RECIPROCATING COMPRESSOR CALCULATION SHEET

WITH INTERCOOLER

Gas properties, flowrate and conditions

(Sheet : ...1..... Of ...4.....)

1	Gas name	Air				
	Item or symbol	Quantity	Unit	Item or symbol	Quantity	Unit
2	Suction pressure, ps	1.013	bar A	Discharge pressure, pd	38.2	bar A
3	Suction temperature, ts	35	^{O}C			
4	Ts	308	^{O}K	p_{CR}	37.70	bar A
5	MW	28.4	kg/kgmol	T_{CR}	132.80	^{O}K
6	k_S	1.400		$p_R = p / p_{CR}$	0.027	
7	R_S	0.293	kJ/kg.^{O}K	$T_R = T / T_{CR}$	2.32	
8	DSs	1.122	kg/m3	Z_S	1.00	
9	MCp	29.14	kJ/kgmol.^{O}K	Cp_S	1.026	kJ/kg
10	G	26000	kg/hr	G_{mol}	917	kgmol/hr
11	Q_S	23173	m^3/hr	Q_N	20540	Nm^3/hr
12						

Compressor Calculation Sheet

	Item	Symbol	Unit	Quantity	Note
13	***Preliminary Calculation***				
14	**Check whether need intercooler**				
15	First Stage Volume flow	Qs	m3/hr	23173	
16	Cylinder intake pressure	ps'	barA	0.98261	
17	Cylinder exhaust pressure	pd'	barA	39.346	
18	Pressure ratio (p_D / p_S)	r'_{TOTAL}	-	40.042	
19	(k-1)/k		-	0.2857	
20	k/(k-1)		-	3.500	
21	Total Hydrodynamic head	H_{TOTAL}	m	60233	Eq. 8.
22	**Check number of stage due to max. temp**				
23	Max. temperature	t_{MAX}	^{O}C	150	See Chapter VI.
24		T_{MAX}	^{O}K	423	
25	Max. pressure ratio	r_{MAX-T}	-	3.04	Equation (11)
26	Is r > r_{MAX} or need intercooler ?			**Yes**	
27	**Expected minimum adiabatic vol. eff.**	η_{V-A}		0.850	
28	Max. clearance space vol.	c_{MAX}	%	12.39	Eq. A.3. If need intercooler, use r = r_{max-T}, otherwise use r_{Total}
29	Clearance space volume	c	%	10	Fill < max.at expected eff.
30	Volumetric efficiency	η_V		0.835	Eq. A.3 and A.4.

	Item	Symbol	Unit	Quantity	Note
1	Supply efficiency	λ/η_V		0.945	Eq. A.5.
2	Required piston capacity	Qp	m3/hr	29379.0	Eq. A.6 and A.7.
3	Max. hydr. Head for each stage	$H_{STG-MAX}$	m	12027	Eq. A.6.
4	Preliminary number of stage	i_{CAL}		5	= Htotal / Hstg-max
5	GHP	GHP		5410	
6	Mechanical efficiency	η_M		0.94	
7	BHP	BHP		5756	
8	**Frame BHP selection**			**Casing I**	
9	Selected frame BHP			5100	See frame BHP table near preliminary BHP in line 7
10	No. of frame			1	Frame BHP data
11	No. of throw per frame			8	Frame BHP data
12	Stroke length			400	Frame BHP data
13	No. of compression acting			2	Frame BHP data
14	Crankshaft speed			500	Frame BHP data
15	Max. diameter			1000	Frame BHP data
16	Max. H per throw			6791	Eq.A.11

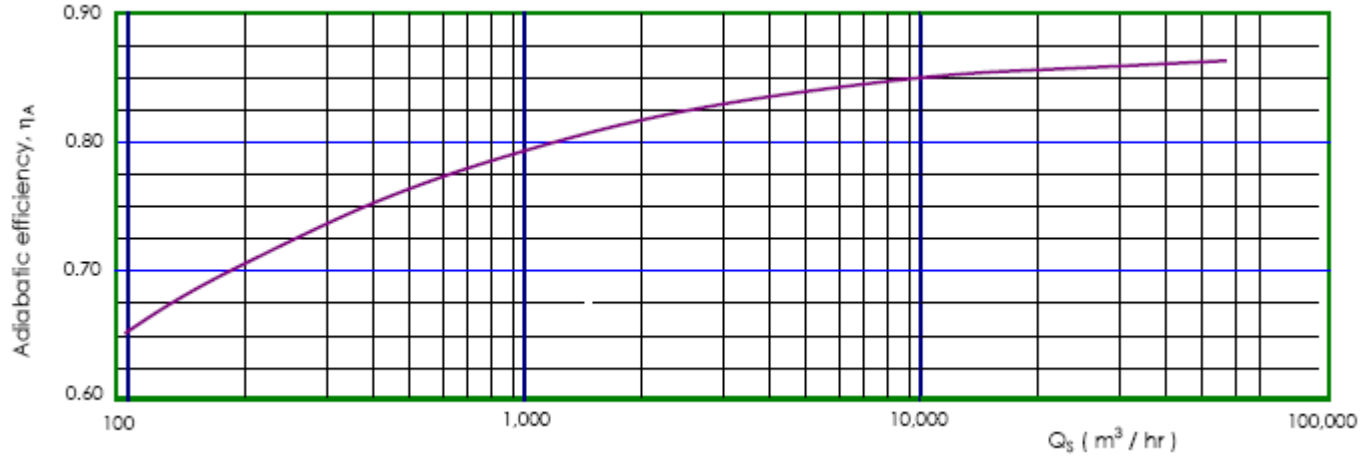
17	***Detail calculation***	CASING I								Note
18		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	
19	**G** (kg/hr)	26000	26000	26000	26000	26000	26000	26000	26000	
20	Max. H per stage for parallel throws	6791.2	6791.2	6791.2	6791.2	6791.2	6791.2	6791.2	6791.2	= line 16
21	Last cylinder exhaust press. (barA)	39.346	39.346	39.346	39.346	39.346	39.346	39.346	39.346	
22	Cyl. intake pressure, **ps'** (barA)	0.98	1.819	3.386	6.389	12.142	23.167	-	-	Eq. A8
23	Suction temperature, **ts** (C)	35.0	45.0	45.0	45.0	45.0	45.0	97.0	#VALUE!	
24	**Ts** (K)	308.0	318.0	318.0	318.0	318.0	318.0	370.0	#VALUE!	
25	Max. discharge temp., **td** max. (C)	**140**	140	140	140	140	140	140	140	Chapter 6
26	**Td** max. (C)	413.0	413.0	413.0	413.0	413.0	413.0	413.0	413.0	
27	**MW**	28.36	28.36	28	28	28	28	28	28	
28	**Rs** = 8.314/MW	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	
29	p_{CR}	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	
30	T_{CR}	132.8	132.8	132.8	132.8	132.8	132.8	132.8	132.8	
31	$p_R = p_{RED} = p / p_{CR}$	0.03	0.048	0.09	0.17	0.32	0.61	#VALUE!	#VALUE!	Appendix B
32	$T_R = T_{RED} = T / T_{CR}$	2.32	2.395	2.39	2.39	2.39	2.39	2.79	#VALUE!	
33	Z_S	1	1	1	1	1	1	1	1	
34	MCp_S (kJ/kgmol.K)	29.14	29.1	29.1	29.1	29.1	29.1	29.1	29.1	
35	**k** = MCp/(MCp-8.314)	1.40	1.400	1.400	1.400	1.400	1.400	1.400	1.400	
36	Cp_S = R.k /(k-1), (kJ/kg.K)	1.03	1.026	1.026	1.026	1.026	1.026	1.026	1.026	
37	**DSs** = 100.ps / (Z.R.Ts), (kg/m3)	1.1	2.0	3.6	6.9	13.0	24.9	#VALUE!	#VALUE!	Eq. 3 up to 7
38	Q_S = G / DSs, (m3/hr)	23173.3	13321.2	7157	3793.6	1996.0	1046.2	#VALUE!	#VALUE!	

	Detail calculation (cont)	CASING I								Note
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	
1	Q_N (Nm3/h)	20540	20540	20540	20540	20540	20540	20540	20540	
2	**(k-1)/k**	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	
3	**k/(k-1)**	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500	
4	**Due to max. temperature**									
5	Pressure ratio, **r '** due to max. temp.	2.792	2.497	2.497	2.497	2.497	1.698	#VALUE!	#VALUE!	Eq. 11, Eq. A.10
6	**Due to max. frame BHP**									
7	Max. **r'** due to max. frame BHP	1.953	1.916	1.916	1.916	1.916	1.916	1.761	#VALUE!	
8	Selected **r'**	**1.953**	**1.916**	**1.916**	**1.916**	**1.916**	**1.698**	**#VALUE!**	**#VALUE!**	
9	Discharge pressure, **pd** (barA)	1.919	3.486	6.489	12.242	23.267	39.348	#VALUE!	#VALUE!	
10	Cylinder exhaust pressure, **pd'** (barA)	1.977	3.591	6.684	12.610	23.965	40.529	#VALUE!	#VALUE!	Eq. A8 for 3 % loss
11	Clearance space volume, **c** (%)	10	10	10	10	10	10	10	10	
12	Volumetric efficiency, η_V	0.892	0.894	0.894	0.894	0.894	0.906	#VALUE!	#VALUE!	Eq. A4
13	Supply efficiency, λ/η_V	0.973	0.974	0.974	0.974	0.974	0.980	#VALUE!	#VALUE!	Eq. A5
14	Required piston capacity, **Qp** (m3)	26709.1	15302.0	8221.4	4357.6	2292.8	1177.9	#VALUE!	#VALUE!	Eq. A7
15	Preliminary Piston speed (m/s)	5	**5**	**5**	**5**	**5**	**5**	**5**	**5**	
16	Stroke length, **L** (mm)	**400**	400	400	400	400	400	400	400	
17	No. of compression acting	2	2	2	2	2	2	2	2	
18	No. of throw for each stage, **z**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**	Max. = **8**
19	Crankshaft speed, **N** (RPM)	**450**	450	450	450	450	450	450	450	Adjust if U > 6 m/s
20	Piston speed, **U** (m/s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	Eq. 12, **max. 6 m/s**
21	Piston displacement vol./stroke, m^3	0.247	0.142	0.152	0.081	0.042	0.022	#VALUE!	#VALUE!	
22	Piston diameter, **D** (mm)	**886.5**	671.0	695.5	506.4	367.3	263.3	#VALUE!	#VALUE!	Max.(mm)= **1000**
23	Hydrodynamic head, **H** (m)	6791.2	6791.2	6791.2	6791.2	6791.2	5434.4	#VALUE!	#VALUE!	Eq. 8
24	**GHP**	**554**	**569**	**569**	**569**	**569**	**447**	**0**	**0**	**Eq. 9**
25	Exhaust temp before cooler, **td** (C)	**100**	**110**	**110**	**110**	**110**	**97**	**#VALUE!**	**#VALUE!**	Eq. 10
26	Need intercooler ?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**-**	**-**	
27	If "Yes", outlet gas temp. (C)	45	45	45	45	45	45	45	45	
28	Pres. drop at inter/stg cooler (bar)	0.10	0.10	0.10	0.100	0.100	0.100	0.100	0.100	
29	Compression continue ?	**Continue**	**Continue**	**Continue**	**Continue**	**Continue**	**Finish**	**-**	**-**	
30	**Total Adiabatic Compression GHP** (kW)	3277.98								
31	Adiabatic eff, when isn' t fully adiabatic	0.90								See figure below
32	Mechanical efficiency	0.94								Fig. A4
33	**Total BHP** (kW)	**3875**								
34	C.W. each cooler (ton/hr)	41.5	41.5	41.5	41.5	41.5	0	0	0	For Δt water = 10 C
35	Total C.W. required (ton/hr)	207.7								

Frame Power Data

Frame power (kW)	Max. dia. Dmax (mm)	Max. no. throw Z	Stroke length, L (mm)	Crank max. speed N (RPM)	Power per throw (kW)
150		2	100		75
300		4	150		75
600		4	200		150
1200		4	250		300
2000		6	300		333
3000		6	350		500
170	350	2	150	1000	85
540	650	4	150	1200	135
790		4	200	750	198
930		4	200	750	233
260		4	178	600	65
650	765	4	230	500	163
1100		4	230	500	275
2100		6	230	514	350
3000		6	315	400	500
4600		6	315	428	767
5500		6	400	300	917
10000		6	400	300	1667
370	400	4	220	700	93
600	500	4	260	600	150
1000	650	4	260	600	250
2600	1000	6	320	500	433
3700	1000	6	360	500	617
5100	1000	6	400	500	850
6600	1000	6	400	375	1100
9200	1000	6	400	375	1533

Frame power (kW)	Max. dia. Dmax (mm)	Max. no. throw Z	Stroke length, L (mm)	Crank max. speed N (RPM)	Power per throw (kW)
8800	1000	12	430	400	733
18000		12	430	360	1500
1500	830	10	267	514	150
3000	1130	10	356	360	300
4400	1130	10	356	360	440
8000	1130	10	508	277	800
15000	1130	10	508	277	1500



Interpretation of adiabatic efficiency from literature (0.65 for small, 0.80 for medium, 0.85 and higher for large reciprocating compressor) when the compressor doesn't work in fully adiabatic compression. Qs is suction flow at first stage of the compressor. When intercoolers and water jacket are applied, adiabatic efficiency higher than above figure.

BHP = GHP /(η_A . η_M)