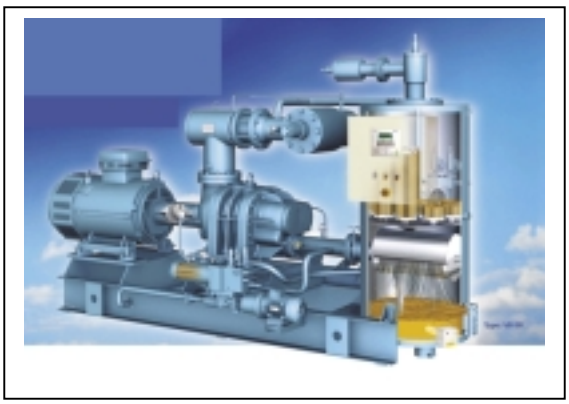
Application Note

Cooling and Refrigeration with Ammonia

Introduction



Refrigeration is a widely used process in industry, transportation and private life. It is being applied where ever the temperature needs to be controlled on a defined level.
Many different refrigerants have been developed in the past for many different applications (Freon, Propane, Ammonia etc). Because of the broad usage refrigerants should be harmless and not interfere with the global environment.
For many years CFCs and HCFCs seemed to be the ideal substances until it was found out that they damage our ozone layer in the earth's atmosphere. Now the search for surrogates is on the way. Ammonia is, because of its high efficiency, a wide spread refrigerant for mid size and bigger systems.
Meanwhile governments have developed standards for the different applications to ensure the safety of workers and environment when refrigerants are being used.

Abbreviation key CFCs, HCFCs, HFCs	
CFCs =	Chloro Fluoro Carbons
HCFCs =	Hydro Chloro Fluoro Carbons
HFCs =	Hydro Fluoro Carbons

Segment

- Food and drink **production**, **processing** and **storage**, freezing tunnels, **slaughter house**
- Refrigerated vehicles for **transportation** on road, train and ships, LNG/LPG vessels
- Heating-Ventilation-Air-conditioning HVAC in domestic and public **buildings**
- Chemical **industry**, **reliquifaction** plants also on ships,
- Sports, ice-arenas and rinks
- Institutes, laboratories and hospitals.

Description of the challenge

Ammonia has been successfully used as a refrigerant in industrial refrigeration plants for over a hundred years. It is a colourless gas, liquefies under pressure, and has a pungent odour. Ammonia

has no ozone depletion potential (ODP = 0) and no direct global warming potential (GWP = 0). Thanks to its high energy efficiency, its contribution to the indirect global warming potential is also low. Ammonia is flammable and is toxic to skin and mucous membranes when highly pressurised.

	GWP_{100}	ODP
HCFC	10^3	1
HFC	10^3	0
Hydrocarbon	3	0
CO_2	1	0
NH_3	0	0
air, water	0	0

However, its ignition energy is 50 times higher than that of natural gas and ammonia will not burn without a supporting flame. Due to the high affinity of ammonia towards (air) humidity it is rated as "hardly flammable". Ammonia is toxic, but has a characteristic, sharp smell which makes a warning below concentrations of 3 mg/m³ ammonia in air possible. This means that ammonia is evident at levels far below those which endanger health. Furthermore ammonia is lighter than air and therefore rises quickly.

Tree fields of applications result from the above.

1. Personnel protection, workplace monitoring

For protecting workers in the plant and or visitors in buildings portable and fixed instrumentation can be used. The measuring range should match the TLV requirements of the applied regulation.

2. Compressor and machinery room and ammonia tanks leak detection

The machinery room houses the refrigeration system. Containing compressor, valves, pumps surge tanks and many joints it is prone to leaks. Small leaks might cause a constant background concentration. The instrumentation should monitor the range beyond the TLV levels to alert the control room and tick ventilation and switch counter measure.

3. Cold storage room leak detection and tainting protection

A tiny Ammonia leak can have a damaging effect on stored goods. Small concentrations can taint food or other refrigerants or causes corrosion. Concentrations to be monitored are in the range up to TLV for getting early warnings. De-icing is an important process, where fast and reliable monitoring is requested to alarm emerging leaks.

Local requirements regarding performance, alarm-thresholds, approvals result from different standards for Ammonia handling, cooling and refrigeration, transportation of dangerous goods, pressurised gases, workplace monitoring.

TLV levels from different sources:

OSHA	**ACGIH**	**ACGIH**	**TRGS900**	**DFG**	**France**	**GB**	**EU**	**EU**		**Lethal conc.**
PEL	TLV	STEL	MAK	MAK	VLE	LTEL	OEL-TWA	OEL-STEL	IDLH	LClo
50 ppm	25 ppm	35 ppm	50 ppm	20 ppm	50 ppm	25 ppm	20 ppm	50 ppm	500 ppm	5000 ppm /5 min
35 mg/m3	17 mg/m3		35 mg/m3	14 mg/m3						

Levels for counter-action from different sources:

	first alarm	second alarm	Ex-Alarm	LEL
EN 378-3	500 ppm / 380 mg/m3		30.000 ppm / 22800 mg/m3	
TRD 452 A2	400 ppm	800 ppm		
EN 50054				154.000 ppm

EN = European Norm; TRD = German Technical Rules for Pressure Vessel

European regulation (EN 378-3) requires detection in compressor/machinery rooms to activate alarms and switch ventilation and electrical equipment.

Besides ammonia there are some other refrigerants being used. The most popular ones are Carbon dioxide CO2, Propane and Propene, Butane, Isobutane and Water.

Additionally some Hydrocarbons with Chlorine- and Fluorine-bonds are still allowed. In the table you find some specifications and our products.

Name	Abbreviation	Formula	MAK / TLV	UEG / LEL	Product IR	Product Pellistor
Carbon dioxide	R 744	CO2	5000	na	Polytron CO2	
Propane	R 290	C3H8	1000	1,7	IR	Ex Kat
Propene/Propylene	R 1270	CH2CHCH3	na	2	IR, IR Ex, EC EO	Ex Kat
Isobutane	R 600a	CH(CH3)3	1000 / 800	1,8 / 1,3	IR Ex	Ex Kat
Tetrafluoroethane	R 134a	C2H2F4			IR Ex	
Difluoromethan	R 32	CH2F2		14 /	Polytron IR Ex	
Blend	R407C	R134a, R125, R32				
Blend	R404A	R125, R143a, R134a				
Blend	R410A	R125, R32				

Solution from Dräger

Ammonia can be detected with our famous electrochemical sensors for low and high concentrations in respective transmitters for stationary installations.

Transmitter with Ex-approval:

Polytron C with	DrägerSensor NH3 LC 6809680	0 to 100ppm
Polytron 2 with	DrägerSensor NH3 LC 6809680	0 to 50ppm up to 0 to 200ppm
Polytron XP-TOX with	DrägerSensor NH3 LC 6809680	0 to 50ppm up to 0 to 200ppm
Polytron C with	DrägerSensor NH3 HC 6809645	0 to 300 ppm
Polytron C with	DrägerSensor NH3 HC 6809645	0 to 1000 ppm
Polytron 2 with	DrägerSensor NH3 HC 6809645	0 to 300 ppm up to 0 to 1000 ppm
Polytron XP-TOX with	DrägerSensor NH3 HC 6809645	0 to 300 ppm up to 0 to 1000 ppm

Transmitter without Ex-approval:

VarioGard NH_3 Bus	8315240	0 to 1200 ppm
VarioGard NH_3 4..20 mA	8315270	0 to 1200 ppm

Ex-Transmitters with pellistors for monitoring LEL:

Polytron SE Ex
Polytron Ex
Polytron TX
Polytron 2 XP Ex

Ex-Transmitters with pellistors for monitoring LEL without Ex-approval:

VarioGard Transmitter Ex

Installation hint

In cooling areas, locate sensors near control / piping end of evaporators and valve stations. Do not mount in front, back or on top of evaporators. When installing sensors near evaporators, keep sensor out of direct airflow from and to the evaporator and away from any moisture created during defrost. Make drip loops for cables on Polytron. Do not mount over door in refrigerated area, because the sensor will become a chunk of ice. Seal all conduit connections for XP- Tox, and Polytron TX.

In compressor rooms the transmitter should be installed at the ceiling. Ammonia is lighter than air and will rise first. So even if you don't smell Ammonia at ground levels the concentration at the ceiling can be high. Because of presence of background concentrations the alarm levels here should not be put at TLV level to avoid false alarms.

For Polytron SE Ex, Polytron 2 XP Ex, Polytron FX, VarioGard Ex, use Ammonia or Methane for calibration. Cross calibration factor between methane and Ammonia almost one.

USP's

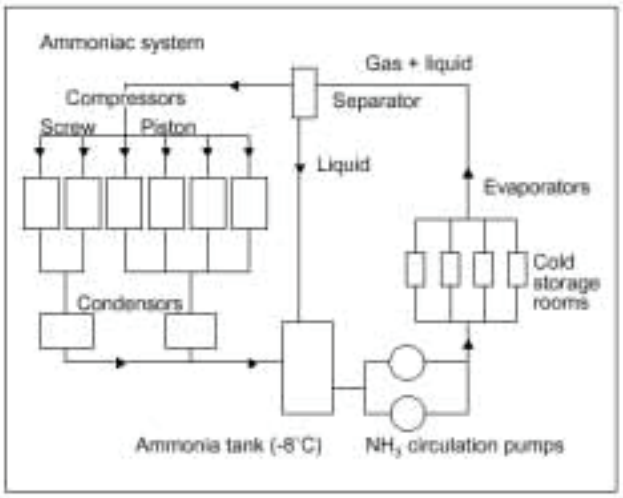
- superior electrochemical sensors with good measurement performance
- fast response and stabile signals.
- low drift, long expected life-time
- extended temperature range – 40°C to + 65°C
- unique electrochemical Ammonia sensor with range up to 1000 ppm
- long-living poison resistant combustible sensor for NH_3
- Approvals for ships

Appendix

http://www.eurammon.com/
http://www.treffpunkt-kaelte.de/kaelte/index.html
http://www.schlosser-moller.no/teknisk_katalog/Gruppe_3/Instruksjoner/kt-640-2.pdf
http://www.heatpumpcentre.org/tutorial/home.htm

Drawings & Pictures

Figure 1: Schematic of ammoniac cooling system.



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