Linde Kryotechnik AG.

Effects of oil contamination on cryogenic plants. Ionic Liquids.

Linde Kryotechnik AG
CELEBRATING
25 YEARS

Andreas Rüegge

Coventry, 6th September 2017

THE LINDE GROUP
Linde

Contents

Linde Kryotechnik AG.
The Company.

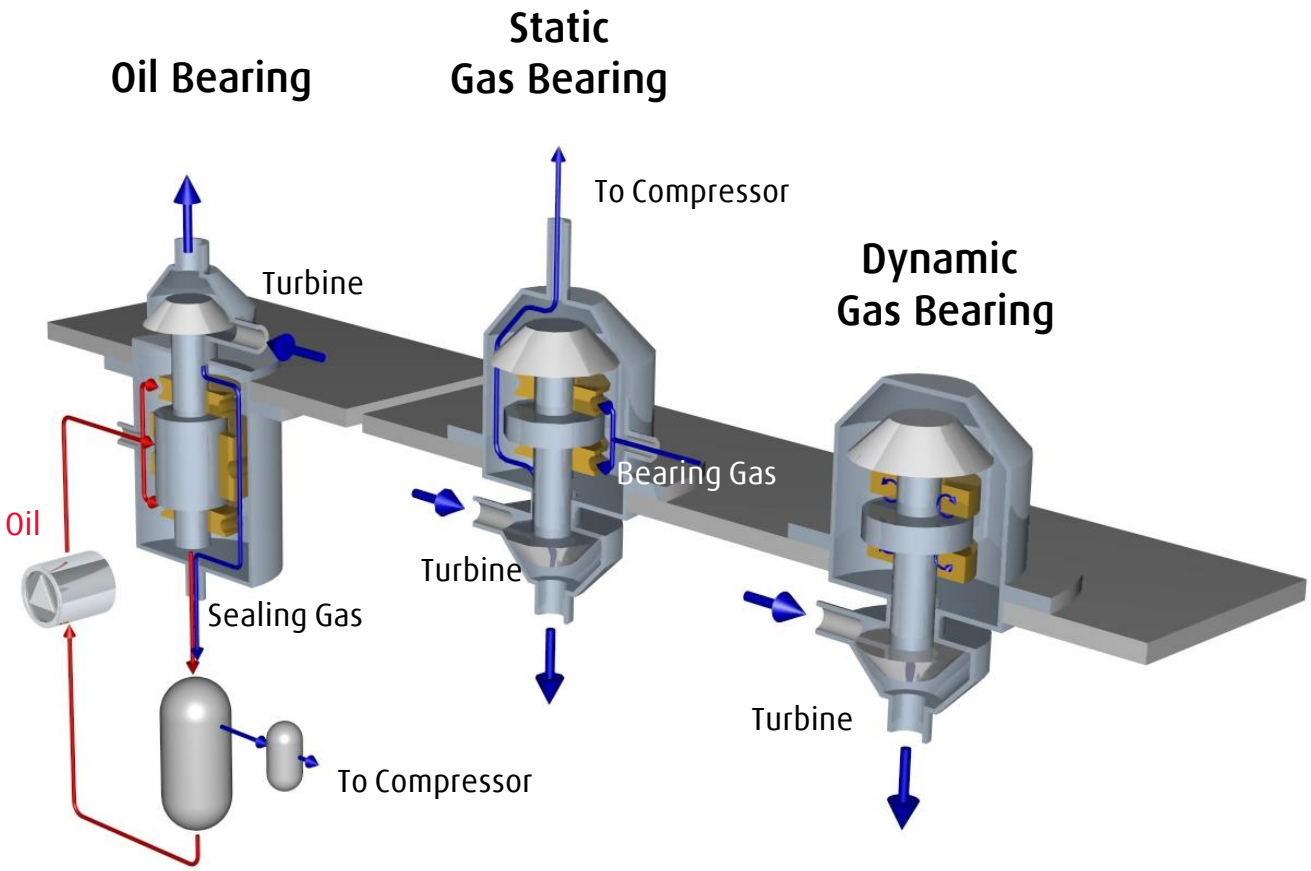
THE LINDE GROUP

Linde

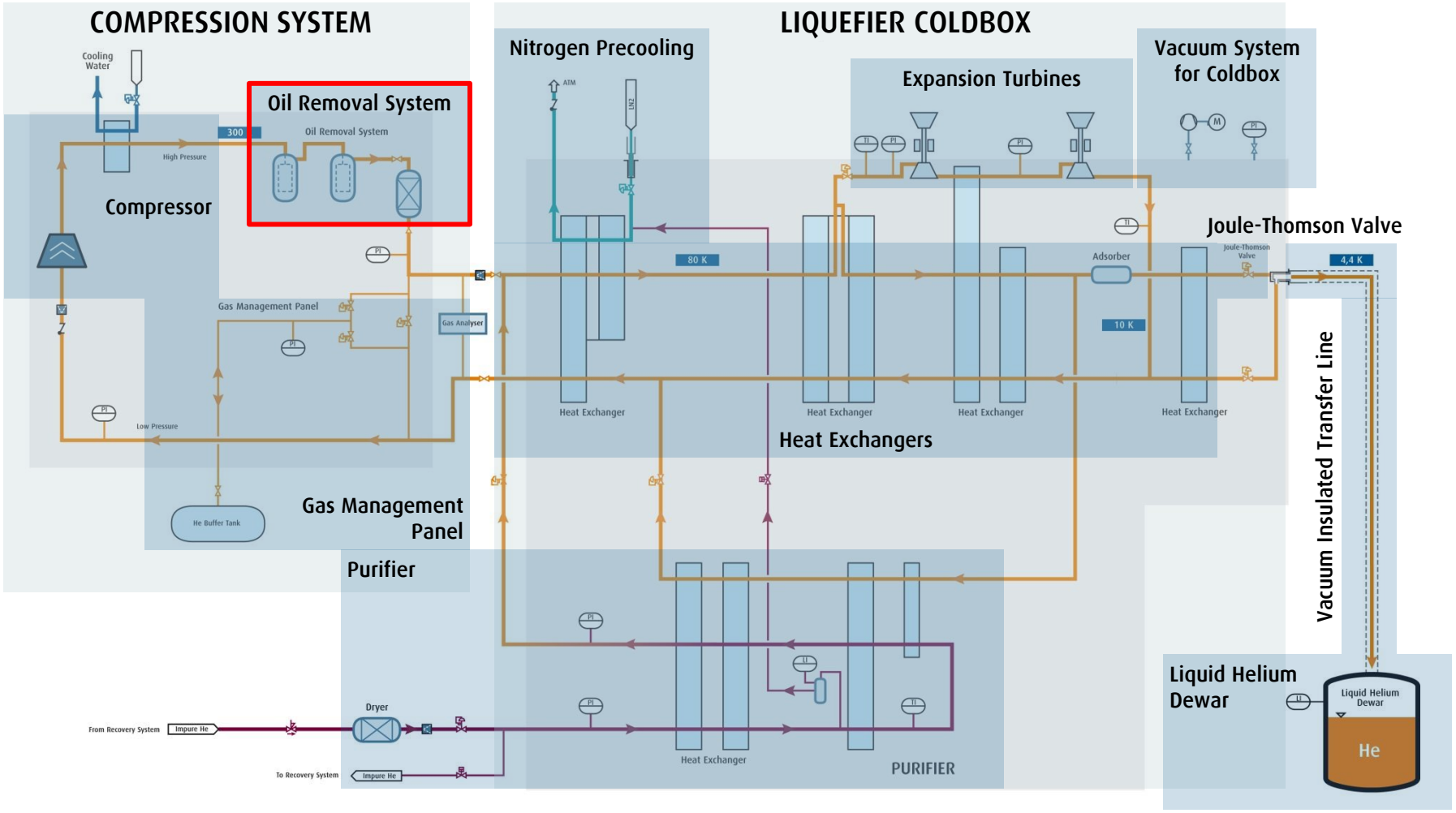
Brief introduction

- Independent company and center of excellence within The Linde Group for low temperature cryogenic equipment (helium and hydrogen liquefaction & refrigeration plants with auxiliaries)
- Established in 1992 to combine the activities of Sulzer and Linde in the field of cryogenics
- Linde Kryotechnik AG is a member of the Engineering Division of the Linde Group situated in Munich
- Average annual turnover of 50 Mio. CHF (50Mio. USD / 46 Mio. €)
- Approx. 90 specialized employees
- 20 min from Airport Zürich

Machinery for Cryogenic Applications
Turbine Bearing Technology



Helium Applications.
The Liquefaction Process.



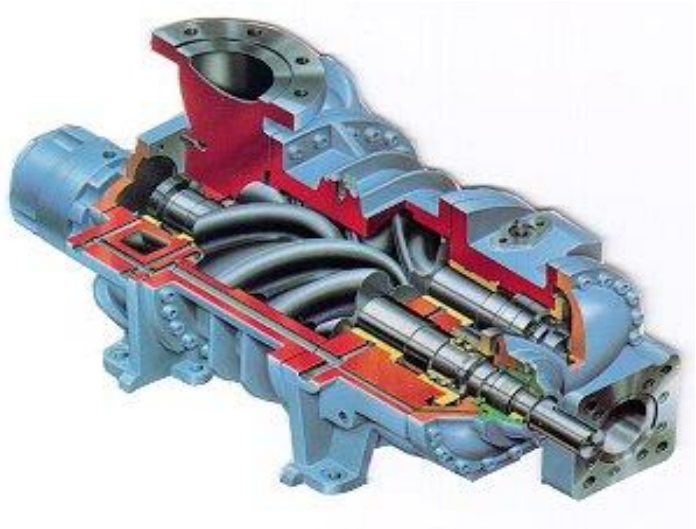
Machinery for Cryogenic Applications.
Recycle Compressors.

THE LINDE GROUP

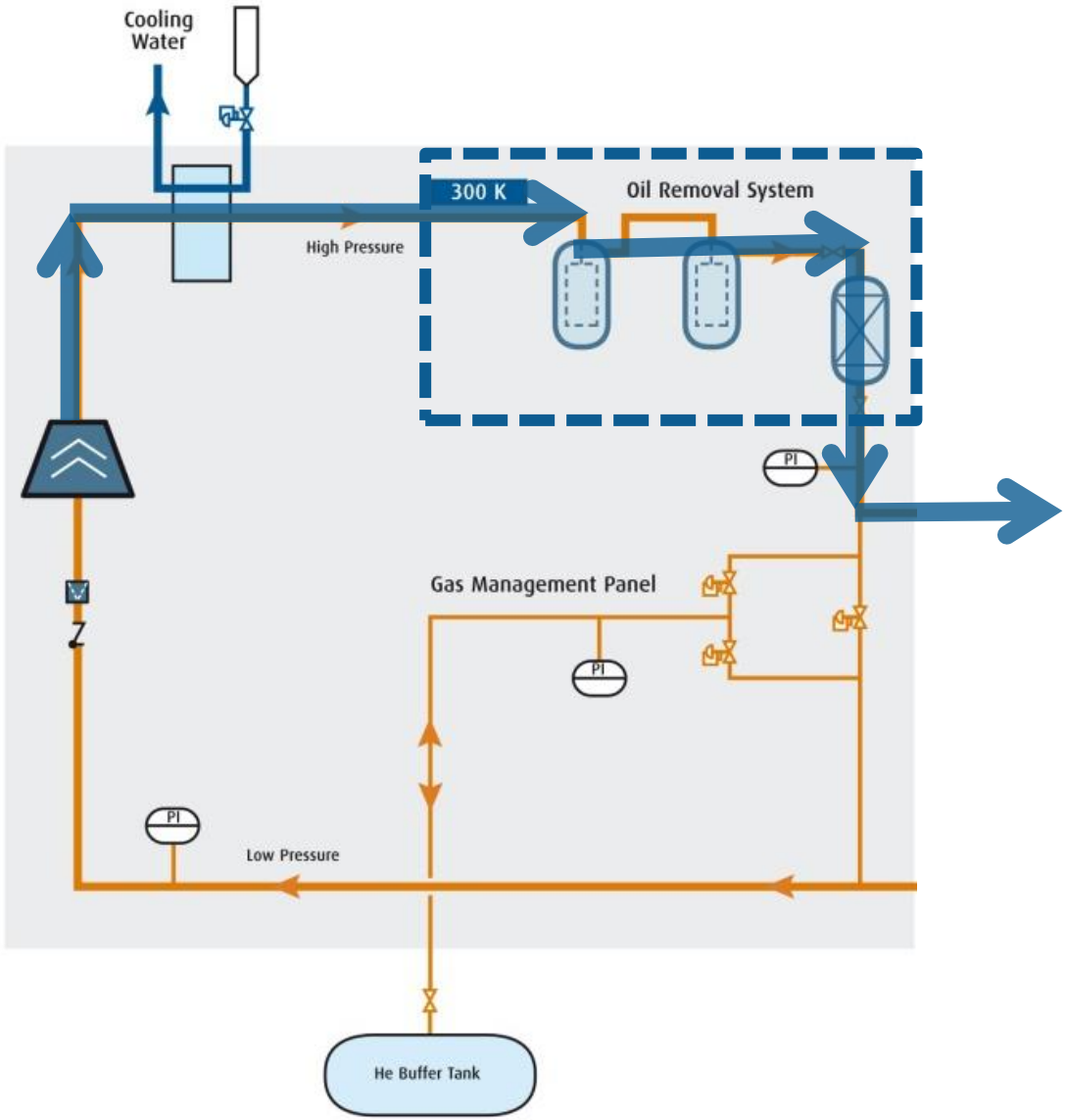
Linde

Small & Medium Plants
Standard Oil Flooded Screw Compressor

Large Plants
Dedicated Oil Flooded Screw Compressor



Oil Removal System.



Basic oil contamination.

An oil lubricated screw compressor with 70 g/s compressor mass flow, operating 10 years continuously with 10 ppb(w) after oil removal system pushes ~220 grams of oil inside the coldbox.

- 70 g/s
- 10 ppb(w)
- 10 years
- ~220 grams of oil
- ~6% loss of heat transfer-performance

Other oil sources:

- Turbine oil bearings
- High pressure recovery compressor
- Backflow of vacuum pumps

Further oil contamination causes.

THE LINDE GROUP

Linde

Bypassed, missed or ignored maintenance intervals:

- Replacement of coalescer cartridges
- Replacement of activated charcoal

Incorrect mechanical service work for:

- Compressor (bulk oil separator, other service components)
- Coalescer cartridges (bypass flow, missing gaskets)
- Condensate drain (service kit, missing gaskets, control)
- Oil adsorber (incorrect filling quantity, loose fill)

High compressor discharge temperature (viscosity)

Low compressor discharge, P< 9bara:

- Adsorber retention time too short

Oil contamination effects.

Performance losses:

– Heat exchanger surface gets coated by oil and loses heat transfer capacity, heat transfer of HP and LP gets misbalanced

Damaged Turbines:

– Frozen oil vapor blocks turbine wheel → mechanical damages (broken blades)

– Bearings (axial & radial) get contaminated by oil through bearing or process gas → turbine operation properties change (start up delay)

Defect 80/ 20K adsorber:

– Activated charcoal adsorbs oil → Nitrogen/ Hydrogen/ Neon adsorption capacity reduces

Oil contamination detection.

- Unexplainable performance losses
- Changed plant behavior, especially: sequence of turbine start up, operating temperatures of first heat exchanger
- Pyrolyzer / MCD measurement
- Visual detection by checking of:
  - Oil adsorber outlet
  - Inner process components: valve seats, turbines, filters, buffer vessels, instrument tubes and other

Oil contamination repair.

THE LINDE GROUP

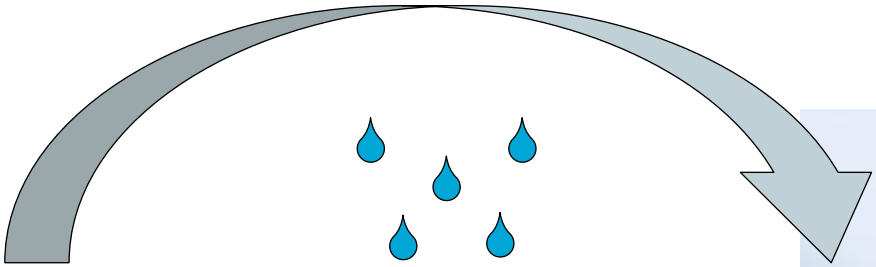
Linde

Heat exchanger washed with cleaning solvent:

- Cleaning procedure is carried out with electrical grounded, air driven membrane pump
- Typically two cleaning cycles (each 4-8 hours) with acetone are sufficient
- Heat exchangers have to be dried with hot nitrogen for several days afterwards
- Re-welding of purging ports, reinstallation of temperature sensors, installation of super insulation
- Pressure and leak test
- After coldbox is reassembled and transported to final position, additional pump and purge thru LN2 cold trap is recommended
- Warm piping: compressor discharge, GMP, coldbox interfaces (bearing gas, warm up line) and buffer vessels should be check and cleaned also

Coldbox oil cleaning.

Safe way to avoid oil carry over?



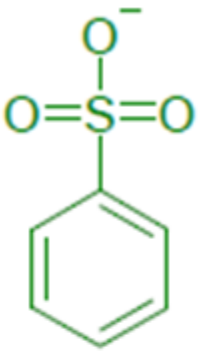
Use of ionic liquids in recycle gas compression.

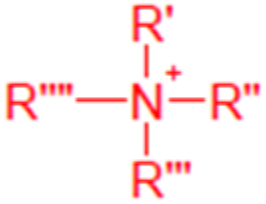
THE LINDE GROUP

Linde

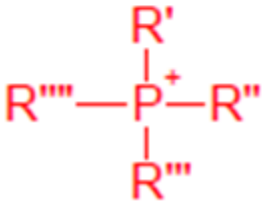
Ionic liquids (IL) are «liquid salts»:

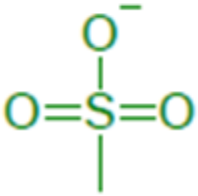
- negligible vapor pressure
- temperature resistant
- ecologically friendly
- non-toxic
- no degradation





Cl^-





Key physical properties of ionic liquids.

THE LINDE GROUP

Linde

Tests proved that ionic liquids can be used for helium recycle gas compression with:

- Similar temperature profiles in the compressor
- No impact on compressor efficiency

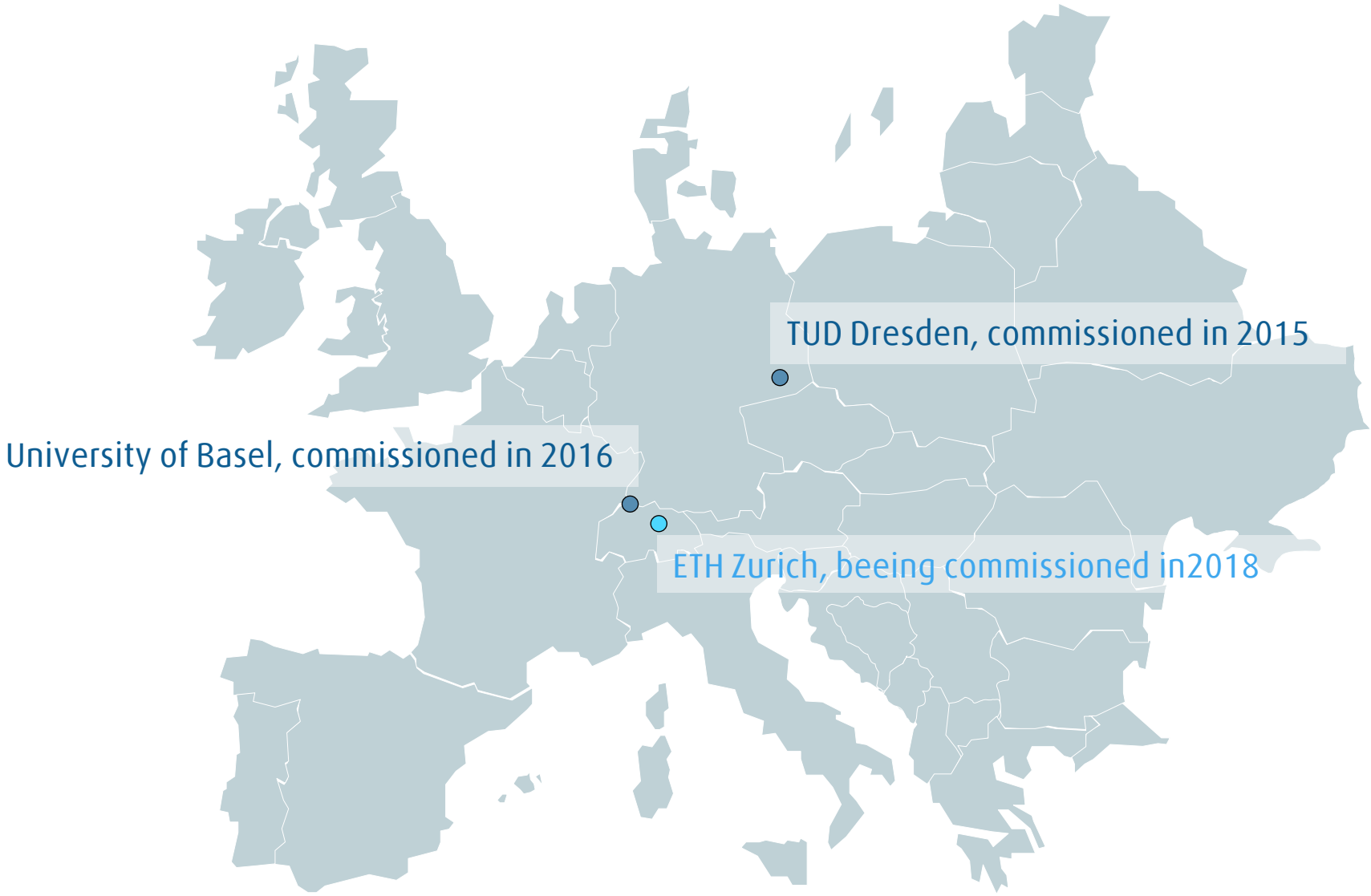
		Ionic Liquids	Oil (HCF 12)
Viscosity @ 40°C	mm^2/s	38.4	43.2
Viscosity @ 100°C	mm^2/s	7.4	7.4
Density	kg/m^3	1'313	841
Heat capacity @ 40°C	J/kg/K	1'772	2'553
Heat capacity @ 100°C	J/kg/K	1'998	2'778

Advantages of ionic liquids.

The negligible vapor pressure of Ionic Liquids allows to remove the adsorber and at least one coalescer of the «Oil Removal System».

- Higher overall efficiency due to higher inlet pressure at coldbox
  → higher liquefaction or refrigeration rate at constant power consumption
- No risk of liquid or vapor carry-over into the coldbox
- Reduced space requirements
- Reduced risk of leakage at ORS
- Reduced overall costs

Systems in operation or planned.



Thank you for your attention.

www.linde-kryotechnik.ch