



National Physical Laboratory

# Design of the NPL Small Guarded Hot Plate

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National  
Measurement  
System



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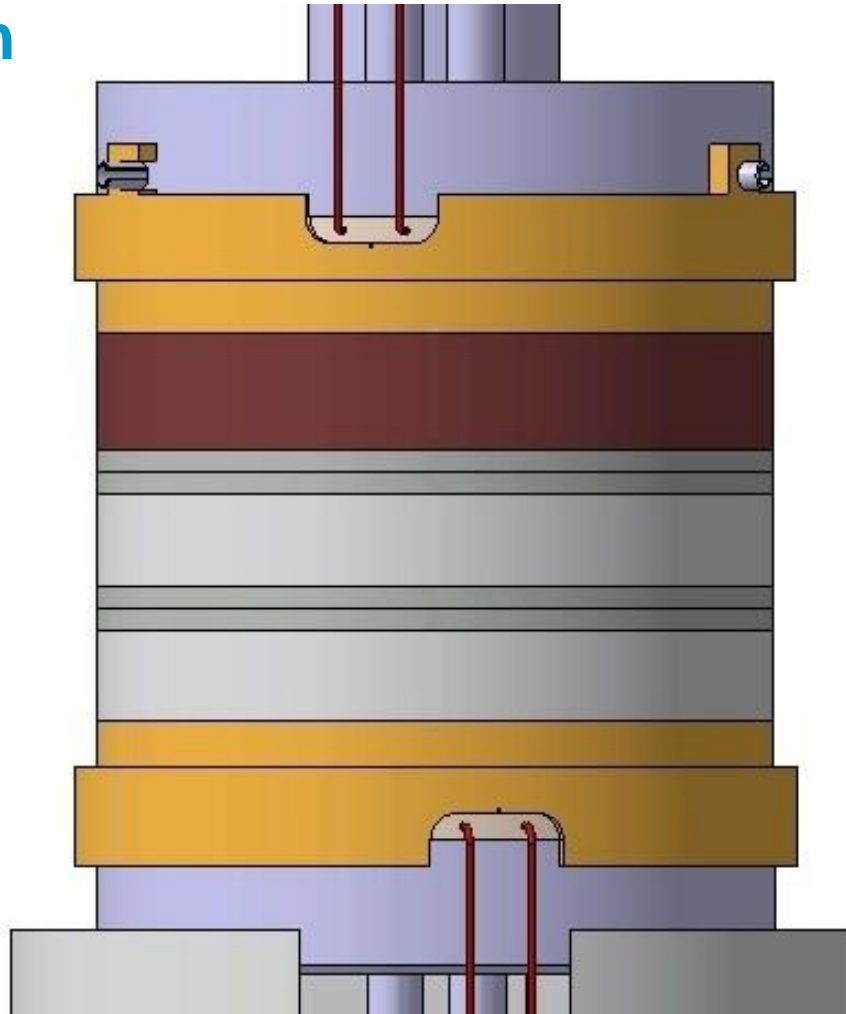
## Industrial Requirements

- Examples of Industrial Requirements:
  - Composites: including polymer composites for aerospace
  - Polymers: including oil pipeline insulation
  - Ceramics & glass: including energy generation applications
  - All becoming more demanding in terms of accuracy and conditions under which materials is tested
- NPL current service based on ASTM E1530 (-100 °C to 250 °C)
  - Not absolute, insufficient accuracy and flexibility
- NPL current service based on ISO 8302 (-20 °C to 70 °C)
  - Specimens too large and insufficient temperature range

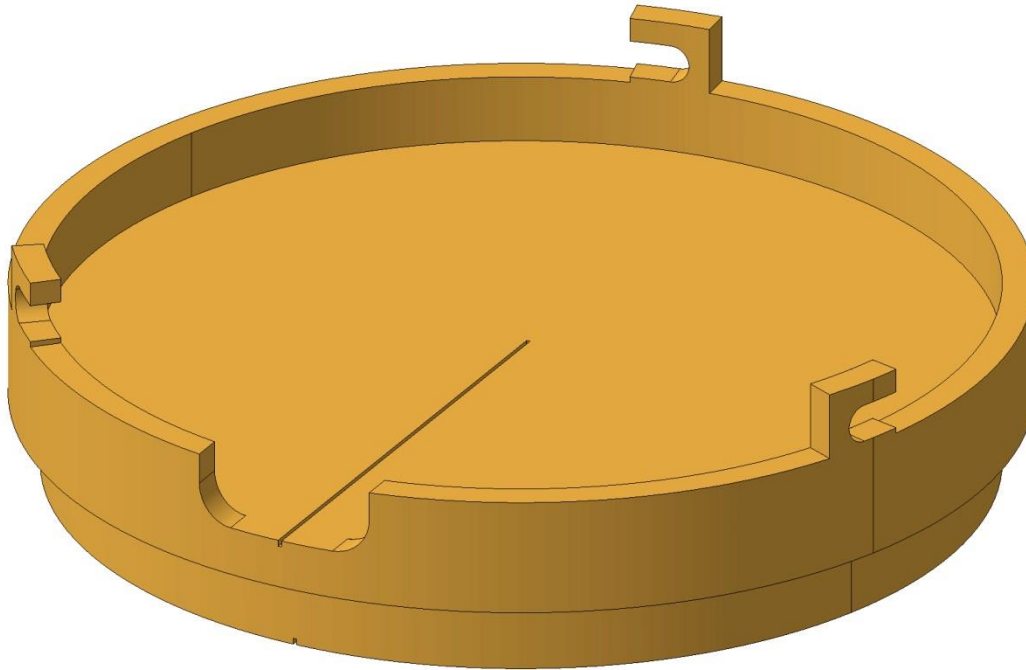
## Project Objective

- Establish new National Facility for thermal conductivity measurements on composites, ceramics and polymers:
  - Guard Hot Plate (absolute and steady-state)
  - Temperature -100 °C to 250 °C
  - Thin specimens (below 5 mm)
  - Lowest available uncertainty
  - Flexibility in environmental conditions
  - Measurements under high compressive loads (up to 9 MPa)

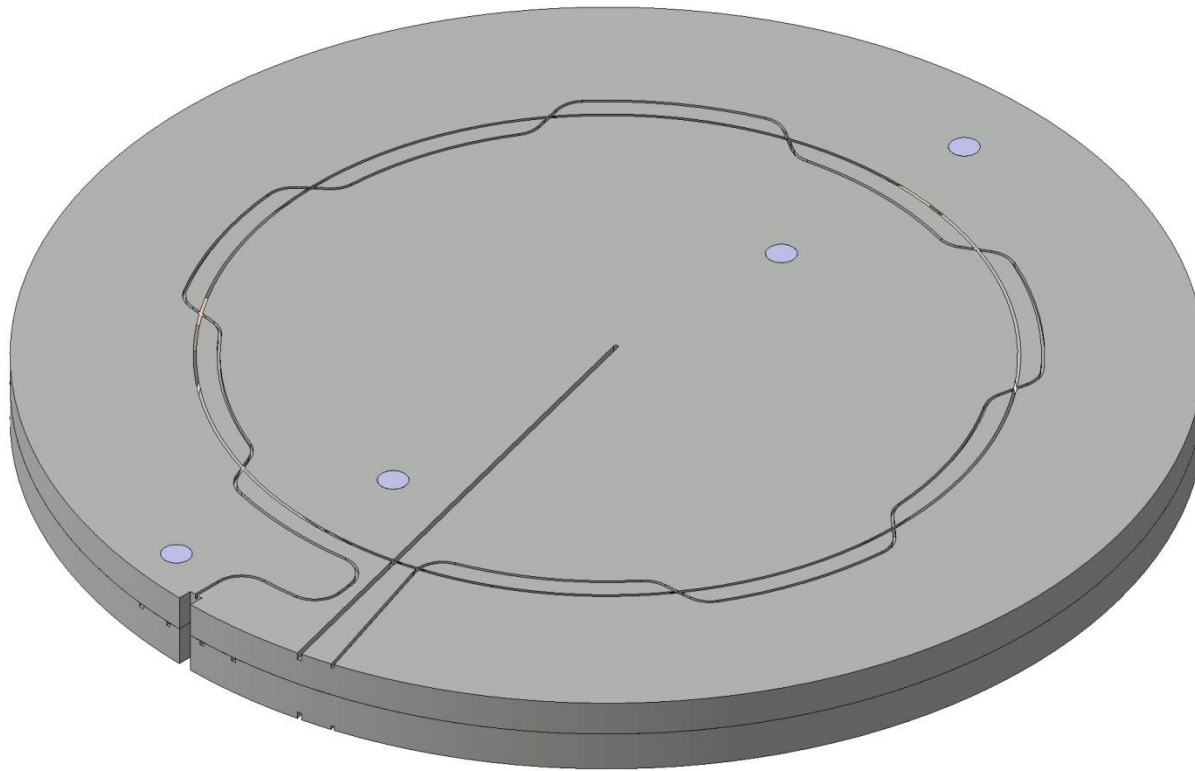
# Configuration



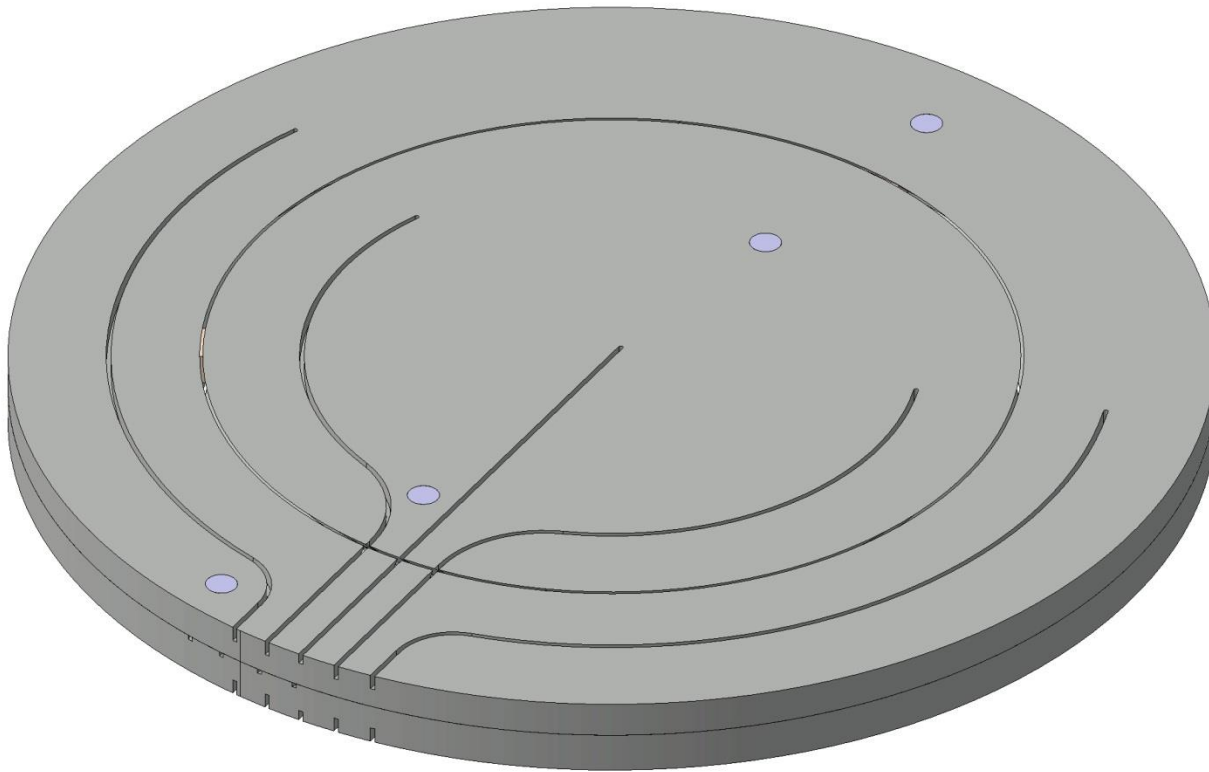
# Cold-Plates



## Guarded Heater-Plate (original design)

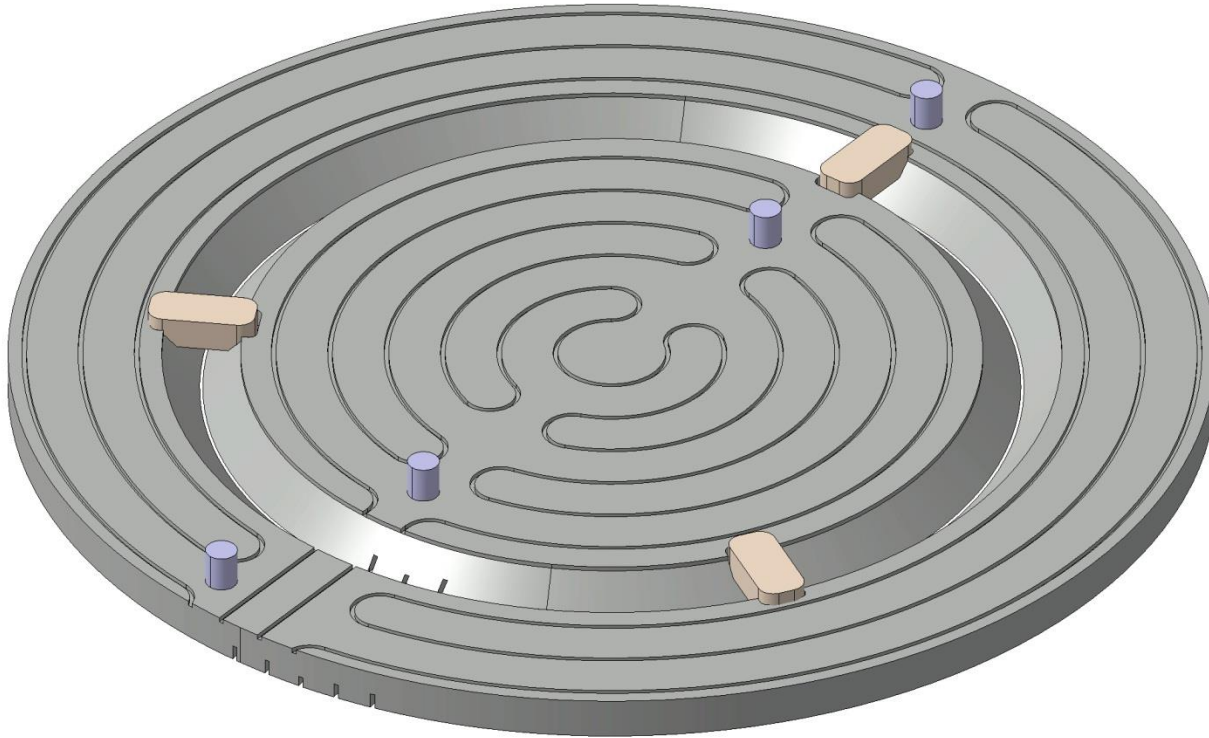


## Guarded Heater-Plate (second design)

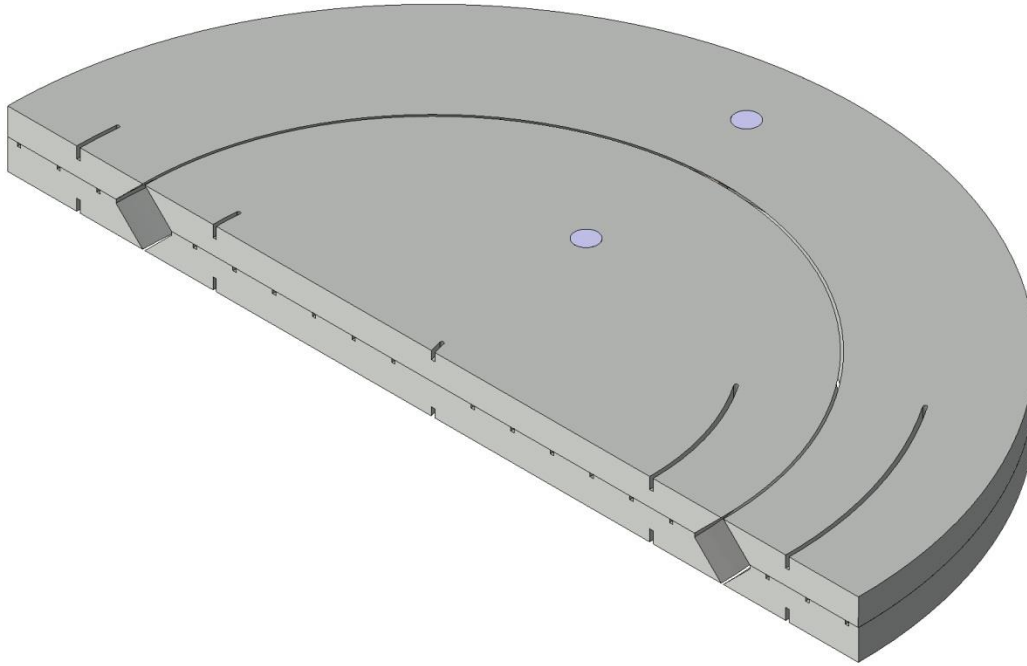




## Guarded Heater-Plate (heater wire grooves)



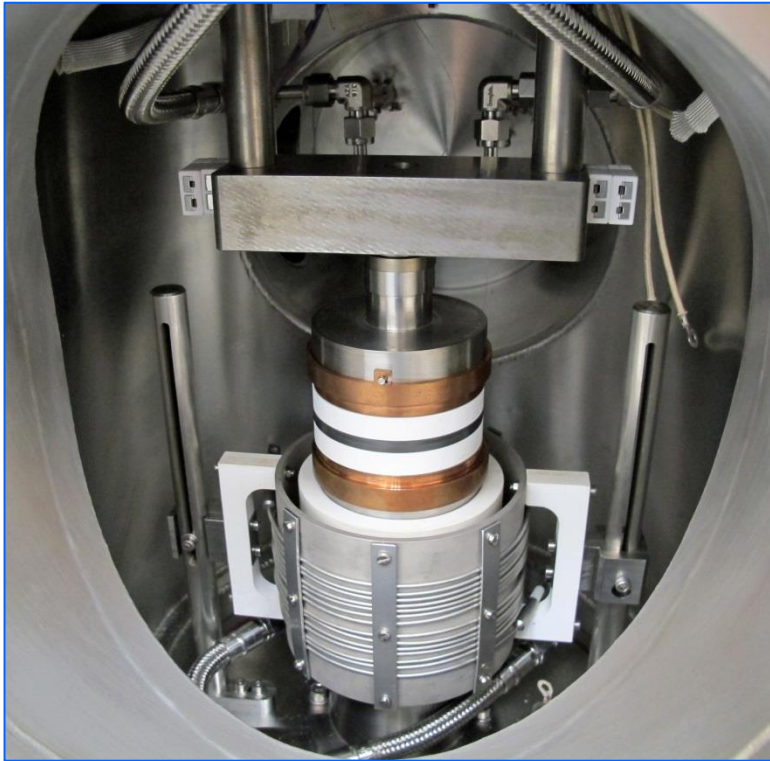
## Guarded Heater-Plate (cross section)



# Specimen Temperature Measurement

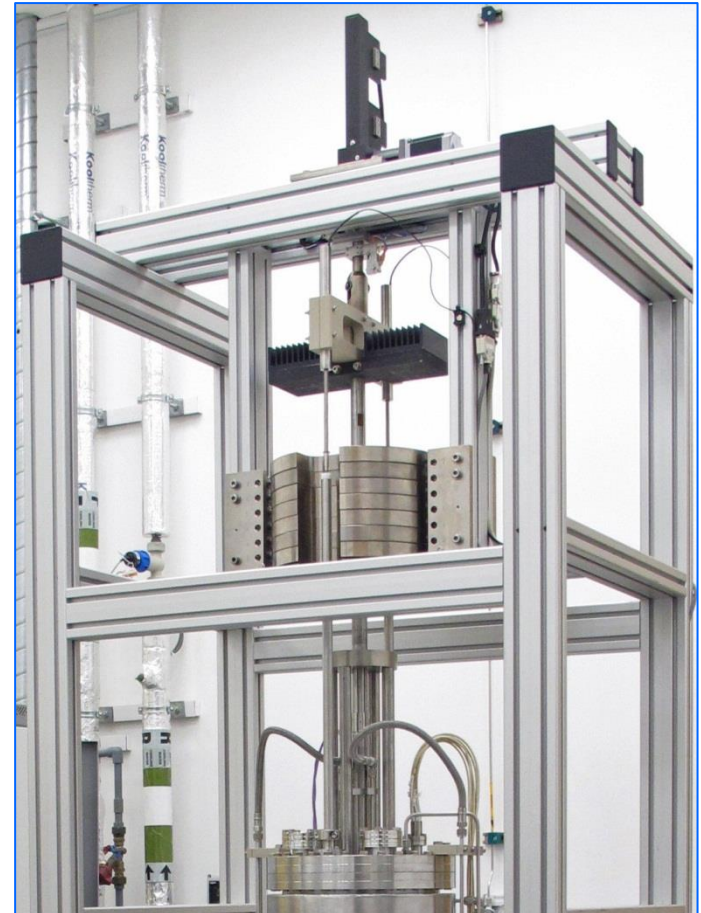
- Measurement Issues:
  - Thermal contact resistance
  - Differential expansion
  - Transducer dimensions compared to thin specimen
- Measurement Solutions:
  - Surface mounted thermocouples (butt-welded, 0.075 mm)
  - Thermal interface materials
  - Thin films (centre-guard gap & absorbent specimens)

# Environmental Chamber



## Compressive Load and Specimen Thickness

- Applied Compressive Load:
  - Nominal 150 kPa
  - Variable (weights)
  - Full design (9 MPa)
- In-Situ Specimen Thickness:
  - Pair of LVDTs
  - Distant from upper cold-plate
  - Double bellows system
  - Calibration of whole system across temperature range



## Future Plans

- EMRP ‘Metrology for Thermal Protection Materials:
  - Investigate minimisation of contact resistance
  - Performance evaluation, optimisation & validation
  - Certified reference materials from composites
- Measurement Services and materials R&D projects
- Extend range of NPL reference materials
- Measurements of thermal conductivity and contact resistance under high compressive loads (9 MPa)

# National Measurement System



*The National Measurement System delivers world-class measurement science & technology through these organisations*



The National Measurement System is the UK's national infrastructure of measurement Laboratories, which deliver world-class measurement science and technology through four National Measurement Institutes (NMIs): LGC, NPL the National Physical Laboratory, TUV NEL The former National Engineering Laboratory, and the National Measurement Office (NMO).

# Euramet EMRP

- EMRP supports the collaboration of European metrology institutes, industrial organisations and academia through Joint Research Projects (JRPs). It is structured around European Grand Challenges in such areas as Health, Energy, the Environment & New Technologies.
- This presentation is one of 17 presentations, 5 posters and 2 workshops at this conference supported by the European Metrology Programme, implemented by EURAMET.
- The last call for EMRP proposals has just closed – but we look forward to its successor - EMPIR. See [www.euramet.org](http://www.euramet.org) for more details.



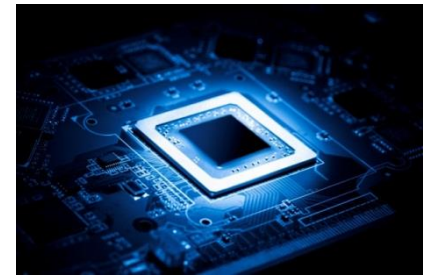
SI Units (2011 & 2012)



Environment (2010 & 2013)



Energy (2009 & 2013)



New Technologies (2011)



Health (2011)



Industry (2010 & 2012)