



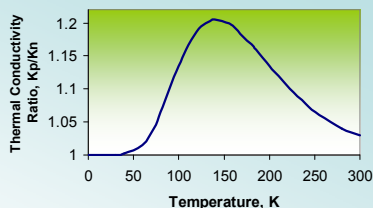
A compact system for the production and quality measurement of para-hydrogen.

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Formerly, the conversion of normal hydrogen to para-hydrogen for ISIS experiments has involved the preparation and maintenance of a helium cryostat. Now para-hydrogen can be produced and quality tested in a comprehensive cold head, gas handling and gauge assembly.

Para-hydrogen:

- Normal hydrogen gas contains 25% para- and 75% ortho-hydrogen.
- Normal hydrogen may be converted to almost 100% para-hydrogen at 20K.
- Para-hydrogen gauges are not available as an off-the-shelf item.
- Ortho- and para- forms of hydrogen have different properties.



Thermal conductivities of normal and para- hydrogen differ by up to 20%.

Para-hydrogen producing rig:

Gas handling cold trap also contains para-hydrogen gauge cell

Vacuum tail

Gas handling:
1/4" stainless steel pipework, baratron, transducer, relief valve, buffer volumes, manual needle valves, screen-printed front panel

Temperature control:
Eurotherms for cell and capillary sensors/heaters

Power supply:
rig powered by single three-phase supply

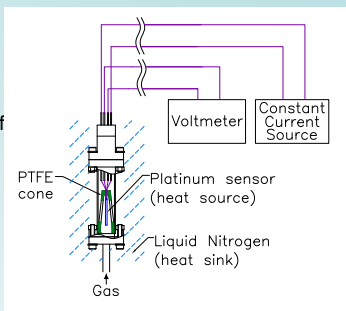


Pumping set: dry rotary and turbo pumps

Leybold 10-40 cold head

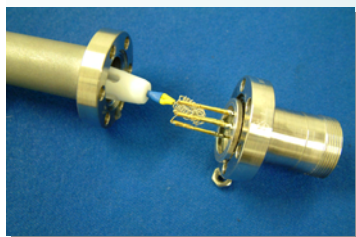
Para-hydrogen quality gauge cell:

- Design exploits variation in thermal conductivities of normal and para-hydrogen.
- Gauge indirectly measures the rate of heat transfer through a gas sample.
- Gauge makes a relative measurement, not a definitive thermal conductivity measurement.
- Unknown samples may be compared to calibration data produced by gauge.

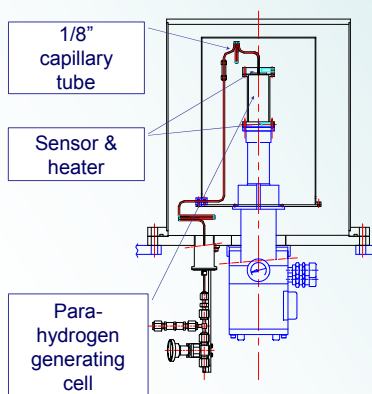


Para-hydrogen gauge measures heat transfer rate through gas sample.

- 100 mA current supplied to sample.
- Voltage measured for 6 minutes.
- Gas temperature rises to 135-145K: corresponds to greatest variation in thermal conductivities.
- Test repeated on multiple gas samples of normal hydrogen, para-hydrogen and normal/para-hydrogen mixtures.



Para-hydrogen gauge cell made from standard Conflat components.

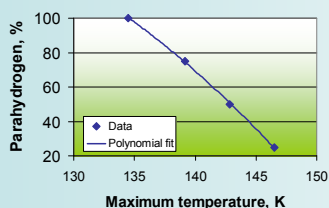
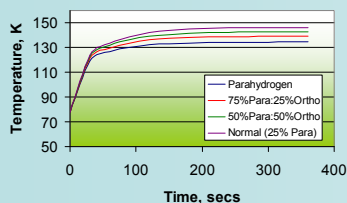


Cold head assembly



Front view

Gauge test results:



- The lower the thermal conductivity of the sample gas, the higher the maximum temperature measured, as expected.
- Almost linear relationship between para-hydrogen percentage and maximum temperature, providing simple calibration for comparison with unknown gas samples.
- The para-hydrogen percentage can be determined with <2% error.
- Sample degradation: fresh samples used for each test and repeated tests on the same sample gave an increasing maximum temperature, indicating decreasing para-hydrogen percentage, as expected.
- Sensor degradation: the sensor was checked for consistency at 77K before each test. The platinum sensor underwent over 30 heating cycles without degradation.
- Pressure and heat convection/radiation changes: these were deemed negligible, providing operating conditions were kept constant.

Rig performance:

- Base temperature of para-hydrogen cell: 16 K in 4 hours.
- Vibrations produced by cold head mix hydrogen sufficiently to bring about maximum conversion through contact with the catalyst.
- Neutron measurements on gas sample confirmed full conversion to para-hydrogen.
- Successful low maintenance replacement for helium cryostat; para-hydrogen now 'on-tap'.