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THERMAL CONDUCTIVITY OF SODIUM-POTASSIUM ALLOY (77.7 WT.-% POTA--ETC(U)
AUG 52 C T EWING, R E SEEBOLD

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NRL MEMORANDUM REPORT No. 47

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CHEMISTRY DIVISION

12 August 1952

NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.

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By

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ABSTRACT

The thermal conductivity of sodium-potassium alloy, 77.7 wt. %K, has been determined between 157° and 676°C. The conductivity curve of this alloy increases from 0.2393 watts/cm-°C at 157°C to a maximum of 0.2618 watts/cm-°C at 445°C and then decreases to 0.2563 watts/cm-°C at 676°C. A graphic correlation of these results with those of two other previously reported sodium-potassium alloys is presented.

PROBLEM STATUS

This is a preliminary report on this subject and further investigations will be carried out in connection with the study of physical-chemical properties of alkali metals.

AUTHORIZATION

NRL Problem No. C11-02

NR 411-020

A thermal conductivity apparatus was designed and built for reliable research measurements on liquid metals. The assembly and its operation were discussed in detail and results were reported for sodium and potassium metals in NRL Report No. 3835. Results on a sodium-potassium alloy (56.5 wt. % K) were reported in NRL Letter Report 3230-135A/51. Further investigation has been carried out on another sodium-potassium alloy (77.7 wt. % K) for which results are reported herein.

The apparatus designated for the alloy work was essentially as previously reported in NRL Report No. 3835 except for minor changes which were incorporated for increased accuracy. The position of the bar sample heater relative to that of the guard-ring heater was raised 0.3 of a cm. By this means, heat exchange with the top of the bar was reduced to only a small fraction of the one percent exchange in the pure metal experiments. The fraction of heat lost to leads, and error therefrom, was reduced noticeably by replacing the platinum leads (to the sample heater) with a two-section lead -- a platinum - 10% rhodium section extending to the fringe of the isothermal zone and a large diameter platinum section extending out of the furnace.

Platinum-platinum rhodium thermocouples were used, as previously, to measure temperatures on the assembly. The same stainless steel (type 304) tube which had been used in the previous alloy work was utilized for this investigation. Thermocouples, which had been intercalibrated against National Bureau of Standards primary couples, and which had been used in the previous alloy measurements were employed for this alloy measurement. Intercalibration of these couples in situ was unnecessary since the thermal conductivity of the stainless steel bar had been accurately determined during the previous measurements on sodium-potassium alloy and this known conductivity served as a positive check on the accuracy and stability of the couples.

No thermal resistance at any alloy interface was apparent during any part of these measurements. The final conductivity results for this alloy (77.7 wt. % K) are listed in Table I in the order measured. Each value represents a series of equilibrium experiments over a period of 48 to 96 hours. The probable error for the average result is not over 1%.

Temperature gradient in the liquid metal alloy was measured with the two outer of three thermocouples peened into the wall of the specimen chamber. An additional check gradient was obtained by extrapolating the temperatures in the stainless steel sections above and below the metal alloy sample. This check gradient was necessarily of lower precision due to the influence of radial heat exchange. The average extrapolated gradients differed by no more than 0.5% from the directly measured gradients and were entirely independent of the directly measured gradients by virtue of being based on thermocouples and bar lengths from other portions of the apparatus. A second check on the overall measured gradient was provided by the extra thermocouple at the middle of the specimen chamber which permitted the measurement of two auxiliary gradients in the metal alloy specimen. Since the auxiliary gradients covered shorter bar lengths they were of lower accuracy than the measured gradients but their average differed by no more than 0.4% from the measured gradients.

Since the steel for both sections of the apparatus used in the present and previous alloy measurements was taken from material adjacent to that used in the upper sections of the sodium and potassium apparatti (NRL Report No. 3835) an excellent means for correlation of results of all the alkali metal measurments was afforded through the use of the steel conductivity. Figure I represents the conductivity of this steel as measured during the sodium and potassium and alloy experiments. To 600°C the maximum deviation of any result from the best curve was less than 1%. Above 600°C extrapolated corrections for the measuring thermocouples were used. The deviations of the values at 717.8°C and at 733.8 from a straight line extrapolation through the lower temperature results were +0.8% and +1.1% respectively.

Thermal conductivity of 48.3 weight percent potassium alloy has been measured by Deem and Russel of Battelle Memorial Institute. Figure II presents a comparison of their results with those of this laboratory for 56.5 wt. % K and 77.7 wt. % K alloy. (Report on Determination of the Thermal Conductivity of Sodium-Potassium Alloy at Elevated Terperatures - Herbert Deem and H. W. Russel published in Argonne National Laboratory, Report No. CT 3554; republished

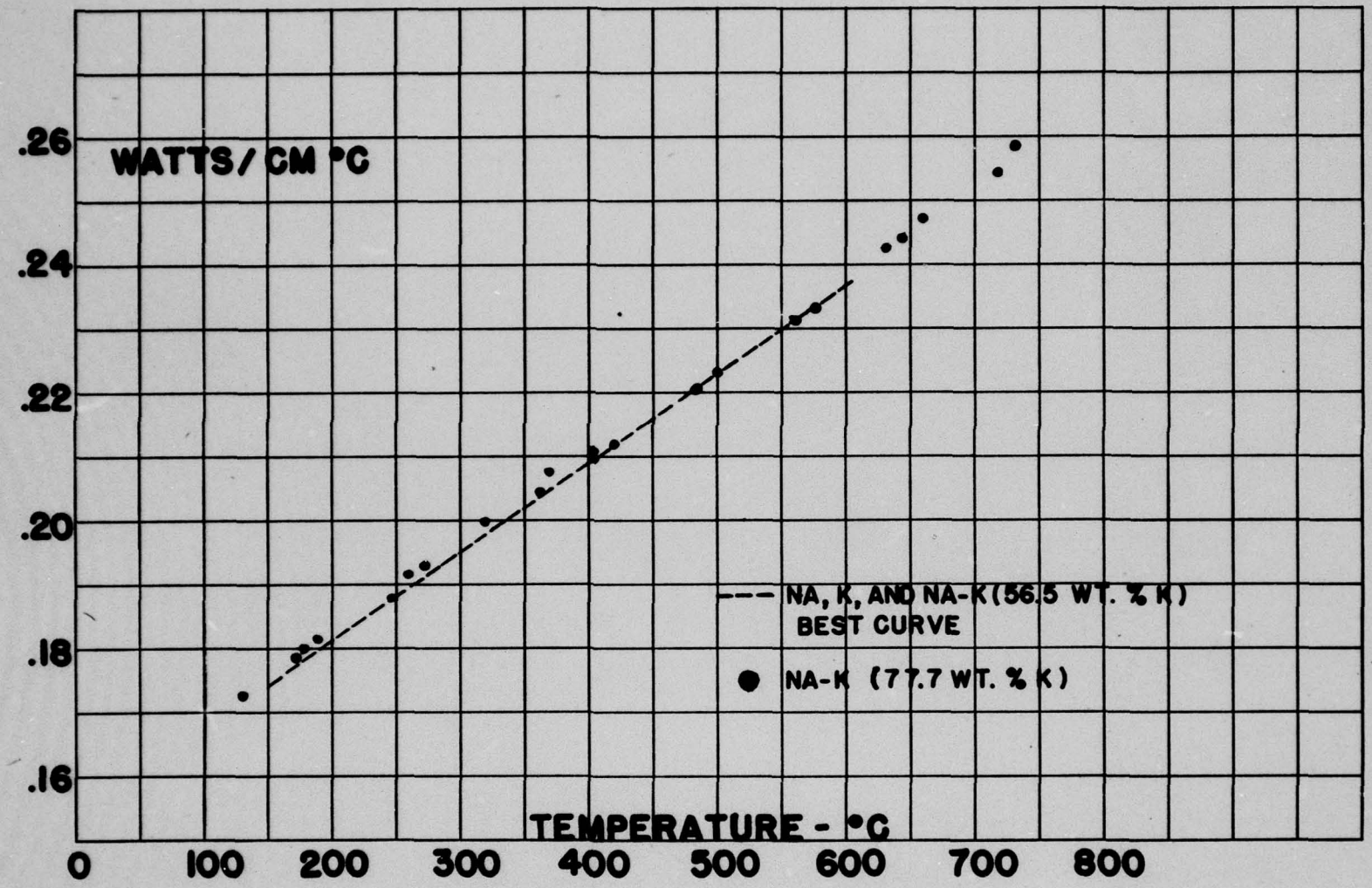
in NRL Report P-3010). In the original Argonne Laboratory report the published data was plotted as a best straight line. It would seem that, based on the data obtained at NRL, the 48.3 wt. % K curve should appear roughly as drawn here with a maximum above 500°C.

TABLE I

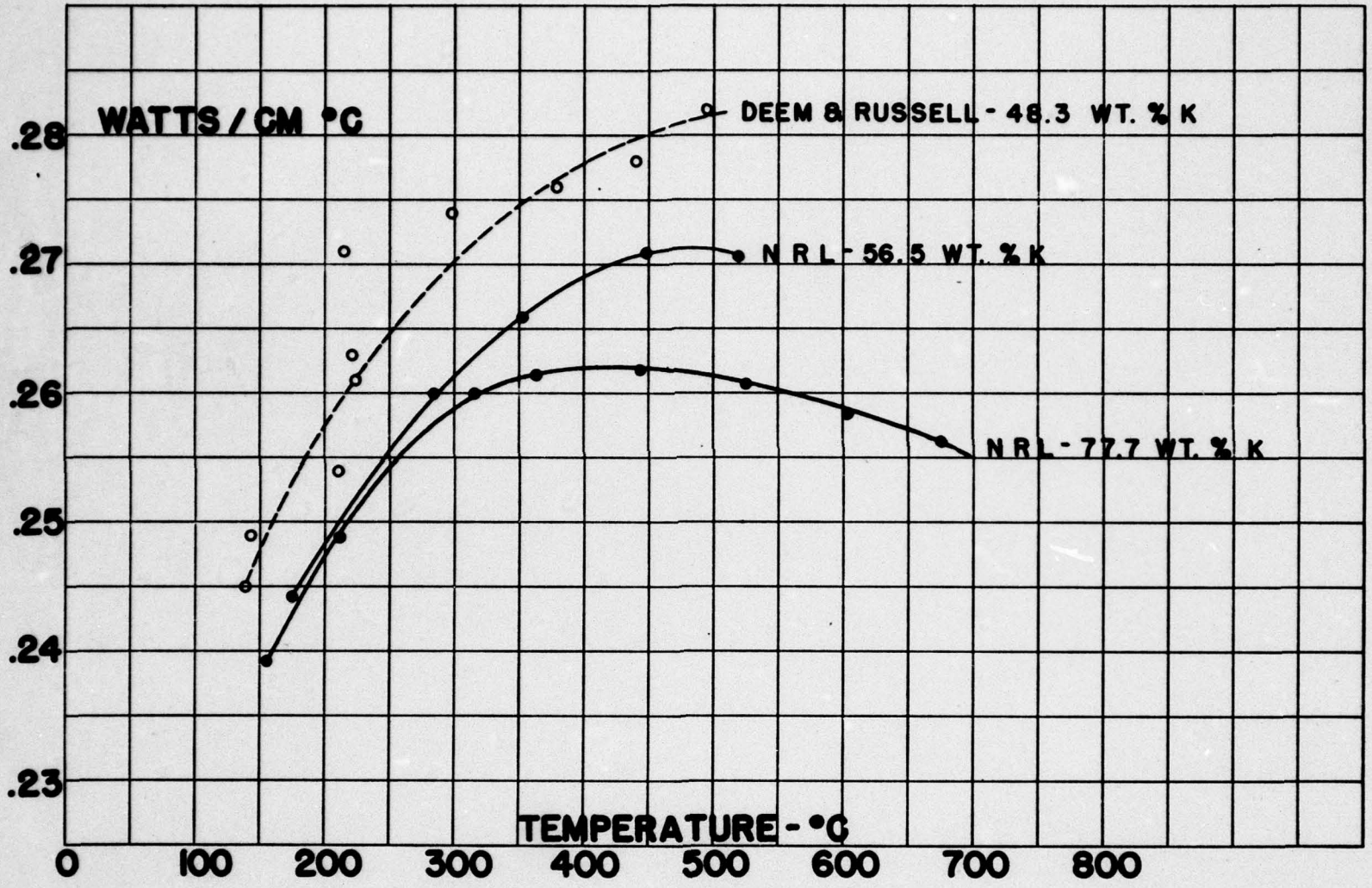
THERMAL CONDUCTIVITY

SODIUM - POTASSIUM ALLOY (77.7 wt. % K)

Run No.	Temp. °C	Thermal Conductivity Watts/cm °C
1	157.1	0.2393
2	316.2	0.2600
3	364.0	0.2614
4	445.2	0.2618
5	525.5	0.2607
6	211.4	0.2487
7	603.5	0.2584
8	676.3	0.2563



THERMAL CONDUCTIVITY
STAINLESS STEEL (TYPE 304)



THERMAL CONDUCTIVITY
SODIUM-POTASSIUM ALLOY