SR555: Heat Transfer in Space Applications

Thermal Insulation and Heat Pipes

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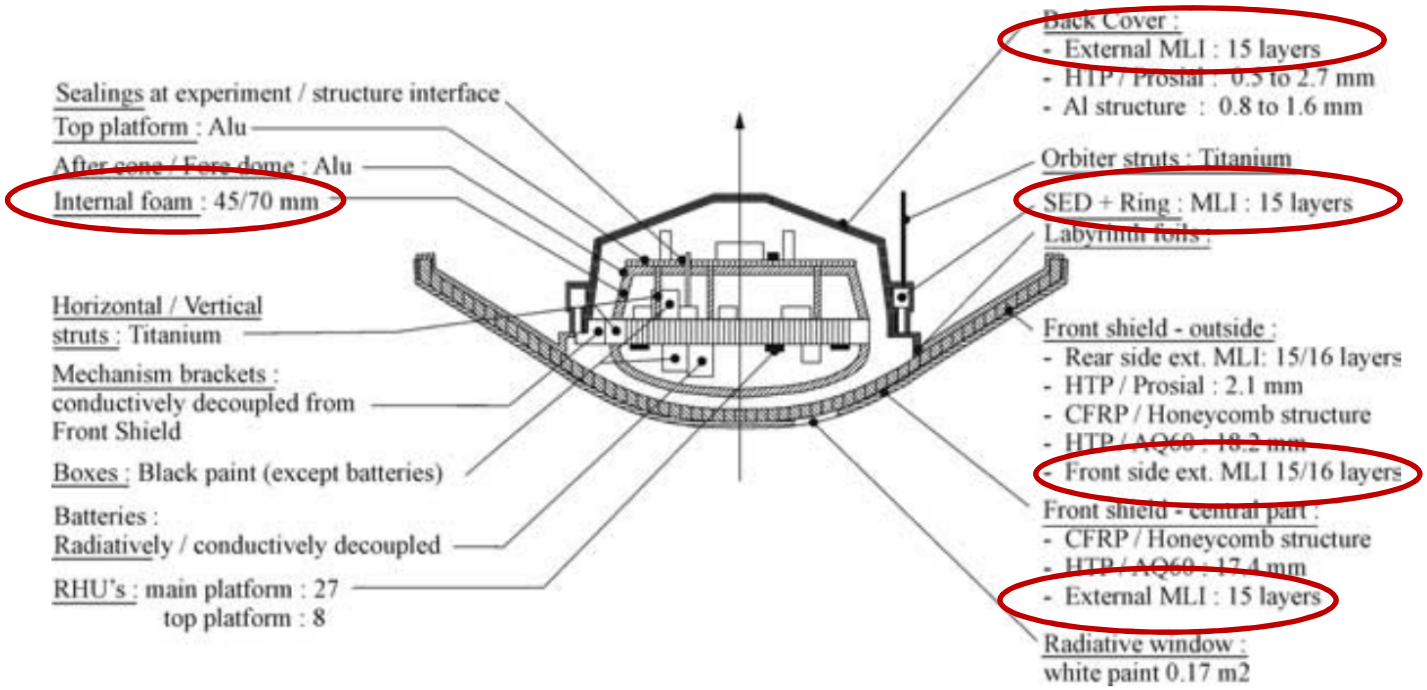
Huygens Probe Insulation

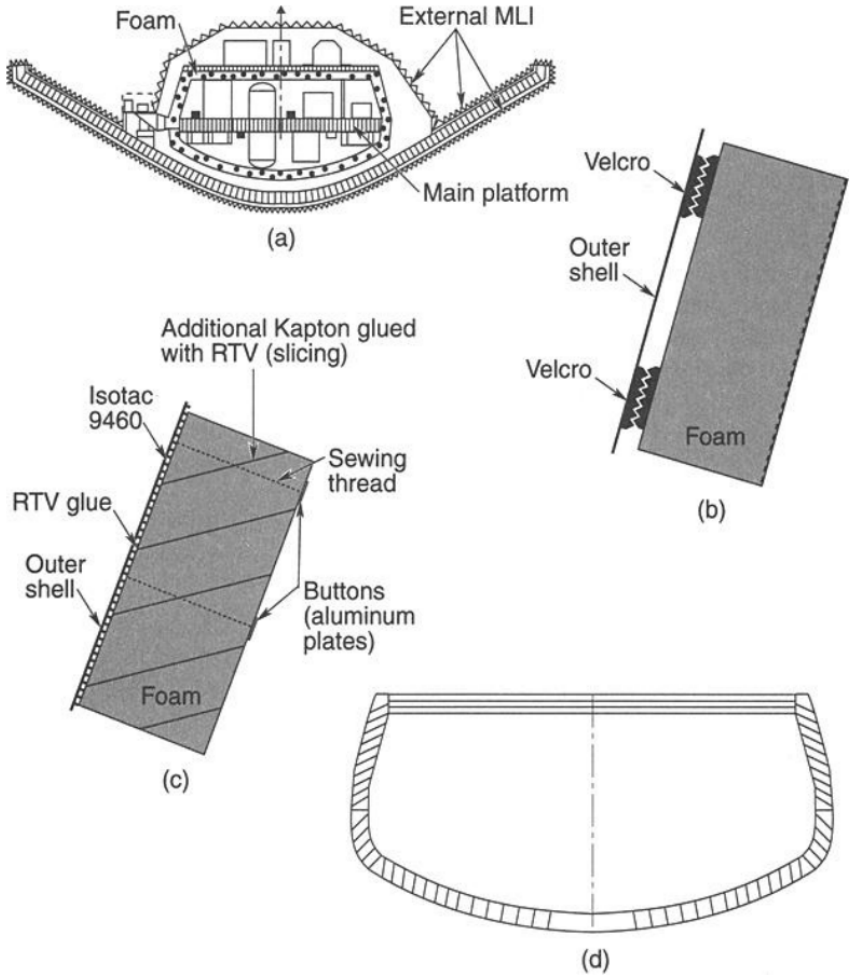
Consult Figure 11 in the uploaded document



- RHU: Radioisotope heater unit
- MLI: Multi-Layer Insulation

Foam Insulation

- Gas conduction is major cause of heat loss
- Convection effects could be important around and within the foam
- Design changes made in the insulation to account for convection are described in p. 201, Gilmore



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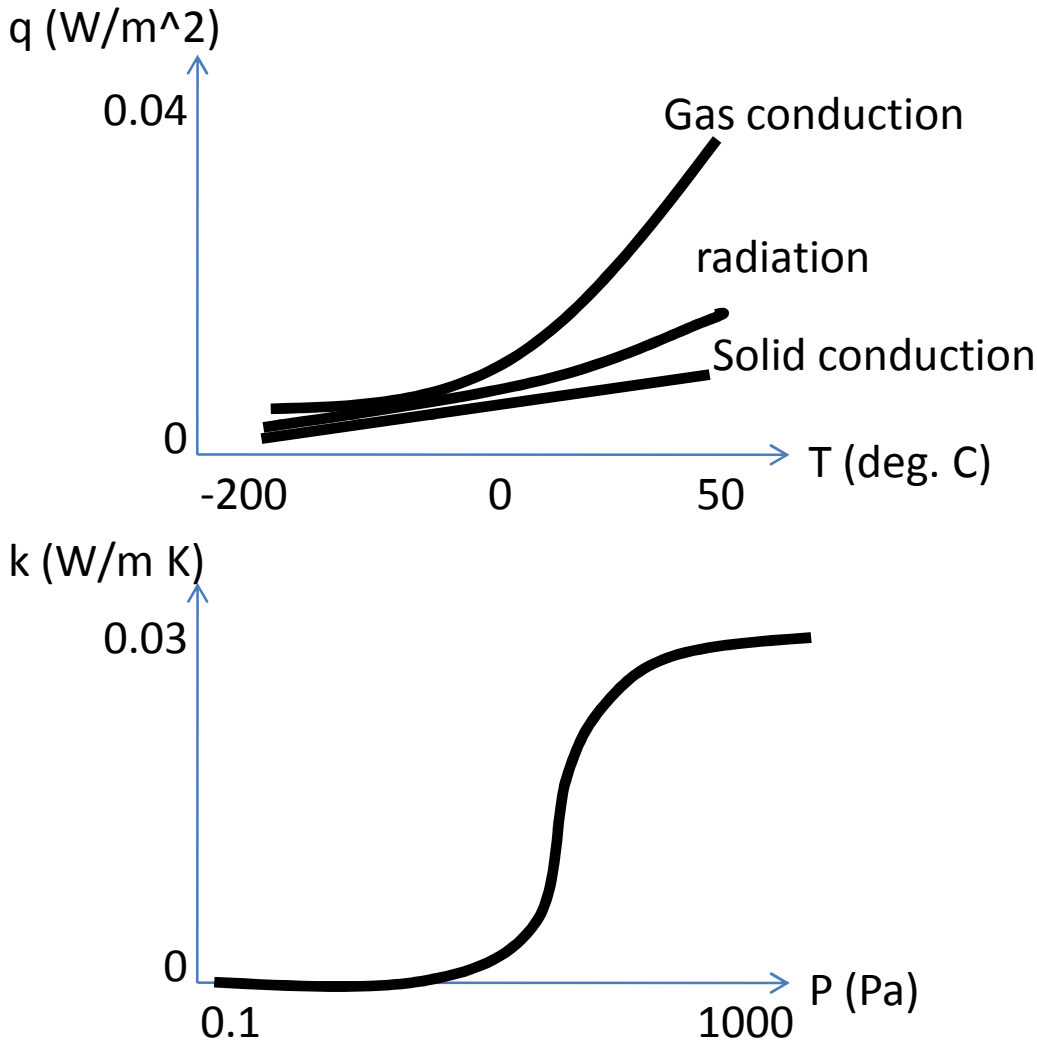


Heat Pipes

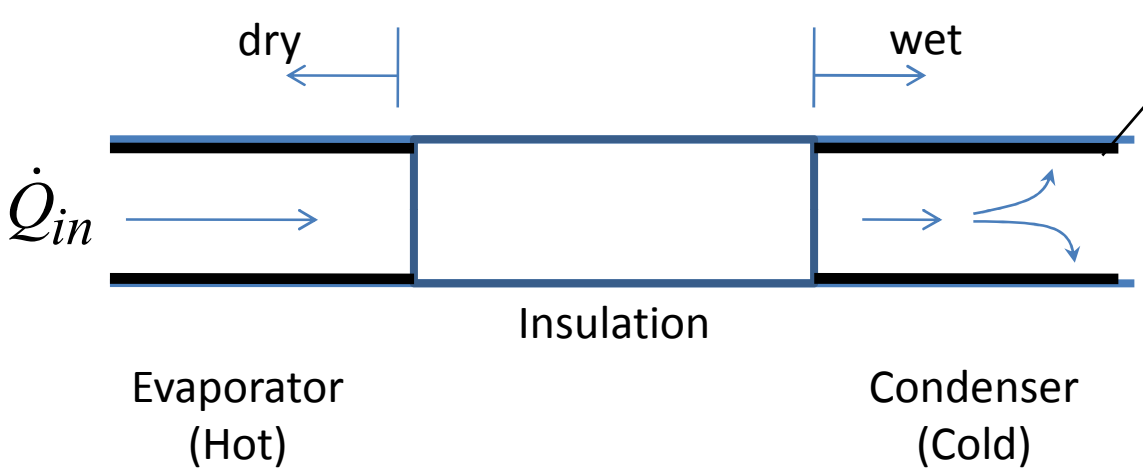
Reference: Chapter 14 / Gilmore

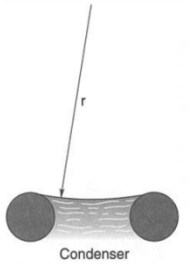
- **Active, conduction based thermal control method for spacecrafts**
- **Principle:**
  - Closed two-phase flow cycle
  - No electric power is involved
  - One-way heat pipes behave like diodes
  - Variable-conductance deigns are also available
  - **Basic principle: capillary action → constrained by gravitational field**

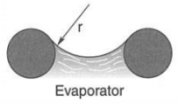
Heat Pipes

- **Principle:**

Equilibrium: vapor and liquid temperatures are equal
→ saturation condition; isothermal environment



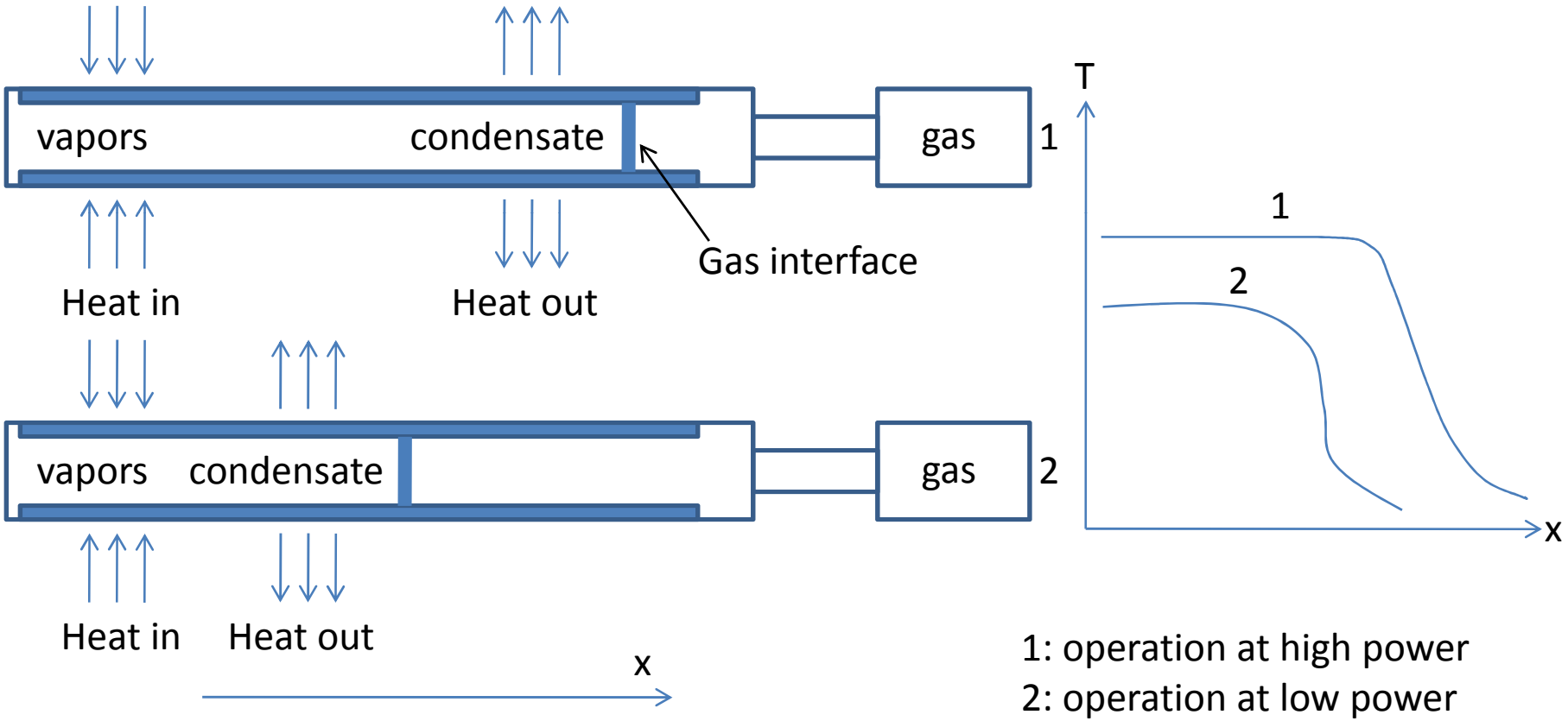




1: applied heat to the evaporator raises temperature and liquid trapped in the wick evaporates; increase in local pressure of vapor→ vapor flows towards condenser
2: capillary pressure difference is generated in the wick in the direction of evaporator and generates flow of liquid through the wick towards evaporator
3: cycle continues

Heat Pipes

- **Operation at different power levels:**



1: operation at high power
2: operation at low power

Heat Pipes

- **Design issues:**
  - Selection and installation of wick (SS, Cu meshes)
  - Selection of liquid (cryogens, water, liquid metal as per operating temperature) → (essential properties: high heat of vaporization, high k, high surface tension, low viscosity, wetting properties, appropriate boiling point)
- **Performance control:**
  - Inert non-condensable gas with automatic control

Heat Pipes

- **Constraints:**
  - Viscous drag in wick at low temperature
  - Ability of wick to move liquid through required capillary pressure difference
  - Drag of vapor on returning liquid
  - Sonic speed in vapor
  - Burnout heat flux during boiling in hot section

References and Reading Material

- Paper on systems design of Huygens probe (uploaded separately)
- **Gilmore / Chapter 14:**
  - Pages 489-496; 518-521