2005 NOx/PCUG Conference

Workshop X

NH3 Systems: Problems and Solutions

Presented by
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Contents:

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STEAG SCR and ancillary System Experience

- experience in the design and construction of SCR since 1984
- 20 years experience with operation in its own plants
- 12 SCR units in coal-fired power plants (5 high dust, 1 low dust and 6 tail-end systems)
- 6 SCR units in two industrial power plants
- operation since 1988 all year round
- Anhydrous ammonia storage capacity of 1 mio gal (in US now >1 mio gal)
- Total vaporization capacity of > 15.000 lbs NH_3/h (in US now >25,000 lb/hr)
- Safe operation - no accidents

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STEAG LLC Customers in the US for Ammonia Systems

- **Dayton Power & Light**
  - Plants Stuart and Killen
- **Alabama Power**
  - Plants Gorgas and Miller
- **Georgia Power**
  - Plants Bowen, Hammond and Wansley
- **Tennessee Valley Authority**
  - Plants Allen, Cumberland, Widows Creek, Bull Run, Colbert and Kingston

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Dayton Power & Light Projects - Scope of Supply

- **Unloading System**
  Truck Tank Unloading System with a capacity of 160 GPM

- **Ammonia Storage**
  4 storage tanks each with a capacity of 66.000 Gal. Ammonia (Stuart)
  2 storage tanks each with a capacity of 35.000 Gal. Ammonia (Killen)

- **Unloading Compressors**
  3 compressors each with 100 % capacity

- **Ammonia Forwarding Pumps**
  forwarding pumps 8000 lbs/hour each (Stuart)

- **Vaporizer System incl. Pressure Control Unit**
  8 vaporizers with a capacity of 1,620 lbs/hr (Stuart)
  2 vaporizers with a capacity of 1,200 lbs/hr (Killen)

- **Dilution Air Fans incl. Flow Control System**

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Southern Company Projects - Scope of Supply

- **Unloading Systems**
  Rail/Truck Tank Unloading System with a capacity of 160 GPM per site

- **Ammonia Storages**
  12 storage tanks each with a capacity of 46.000 Gal. Ammonia
  2 storage tanks each with a capacity of 20.500 Gal. Ammonia

- **Unloading Compressors**
  2 compressors each with 100 % capacity per site

- **Ammonia Forwarding Pumps**
  2 forwarding pumps 4050 lbs/hour each per site

- **Control Systems**
  Allen Bradley PLC

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TVA Projects - Scope of Supply

- **Ammonia Forwarding Pumps**
- **Vaporizer System incl. Pressure Control Unit**
  - 8 vaporizers (condensate) with a capacity from 600 to 2,600 lbs/hr
  - 6 vaporizers (electrical) with a capacity of 2,600 to 3,600 lbs/hr
- **Flow Control System**
- **Static Mixers**
- **Dilution Air Fans**

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Design Objectives

1. Maximize Operator Safety
2. Minimize Threat to Surroundings
3. Ease of Operations and Maintenance
4. System Reliability

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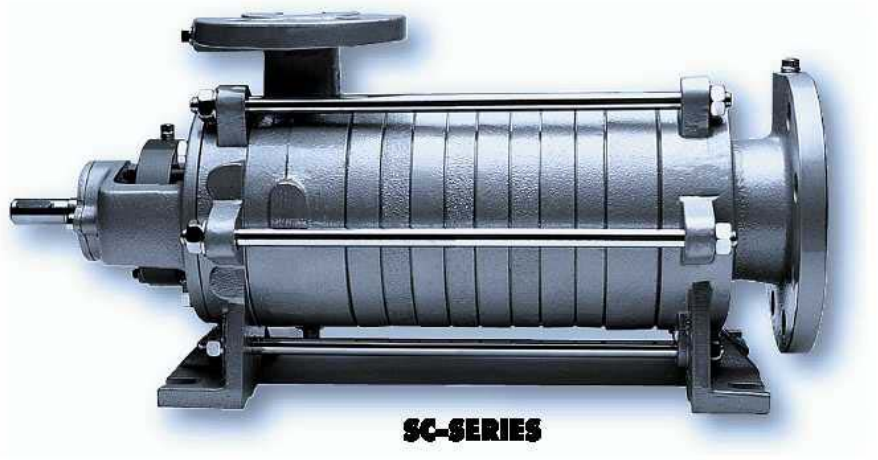
Selection of design features to achieve the objectives

1. Only flanged connections, no screwed or welded connections
2. All instruments, valves and actuators at one location atop the tanks
3. Access platform to the top of the tanks
4. Pressure release backwards to the tanks to prevent the HRVs and PRVs from opening
5. Insulation and heat tracing of vapor lines to prevent condensation of ammonia water
6. Nitrogen purging to prevent stress corrosion cracking of pressure vessels (tanks and vaporizers)

Ammonia Forwarding Pumps

Side channel pumps



Advantages:

- Low inlet requirements (npsh)
- High percentage of entrained vapor allowable

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Ammonia Forwarding Pumps

"Disadvantage" of side channel pumps for NH3 application:

- **small tolerances between impellers and casing**

Consequences:

- **vulnerable to debris**
- **vulnerable to ammonia flow beyond its design limits**

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Ammonia Forwarding Pumps

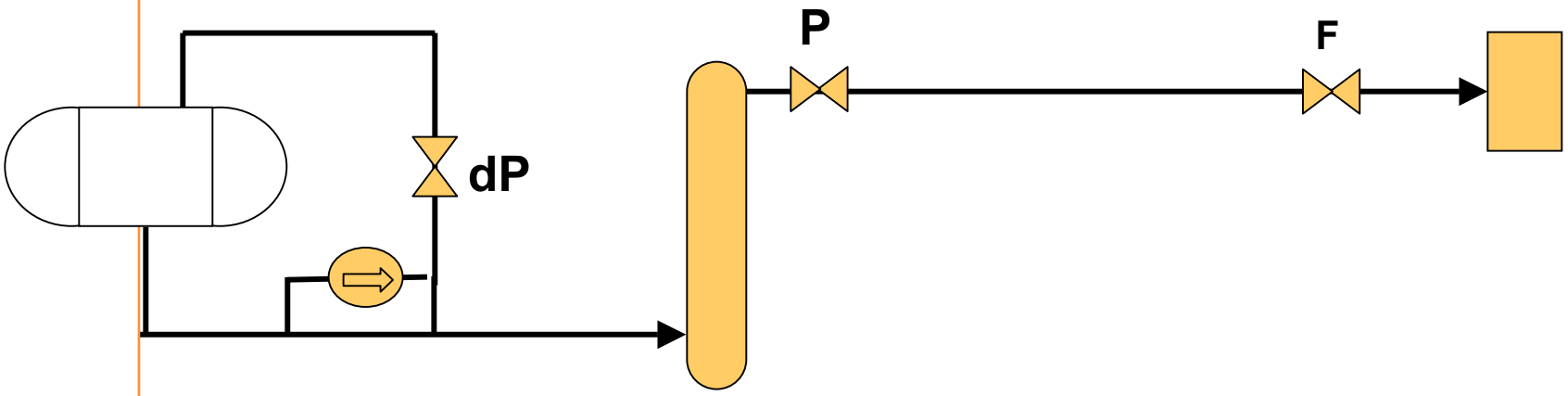
Solution for damaging by debris:

strainers (temporarily or permanent)

Solution for damaging by exceeding of flow limits:

operation of the pumps

Ammonia Forwarding Pumps - Operation



a) There is always ammonia vapor in the liquid lines

b) Vapor volume depends on heat transfer and line routing (e.g. velocity of ammonia; length, diameter and insulation of liquid line; ambient temperature; trapping of vapor)

c) At the start-up the pump operates beyond its design limits (too high flow) until all bubbles are compressed and the design differential pressure builds up

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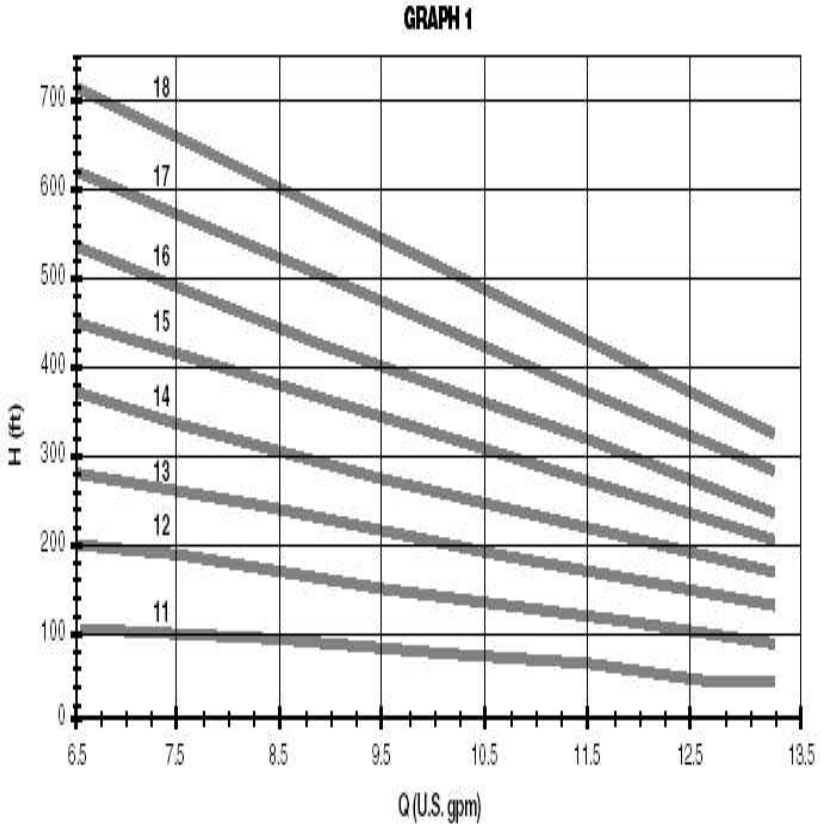
Ammonia Forwarding Pumps - Operation



a) Manual start-up, if the tank pressure falls below 45 (50) psig

a) Start in return mode and open discharge valve a little, until discharge pressure increases. Monitor return flow during this phase.

b) Open discharge valve completely, when discharge pressure is at the set point of the pressure regulator in the return line

c) Shut-off pump in manual, when tank pressure is above 55 (60) psig

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Pressure Swings

1. Pressure swings because of wrong liquid line design

2. Pressure swings during forwarding pump operation

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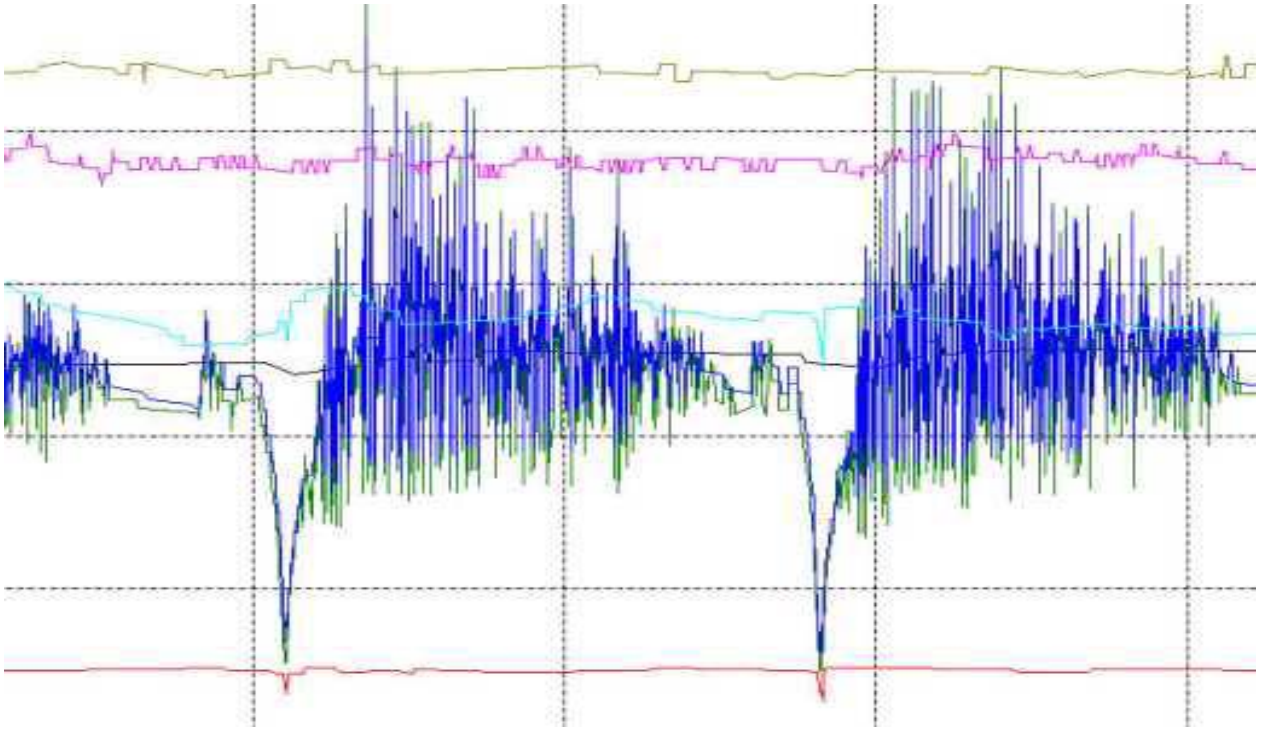
Pressure swings because of liquid line routing



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Pressure swings because of liquid line routing

Cause:

Build-up and trapping of ammonia vapor in the liquid line because of

a) **High point in the liquid line between tanks and vaporizers**

b) **Insulation too small**

c) **Low velocity of the ammonia flow**

Correct sizing of line diameter, thickness of insulation and routing with constant slope

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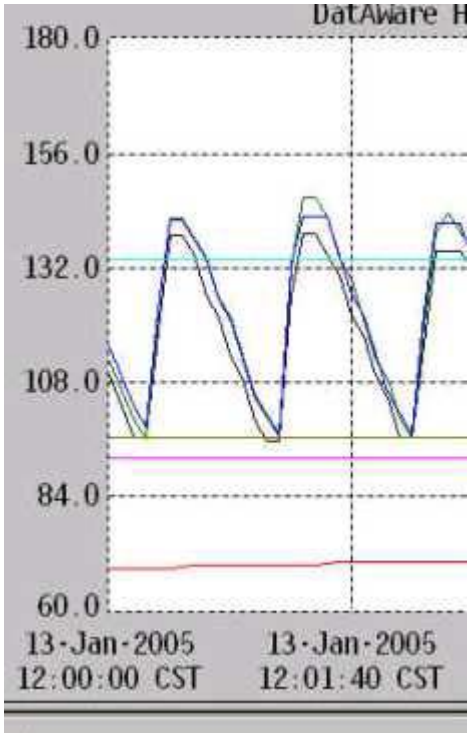
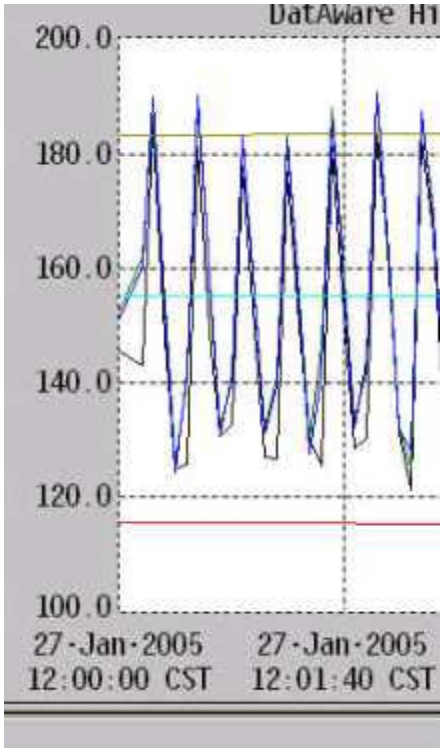
Pressure swings during forwarding pump operation





With pump operatio

Higher frequency

Higher swings

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Pressure swings during forwarding pump operation

Cause of the problem and solution:

still under investigation

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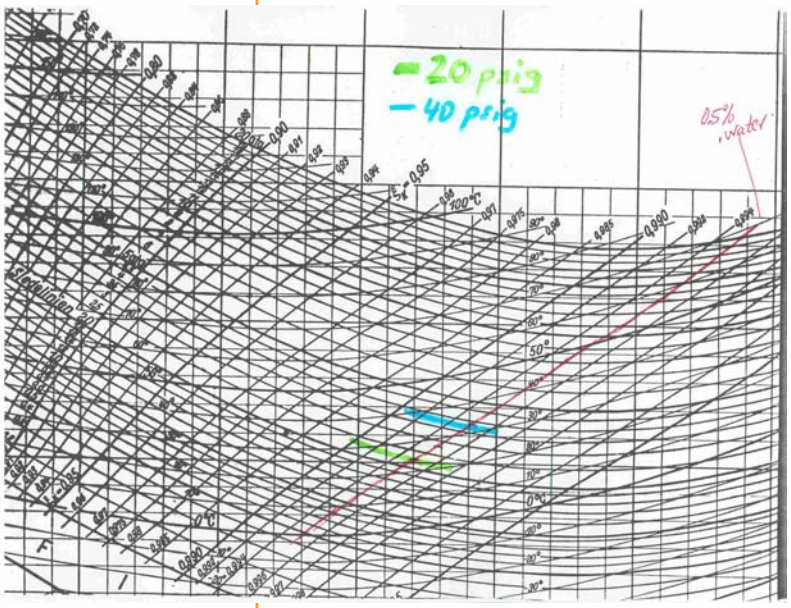
Condensation of Ammonia Water



Dew point depends on pressure and water content:

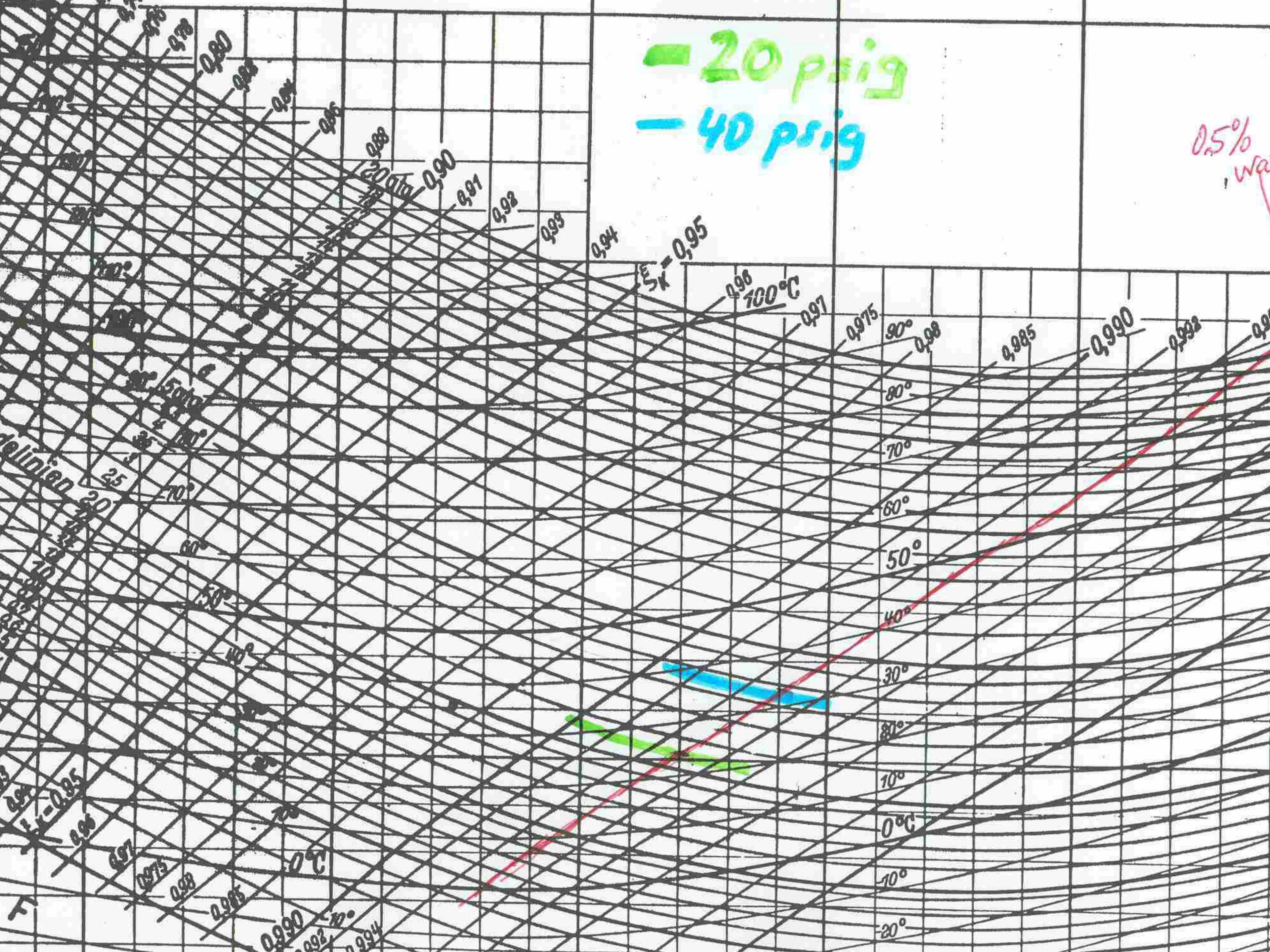
0.5 % water

20 psig	80 degree F
40 psig	91 degree F

1.0 % water

20 psig	91 degree F
40 psig	104 degree F

Condensed water cannot evaporate; it has to be drained !



20 psig
40 psig
0,5%
wa
0,80
0,90
0,91
0,92
0,93
0,94
ε/K = 0,95
0,96
100°C
0,97
0,975
0,98
0,985
0,990
0,992
20 ata
50 ata
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°C
-10°
-20°
25
20
0,994

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Condensation of Ammonia Water

Consequences:

1. **Reduce the ammonia vapor pressure to a minimum (< 20 psia)**
2. **Keep the vapor temperature as high as possible (> 130 degree F)**
3. **Avoid cold spots**
4. **Insulation (and heat tracing)**
5. **Check regularly**
6. **Installation of drain facilities at a low point**

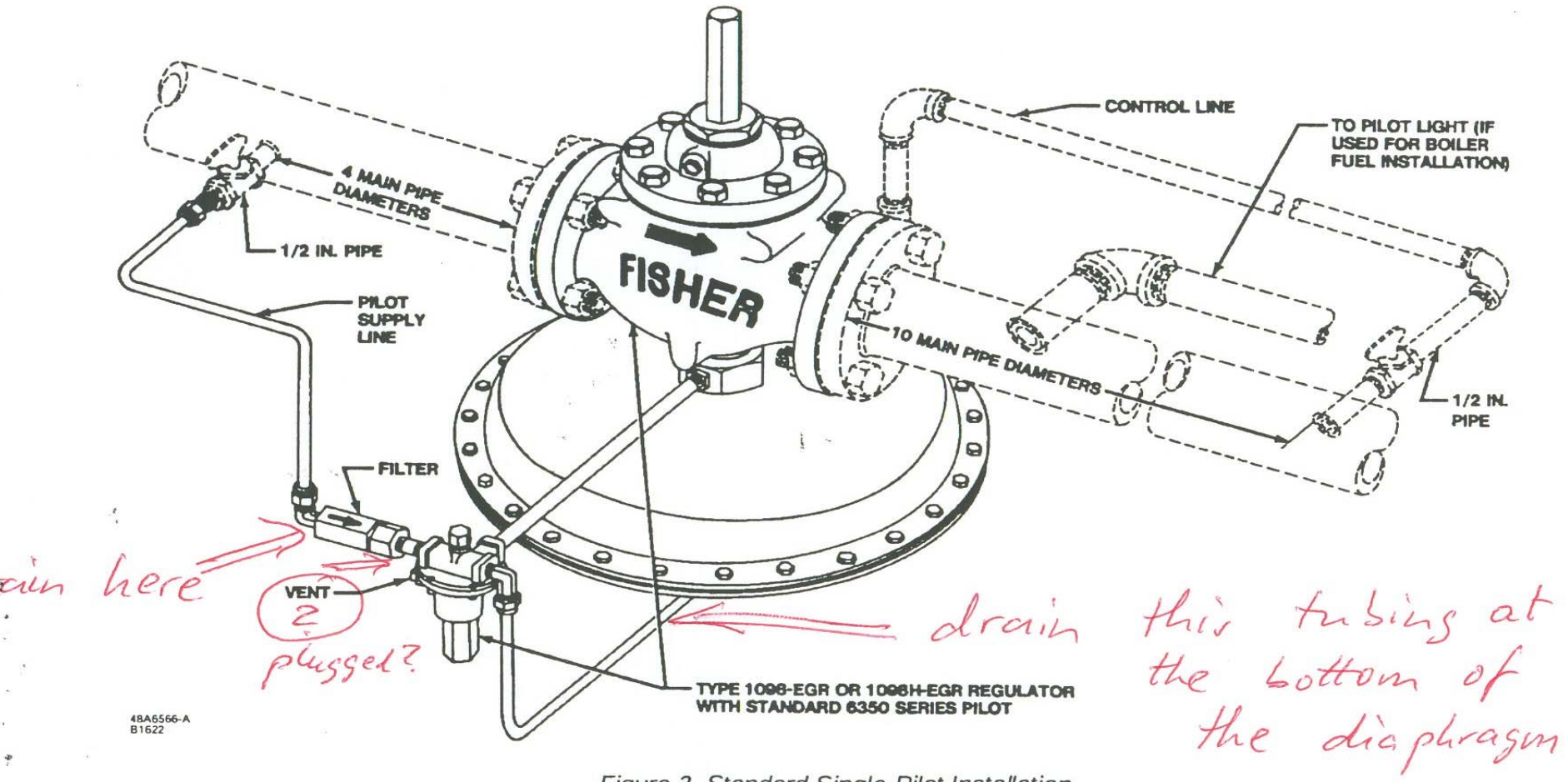

Figure 3. Standard Single-Pilot Installation

2. Install a three-valve bypass around the regulator if continuous operation is necessary during maintenance or inspection.

The standard pilot mounting position is shown in figure 1, the pilot may be field-changed to the opposite-side mounting position by swapping the pilotp ipe nipple to the opposite bonnet tapping. into the 1/4-inch NPT vent tapping. The Type 61LD pilot is vented by installing the vent piping in place of the pipe plug (key 22, figure 18). Then remove the closing cap assembly (key 5, figure 18) in order to remove the machine screw from inside the closing cap and tightly install it in the venth ole in the center of the closing cap. Provide protection on a remote vent by installing a screened ventc ap into the remote end oft he vent pipe.

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Maintenance during off-season

1. Keep the system under ammonia vapor (no air in the system; nitrogen purging not necessary)
2. Check the system regularly for leaks and operability
3. Check for leaks in the control air tubing
4. Check the heat tracing for the water lines of the spray system
5. Check for condensation of ammonia water

The ammonia system is still in operation, even if there is no ammonia flow to the SCR.

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Operation during wintertime

Condensation of ammonia water may occur at low temperatures

Countermeasures:

see section “Condensation of Ammonia Water”