AT/39.2/031
(see also AT/44.2/010)

# Thermal Conductivity Considerations of Stainless Steel Components.

## Introduction.

The standard thermal conductivity tables for stainless steel provide values for temperature differentials 300K-77K, 300K-4K, and 77K-4K. The differentials 300K-20K and 77K-20K do not form part of the standard tables. The purpose of this is to calculate the mean thermal conductivity for stainless steel for these temperature differentials, to be used as a reference.

## Theory.

The mean thermal conductivity can be represented by the following equation (White,1979) :

$$\overline{\lambda} = (T_1 - T_2)^{-1} \int_{T_1}^{T_2} \lambda(T)\, dT \qquad (1)$$

This equation requires knowledge of the function $\lambda(T)$, which at this point is unknown. Curve H in Figure 1 from Scott, p345, is the logarithmic plot of the thermal conductivity of stainless steel.This curve is plotted on a linear scale in Figure 2 and an estimate of the function of the curve has been made as:

$$\lambda(T) = -4.7127 + 1.4280T - (5.1049\times10^{-3})T^2 + (6.5181\times10^{-6})T^3 \qquad (2)$$

Units : mW/cm.K

Integrating equation (2) so it can be substituted in equation (1) gives :

$$\int \lambda(T)\, dT = -4.7127T + 0.7140T^2 - (1.7016\times10^{-3})T^3 + (1.6295\times10^{-6})T^4 \qquad (3)$$

This is the equation to be used in calculations.

## Calculations.

The mean thermal conductivity was calculated for the following temperature differentials:

$T_2 = 300K$ $T_1 = 77K$
$T_2 = 300K$ $T_1 = 20K$
$T_2 = 77K$ $T_1 = 20K$

The table below presents the results of the calculations.

| Temperature Differential (degrees Kelvin) | Mean Thermal Conductivity $\bar{\lambda}$ W/m.K |
|---|---|
| 300 - 77 | 12.086 (12.3 - White,p133) |
| 300 - 20 | 10.687 |
| 77 - 20 | 5.216 |

## Conclusions.

As the first set of values from the table shows, the model used to calculate the conductivity values for the other two temperature differentials is fairly accurate. Hence, the thermal conductivity values calculated for the temperature differentials listed can be used as good estimates of the true thermal conductivity of stainless steel for those temperature differentials.

## References.

White, G.K. Experimental Techniques in Low-Temperature Physics Third Edition Oxford , 1979

Scott, R.B. Cryogenic Engineering New Jersey , 1959

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Figure 1. Thermal Conductivity of Stainless Steel (log scale)

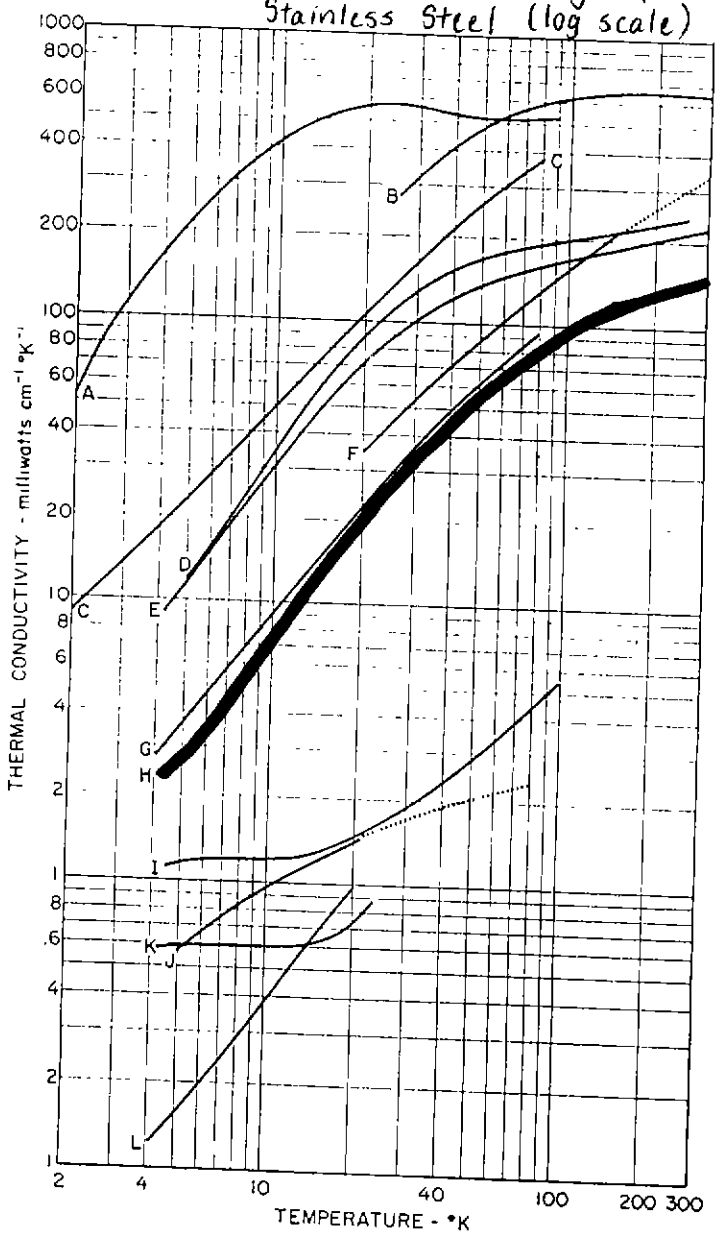


FIGURE 10.8. Low-temperature thermal conductivities of some solids with relatively low conductivities. A, 50-50 lead-tin solder [44]; B, steel, SAE 1020 [39]; C, beryllium copper [44]; D, constantan [39]. E, Monel[reg] [39]; F, silicon bronze [42]; G, Inconel[reg] [39], H, type 347 stainless steel [39]; I, fused quartz [39]; J, polytetrafluoroethylene (Teflon[reg]) [41]; K, polymethylmethacrylate (perspex) [39]; L, nylon [44].

Figure 2. **Thermal Conductivity of Stainless Steel**