Wellcome

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2nd Feb 24 AAR ARCON 2024
Chennai 1

1

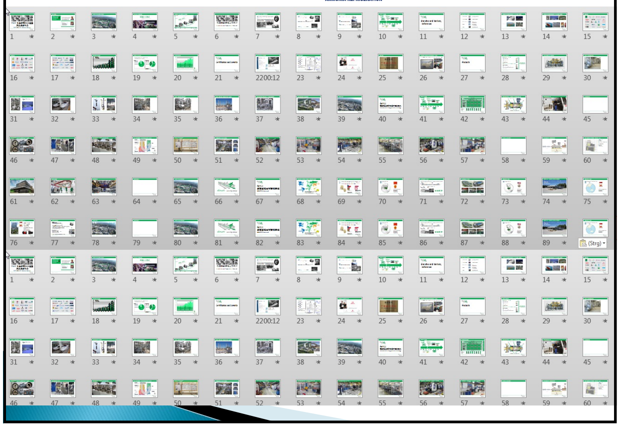
Optimizing Ammonia Pump Performance

India is the world's largest producer of milk and the second-largest producer of fruit and vegetables.

2

2

Overview of Slides 1- 37 / Achim Surber



3

AGENDA

2nd Feb. Chennai

01	**Types of pumps for Ammonia applicaton**	10'
02	Optimizing performance - operation	15'
03	Common mistakes – pump installation	10'
04	Pump performance problems - Cavitation	10'

2nd Feb 24 AAR ARCON 2024
Chennai 4

4

Pump is a very small but important part

Picture: Cooling system for modern 1800m3 tunar fishing vessel

2nd Feb 24 AAR ARCON 2024
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5

Conventional pump with shaft seal

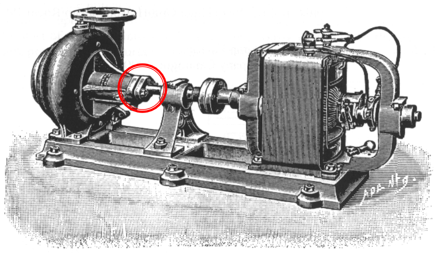

Fig 1.6 First standard production centrifugal pump from the W. Lederle Engine and Pump Factory from 1898.

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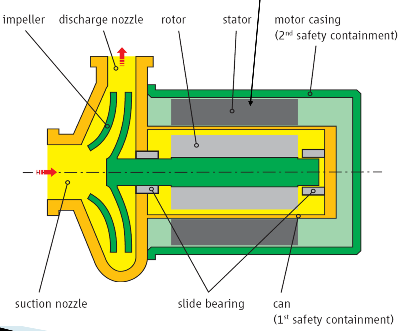
6

Technical Principle of seal-less canned motor pump

=> Not in contact with ambient atmosphere
=> No condensation and freezing inside



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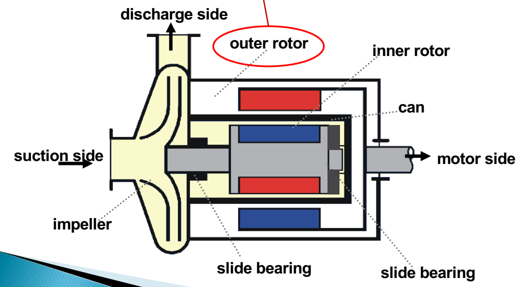
7

Technicl principle of sealless magnetic coupled pump

Problematic at liquid with cold temp
=> during operation heat in outer rotor
=> at stop condensation and freezing in outer rotor



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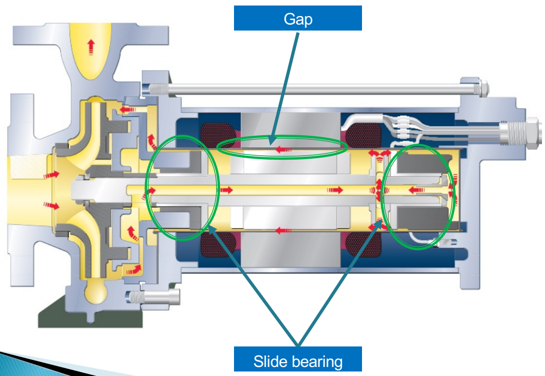
8

Internal Flow



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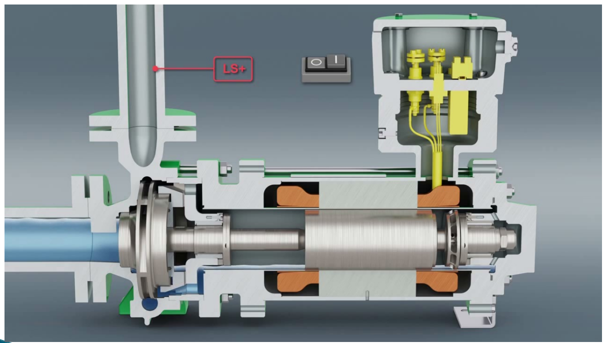
9

Internal flow



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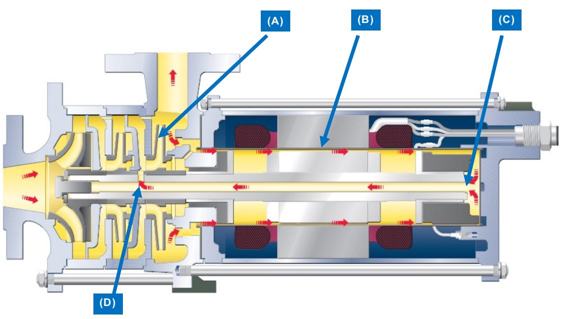
10

10

Internal flow mutlistage



Multistage
partial flow is devided at high pressure level from the last impeller (A) through the motor (B) and flows back (C) to a lower pressure level between the stages (D)

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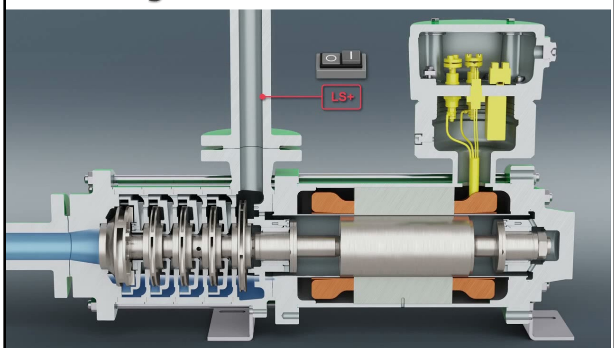
11

Multistage Internal Flow



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12

Technology compare

Conventioal seals | Seal less

	conventional seal	sealless
Pump efficiency	10-70%	10-70%
Motor efficiency	90-97%	appr. 85% because of can
Maintenance interval	2-3 years (seals, roller ball bearings)	8-10 years Up to 30 years at constant operation
Operational safety	Leakage, mechanical seal	Leakage free
Seal failure	Possible	Non seal

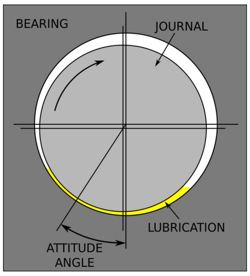
13

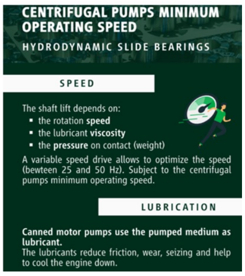
Technology compare

	multi stage	single stage
Pump efficiency	Lower flow – high head	Higher flow – lower head
Typical Flow / Head	0,5-35m3/h / max. 130m	10-60m3/h / max. 55m
Head	By number of stages	By increase diameter
Hydraulic efficiency	At higher head better	Lower at higher head
NPSH	Lower Often special suction impeller	higher
Vapor pressure	High vapor pressure	Lower in vapor pressure handling

14

Technology slide bearing





15

Sealles pumps should never run dry

16

AGENDA

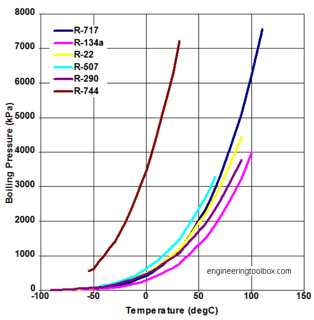
24th January 2020 / Mumbai

Association of AMMONIA REFRIGERATION

17

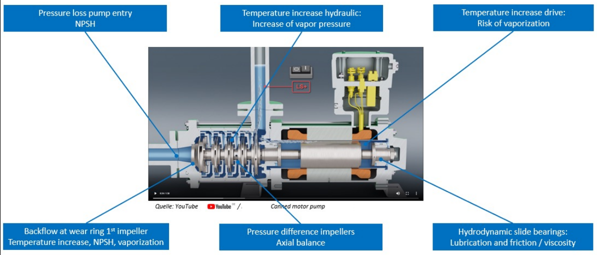
Refrigeration Liquid for pumping system

Liquid	Population
R717 (NH3)	80%
R22 (Frigen)	
R744 (CO2)	12%
R134a	
R11	
R12	
Propan	
Butan	
……..	



18

Knowledge for correct Ammonia pump design



2nd Feb 24 AAR ARCON 2024
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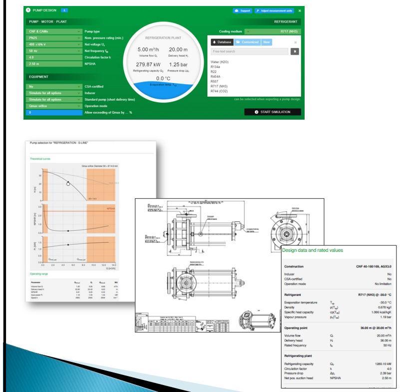
19

Software assisted selection of pump type



Modern pump selection software Input:
- flow & head
- Liquid & temperature
- Refrigeration capacity

Software calculation:
- > 200 calculations in background
- Hydaulic and motor
- Thermal balance
- Vaporisation
- NPSH
- Min, max flow
- Data sheets
- GA drawing
- Sectional drawing

2nd Feb 24 AAR ARCON 2024
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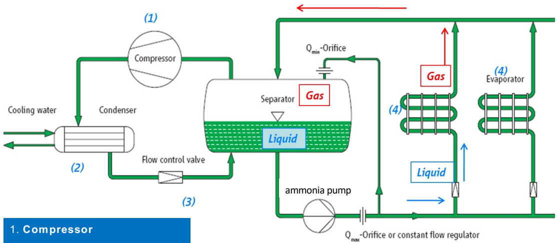
20

Installation and Operation principle



1. Compressor
2. Condenser
3. Expansion valve
4. Evaporator

2nd Feb 24 AAR ARCON 2024
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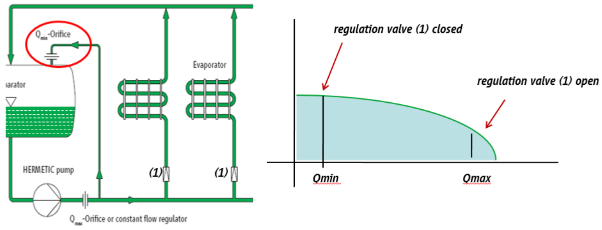
21

Installation and Operation principle – min flow



Why Qmin orifice/bypass:

- Continuous operating, even when expansion valve (1) at evaporator is closed
- Automatic venting when pump is stopped after operation

2nd Feb 24 AAR ARCON 2024
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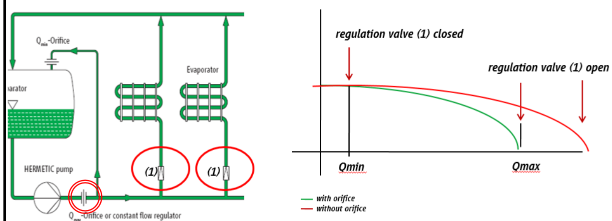
22

Installation and Operation principle – max flow



Why Qmax Protection:

if all regulation valves are open,
pressure ↓, flow ↑, NPSHR ↑
Protecting against over flow

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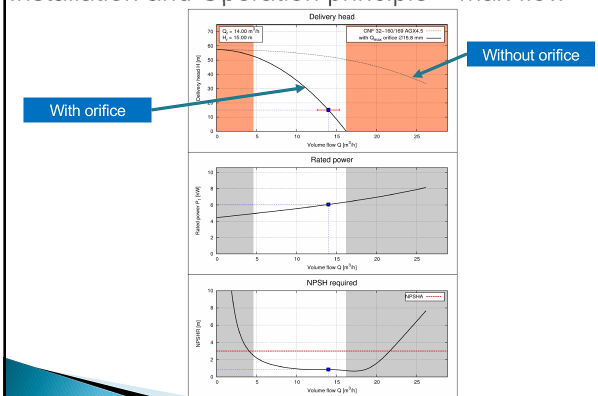
23

Installation and Operation principle – max flow



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24

Operation

Operation outside of allowable operation range

Flow smaller than Q - min:

=> axial balance of pump disturbed
=> heating up of liquid,
=> vaporization in motor
(mixed friction or dry running slide bearings)
=> increasing NPSH value

Exceeding Q - max:

=> high power consumption
=> increasing NPSH value
=> axial balance disturbed

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25

AGENDA

24th January 2020 / Mumbai

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2nd Feb 24 AAR ARCON 2024
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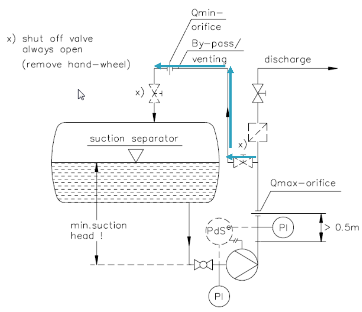
26

Installation and Operation - Venting

Automatic venting of the pumps

During standstill, the by-pass is used as a vent line. The pump should not be started unless it is primed with liquid refrigerant. During first priming or re-starting, wait until all pump parts have cooled down almost to the refrigerant temperature. When using non-return valves at the pump discharge, note that the by-pass line must be installed before the non-return valve, to permit automatic venting, IMPORTANT: No check valve should be used in the bypass line.



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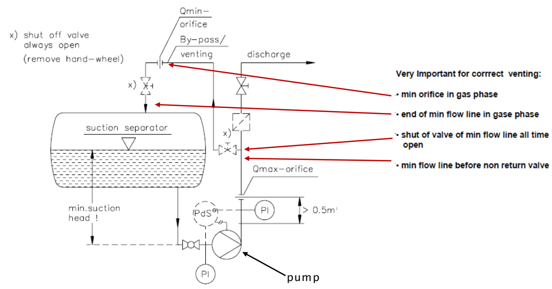
27

Venting / be aware of….



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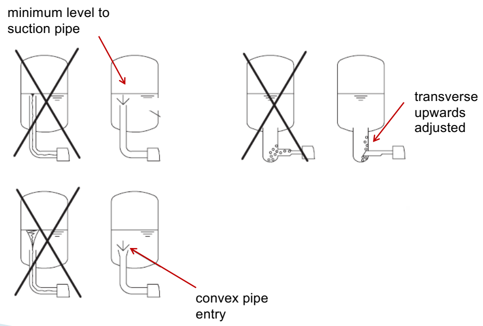
28

Failure caused suction conditions

Installation VESSEL



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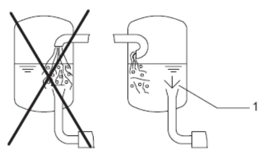
29

Failure caused suction conditions

Installation VESSEL



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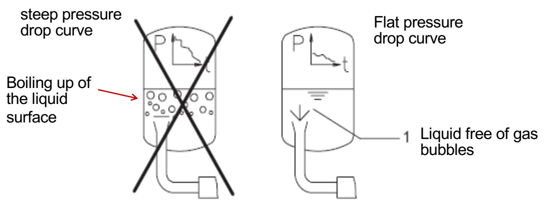
30

Failure caused suction conditions

Pressure lowering speed: pressure drop diagram



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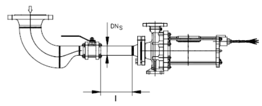
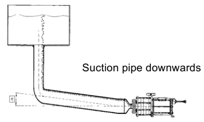
31

Failure caused suction conditions

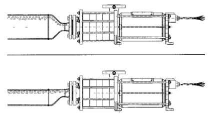
Installation suction pipe



Inlet sizing principle:
L = 5*DNs
Diameter pipe ≥ 2* Diameter suction nozzle
Flow speed: 0,3-0,5m/s



wrong



correct

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32

Suction Filter

- Suction filter is only for the commissioning period.
- mesh < 0,8mm
- Must be removed as soon as possible, or must be monitoring with Δpressure measurement

If necessary, install a sieve in the suction pipe only during the start-up phase

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Chennai

33

AGENDA

24th January 2020 / Mumbai

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2nd Feb 24 AAR ARCON 2024
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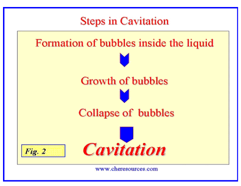
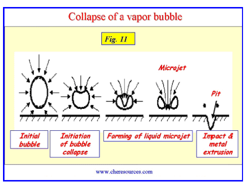
34

What is cavitation → Resons

- on the suction side - the static pressure of the flowing liquid falls below steam pressure
- bubbles occurs
- at areas of higher pressure steam bubbles will suddenly implode
- this imploding is the cause for very high short-term pressure peaks of up to some 1,000 bar





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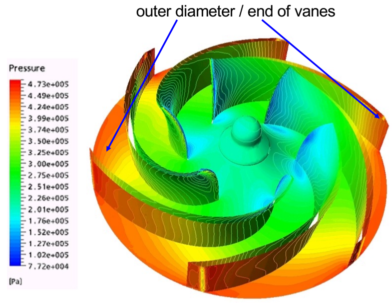
35

What is cavitation → Locations

at areas of higher pressure, steam bubbles will suddenly implode

outer diameter / end of vanes



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36

What is cavitation → Effects

pressure peaks of imploding bubbels lead to material erosions

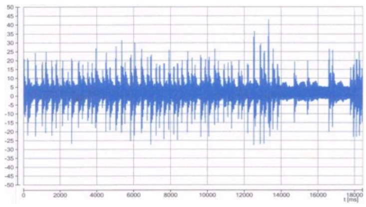
damage of impeller

37

What is cavitation → Effects

How we can deduct cavitation

- We experience a loss in capacity
- We can no longer build the same head (pressure drops, 3% value)
- The efficiency drops
- The cavities or bubbles will collapse when they pass into the higher regions of pressure causing noise, vibration



Picture: cavitation causes excessive oscillation amplitudes, which courses are not cyclical over the timeline

38

NPSH → Introduction

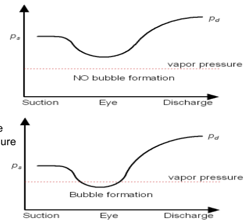
- **NPSH** = **N**et **P**ositive **S**uction **H**ead
- If the static pressure in the suction nozzle falls below the vapor pressure of the flowing liquid **CAVITATION** occurs.
- The **NPSH** value helps to describe and avoid such situation

39

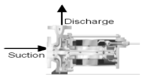
NPSH

Two NPSH values:
1.) NPSHr = NPSH required
2.) NPSHa = NPSH available

NPSHr = NPSH value of the pump.
When liquid flows into suction nozzle, the pressure falls shortly down.
This pressure drop is described in the NPSHr value of pump.



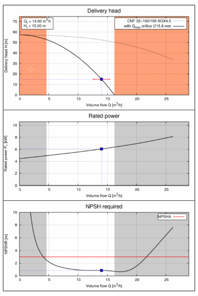
Ps = suction pressure
Pd = discharge pressure

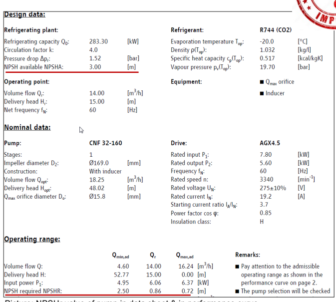


Pressure inside the pump must be all the time higher than the vapor pressure.

40

NPSHA > NPSHR





Design data:

Refrigerating plant:			**Refrigerant:**	**R744 (CO2)**	
Refrigerating capacity Q_0:	283.30	[kW]	Evaporation temperature T_{op}:	-20.0	[°C]
Circulation factor k:	4.0		Density $\rho(T_{op})$:	1.032	[kg/l]
Pressure drop Δp_r:	1.52	[bar]	Specific heat capacity $c_p(T_{op})$:	0.517	[kcal/kgK]
NPSH available NPSHA:	3.00	[m]	Vapour pressure $p_v(T_{op})$:	19.70	[bar]
Operating point:			**Equipment:**	■ Q_{max} orifice	
Volume flow Q_r:	14.00	[m³/h]		■ Inducer	
Delivery head H_r:	15.00	[m]			
Net frequency f_N:	60	[Hz]			

Nominal data:

Pump:	**CNF 32-160**		**Drive:**	**AGX4.5**	
Stages:	1		Rated input P_1:	7.80	[kW]
Impeller diameter D_2:	Ø169.0	[mm]	Rated output P_2:	5.60	[kW]
Construction:	With inducer		Frequency f_N:	60	[Hz]
Volume flow Q_{opt}:	18.25	[m³/h]	Rated speed n:	3340	[min⁻¹]
Delivery head H_{opt}:	48.02	[m]	Rated voltage U_N:	275±10%	[V]
Q_{max} orifice diameter D_o:	Ø15.8	[mm]	Rated current I_N:	19.2	[A]
			Starting current ratio I_A/I_N:	3.7	
			Power factor cos φ:	0.85	
			Insulation class:	H	

Operating range:

	$Q_{min,ad}$	Q_r	$Q_{max,ad}$		**Remarks:**
Volume flow Q:	4.60	14.00	16.24	[m³/h]	■ Pay attention to the admissible operating range as shown in the performance curve on page 2.
Delivery head H:	52.77	15.00	0.00	[m]	
Input power P_1:	4.95	6.06	6.37	[kW]	
NPSH required NPSHR:	2.50	0.86	0.72	[m]	■ The pump selection will be checked

Picture: NPSHr value of pump in data sheet & in performance curve

Theoretically NPSHa should be at least same level like NPSHr
For trouble free and safe operation:
NPSHa > NPSHr + 0,5m

41

Conclusion

Sealless No leackage Less Maintenance	01		04	**Cavitation** Cause & Effect
Installation Min & Max Flow Orifices	02		05	**NPSH** NPSHA & NPSHR Safety Margin
Guideline for Installation Venting Suction Conditions Filters	03		06	**End**

42

ARTICLE

One-Third of Adults Have Snoozed During PowerPoint Presentations

AMMONIA REFRIGERATION

24.01.2020 AAR ARCON Mumbai 43

43