency, η_{WET}		0.983		
27	Reaction stages efficiency, η		0.86		$= \eta_R \times \eta_{WET}$
28	Reaction stages power, P_R	kW	10577		$= m_R \times \Delta hs_R \times \eta$
29	Reaction + impulse power	kW	12491		$= P_R + P_{IMP}$
30	Mechanical efficiency, η_m		0.995		
31					
32	BHP	kW	12429		$= (P_R + P_{IMP}) \times \eta_m$
33					
34					
35					


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
0.95
0.90
0.85
0.80
A
B
B1
C
D
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


Live steam, ton/hr
56
48
40
32
Extracted flow
7
5
3
4000
8000
12000
16000
20000
Power, kW