THE THERMAL CONDUCTIVITY OF REFRIERANT 13 (CCIF₃)

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ABSTRACT:
An absolute transient line source technique was utilized to obtain the thermal conductivity of R-13 over the temperature range 100 to 425K at pressures from 0.17 to 21 MN m⁻² including the critical region. The accuracy of the data was established by measurements for CO₂ and is thought to better than ±2% outside the critical region. Analysis of the critical isochore data yielded power law exponents of A = 0.0018 ±0.0002 and φ = -0.57 ±0.08. The saturation liquid values, which were significantly below those obtained by steady-state apparatus, supports the conclusion that a substantial fluid radiation conductivity exists for this fluid.

INTRODUCTION:
Most refrigerants are fluorocarbon compounds and find extensive application in the heat transfer field. There is, however, a wide disparity in the existing thermal conductivity values of these compounds (1) and the establishment of reliable data covering a large range of temperatures and pressures is essential. A thorough investigation of the influence of anomalous effects in the normal temperature of usage of fluids is also important.

Precise determination of thermal conductivity for the commonly used refrigerants is very difficult because of their low thermal conductance and heat capacity. Thermal conductivity of most refrigerants lies in the

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range of 6 to 7 mW/M-K in the vapor state (one bar) and 100 to 130 mW/M-K in the liquid state (1, 2, 3). Hence the precision of measurement for most techniques is very low especially in the vapor state. For transient determinations, the small heat capacity of refrigerants in the vapor state gives a low value of heat capacity ratio, \( \omega \), and a very high correction factor to the transient line source technique as will be discussed later.

As part of a continuing programme on the refrigerants (4, 5) Refrigerant 13 was chosen for this investigation. This fluid has the following physical properties (6, 7):

**METHOD:**

**Theory:**

A transient hotwire cell consists of an electrically heated wire, suspended vertically in the fluid medium of which the thermal conductivity is to be measured. The fluid is contained in a cylindrical enclosure maintained at a constant temperature. The transient behaviour of this hotwire is idealized by the solution of the transient one-dimensional conduction analysis.

Mani (8) gives a detailed account of the mathematical analysis, the various corrections to the ideal model and of the experimental apparatus used in this investigation: simply stated the equation expressing the conservation of energy for the wire is:

\[
\rho C_p \frac{dT}{dt} = -q
\]

where \( q \) is the heat flow, expressed as

\[
q = -\lambda \frac{dT}{dr}
\]

with boundary conditions:

\[
T(r, 0) = T_\infty, \ \text{a constant,}
\]

\[
\lim_{r\to\infty} T(r, t) = T_\infty, \ \text{and}
\]

\[
\lim_{r_1, r_2\to0} r \left( \frac{dT}{dr} \right) = \frac{Q_L}{2\pi\lambda}, \ \text{a constant for } t > 0
\]

where \( Q_L \) is the heat generated per unit length of the source.

The solution to equation 1 is

\[
T(r, t) - T_\infty = -\frac{Q_L}{4\pi\lambda E_1(-r^2/4\alpha t)}
\]


\[
\text{Freezing point} \quad 92 \text{ K}
\]

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical temperature</td>
<td>302 K</td>
</tr>
<tr>
<td>Critical pressure</td>
<td>39.2 atm</td>
</tr>
<tr>
<td>Critical density</td>
<td>0.578 gm/cc</td>
</tr>
<tr>
<td>Decomposition temperature</td>
<td>about 430 K</td>
</tr>
</tbody>
</table>

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