

Set-up of the cryogenic phase equilibria test stand CryoPHAEQTS

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Motivation

- HTS cooling with liquid N₂ limited by triple point at 63 K
- Cryogenic mixed refrigerants reach lower temperatures more efficiently than pure substances
- Physical property data unavailable today

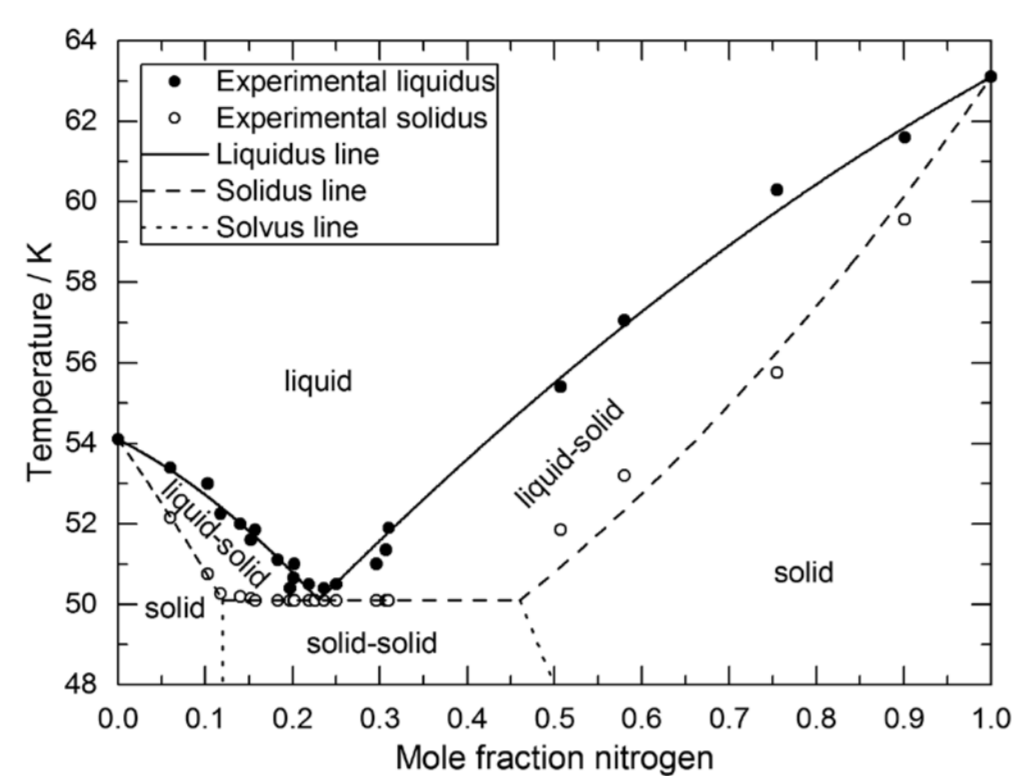


Fig. 1: Solid-liquid equilibrium of the nitrogen-oxygen system (T-x) [1].

Test stand features

- Phase equilibria measurements of cryogenic fluid mixtures

Process parameters	
Temperature range	15 – 300 K
Pressure range	Up to 15 MPa
Fluids	Cryogenic mixtures, incl. flammable or oxidizing fluids (ATEX compliant)
Phase equilibria types	VLE (vapor-liquid equilibria), VLLE (vapor-liquid-liquid equilibria) SLE (solid-liquid equilibria)

Process design

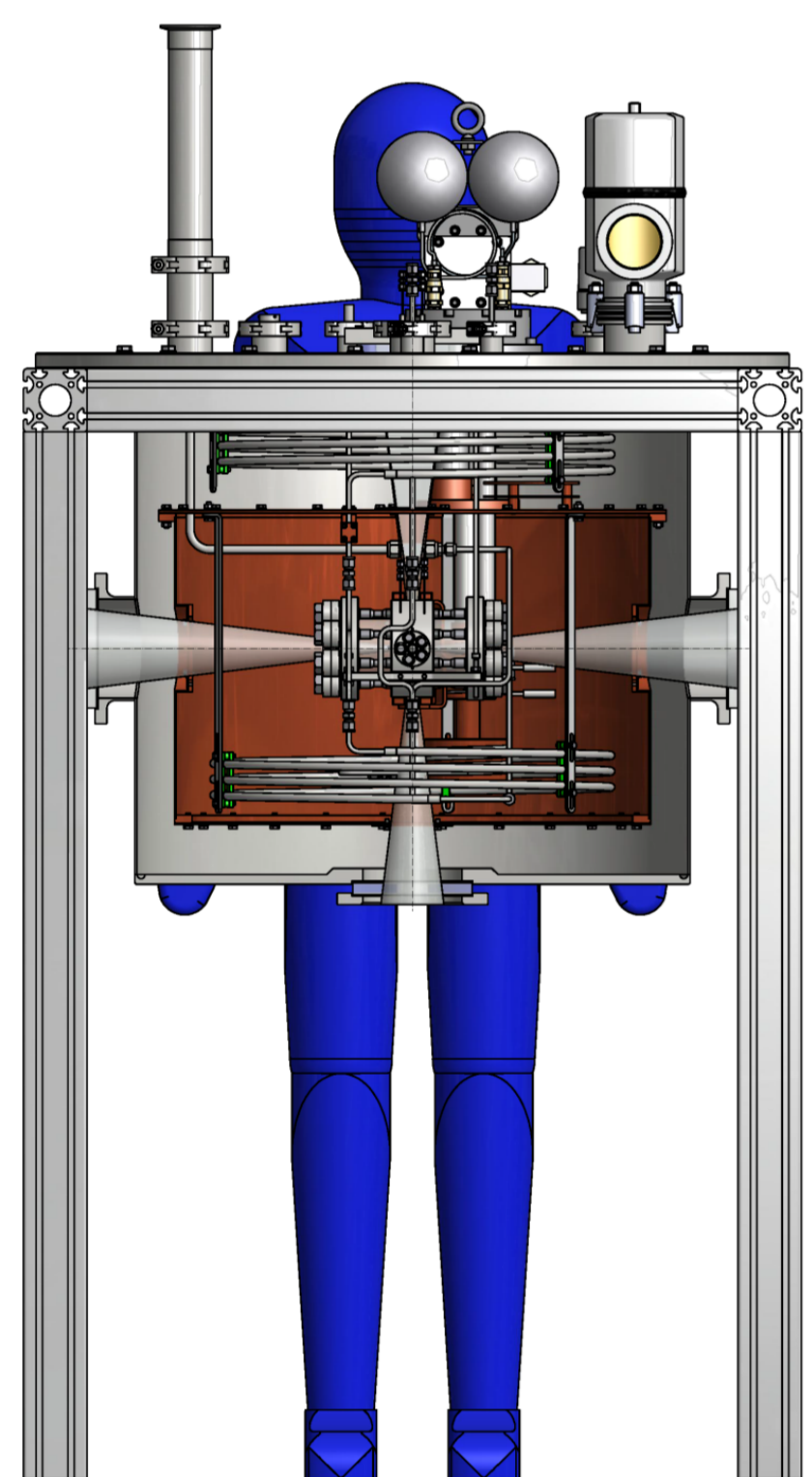


Fig. 2: Cryostat design (left) and equilibrium cell design (right).

Pressure and temperature measurement

- Pressure measurement by differential pressure to secondary nitrogen system
- Temperature measurement by 4 CERNOX™ sensors
- Temperature control by pulse tube cryocooler and counter heater
- Fast equilibration by gas phase circulation

Composition analysis

- Direct sampling from 3 positions in the equilibrium cell through capillaries
- ROLSI™ valves offer sample volumes in μL range [3]
- Analysis in gas chromatograph with molecular sieve type columns
- Investigation of VLE, VLLE and SLE*

*For SLE, only the liquidus line can be obtained from liquid phase analysis

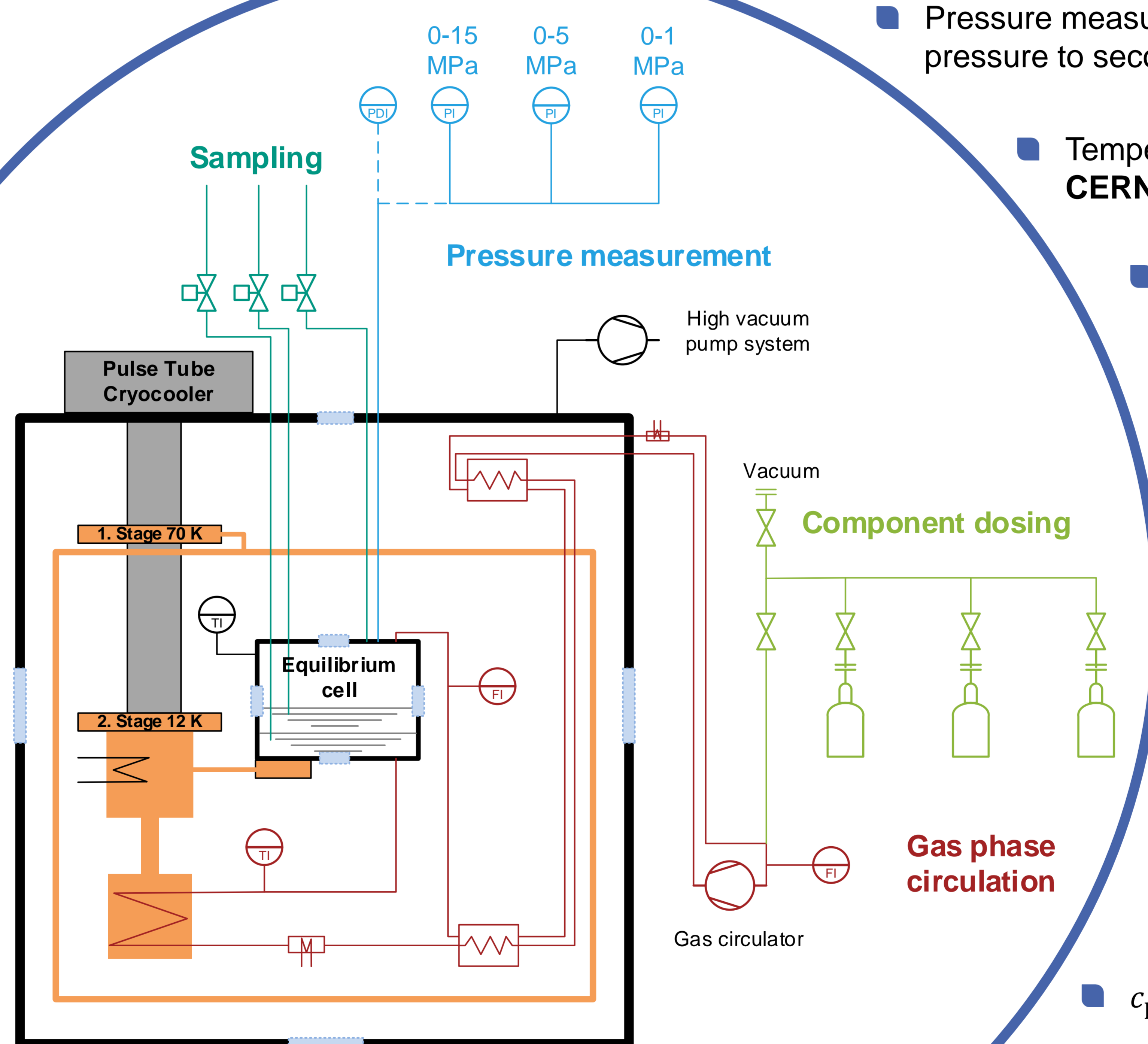


Fig. 3: Process flow diagram (simplified) [2].

c_p measurement

- New cryogenic thermal flow meter (WEKA Sense®) [4] combined with Coriolis flow meter at room-temperature

$$c_p = \frac{\dot{Q}_{th}}{\dot{M}_{Cor} \Delta T_{th}}$$

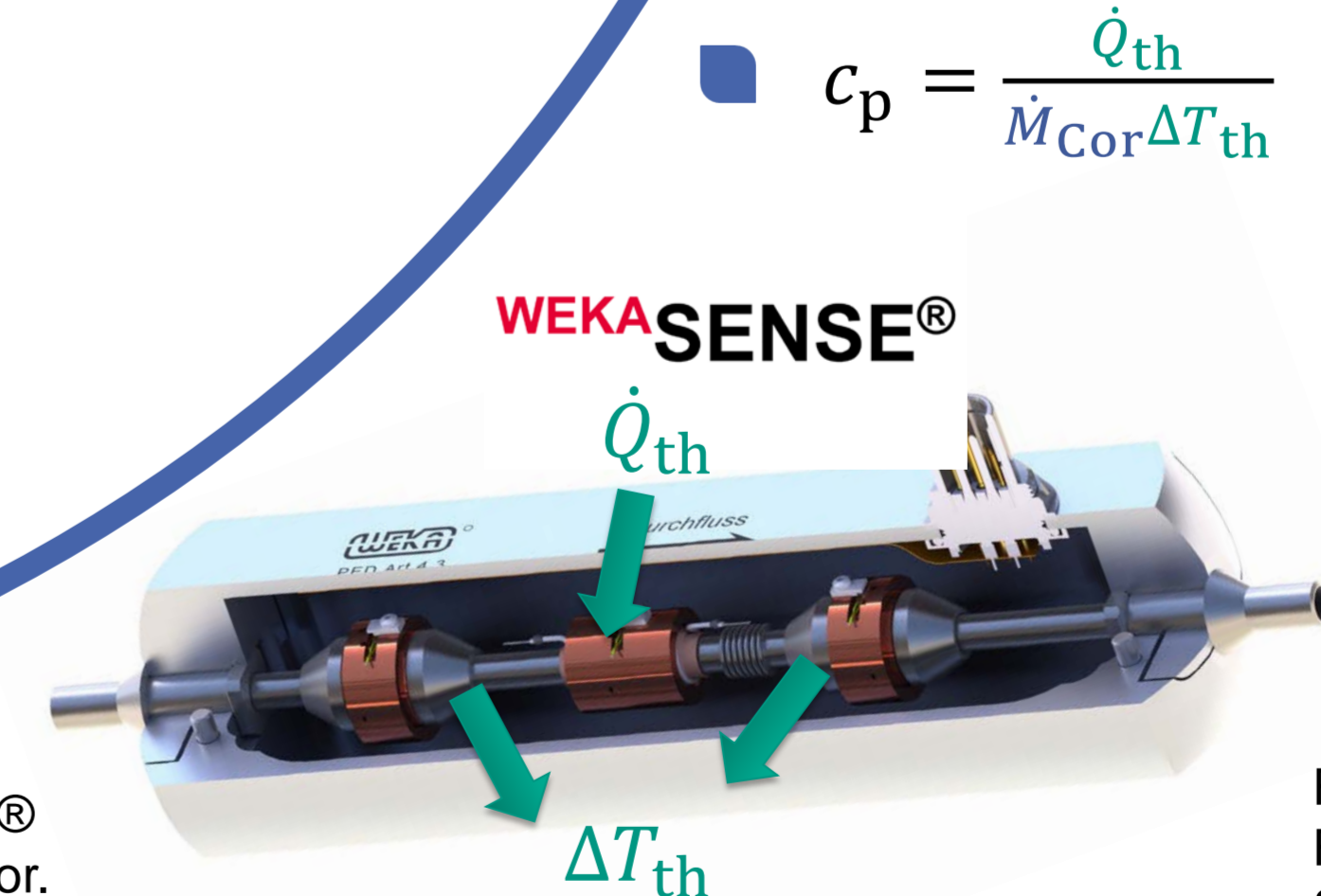


Fig. 4: WEKA Sense® cryogenic flow sensor.



Fig. 5: Bronkhorst mini CORI-FLOW sensor. Source: Bronkhorst.

Outlook

- Test stand offers optical access to allow light scattering experiments
- Future upgrade to measure surface tension and transport properties (diffusivity, viscosity, thermal conductivity) by dynamic light scattering (DLS) and surface light scattering (SLS)

References

- Ruhemann M, Lichter A and Komarov P 1935 Zustandsdiagramme niedrig schmelzender Gemische: 2. Das Schmelzdiagramm Sauerstoff Stickstoff und das Zustandsdiagramm Stickstoff-Kohlenoxyd. *Physikalische Zeitschrift der Sowjetunion* 8 326–36.
- Tamson J, Kochenburger T M, Stamm M and Grohmann S 2017 CryoPHAEQTS : Cryogenic Phase Equilibria Test Stand Poster at the II. International Workshop on Cooling Systems for HTS Applications 2017
- Guilbot P, Valtz A, Legendre H and Richon D 2000 Rapid on-line sampler-injector: a reliable tool for HT-HP sampling and on-line GC analysis *Analyst* 28(5) 426-31
- Grohmann S 2014 A new method for flow measurement in cryogenic systems *Cryogenics* 60 9-18