Heat Rejection

Power Source	η–%
Radioisotope	**5-10**
Thermionic	**10-15**
Rankine	**≈20**
Brayton	**20-30**
Stirling	**≈25**

Burst Mode Operation; Could use thermal inertia, or phase changes

Steady State Operation; Transport waste heat to radiators is only solution

How Do We Get The Heat From The Power Source to The Radiator?

- **Conduction** *(Mass)*
- **Convection** *(No gravity)*
- **Heat Pipe** *(Effective thermal conductivity > 1000 X Ag)*

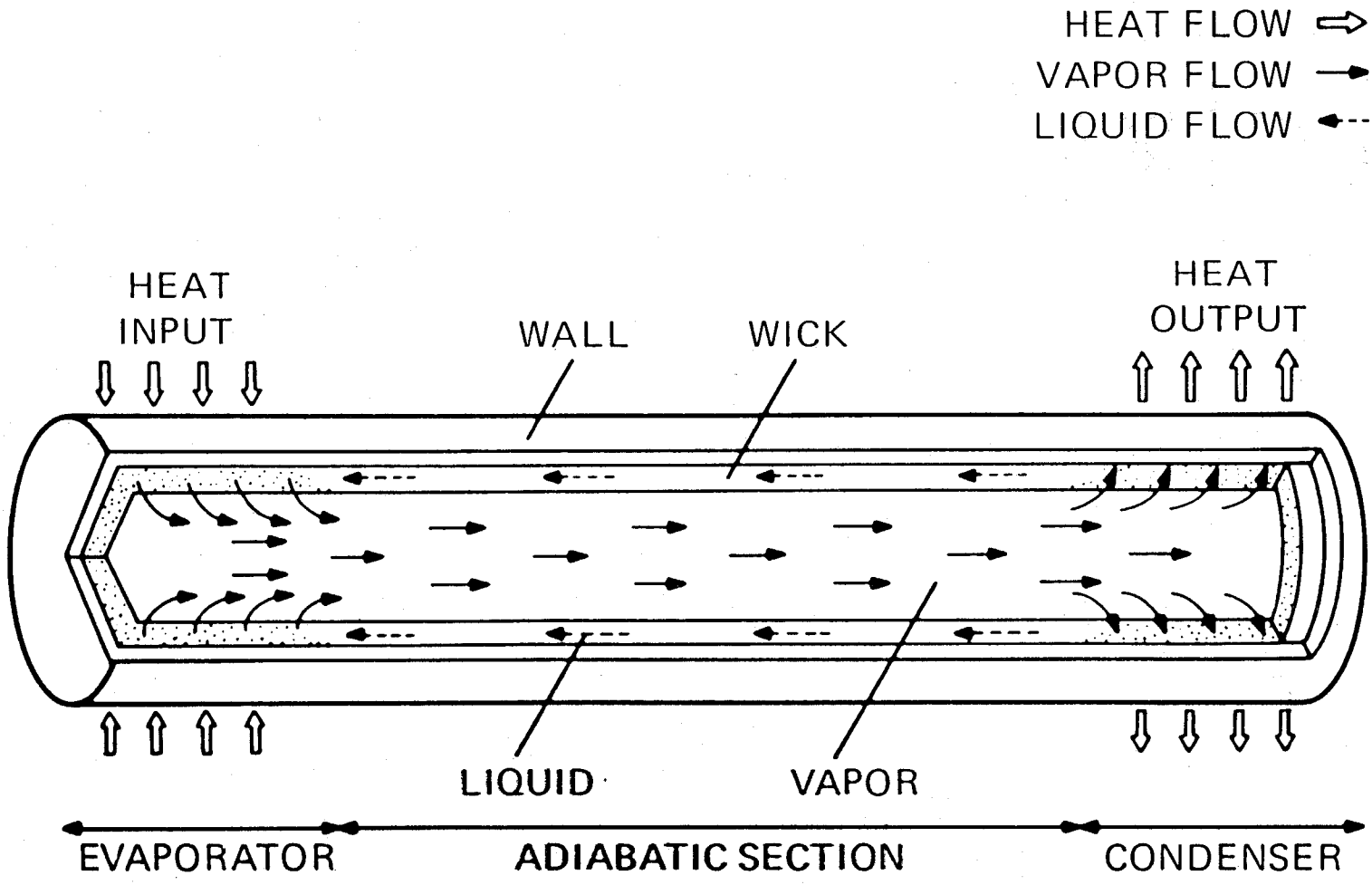

Fig. 4.7 Heat pipe operating principle. *Courtesy of Los Alamos National Laboratory.*

DESIGN AND TECHNOLOGY OF HEAT PIPES FOR COOLING AND HEAT EXCHANGE

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Bethel Park, Pennsylvania

HEMISPHERE PUBLISHING CORPORATION
A member of the Taylor & Francis Group
Washington Philadelphia London

History

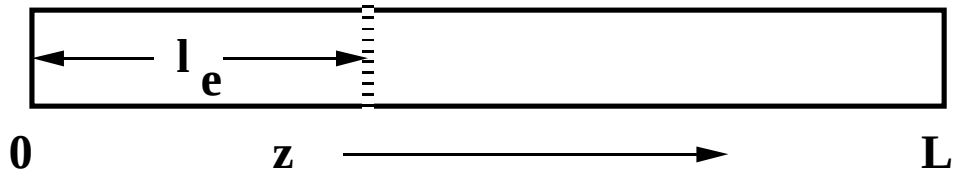
1944 R. Gaughler Proposed Capillary Pumping For Refrigeration Application

1962 L. Trefethan Proposed Capillary Pumped Device For Satellite Application

1963 George Grover (LANL) Devised Working Model of Heat Pipe- Granted High Temperature Heat Pipe Patent

Heat Pipes now operate from cryogenic temperatures to 2000 °C.

General Performance Factors of Heat Pipes



$$Q_o(z) = \lambda \dot{m}_v(z) \quad \text{Watts}$$

Latent Heat — λ

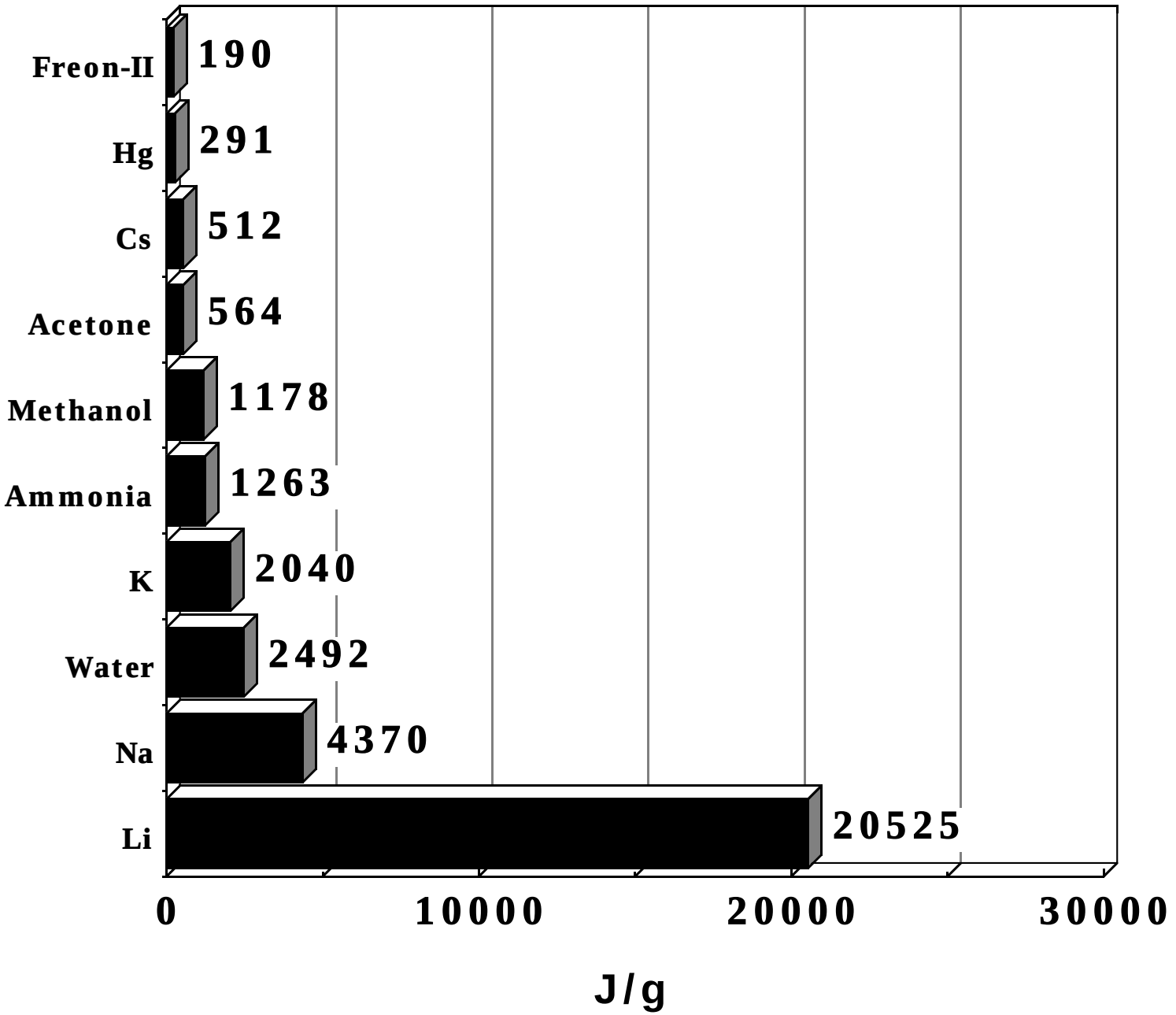
Vapor Mass Flow rate — $\dot{m}_v$

$$= (z/l_e)\, Q_e \quad \text{for } 0 < z < l_e \quad \text{Input}$$

Total Heat Flow to Evaporator — Q_e

$$= \left(\frac{L-z}{L-l_e}\right) Q_e \quad \text{for } l_e < z < L, \text{ Ht Rejection}$$

Liquids Commonly Used in Heat Pipes



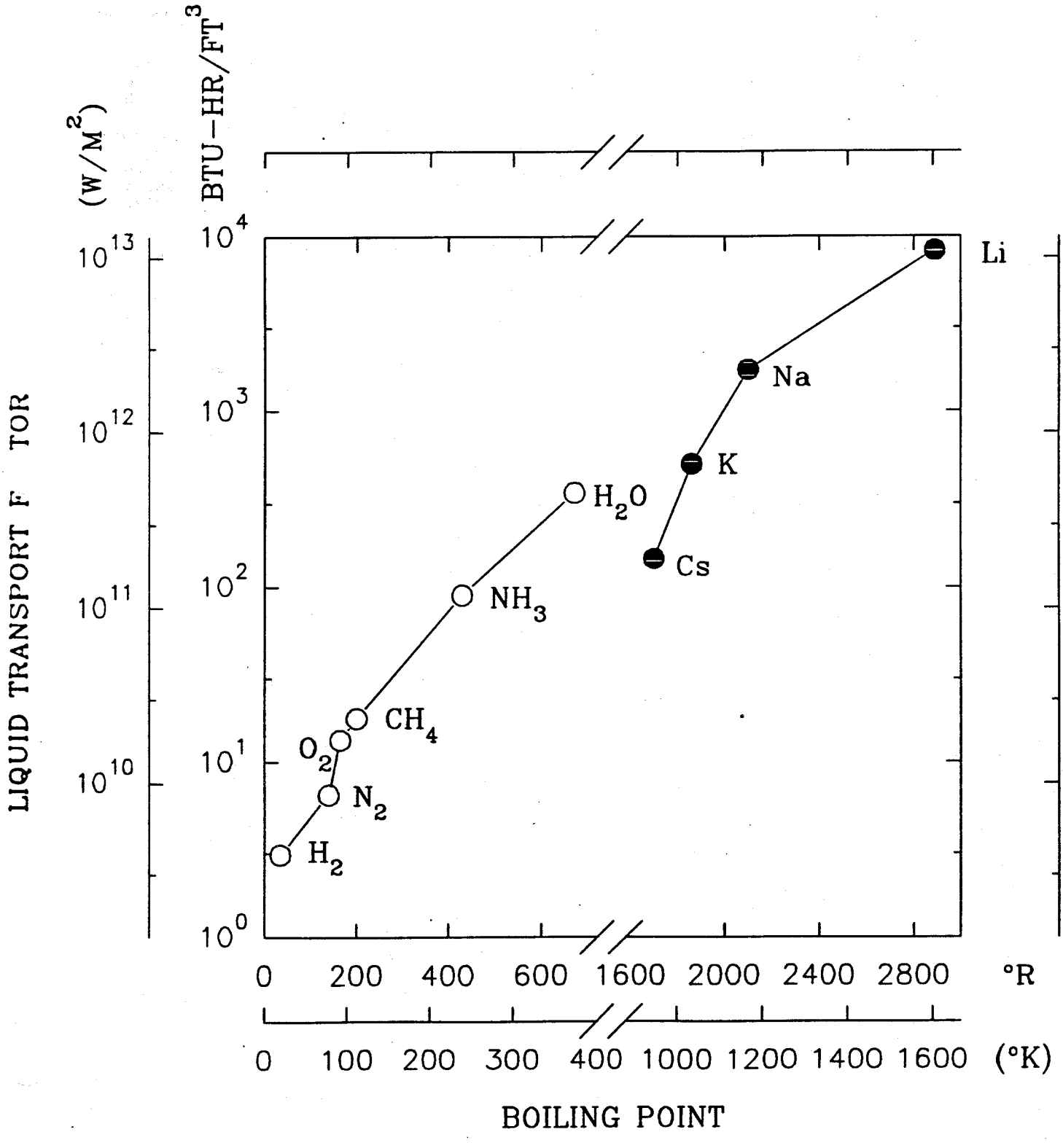


Figure 3.3. Liquid transport factor at boiling point versus boiling point.

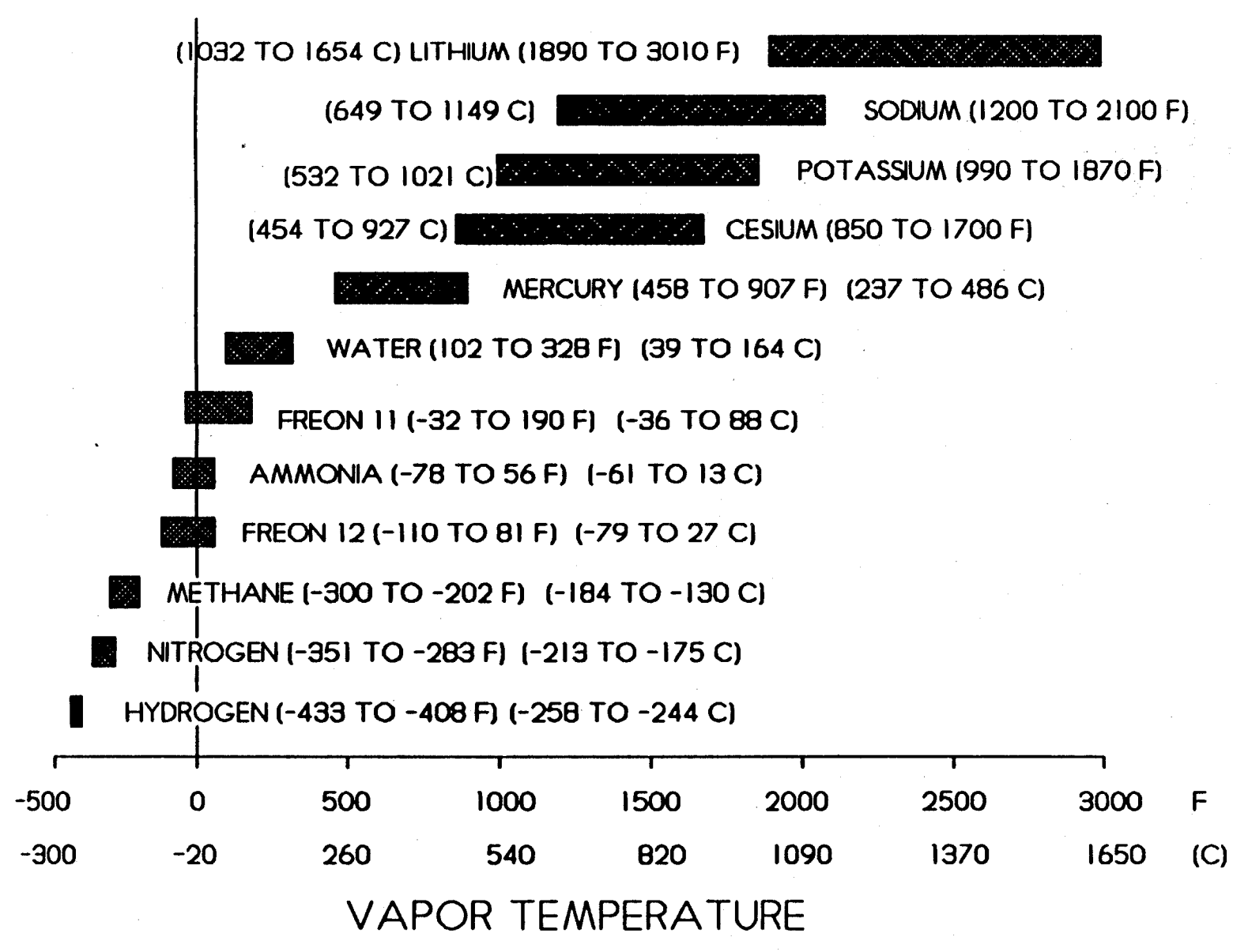
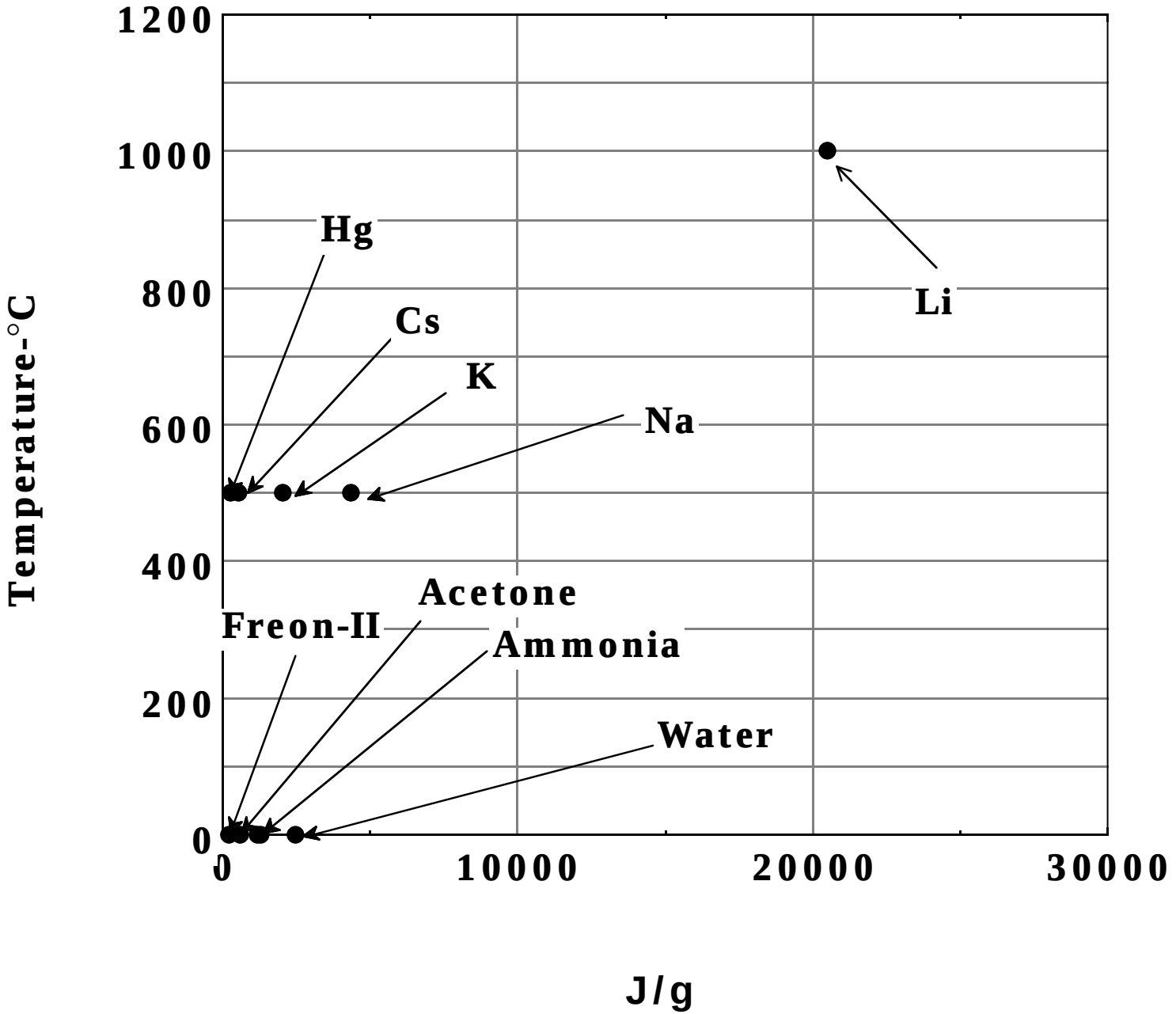


Figure 3.2. Operating temperature ranges of various heat pipe fluids.

Typical Operating Regimes For Heat Pipe Fluids



Wick Characteristics

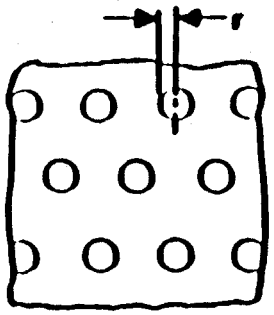
Can be :

- ***Woven Cloth***
- ***Metal screen***
- ***Grooves in Wall***
- ***Porous Solid***
- ***Packed Spheres***

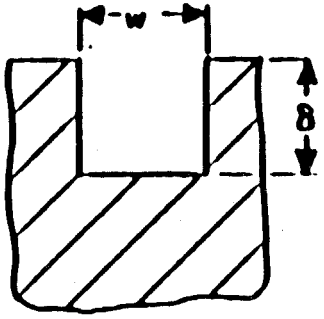
Figures (2)

Effectiveness of Wick Determined by:

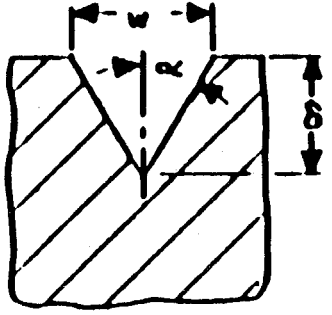
- ***Mean pore radius***
- ***Liquid volume fraction***
- ***Permeability***



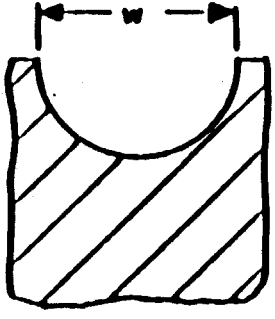
(1) Cylindrical Pores



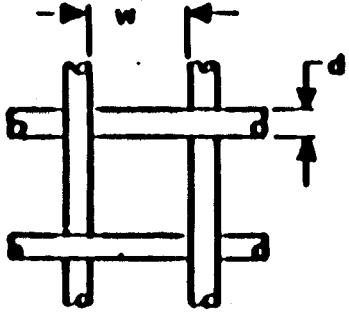
(2) Rectangular Grooves



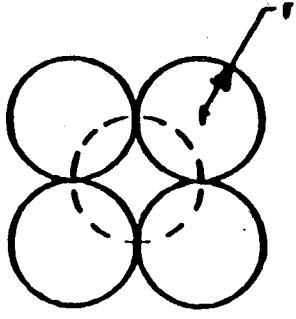
(3) Triangular Grooves



(4) Semicircular Grooves

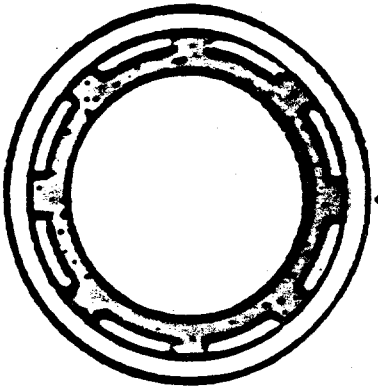


(5) Square Mesh

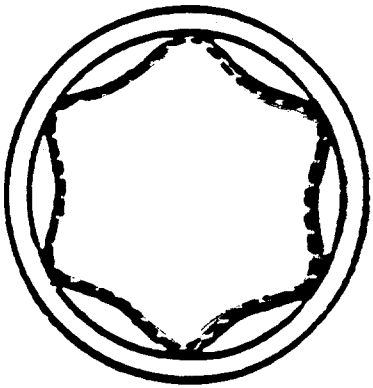


(6) Packed Spheres

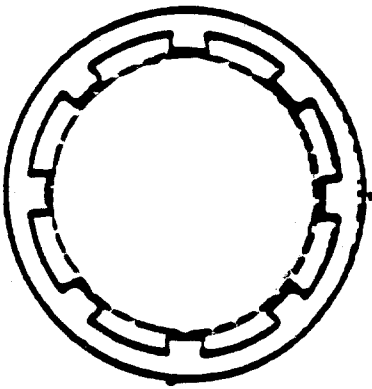
Figure W-1. Cases for Which the Effective Pore Radius can be Estimated



POWDER METAL
TUNNEL WICK



SCREEN WICK WITH
SEGMENTED ANNULUS



SCREEN WICK
COVERED GROOVES

ALTERNATIVE HEAT PIPE
WICK CONFIGURATIONS