RECIPROCATING COMPRESSOR CALCULATION SHEET
ISOTHERMAL COMPRESSION

Gas properties, flowrate and conditions

1	Gas name	Air					
	Item or symbol	Quantity	Unit	Item or symbol	Quantity	Unit	Formula
2	Suction pressure, ps	1.013	bar A	Discharge pressure, pd	38.2	bar A	
3	Suction temperature, ts	35	^{O} C				Head (m) :
4	Ts	308	^{O} K	p_{CR}	37.70	bar A	$H_{IS} = 234.86\ R.T1\{ Log\ (r') + 0.05\}$
5	MW	28.4	kg/kgmol	T_{CR}	132.80	^{O} K	Gas horse power (kW) :
6	k_S	1.400		$p_R = p / p_{CR}$	0.027		$GHP_{IS} = 0.064\ Q1.p1.\{ Log\ (r') + \Delta C \} / Z1$
7	R_S	0.293	kJ/kg.^{O}K	$T_R = T / T_{CR}$	2.32		ΔC is approx.< 0.05 for Δp < 50 bar
8	DSs	1.123	kg/m3	Z_S	1.00		,p<200 bar A and temperature at
9	MCp	29.14	kJ/kgmol.^{O}K	Cp_S	1.025	kJ/kg	near 50 C for each stage
10	G	12000	kg/hr	G_{mol}	423	kgmol/hr	
11	Q_S	10681	m^3/hr	Q_N	9467	Nm^3/hr	Q1 capacity (m3/hr) at refference
12							pressure p1 and t1

Compressor Calculation Sheet

	Item	Symbol	Unit	Quantity	Note
13	***Preliminary Calculation (General method)***				
14	**Adiabatic compression**				
15	First Stage Volume flow	Qs	m3/hr	10681	Isothermal efficiency : When cooling system for cylinder and interstage
16	Cylinder intake pressure	ps'	barA	0.98261	cooler is applied and crankshaft speed is low, L/D is high, isothermal
17	Cylinder exhaust pressure	pd'	barA	39.346	efficiency will increase.
18	Pressure ratio (p_D / p_S)	r	-	40.042	
19	(k-1)/k		-	0.2857	
20	k/(k-1)		-	3.500	
21	Total Hydrodynamic head	$H_{IS-TOTAL}$	m	34994	
22	**Expected isothermal compr. eff.**			0.750	Average isothermal efficiency is approximatelly 0.63 up to 0.70 from medium to large compr.

23									
24	**Frame BHP selection at first stage**			Casing I					
25	No. of compression acting			2	Fig. A.2/A.3	Approx. no. of stage		7	
26	Stroke length, L		mm	430	Fig. A.2/A.3	Approx. pressure ratio, r'		1.6941	
27	No. of throw at first stage, z			3	Fig. A.2/A.3	for each stage			
28	Crankshaft speed, N		RPM	200	Fig. A.1				
29	Max. diameter, Dmax (= L / 0.6)		mm	717					
30	No. of frame			1					
31	Calculated frame BHP/throw, 0.11 Qp1		kW	229	App. (A.4)				
32	Max. H per throw		m	5261	Eq.A.11				

1	***Detail calculation***									Note
2		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	
3	Mass flow, G	12000	12000	12000	12000	12000	12000	12000	12000	
4	Max. H per stage for parallel throws	5261.1	5261.1	5261.1	5261.1	5261.1	5261.1	5261.1	5261.1	
5	Last cylinder exhaust press. (barA)	39.346	39.346	39.346	39.346	39.346	39.346	39.346	39.346	
6	**p1**	1.013	1.013	1.013	1.013	1.013	1.013	1.013	1	Refference condition in
7	**t1**	35	35	35	35	35	35	35	35	this sheet is equal with
8	**Q1**	10681.1	10681.1	10681.1	10681.1	10681.1	10681.1	10681.1	10681	intake condition
9	Cyl. intake pressure, **ps'** (barA)	0.98	1.665	2.820	4.777	8.093	13.710	23.226	-	
10	Suction temperature, **ts** (C)	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	
11	**Ts** (K)	308.0	308.0	308.0	308.0	308.0	308.0	308.0	308.0	
12	**MW**	28.40	28.40	28	28	28	28	28	28	
13	**Rs** = 8.314/MW	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	
14	p_{CR}	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	
15	T_{CR}	132.8	132.8	132.8	132.8	132.8	132.8	132.8	132.8	
16	$p_R = p_{RED} = p / p_{CR}$	0.03	0.044	0.07	0.13	0.21	0.36	0.62	#VALUE!	
17	$T_R = T_{RED} = T / T_{CR}$	2.32	2.319	2.32	2.32	2.32	2.32	2.32	2.32	
18	Z_S	1	1	1	1	1	1	1	1	
19	MCp_S (kJ/kgmol.K)	29.14	29.1	29.1	29.1	29.1	29.1	29.1	29.1	
20	**k** = MCp/(MCp-8.314)	1.40	1.399	1.399	1.399	1.399	1.399	1.399	1.400	
21	Cp_S = R.k /(k-1), (kJ/kg.K)	1.02	1.026	1.026	1.026	1.026	1.026	1.026	1.025	
22	**DSs** = 100.ps / (Z.R.Ts), (kg/m3)	1.1	1.8	3.1	5.3	9.0	15.2	25.8	#VALUE!	
23	Q_S = G / DSs, (m3/hr)	10681.1	6500.0	3836.9	2264.9	1337.0	789.2	465.9	#VALUE!	
24	**r'**	**1.694**	**1.694**	**1.694**	**1.694**	**1.694**	**1.694**	**1.694**	**1.694**	
25	Discharge pressure, **pd** (barA)	1.665	2.820	4.777	8.093	13.710	23.226	39.346	#VALUE!	
26	Cylinder exhaust pressure, **pd'** (barA)	1.715	2.905	4.921	8.336	14.121	23.922	40.526	#VALUE!	Eq. A8
27	Clearance space volume, **c** (%)	**5.0**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
28	Volumetric efficiency, η_V	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928	Eq. A4
29	Supply efficiency, λ/η_V	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980	Eq. A5
30	Required piston capacity, **Qp** (m3)	11740.1	7144.6	4217.4	2489.5	1469.5	867.5	512.1	#VALUE!	Eq. A7
31	Preliminary Piston speed (m/s)	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	
32	Stroke length, **L** (mm)	**430**	430	430	430	430	430	430	430	
33	No. of compression acting	2	2	2	2	2	2	2	2	
34	No. of throw for each stage, **z**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**0**	Fill for D < Dmax
35	Crankshaft speed, **N** (RPM)	**200**	200	200	200	200	200	200	200	
36	Piston speed, **U** (m/s)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	Eq. 12, **max. 6 m/s**
37	Piston displacement vol./stroke, m^3	0.163	0.149	0.088	0.104	0.061	0.036	0.021	#VALUE!	
38	Piston diameter, **D** (mm)	**694.3**	663.3	509.6	553.7	425.4	326.9	251.1	#VALUE!	Max.(mm)= **717**
39	Compression continue ?	**Continue**	**Continue**	**Continue**	**Continue**	**Continue**	**Continue**	**Finish**	**-**	
40	GHP_{IS}	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**0**	**Eq. 9**
41	**Average Isothermal efficiency**	**0.750**								
42	**Total GHP** (kW)	1802.76								
43	Mechanical efficiency	0.94								Fig. A4
44	**Total BHP** (kW)	**2557**								

RECIPROCATING COMPRESSOR CALCULATION SHEET
ISOTHERMAL COMPRESSION

Gas properties, flowrate and conditions

1	Gas name	Air					
	Item or symbol	Quantity	Unit	Item or symbol	Quantity	Unit	Formula
2	Suction pressure, ps	1.013	bar A	Discharge pressure, pd	38.2	bar A	
3	Suction temperature, ts	35	^{O} C				Head (m) :
4	Ts	308	^{O} K	p_{CR}	37.70	bar A	$H_{IS} = 234.86\ R.T1\{ Log\ (r') + 0.05\}$
5	MW	28.4	kg/kgmol	T_{CR}	132.80	^{O} K	Gas horse power (kW) :
6	k_S	1.400		$p_R = p / p_{CR}$	0.027		$GHP_{IS} = 0.064\ Q1.p1.\{ Log\ (r') + \Delta C \}/Z1$
7	R_S	0.293	kJ/kg.^{O}K	$T_R = T / T_{CR}$	2.32		ΔC is approx.< 0.05 for Δp < 50 bar
8	DSs	1.123	kg/m3	Z_S	1.00		,p<200 bar A and temperature at
9	MCp	29.14	kJ/kgmol.^{O}K	Cp_S	1.025	kJ/kg	near 50 C for each stage
10	G	6000	kg/hr	G_{mol}	211	kgmol/hr	
11	Q_S	5341	m^3/hr	Q_N	4734	Nm^3/hr	Q1 capacity (m3/hr) at refference
12							pressure p1 and t1

Compressor Calculation Sheet

	Item	Symbol	Unit	Quantity	Note			
13	***Preliminary Calculation (General method)***							
14	**Adiabatic compression**							
15	First Stage Volume flow	Qs	m3/hr	5341				
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	$H_{IS-TOTAL}$	m	34994				
22	**Expected isothermal eff.**			0.750	Average isothermal efficiency is approximatelly 0.63 (medium size) up to 0.70 (large)			
23								
24	**Frame BHP selection at first stage**			**Casing I**				
25	No. of compression acting			1	Fig. A.2/A.3	Approx. no. of stage, i	4	
26	Stroke length, L		mm	400	Fig. A.2/A.3	Approx. pressure ratio, r'	2.5155	$= r_{TOTAL}^{(1/I)}$
27	No. of throw at first stage, z			4	Fig. A.2/A.3	for each stage		
28	Crankshaft speed, N		RPM	200	Fig. A.1			
29	Max. diameter, Dmax (= L / 0.6)		mm	667				
30	No. of frame			1				
31	Calculated frame BHP/throw, 0.11 Qp1		kW	185	App. (A.4)			
32	Max. H per throw		m	8470	Eq.A.11			

1	***Detail calculation***									Note
2		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	
3	Mass flow, G	6000	6000	6000	6000	6000	6000	6000	6000	
4	Max. H per stage for parallel throws	8469.9	8469.9	8469.9	8469.9	8469.9	8469.9	8469.9	8469.9	
5	Last cylinder exhaust press. (barA)	39.346	39.346	39.346	39.346	39.346	39.346	39.346	39.346	
6	**p1**	1.013	1.013	1.013	1.013	1.013	1.013	1.013	1	Refference condition in
7	**t1**	35	35	35	35	35	35	35	35	this sheet is equal with
8	**Q1**	5340.5	5340.5	5340.5	5340.5	5340.5	5340.5	5340.5	5341	intake condition
9	Cyl. intake pressure, **ps'** (barA)	0.98	2.472	6.218	15.641	-	-	-	-	
10	Suction temperature, **ts** (C)	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	
11	**Ts** (K)	308.0	308.0	308.0	308.0	308.0	308.0	308.0	308.0	
12	**MW**	28.40	28.40	28	28	28	28	28	28	
13	**Rs** = 8.314/MW	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	
14	p_{CR}	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	
15	T_{CR}	132.8	132.8	132.8	132.8	132.8	132.8	132.8	132.8	
16	$p_R = p_{RED} = p / p_{CR}$	0.03	0.066	0.16	0.41	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
17	$T_R = T_{RED} = T / T_{CR}$	2.32	2.319	2.32	2.32	2.32	2.32	2.32	2.32	
18	Z_S	1	1	1	1	1	1	1	1	
19	MCp_S (kJ/kgmol.K)	29.14	29.1	29.1	29.1	29.1	29.1	29.1	29.1	
20	**k** = MCp/(MCp-8.314)	1.40	1.399	1.399	1.399	1.399	1.399	1.399	1.400	
21	Cp_S = R.k /(k-1), (kJ/kg.K)	1.02	1.026	1.026	1.026	1.026	1.026	1.026	1.025	
22	**DSs** = 100.ps / (Z.R.Ts), (kg/m3)	1.1	2.7	6.9	17.3	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
23	Q_S = G / DSs, (m3/hr)	5340.5	2188.7	870.1	345.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
24	**r'**	**2.516**	**2.516**	**2.516**	**2.516**	**2.516**	**2.516**	**2.516**	**2.516**	
25	Discharge pressure, **pd** (barA)	2.472	6.218	15.641	39.346	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
26	Cylinder exhaust pressure, **pd'** (barA)	2.546	6.404	16.110	40.526	#VALUE!	#VALUE!	#VALUE!	#VALUE!	Eq. A8
27	Clearance space volume, **c** (%)	**1.0**	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
28	Volumetric efficiency, η_V	0.941	0.941	0.941	0.941	0.941	0.941	0.941	0.941	Eq. A4
29	Supply efficiency, λ/η_V	0.958	0.958	0.958	0.958	0.958	0.958	0.958	0.958	Eq. A5
30	Required piston capacity, **Qp** (m3)	5923.7	2427.7	965.1	383.6	#VALUE!	#VALUE!	#VALUE!	#VALUE!	Eq. A7
31	Preliminary Piston speed (m/s)	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	
32	Stroke length, **L** (mm)	**400**	400	400	400	400	400	400	400	
33	No. of compression acting	1	1	1	1	1	1	1	1	
34	No. of throw for each stage, **z**	**4**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	Fill for D < Dmax
35	Crankshaft speed, **N** (RPM)	**200**	200	200	200	200	200	200	200	
36	Piston speed, **U** (m/s)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	Eq. 12, **max. 6 m/s**
37	Piston displacement vol./stroke, m^3	0.123	0.101	0.080	0.032	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
38	Piston diameter, **D** (mm)	**626.2**	566.9	505.5	318.7	#VALUE!	#VALUE!	#VALUE!	#VALUE!	Max.(mm)= **667**
39	Compression continue ?	**Continue**	**Continue**	**Continue**	**Finish**	**-**	**-**	**-**	**-**	
40	GHP_{IS}	**156**	**156**	**156**	**156**	**0**	**0**	**0**	**0**	**Eq. 9**
41	**Average Isothermal efficiency**	**0.750**								
42	**Total GHP** (kW)	832.13								
43	Mechanical efficiency	0.94								Fig. A4
44	**Total BHP** (kW)	**1180**								

Stroke length for low piston speed.