REFRIGERATION COMPRESSORS

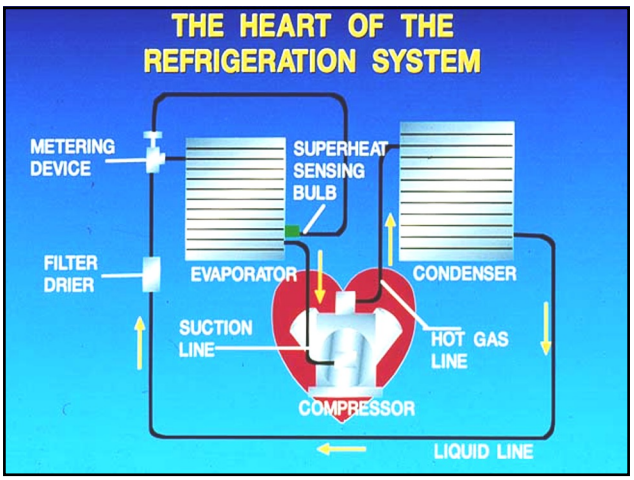
- Fellow Life member ASHRAE
- Fellow member -ISHRAE
- Cell No.+9120-9822398220
- Mail: Ramesh.paranjpey@gmail.com
- Web: http://Ramesh-paranjpey.com

1

REFRIGERATION COMPRESSORS

2

THE HEART OF THE REFRIGERATION SYSTEM

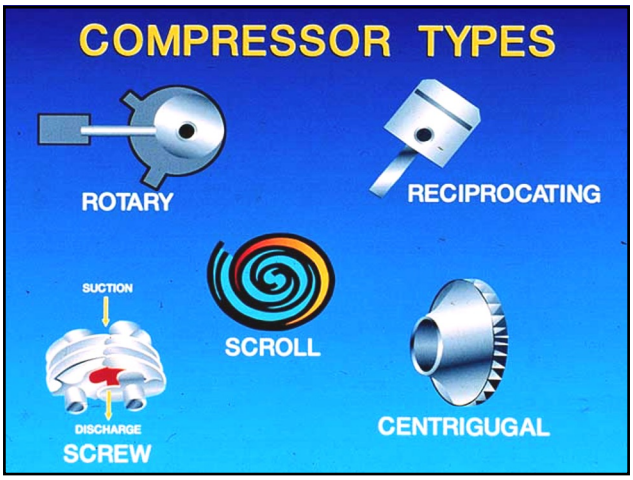


3

The Function of the compressor is to take refrigerant vapour at a low pressure & temperature and raise it to higher pressure and temperature to increase the energy level so that its able to reject heat to the cooling medium through the condenser.

(Either air cooled or water cooled condenser)

4



5

DIFFERENT TYPE OF COMPRESSORS

1. **Positive displacement compressors-**

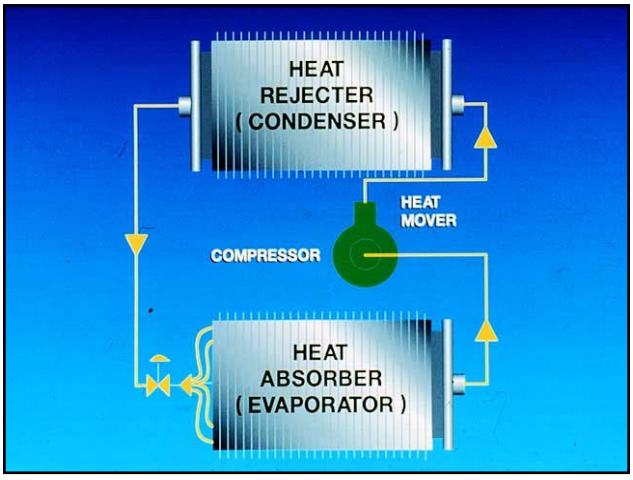
Positive displacement compressors trap a fixed volume of gas and shrink its internal space to raise the pressure,

a. Reciprocating compressors
b. Screw compressors
c. Scroll compressors

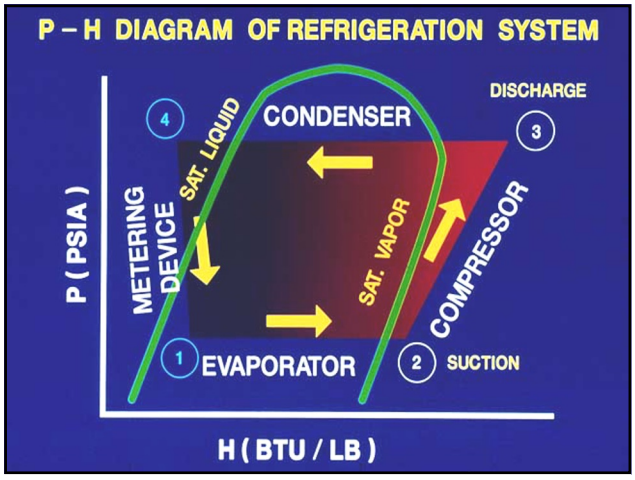
2.**Centrifugal compressors-**

Centrifugal compressors use high-speed spinning impellers to accelerate gas and convert kinetic energy into static pressure.

6



7



8

TYPICAL COMFORT AIR CONDITIONING COMPRESSOR READINGS

	@ Compressor Suction	@ Compressor Discharge
Saturation Temperature (F)	40	120
Actual Gas Temperature	50	165
Superheat (F)	10	45
Pressure (PSIA)	83.7	277.7
Pressure (PSIG)	69.0	263.0
Enthalpy (BTU / Lb.)	110	125

9

	@ Compressor Suction	@ Compressor Discharge
Saturation Temperature (F)	40	120
Actual Gas Temperature	50	165
Superheat (F)	10	45
Pressure (PSIA)	83.7	277.7
Pressure (PSIG)	69.0	263.0
Enthalpy (BTU / Lb.)	110	125

COMPRESSION RATIO

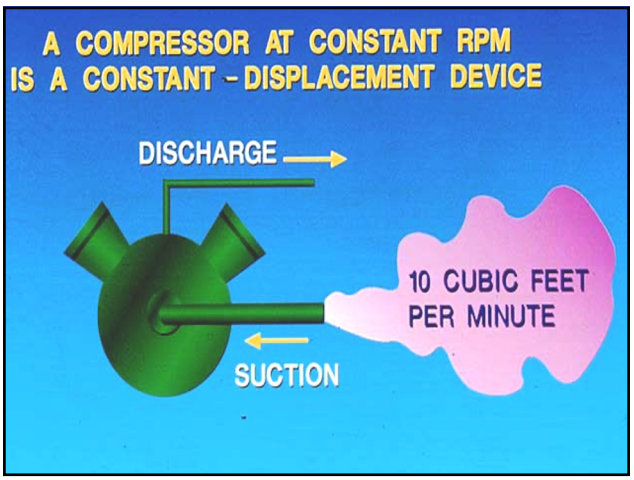
277.7 PSIA Absolute Discharge Pressure

83.7 PSIA Absolute Suction Pressure

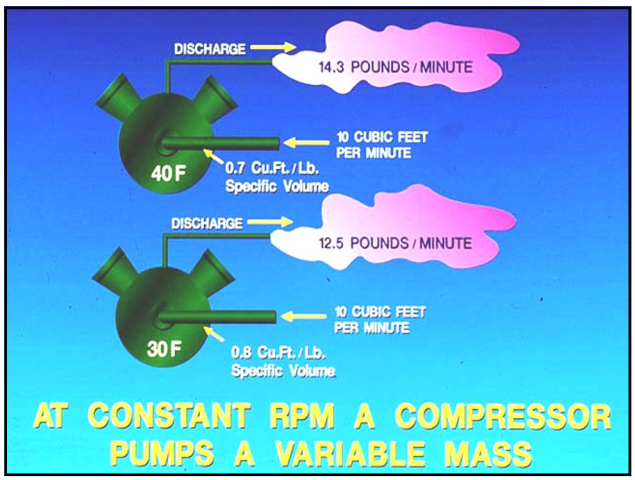
277.7 PSIA ÷ 83.7 PSIA = 3.32

10

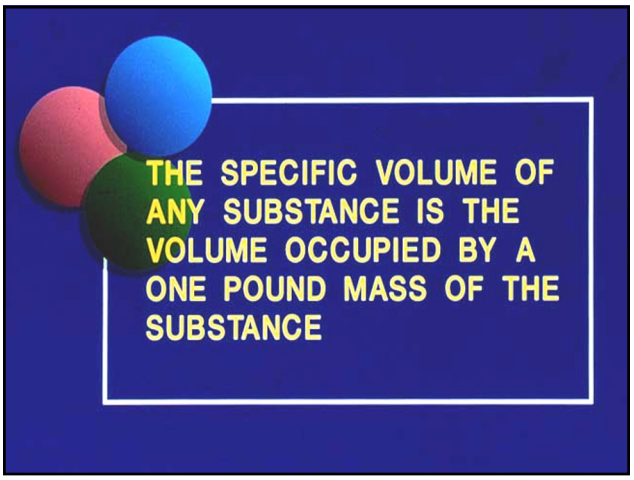
A COMPRESSOR AT CONSTANT RPM IS A CONSTANT - DISPLACEMENT DEVICE



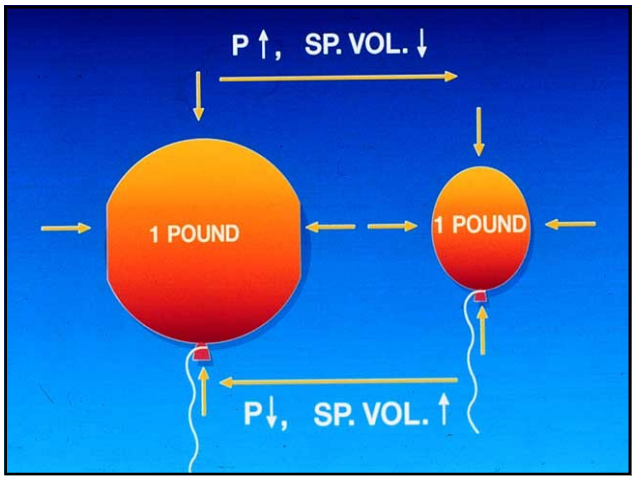
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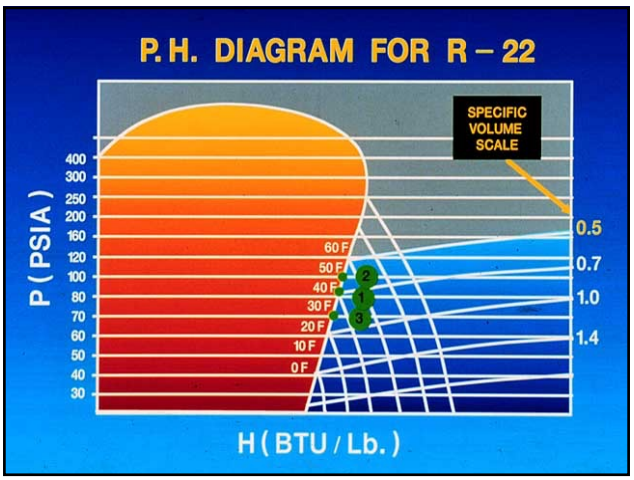
12


THE SPECIFIC VOLUME OF ANY SUBSTANCE IS THE VOLUME OCCUPIED BY A ONE POUND MASS OF THE SUBSTANCE

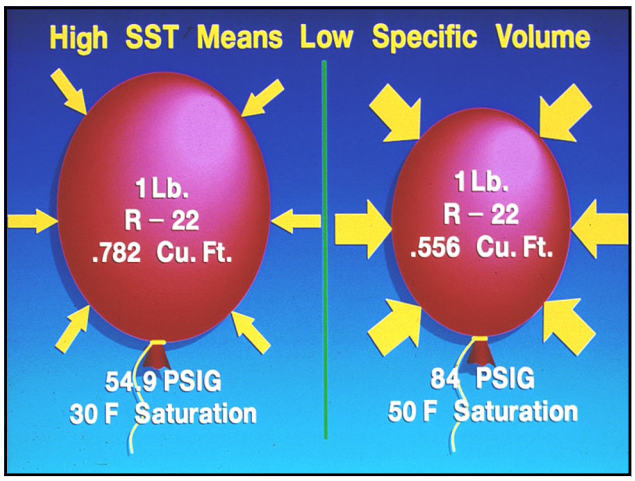
13


P ↑, SP. VOL. ↓
1 POUND
1 POUND
P ↓, SP. VOL. ↑

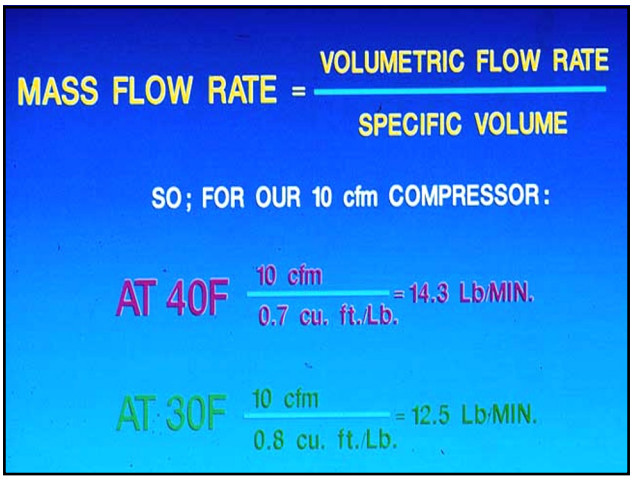
14


P. H. DIAGRAM FOR R – 22
SPECIFIC VOLUME SCALE
P (PSIA)
400
300
250
200
160
120
100
80
70
60
50
40
30
60 F
50 F
40 F
30 F
20 F
10 F
0 F
0.5
0.7
1.0
1.4
H (BTU / Lb.)

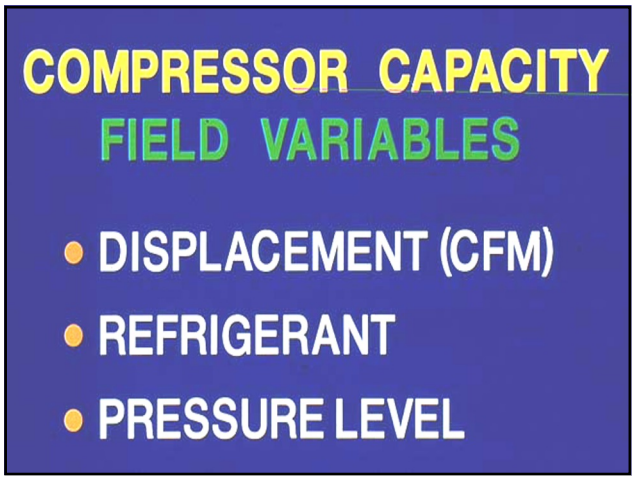
15


High SST Means Low Specific Volume
1 Lb.
R – 22
.782 Cu. Ft.
54.9 PSIG
30 F Saturation
1 Lb.
R – 22
.556 Cu. Ft.
84 PSIG
50 F Saturation

16


MASS FLOW RATE = VOLUMETRIC FLOW RATE / SPECIFIC VOLUME
SO; FOR OUR 10 cfm COMPRESSOR:
AT 40F 10 cfm / 0.7 cu. ft./Lb. = 14.3 Lb/MIN.
AT 30F 10 cfm / 0.8 cu. ft./Lb. = 12.5 Lb/MIN.

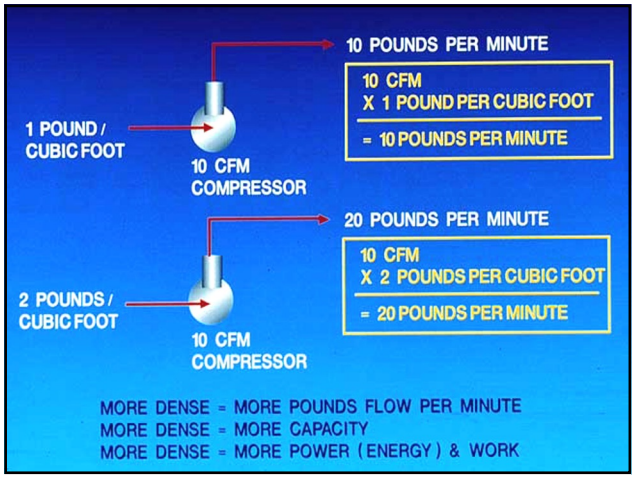
17


COMPRESSOR CAPACITY
FIELD VARIABLES
• DISPLACEMENT (CFM)
• REFRIGERANT
• PRESSURE LEVEL

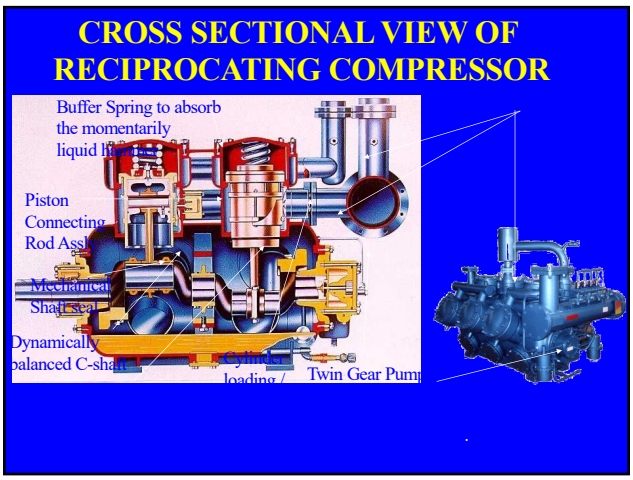
18


DISPLACEMENT
• ON / OFF CYCLING
• CYLINDER UNLOADING
• SPEED CONTROL

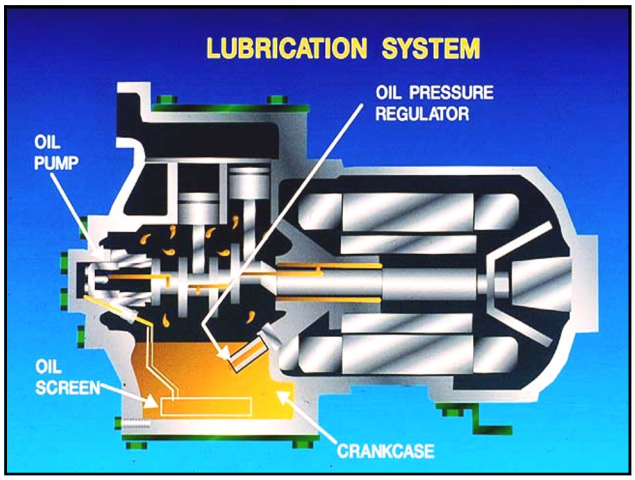
19


10 POUNDS PER MINUTE
10 CFM
X 1 POUND PER CUBIC FOOT
= 10 POUNDS PER MINUTE
1 POUND / CUBIC FOOT
10 CFM COMPRESSOR
20 POUNDS PER MINUTE
10 CFM
X 2 POUNDS PER CUBIC FOOT
= 20 POUNDS PER MINUTE
2 POUNDS / CUBIC FOOT
10 CFM COMPRESSOR
MORE DENSE = MORE POUNDS FLOW PER MINUTE
MORE DENSE = MORE CAPACITY
MORE DENSE = MORE POWER (ENERGY) & WORK

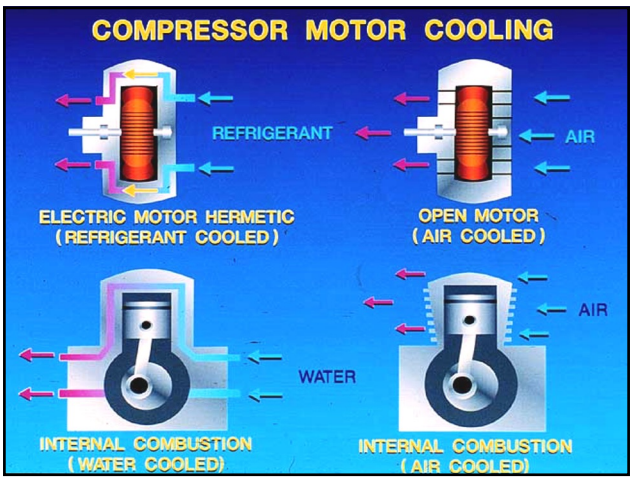
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21



22



23

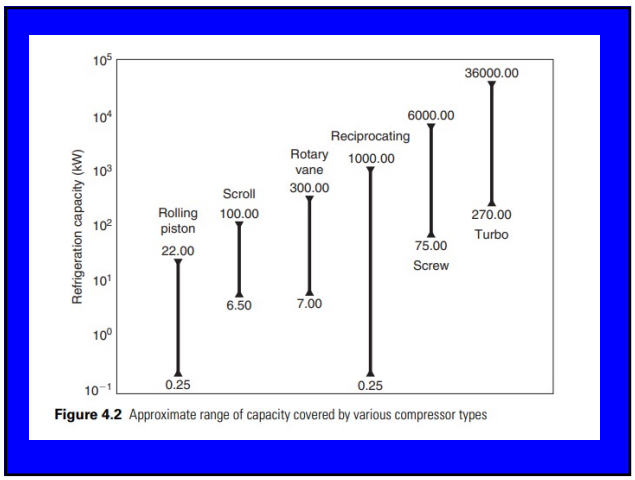
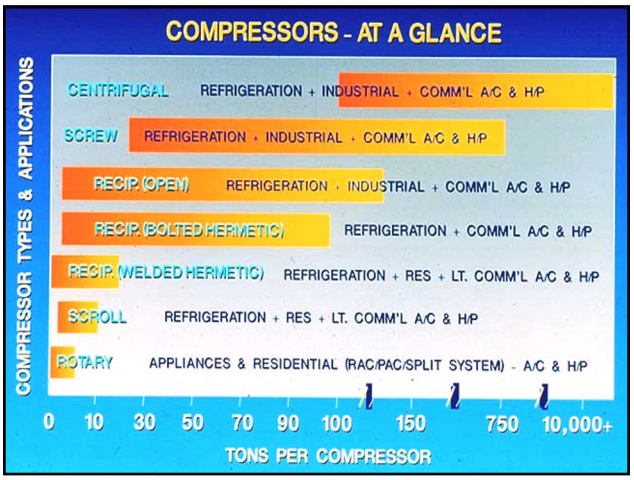


Figure 4.2 Approximate range of capacity covered by various compressor types

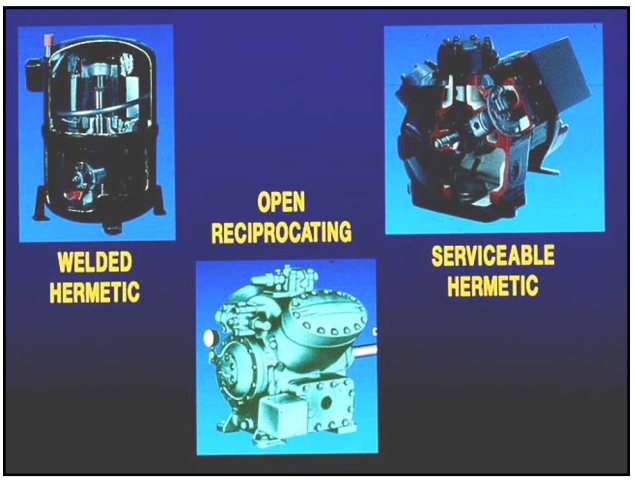
24


COMPRESSORS - AT A GLANCE
COMPRESSOR TYPES & APPLICATIONS
CENTRIFUGAL
REFRIGERATION + INDUSTRIAL + COMM'L A/C & H/P
SCREW
REFRIGERATION + INDUSTRIAL + COMM'L A/C & H/P
RECIP. (OPEN)
REFRIGERATION + INDUSTRIAL + COMM'L A/C & H/P
RECIP. (BOLTED HERMETIC)
REFRIGERATION + COMM'L A/C & H/P
RECIP. (WELDED HERMETIC)
REFRIGERATION + RES + LT. COMM'L A/C & H/P
SCROLL
REFRIGERATION + RES + LT. COMM'L A/C & H/P
ROTARY
APPLIANCES & RESIDENTIAL (RAC/PAC/SPLIT SYSTEM) - A/C & H/P
0 10 30 50 70 90 100 150 750 10,000+
TONS PER COMPRESSOR

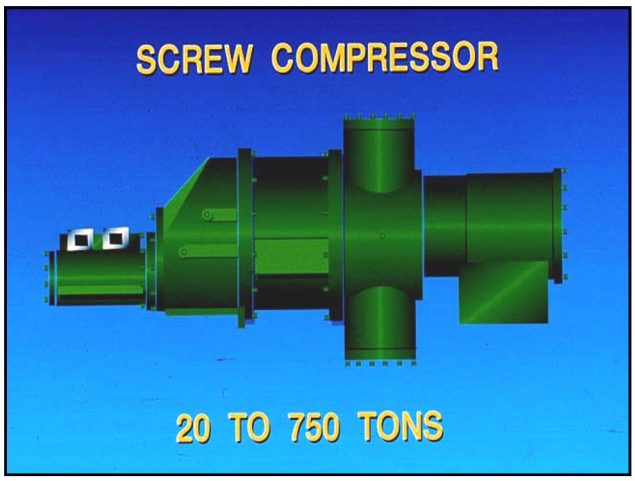
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SCROLL COMPRESSOR
5 TO 10 TONS

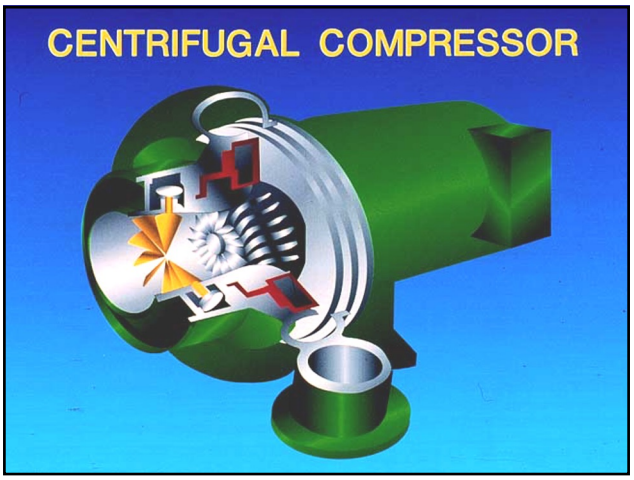
26


WELDED HERMETIC
OPEN RECIPROCATING
SERVICEABLE HERMETIC

27


SCREW COMPRESSOR
20 TO 750 TONS

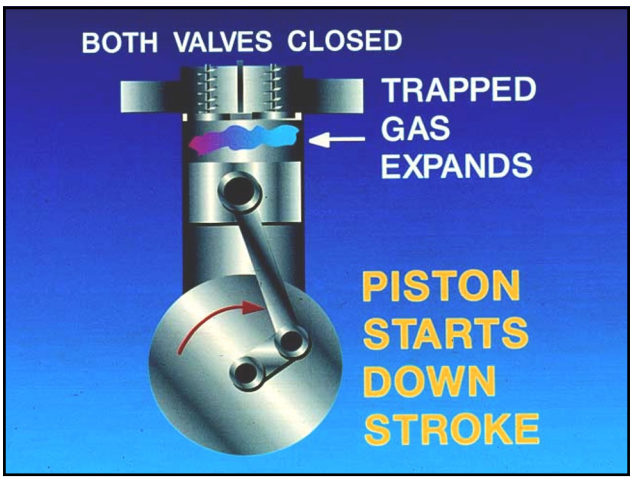
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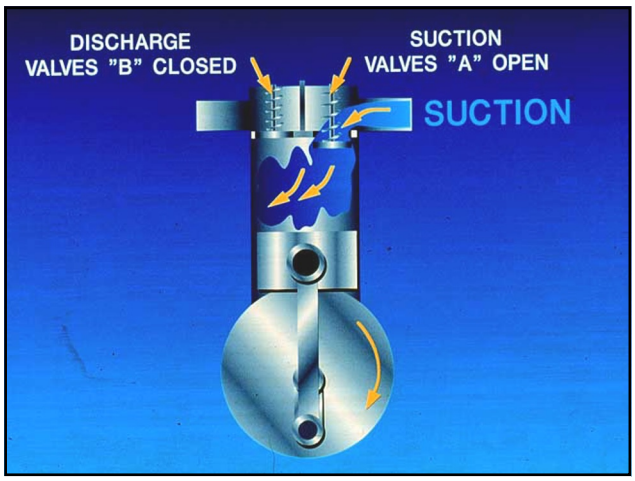
29

WORKING OF RECIPROCATING COMPRESSOR

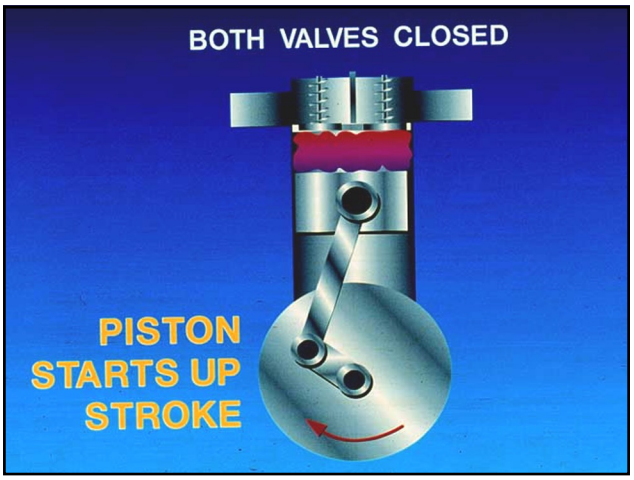
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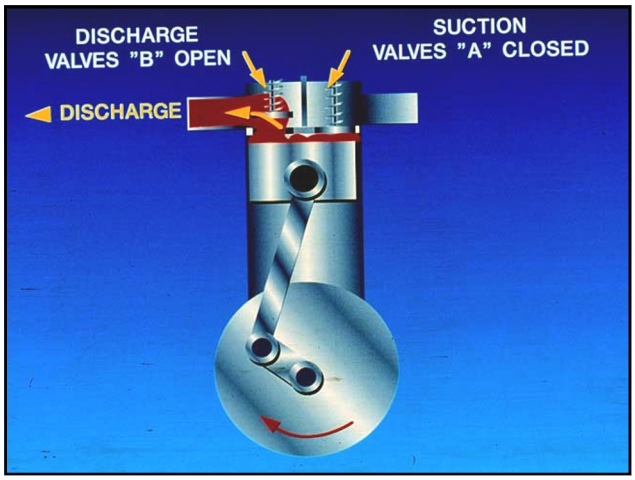
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32

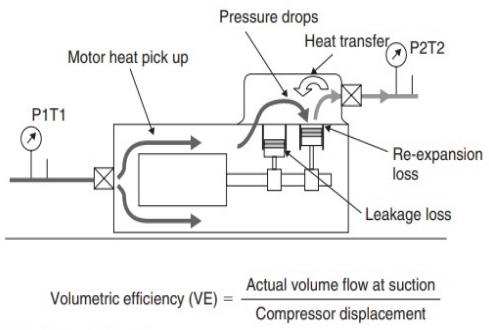


33



34

VOLUMATRIC EFFICIENCY-(LOSSES)



$$\text{Volumetric efficiency (VE)} = \frac{\text{Actual volume flow at suction}}{\text{Compressor displacement}}$$

Figure 4.15 Volumetric losses

35

VOLUMATRIC EFFICIENY COMPARISON OF VARIOUS COMPRESSORS

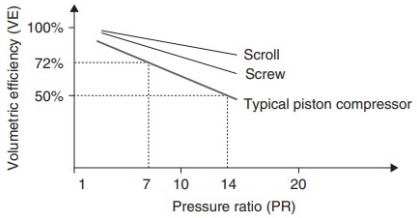
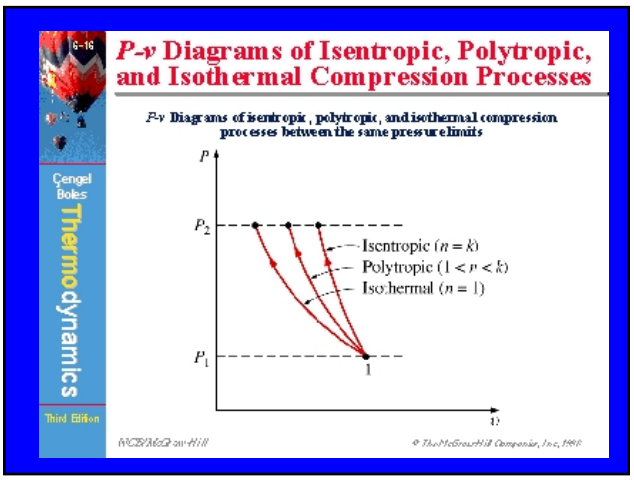


Figure 4.16 Typical VE characteristics for various compressor types

36



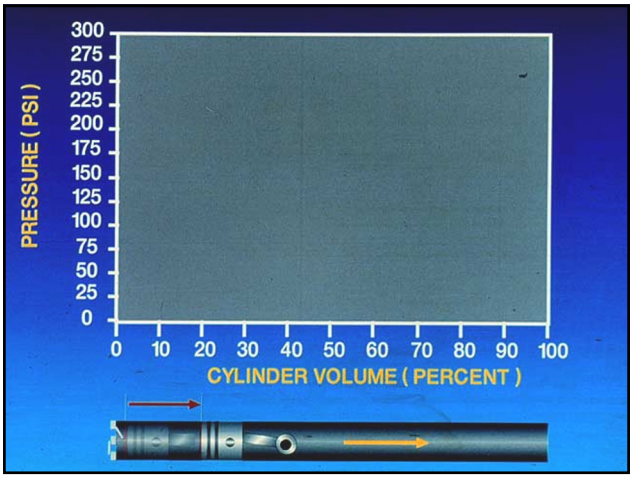
37

WORKING OF

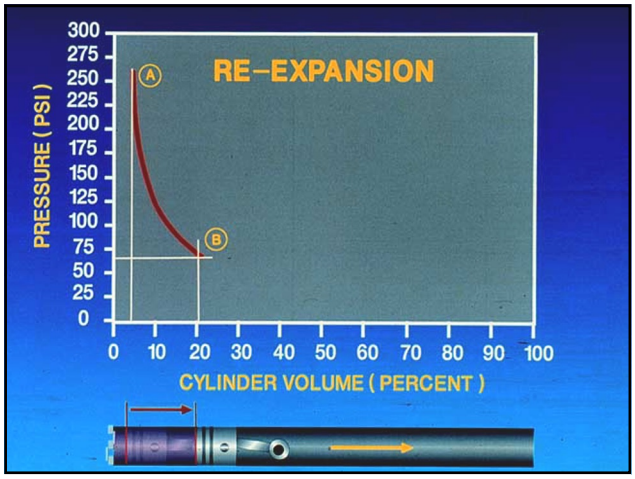
RECIPRCATING

COMPRESSOR

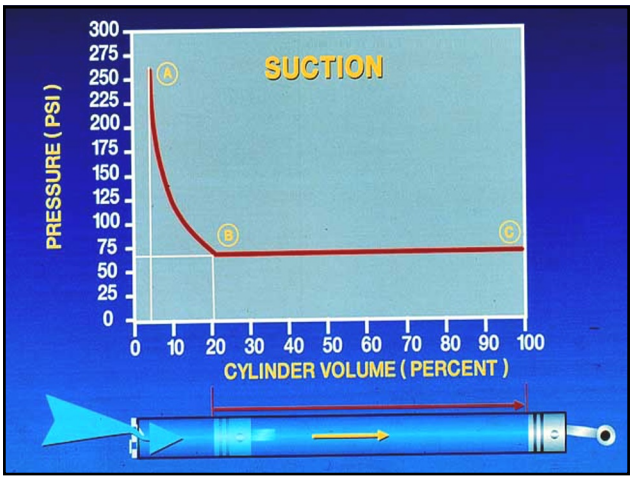
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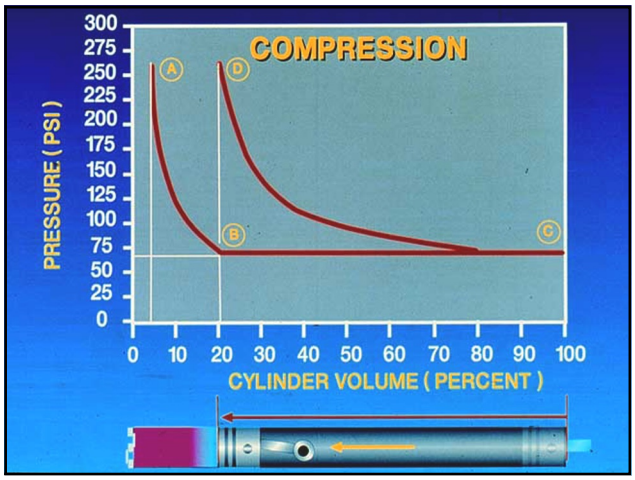
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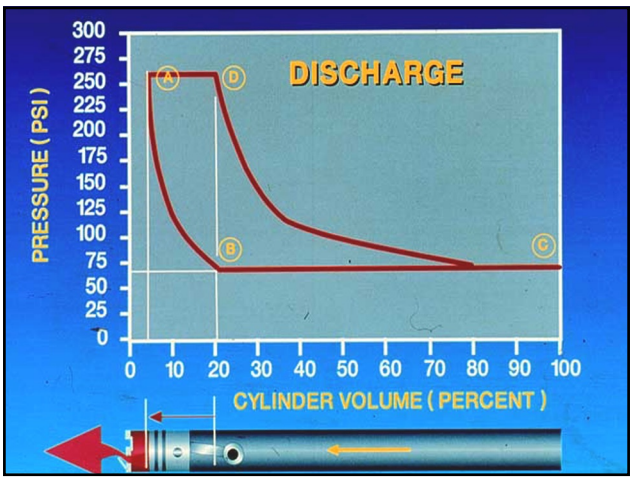
40


SUCTION
PRESSURE (PSI)
300
275
250
225
200
175
150
125
100
75
50
25
0
A
B
C
0 10 20 30 40 50 60 70 80 90 100
CYLINDER VOLUME (PERCENT)

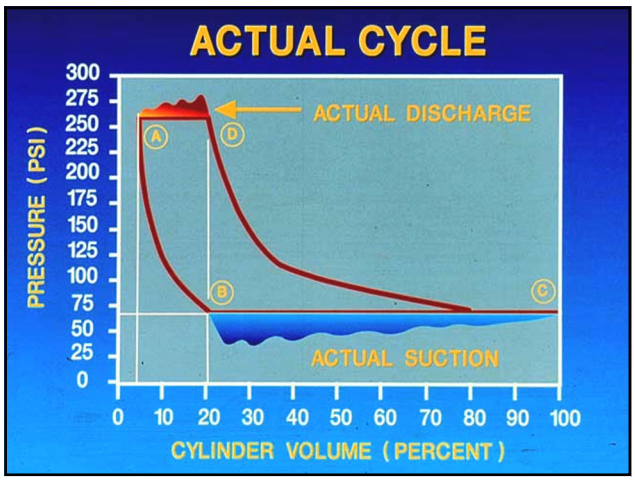
41


COMPRESSION
PRESSURE (PSI)
300
275
250
225
200
175
150
125
100
75
50
25
0
A
D
B
C
0 10 20 30 40 50 60 70 80 90 100
CYLINDER VOLUME (PERCENT)

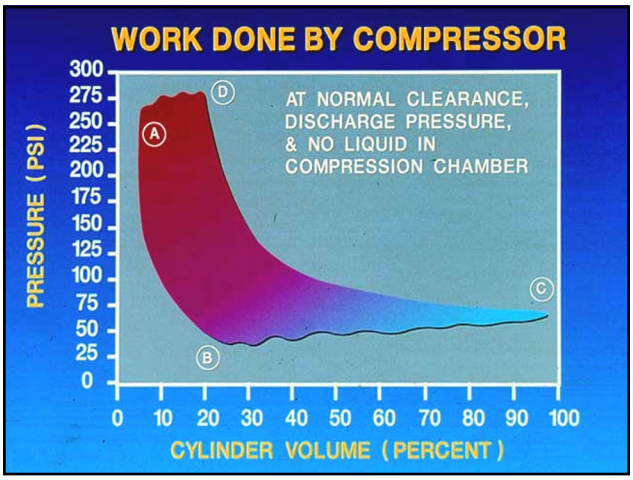
42


DISCHARGE
PRESSURE (PSI)
300
275
250
225
200
175
150
125
100
75
50
25
0
A
D
B
C
0 10 20 30 40 50 60 70 80 90 100
CYLINDER VOLUME (PERCENT)

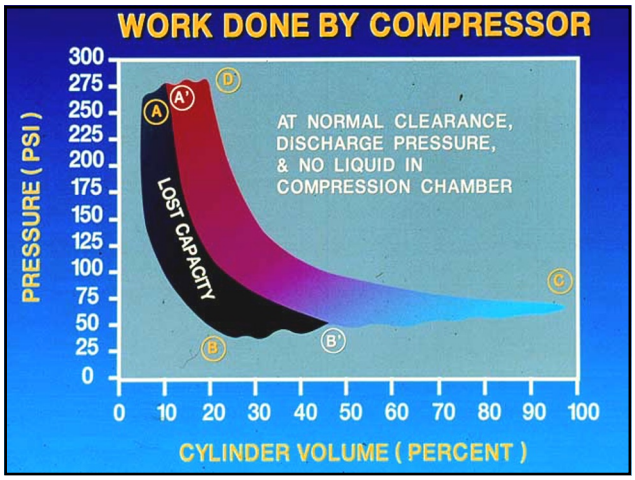
43


ACTUAL CYCLE
PRESSURE (PSI)
300
275
250
225
200
175
150
125
100
75
50
25
0
ACTUAL DISCHARGE
ACTUAL SUCTION
A
D
B
C
0 10 20 30 40 50 60 70 80 90 100
CYLINDER VOLUME (PERCENT)

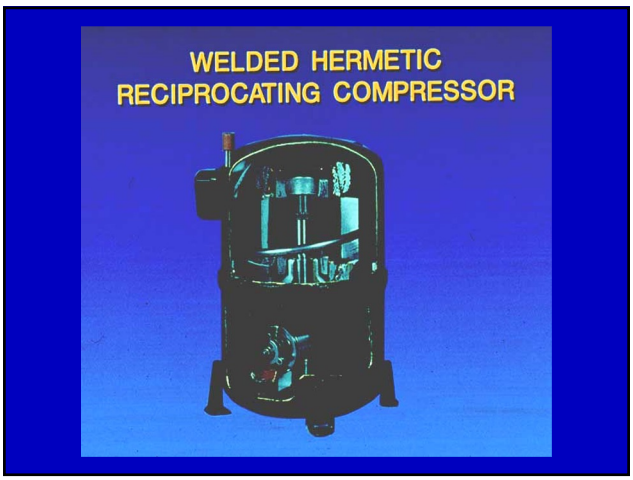
44


WORK DONE BY COMPRESSOR
PRESSURE (PSI)
300
275
250
225
200
175
150
125
100
75
50
25
0
A
B
C
D
AT NORMAL CLEARANCE,
DISCHARGE PRESSURE,
& NO LIQUID IN
COMPRESSION CHAMBER
0 10 20 30 40 50 60 70 80 90 100
CYLINDER VOLUME (PERCENT)

45


WORK DONE BY COMPRESSOR
PRESSURE (PSI)
300
275
250
225
200
175
150
125
100
75
50
25
0
A
A'
B
B'
C
D
LOST CAPACITY
AT NORMAL CLEARANCE,
DISCHARGE PRESSURE,
& NO LIQUID IN
COMPRESSION CHAMBER
0 10 20 30 40 50 60 70 80 90 100
CYLINDER VOLUME (PERCENT)

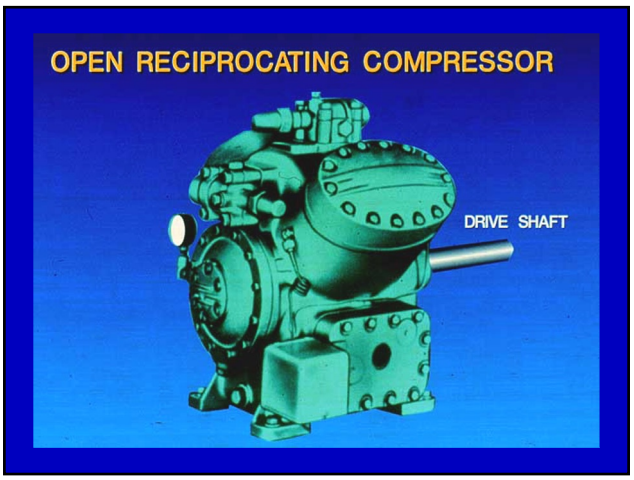
46


WELDED HERMETIC
RECIPROCATING COMPRESSOR

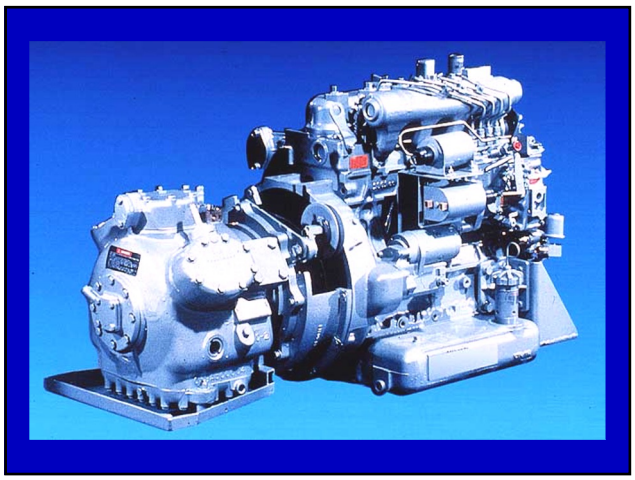
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BOLTED HERMETIC

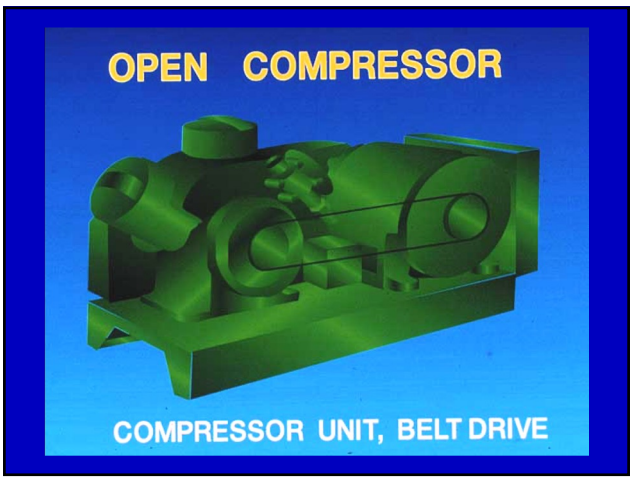
48


OPEN RECIPROCATING COMPRESSOR
DRIVE SHAFT

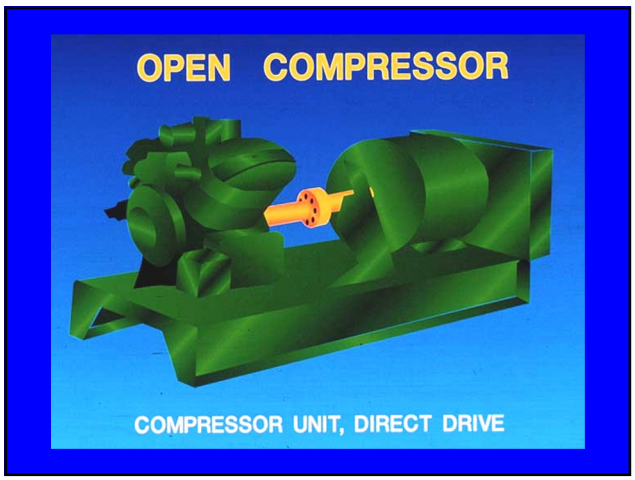
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50


OPEN COMPRESSOR
COMPRESSOR UNIT, BELT DRIVE

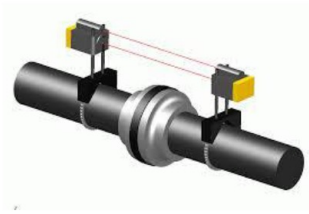
51


OPEN COMPRESSOR
COMPRESSOR UNIT, DIRECT DRIVE

52

LASER ALIGNMENT TOOLS- SHAFT ALIGNMENT





53

ALINMENT

Alignment of motor to compressor is Very important especially in high speed Rotation. This can prolong the mechanical Seal life and bearings.

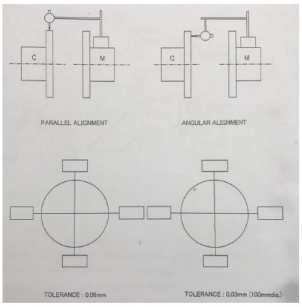
Poor alignment will result to refrigerant and Oil leaking in the shaft.

Alignment tolerance

Parallel – 0.06mm max
Angular – 0.03mm max

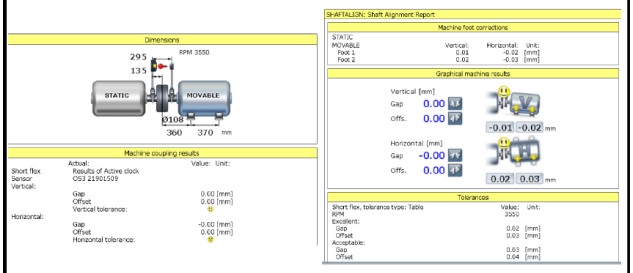
By laser alignment tool, alignment can be Done nearly to 0.0mm. Almost perfect Alignment.

Laser tool alignment needs to be calibrated every 2years as per supplier.



54

EXAMPLE OF ALIGNMENT REPORT



55

RECIPROCATING COMPRESSOR CAPACITY CONTROL

1. CYCLING MULTIPLE COMPRESSORS
2. MOTOR SPEED CONTROL
3. CYLINDER UNLOADING
4. COMBINATIONS OF 1&3 OR 1&2

56

COMPRESSOR CAPACITY DROPS DRASTICALLY WHEN DISCHRAGE PRESSURE INCREASES

3 Cylinder Compressor

	Capacity - Ton	Power Consumption kW	kW / TON
25^{0}C / +5^0 C	117.75	63.5	0.539
+35^{0}C / +5^0 C	106.91	75.5	0.706
+45^{0}C / +5^0 C	95.66	88.65	0.926

57

57

COMPRESSOR CAPACITY DROPS DRASTICALLY WHEN SUCTION PRESSURE DROPS

	Capacity Ton	Power Consumption kW	kW / TON
40^0 C / +5^0 C	101.32	82.0	0.809
+40^{0}C / -15^0 C	44.47	63.5	1.427
+40^{0}C / -30^0 C	19.21	40.2	2.092

58

58

Lower Suction means more Energy

Compressor operating conditions	Capacity –kW	Power consumption -kW
+38^{0}C/-2^{0}C-- 43 psig suction pr.	202	40.42
+38^{0}C/-10^{0}C---27.4 psig	202	59.07 (18.65 Extra Power)
Extra cost	18.65kW x Rs. 5/kW x 20 hrs x300 days=Rs.5,59,500	

59

SUPERHEAT REDUCES CAPACITY

+ 40^0 C / +5^0 C , Ammonia

Superheat	CAPACITY kcal/hr
0 K	359400
5 K	350700
10 K	342600

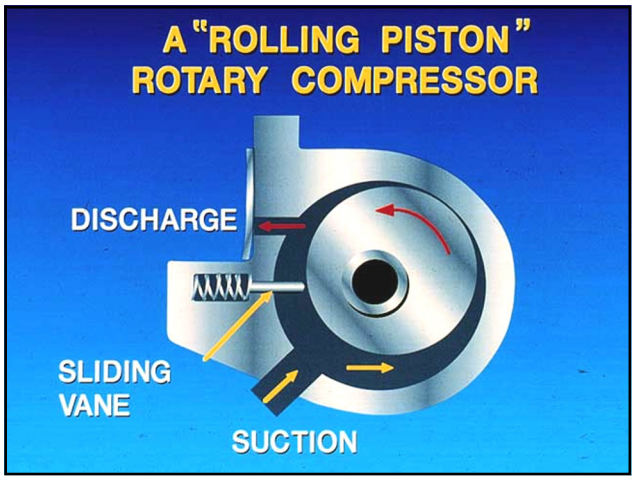
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60

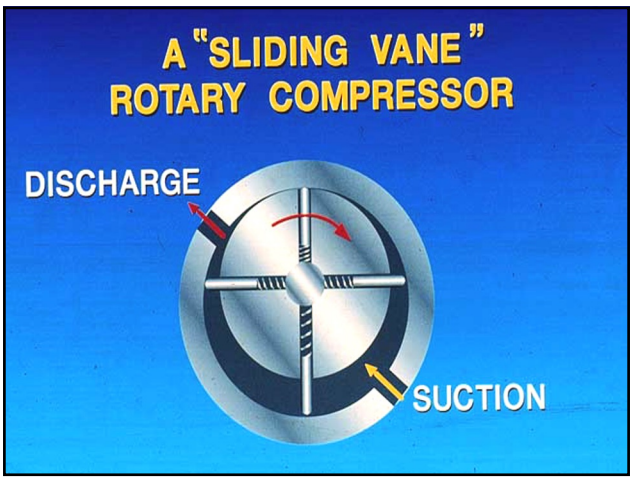
SUBCOOLING INCREASES COMPRESSOR CAPACITY-
40^0C/-15^0C-R22 Refrigerant—Coolpack software

Sub cooling-^{0}C	Capacity - kJ/kg	Power consumption- kJ/kg	C.O.P
0^0C	149.879	41.812	3.58
5^0C	156.452	41.812	3.74
10^0C	162.902	41.812	3.90

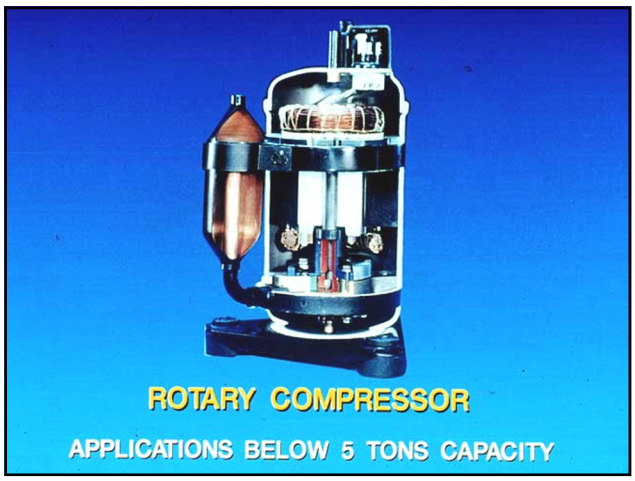
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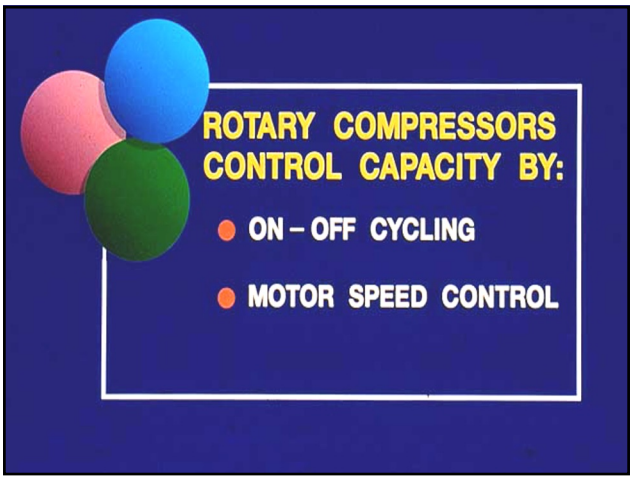
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63



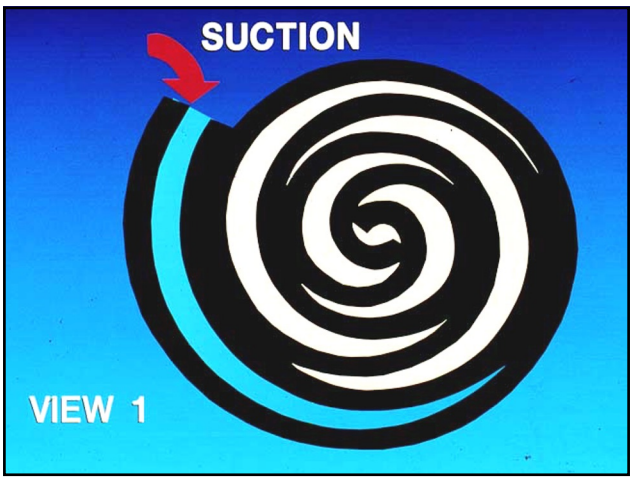
64


ROTARY COMPRESSORS
CONTROL CAPACITY BY:
ON – OFF CYCLING
MOTOR SPEED CONTROL

65


SCROLL COMPRESSOR

66


SUCTION
VIEW 1

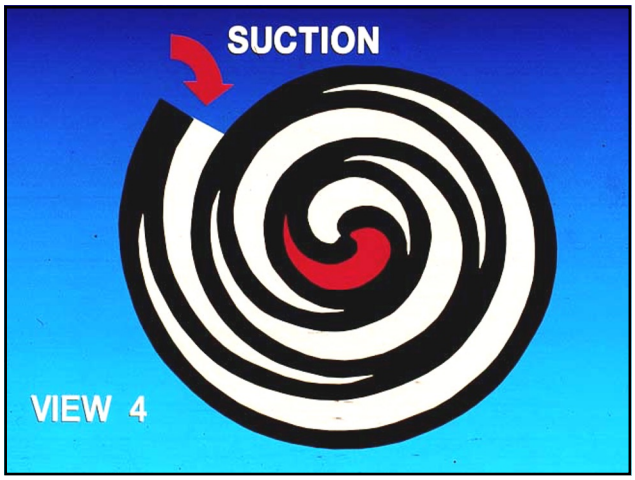
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SUCTION
VIEW 2

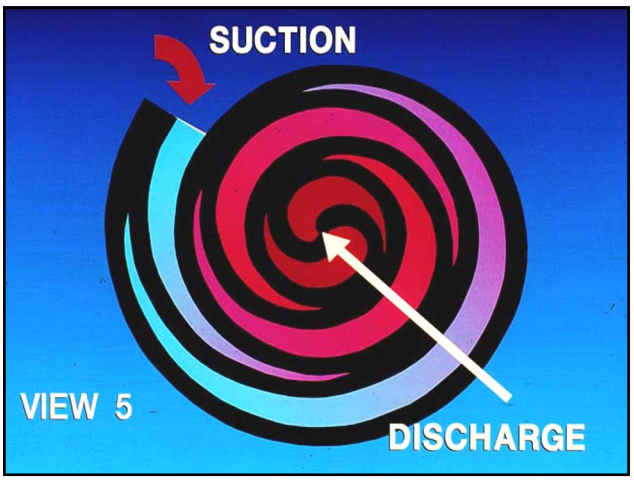
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SUCTION
VIEW 3

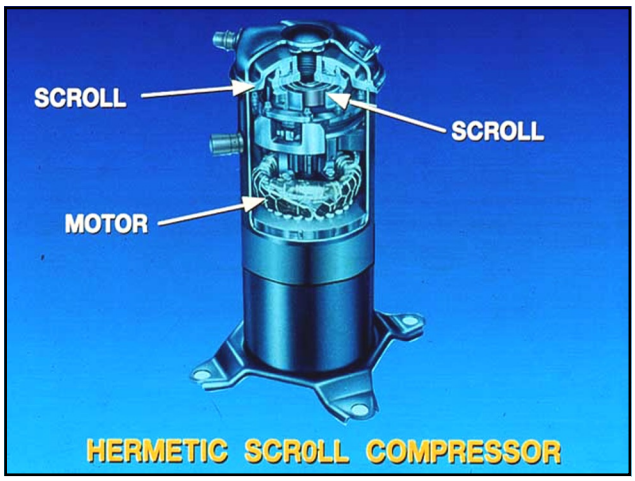
69


SUCTION
VIEW 4

70


SUCTION
VIEW 5
DISCHARGE

71


SCROLL
SCROLL
MOTOR
HERMETIC SCROLL COMPRESSOR

72

COMPLIANT SCROLL DESIGN IS MORE TOLERANT TO LIQUID REFRIGERANT



73

ROTARY COMPRESSORS CONTROL CAPACITY BY:

- ON – OFF CYCLING
- MOTOR SPEED CONTROL

74

WORKING OF SCREW COMPRESSOR

75

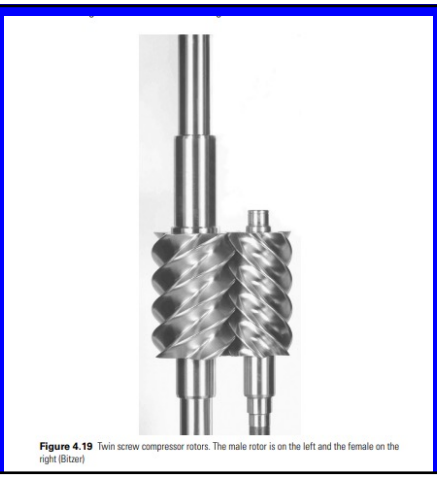
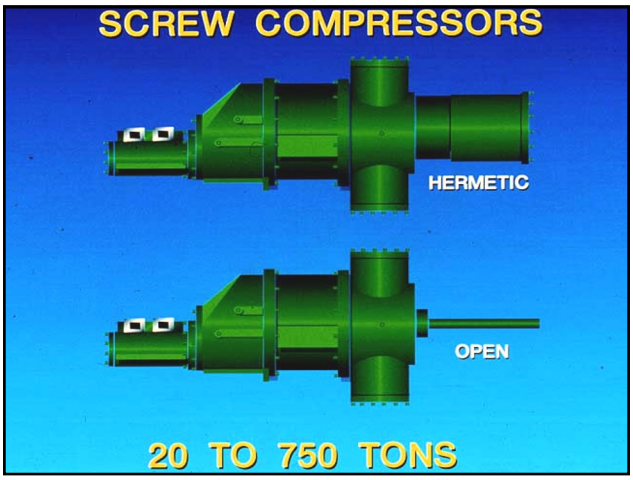
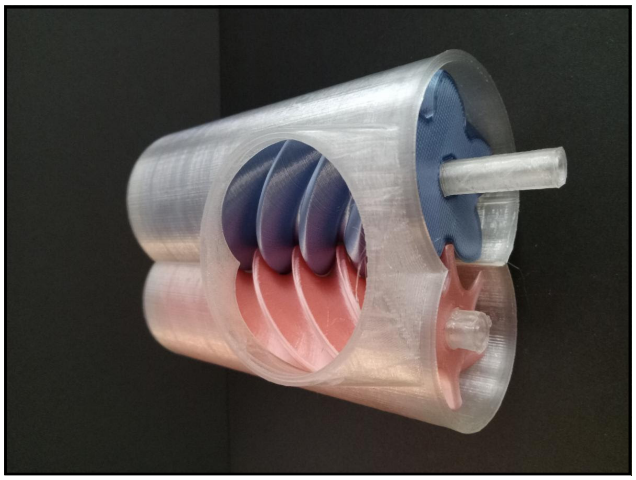


Figure 4.19 Twin screw compressor rotors. The male rotor is on the left and the female on the right (Bitzer)

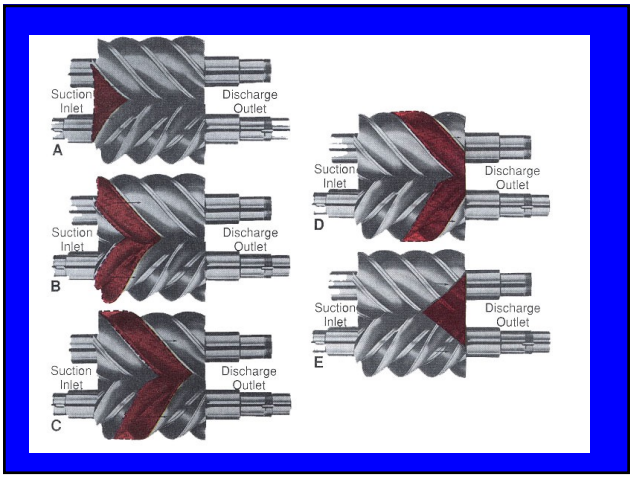
76


SCREW COMPRESSORS
HERMETIC
OPEN
20 TO 750 TONS

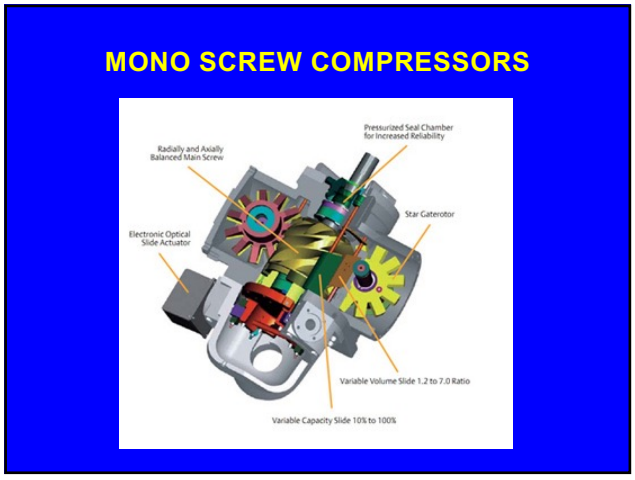
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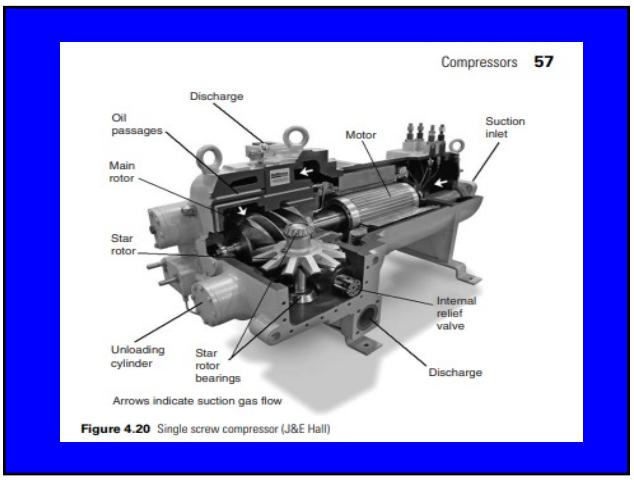
78


Suction Inlet
Discharge Outlet
A
B
C
D
E

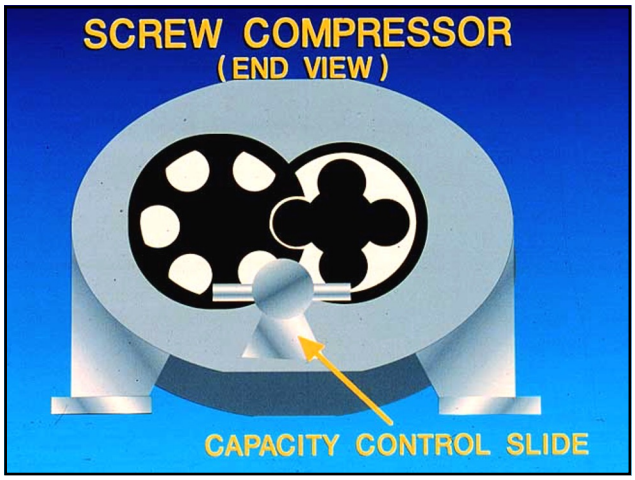
79


MONO SCREW COMPRESSORS
Radially and Axially Balanced Main Screw
Pressurized Seal Chamber for Increased Reliability
Star Gaterotor
Electronic Optical Slide Actuator
Variable Volume Slide 1.2 to 7.0 Ratio
Variable Capacity Slide 10% to 100%

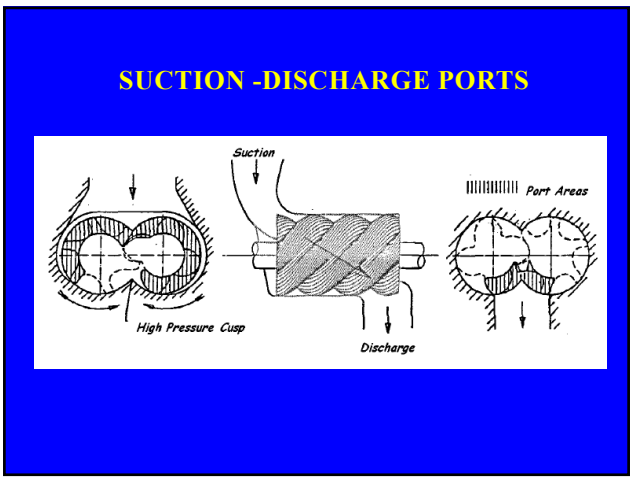
80


Compressors 57
Discharge
Oil passages
Motor
Suction inlet
Main rotor
Star rotor
Internal relief valve
Unloading cylinder
Star rotor bearings
Discharge
Arrows indicate suction gas flow
Figure 4.20 Single screw compressor (J&E Hall)

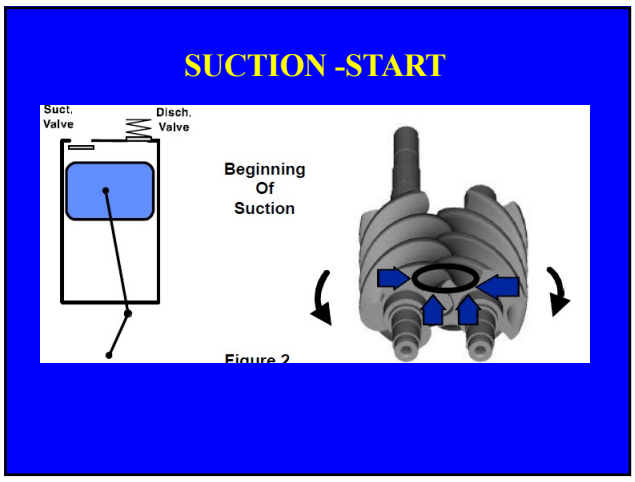
81


SCREW COMPRESSOR
(END VIEW)
CAPACITY CONTROL SLIDE

82

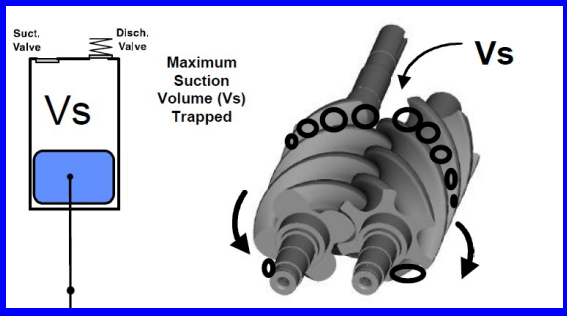

SUCTION -DISCHARGE PORTS
Suction
Port Areas
High Pressure Cusp
Discharge

83


SUCTION -START
Suct. Valve
Disch. Valve
Beginning Of Suction
Figure 2

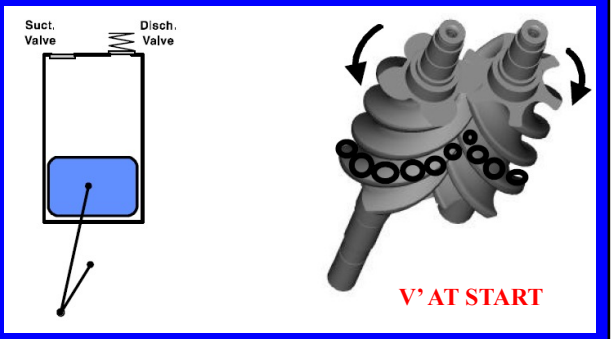
84

END OF SUCTION



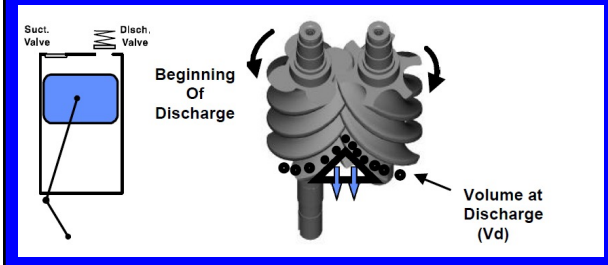
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START OF COMPRESSION



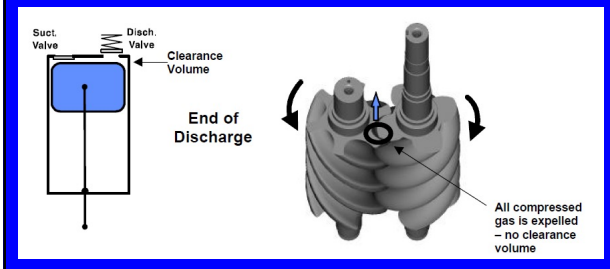
86

START -DISCHARGE

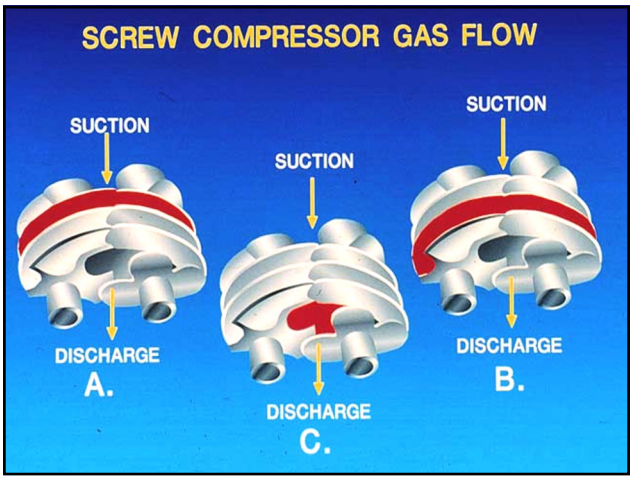


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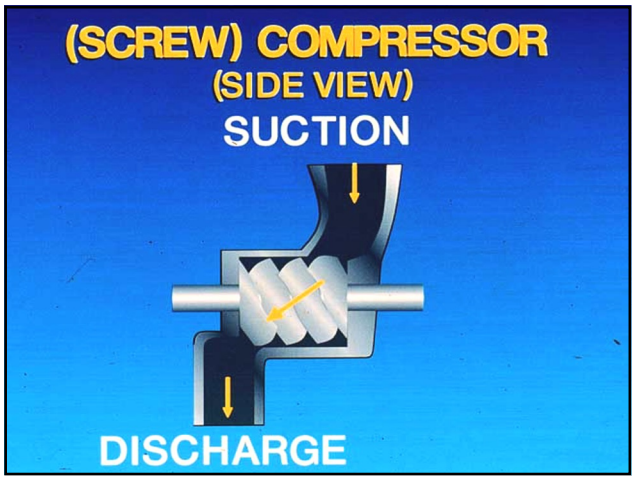
END OF DISCHARGE



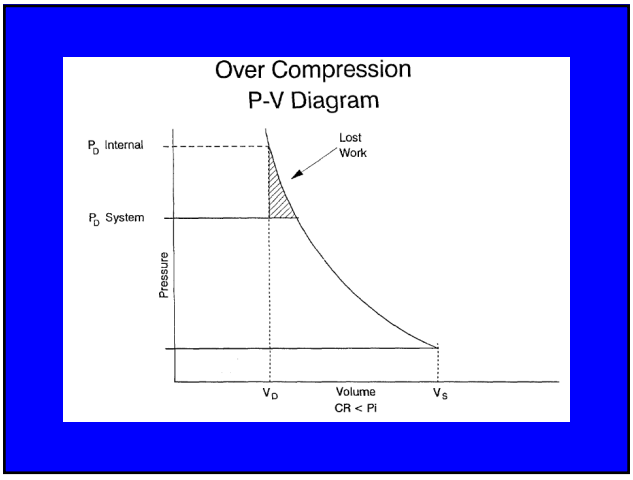
88


SCREW COMPRESSOR GAS FLOW
SUCTION
DISCHARGE
A.
SUCTION
DISCHARGE
C.
SUCTION
DISCHARGE
B.

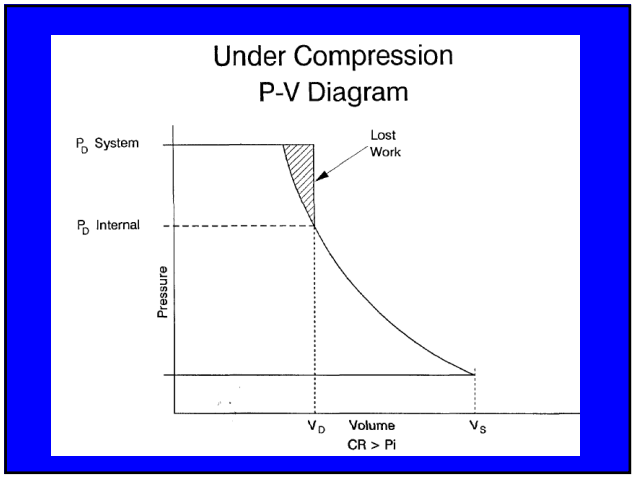
89


(SCREW) COMPRESSOR
(SIDE VIEW)
SUCTION
DISCHARGE

90

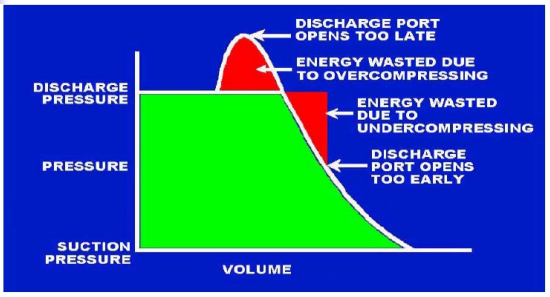

Over Compression
P-V Diagram
P_D Internal
Lost
Work
P_D System
Pressure
V_D
Volume
CR < Pi
V_S

91


Under Compression
P-V Diagram
P_D System
Lost
Work
P_D Internal
Pressure
V_D
Volume
CR > Pi
V_S

92

Screw Compressor Efficiency



93

A reciprocating compressor can be more efficient because it has a well-defined compression volume with relatively low internal leakage and can achieve excellent volumetric and isentropic efficiency.

But:

A screw compressor sacrifices some efficiency through internal leakage and oil/rotor-related losses, while gaining major advantages in large-capacity, continuous-duty applications.

94

1. Reciprocating compressor — variable compression ratio

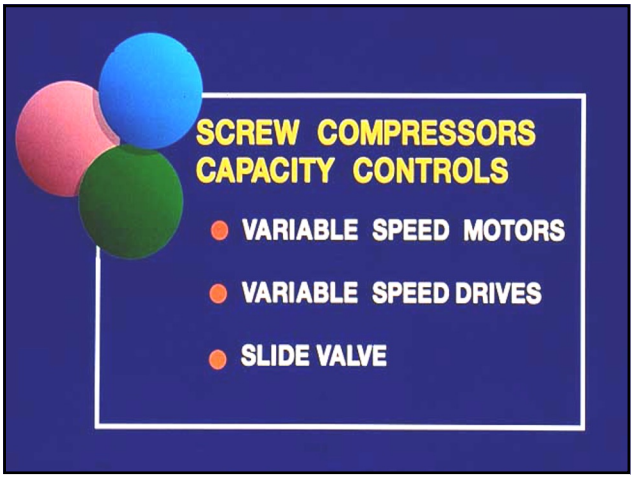
In a reciprocating compressor, the end of compression is not fixed by the compressor geometry. The discharge valve opens when the cylinder pressure becomes slightly higher than the discharge pressure.

2. Screw compressor has a built-in geometric relationship:

$$V_i = \frac{V_{\text{suction pocket}}}{V_{\text{discharge pocket}}}$$

Which means fixed internal compression ratio

95



96

Screw compressor for given speed is constant volume, variable mass With constant internal compression and variable external compression ratio machine

97

DIFFERENCE IN RECIP. AND SCREW COMPRESSOR

Reciprocating compressor for given speed is constant volume , variable mass flow and variable compression ration machine

Screw compressor for given speed is constant volume, variable mass and constant internal compression and variable external compression ratio machine

98

Reciprocating Compressor

$\downarrow t_0$(°C)	$\downarrow \triangle t_k$(K)		$\rightarrow t_c$(°C)	+20	+25	+30	+35	+40	+45
+10	0	Q_0 (kcal/h)	—	968 200	937 400	905 600	872 800	839 100
	5		—	944 400	914 300	883 300	851 300	818 500
	10		—	922 300	892 900	862 600	831 400	799 300
	—	P_e (kW)	—	102.2	118.9	136.6	155.0	173.8
+ 5	0	Q_0 (kcal/h)	830 900	804 300	776 800	748 300	718 900	688 600
	5		810 800	784 800	758 000	730 200	701 500	671 900
	10		792 000	766 600	740 400	713 300	685 200	656 400
	—	P_e (kW)	88.3	103.1	118.6	134.8	151.3	167.8
0	0	Q_0 (kcal/h)	685 200	661 500	636 800	611 300	584 800	557 000
	5		667 700	644 600	620 600	595 700	569 900	543 200
	10		652 500	629 900	606 400	582 100	556 900	530 800
	—	P_e (kW)	88.9	102.6	116.7	131.1	145.4	159.2
— 5	0	Q_0 (kcal/h)	558 900	537 600	515 500	492 500	468 500	443 700
	5		545 700	525 000	503 400	480 900	457 500	433 300
	10		533 400	513 100	492 000	470 000	447 200	—
	—	P_e (kW)	88.3	100.6	113.0	125.3	137.0	147.7
—10	0	Q_0 (kcal/h)	450 200	431 000	411 000	390 200	368 400	—
	5		439 600	420 900	401 400	381 000	359 800	—
	10		429 700	411 400	392 400	372 500	—	—
	—	P_e (kW)	86.2	96.9	107.3	117.1	125.8	—

2nd

99

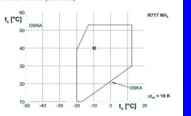
Screw Compressor

Compressor Selection: Open Screw Compressors

Input Values

Compressor model	OSKA8581-K
Refrigerant	R717 [NH3]
Reference temperature	Dew point temp.
Evaporating SST	-10°C
Condensing SDT	40°C
Operating mode	Standard
Liquid subcooling	0K
Discharge gas temp.	80°C
Suct. gas superheat	10K
Useful superheat	100%
Speed	2900 /min
Capacity Control	100%

Application Limits (Standard)



Output

Compressor model	OSKA8581-K
Cooling capacity	300 kW
Cooling capacity *	303 kW
Evaporator capacity	300 kW
Power input	93.9 kW
Condensing capacity	337 kW
COP/EER	3.19
COP/EER *	3.23
Mass flow LP	994 kg/h
Mass flow HP	994 kg/h
Operating mode	Standard
Liquid temp.	40.0 °C
Oil volume flow	2.99 m³/h
Oil cooler outlet	40.4 °C
Oil cooler load	56.9 kW
Necces. driving motor	110.0 kW
DG w/o cooling	158.5 °C

Starting point for motor selection see T. Data/ Notes
Additional cooling/ Limitations (see Limits + T. Data)!
Tentative Data.
*According to EN12900 (5K suction gas superheat, 0K liquid subcooling)

2nd August 20

100

Compressor Selection-40^{0}C/-2^{0}C

- Reciprocating- 3 cylinder-KC3- 650 RPM
- 56.39 TR(198.34kW), 46.88kW Power
- 0.831kW/TR (COP=4.23)

- Screw-OSKA 7461-K - 2900 RPM
- 52.74 TR(185.5 kW),, 46.9 kW Power
- 0.8893kW/TR(COP=3.96)

101

SCREW V/S RECIPROCATING- Ammonia Refrigerant +40^{0}C/-45^{0}C

Make -Model	Capacity-kW	Power consumption-kW	kW/Ton
Mycom - MCN2520	244	194.3	3.065
MCN250B+MCN160ME	243.8	177.9	2.566
Howden WRV255-110	225	193	3.01
KC72-system 'C'	106.5	71.5	2.36

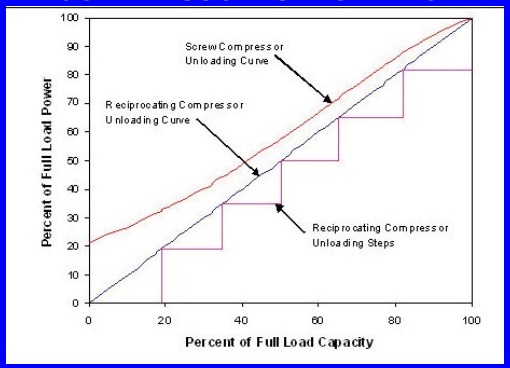
102

ENERGY SAVING USING RECIPV/S SCREW

- (3.065-2.36)x80 Ton x 20 hrs x 30days x8months x 8Rs/kW= Rs. 21,65,760 per year besides capital cost of nearly 53,00,000

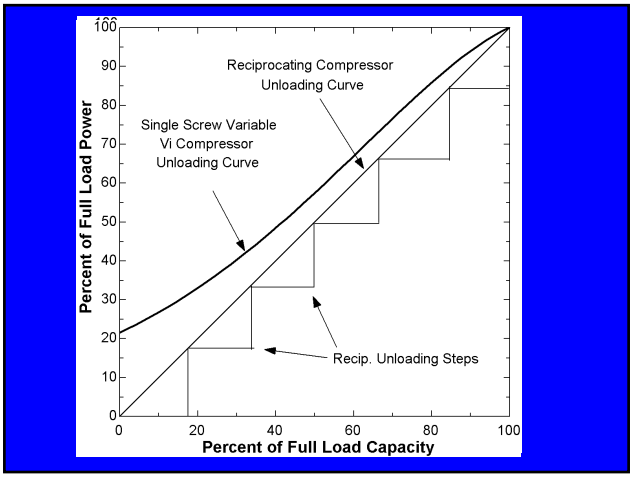
103

COMPRESSOR UNLOADING



Ref: ASHRAE Journal Article November 2013

104



105

SCREW V/S RECIPROCATING POWER COMPARISON

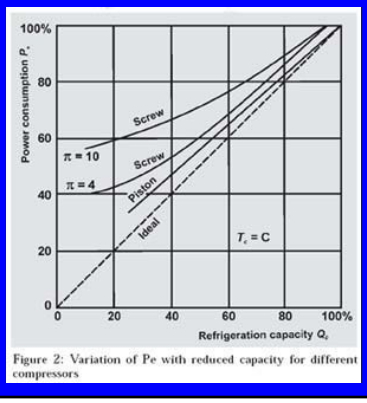


Figure 2: Variation of Pe with reduced capacity for different compressors

REF: ISHRAE Journal – Jan-March 2004

106

PART LOAD COMPARISON –SCREW V/S RECIP.

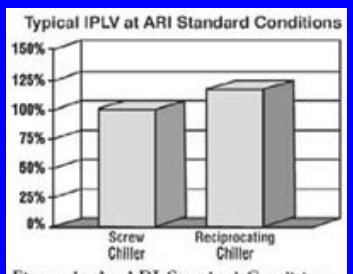


Figure 1: At ARI Standard Conditions, the Integrated Part Load Value of reciprocating chillers is 10-15% better than screw chillers.

107

HEAT PUMP PERFORMANCE-HIGH AMBIENT TEMPERATURE

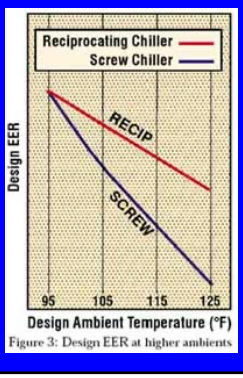
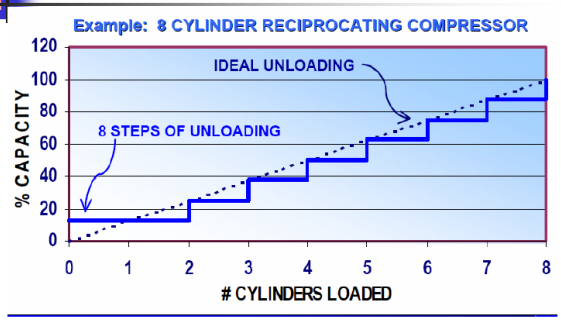


Figure 3: Design EER at higher ambients

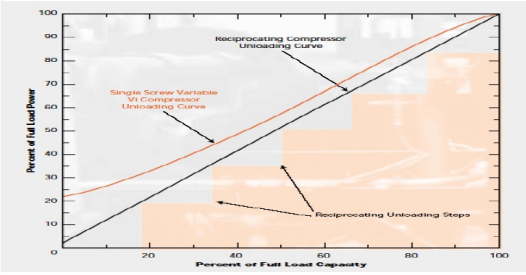
108

Reciprocating Compressor Unloading



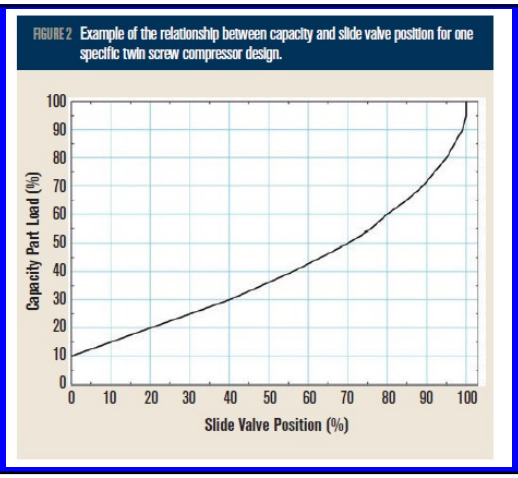
109

Part Load Efficiencies

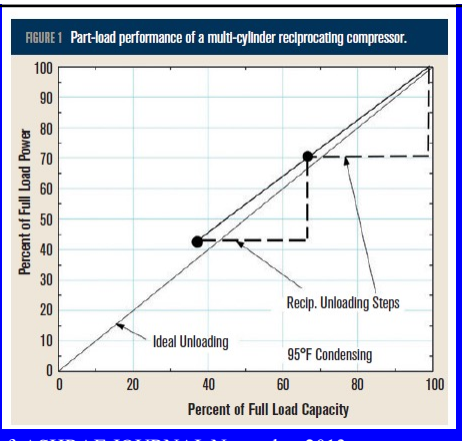


Ref; I(SHRAE Journal-Jan-march 2004

110

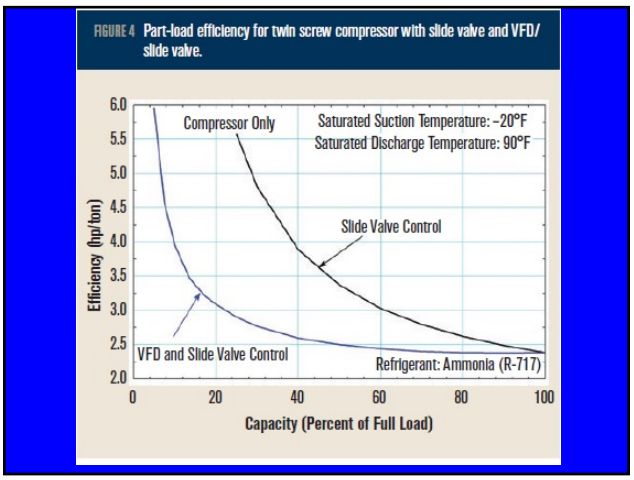


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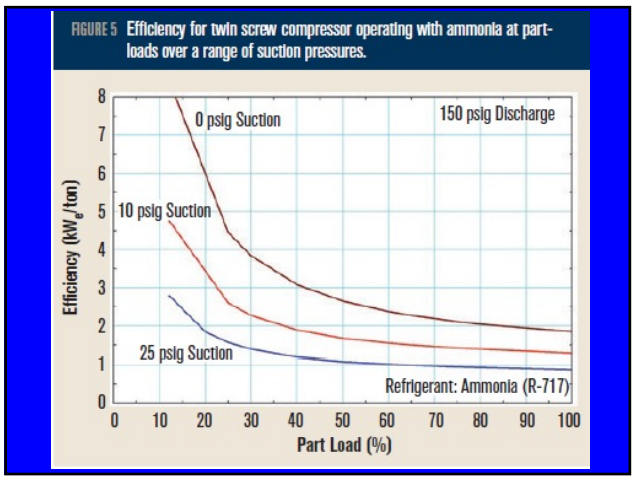


Ref: ASHRAE JOURNAL November 2013

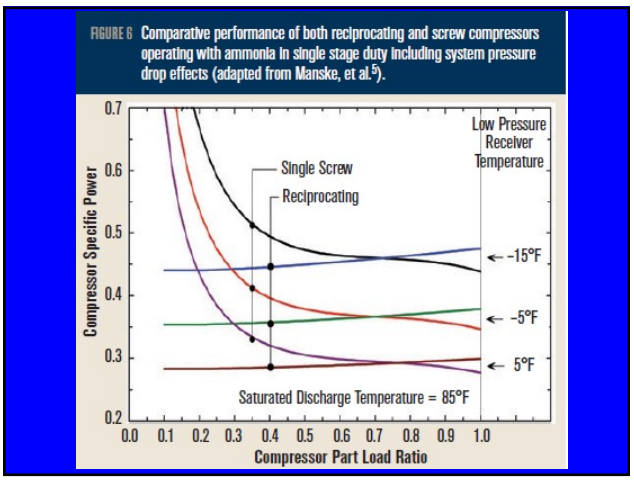
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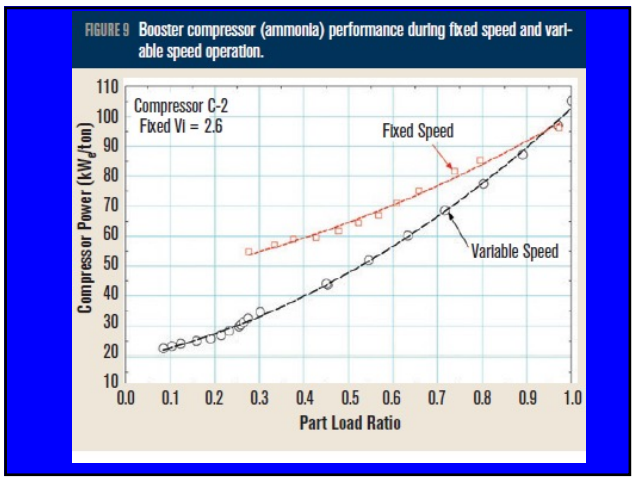
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114



115



116

WHEN SCREW COMPRESSORS ARE MORE EFFICIENT

Continuous Operation: They are built for a **100% duty cycle** (running non-stop) without overheating, whereas piston compressors typically require a 20% to 50% rest-and-cooling cycle.

Fewer Mechanical Losses: They use rotating helical screws with fewer rubbing parts than reciprocating pistons, translating to smoother airflow and less wasted energy.

Variable Speed Drive (VSD) Options: Modern VSD screw units adjust motor speed to match exact air demand, cutting energy usage significantly compared to fixed-speed or load/unload machines

Reciprocating compressors loose efficiency over the period due to frictional losses, and requires regular maintenance to keep them working at the highest efficiency

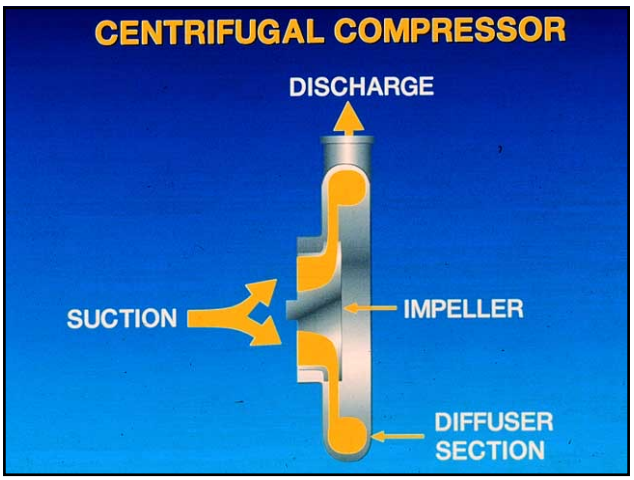
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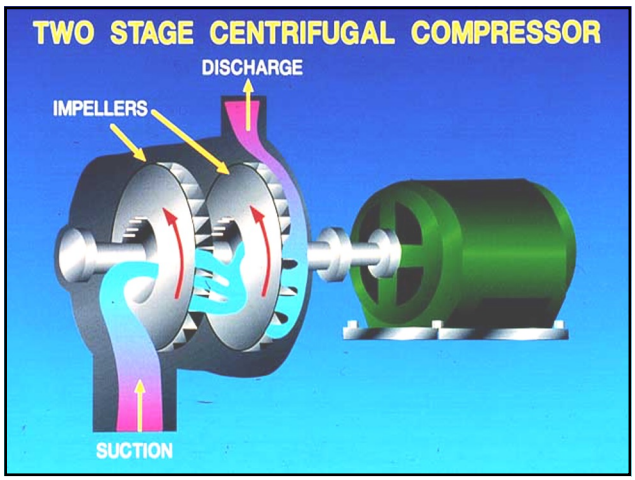
SCREW V/S RECIPROICATING COMPARISON

The screw compressor has two moving parts which do not touch	Reciprocating compressor has many moving parts like pistions, crankshaft,piston rings, valve plates that cause wear and tear
Operating temperatures are low	Operating temperatures are high, may require water cooling
Low or Nil vibrations	Requires foundation , flywheel , reciprocating machine has always the vibrations
Low MTBF	Requires regular Maintenance
Has independent oil circulation pump, compressor speed can be regulated over a wide range with VFD	Has built in oil pump, lower sped limit essential to ensure proper lubrication

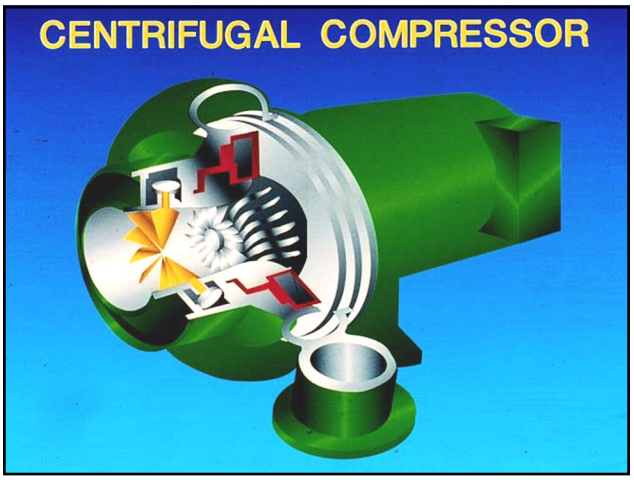
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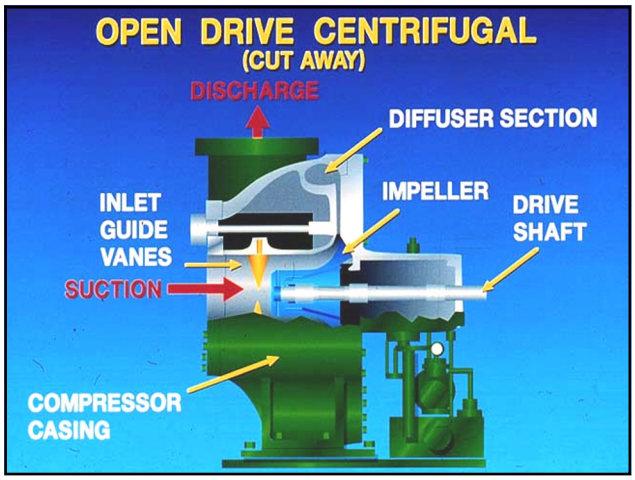
119



120



121



122

CENTRIFUGAL CHILLER EFFICIENCY PROGRESS

EFFICIENCY - kW/TON

YEAR	AVERAGE	GOOD
1979	0.80	0.72
1980	0.72	0.68
1990	0.65	0.62
1991	0.64	0.60
1993	0.63	0.55
1995	0.61	0.52
1997	0.60	0.50
1999	0.59	0.49
2000	0.58	0.48
2002/2006	0.56	0.45
2012-2013	0.45	0.32 IPLV

0.1 kW/TON = 9.9 billion kg of CO_2 + 6.3 grams SO_2,
+ 3.5 billion gms NOx OR = 3 MILLION CARS OFF ROAD
OR = PLANTING 600 MIL. TREES

123

IMPROVEMENTS OVER THE YEARS
IN RECIPROCAING COMPRESSORS

124

GOELDNER GERMAN AMMONIA COMPRESSOR-SMALL CAPACITY-6m3/hr-6kW



125

BOCK GERMANY-F2 AMMONIA COMPRESSOR: 10.5 M^3/H Capacity 10.3kW



126

AMMONIA SLOW SPEED COMPRESSORS-SLOW SPEED COMPRESSORS-UP TO 400 RPM TILL 1970





127

MEDIUM SPEED AMMONIA COMPRESSORS-UP TO 750 RPM



128

MEDIUM SPEED AMMONIA COMPRESSORS-
UP TO 1000 RPM



129

MEDIUM SPEED AMMONIA COMPRESSORS-
UP TO 1200 RPM



130

HIGH SPEED AMMONIA COMPRESSORS-
UP TO 1450RPM



131

SEMI HERMATIC RECIPROCATING COMPRESSORS-NOT
FOR AMMONIA REFRIGERANT



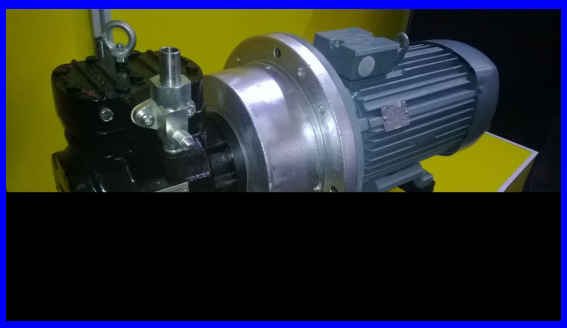
132

Hermetic Reciprocating Compressor



133

Small capacity -7kW Ammonia Reciprocating Compressor - HKT –GOELDNER-GERMANY



134

Carrier Corporation has developed new Ammonia compressor & has entered in Ammonia market



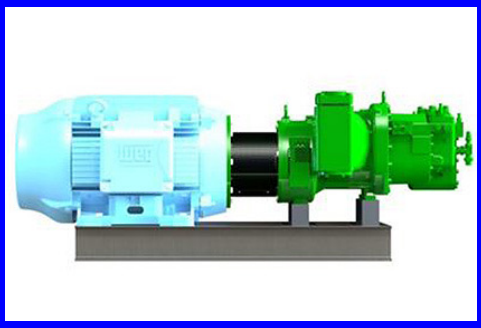
135

SCREW COMPRESSOR



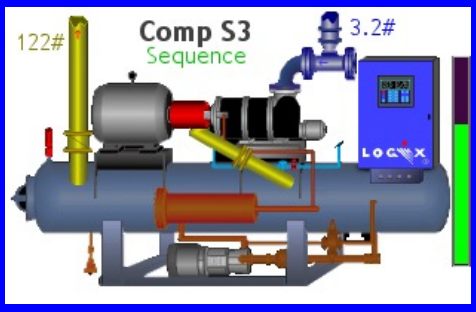
136

HIGH SPEED AMMONIA SCREW COMPRESSORS-
3000 /3600 RPM



137

COMPRESSOR-MOTOR SET



138

PAIR OF ROTORS FOR SCREW



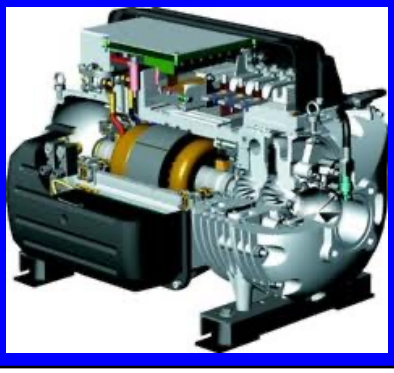
139

MONO SCREW COMPRESSOR



140

TERBOCOR COMPRESSOR



141

TERBOCOR CHILLER



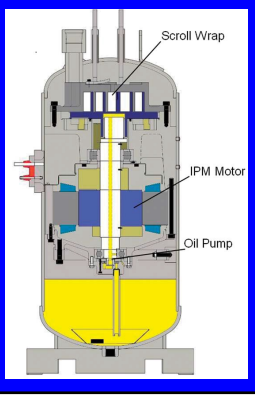
142



HERMETIC AMMONIA SCROLL COMPRESSOR WITH ENCAPSULATED COPPER WINDING MOTOR

143

HERMETIC AMMONIA SCROLL COMPRESSOR



144

New Technology for use of encapsulated copper winding motors for Ammonia

A new electromotor technology is being developed now, using encapsulated copper windings or aluminium windings for semi-hermetic ammonia compressor. A hermetic scroll compressorfor ammonia small refrigerating systems is announced and first small chilling units are sold on the market. The DX evaporators require miscible oil with ammonia; new compressor oil types are developed.

145

Semi Hermetic Ammonia Compressor with aluminum winding motor



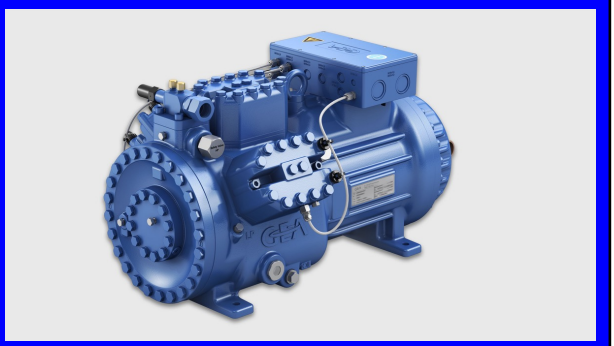
146

CO2 COMPRESSOR-(Car Air conditioning)



147

CO_2 COMPRESSOR- (Industrial applications)



148

ASHRAE HVAC&R INDUSTRY NEWS

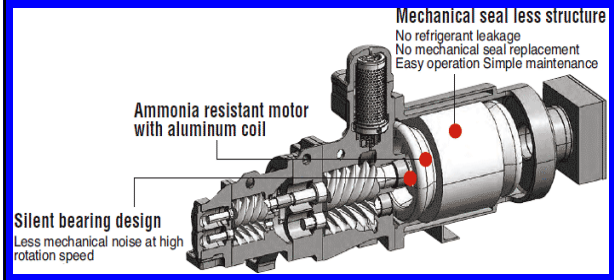


Semi-Hermetic Ammonia System Heats, Cools Dutch Business, Apartment Complex

EINDHOVEN, The Netherlands—An ammonia heat pump has been installed to heat and cool 40,000 m^2 of apartments and business premises in the Netherlands. The re-modeled office complex, a former factory for conglomerate Philips, will use the 800 kW ammonia heat pump system fitted with two twin screw compressors for space heating during the winter and air conditioning during the summer. One of the compressors is redundant in case the system fails. An ammonia heat pump was selected to heat and cool the building complex due to its high-efficiency, zero global warming potential and zero ozone-depleting potential, said the developer.- 18th October 2018

149

AMMONIA SEMI HERMETIC SCREW COMPRESSORS- KOBELCO-MYCOM



150

TERBOCOR CENTRIFUGAL COMPRESSOR WITH MAGNETIC BEARINGS-OIL FREE AND HIGH SPEED UP TO 40000 RPM



151

TITANIUM IMPELLERS FOR CENTRIFUGAL COMPRESSORS



152

1.In addition to Titanium rotors,
2.The development of magnetic bearings allows no lubrification for centrifugal machines and new relatively small centrifugal compressors have been appearing on the market since last five years.
3. This trend is also associated with significant increase in RPMs of those centrifugal compressors. Velocities higher than 25,000 rpm are foreseen.
4. The development of new software enables rapid design of wheels and possible new developments of high speed non-lubricated centrifugal compressors seem a new opportunity.

153

CENTRIFUGAL CHILLER EFFICIENCY PROGRESS

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154

ADVANTAGES OF SCREW COMPRESSORS

1. More reliable machine since less number of parts compared to reciprocating compressor, hence fewer parts means less chances of failure.
2. Fully balanced machine, hence no vibrations during operation. Reciprocating compressor cannot be fully balanced and some amount of unbalance would remain.
3.In case of screw compressors, there is no wear and tear as there are no rubbing parts. The rotors do not touch each other or to the casing and there is lubricating oil encompassing these parts. Only the end bearings which ensure that rotors do not touch each other and the roller bearings can be replaced easily.
4. Screw compressor set does not require foundation and can be mounted on load bearing slab or rigid concrete flooring.

155

ADVANTAGES OF SCREW COMPRESSORS

5. High speed operation 2900 RPM compared to reciprocating compressors for maximum 1500 RPM, hence more compact and requires less space
6. For large capacity requirements, screw compressors are available and preferred. If one wants to use reciprocating compressors, large number of compressors would be required.
7. Generally lubricated with external oil pump hence compressor speed can be controlled to a low level with the help of VFD. Reciprocating compressors cannot be operated below certain speed for the fear of lubrication malfunction leading to higher wear, since the oil pump is directly mounted on crankshaft and runs at the same speed as compressor.
8. The Mean Time between failures (MTBF) or planned maintenance gap is more & better, compared to reciprocating compressors as they require frequent, at least yearly planned shut down for maintenance.

156

ADVANTAGES OF RECIPROCATING COMPRESSORS

1. Reciprocating compressor is variable compression machine and automatically adjusts to match ambient temperature variations. Screw compressor has mostly fixed internal compression ratio and therefore there is over or under internal compression, leading to higher power consumption compared to reciprocating compressors.
2. The power consumption of screw compressor is higher than reciprocating compressors to the tune of 5 to 15 % depending on operating conditions.
3. Part load performance & power consumption of screw compressor with slide valve control is much poorer compared to multi-cylinder reciprocating compressors with automatic step control mechanism. A combination of VFD+ slide valve is more useful for screw compressors.

157

ADVANTAGES OF RECIPROCATING COMPRESSORS

4. For low temperature operation –say -40^{0}C or below, single stage screw compressor cannot be used and one has to use combination of high stage compressor and booster. This increases number of compressors and motor sets. There are few manufacturers who manufacture two stage screw compressors in single frame using 2 pairs or rotors and common single motor. In case of reciprocating compressors single frame uni-build two stage compressors is available and single compressor can be utilized for +40^0 C/-40^{0}C operation or even lower.
5. The capacities and power consumption values for screw compressors are normally published with economizer in circuit. This shows better capacity without increase in power consumption i.e. lower kW/ton. It should be however noted that the economizer efficiency gain is not available for part load operation when slide valve moves beyond economizer port.

158

ADVANTAGES OF RECIPROCATING COMPRESSORS

Hence, advantage of economizer is received only when compressor is operating with a slide valve position between full load and economizer port. In most of the cases due to various safety factors, build in design and operating conditions, if the plant operates at less than full capacity & when the economizer port is bypassed, no benefit is received. The capacity and power consumption should therefore be checked without economizer. Of course the economizer would always be useful if instead slide valve capacity control, a VFD is used so that economizer is always available for all loads.
6. The reciprocating compressor and accessories can be purchased independently and installed at site, whereas screw compressor set has to be purchased as a set

159

DISADVANTAGES OF RECIPROCATING COMPRESSORS

The disadvantage of reciprocating compressors is, there is continuous wear and tear of piston rings. This reduces efficiency as the compressor. Efficiency therefore deteriorates over the period unless it is maintained properly and timely by replacing parts as per suggested maintenance practices.
The reciprocating compressors are generally belt driven and hence as the belts wear out the transmission losses increase, unless belts are tightened periodically.

160



Thank you for listening

161

Thank you

Any Questions ?

Ramesh Paranjpey

Fellow Life member ASHRAE

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ramesh.paranjpey@gmail.com

162