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O T T A W A January 6th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1561.

Determination of Cooling Rates of Steel Plate.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Request and Purpose of Investigation:

On December 20th, 1943, Capt. M. J. Ward of the Directorate of Small Arms and Small Arms Ammunition, Inspection Board of United Kingdom and Canada, Ottawa, Ontario, requested that tests be made on steel plate in order to determine the length of time required to cool plates of standard thickness to various low temperatures.

The purpose of the investigation was to determine the minimum time which the various small arms weapons should be kept in a cold room in order to ensure complete cooling.

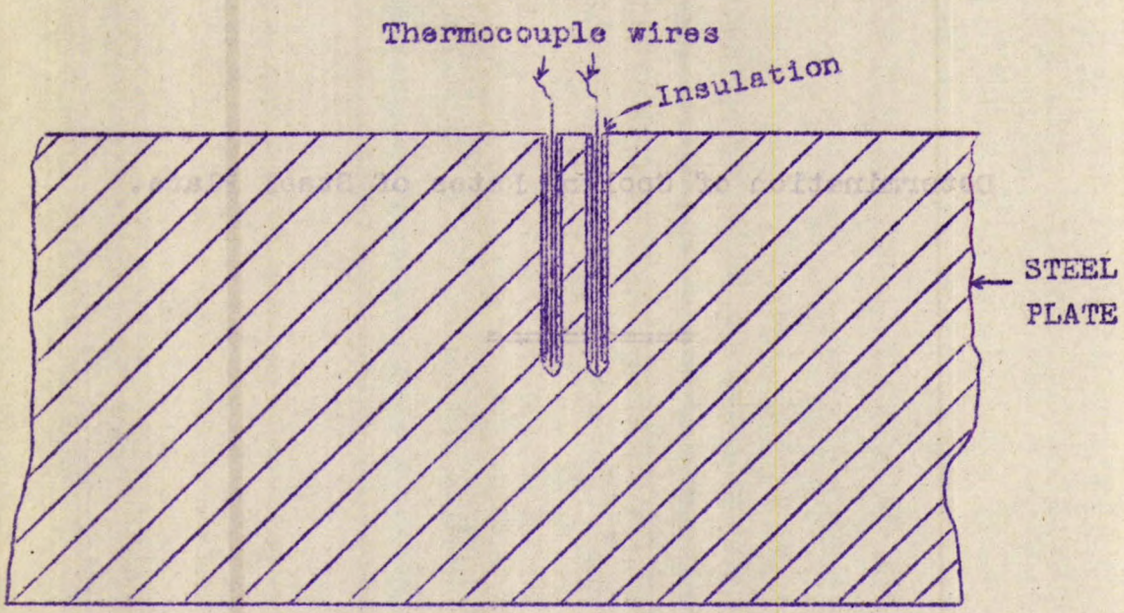
Method of Investigation:

Two pieces of armour plate steel were used for the experiment:

A. 4" x 8" x 2" thick,

B. 6" x 8" x 1½" thick.

The temperature of the centre of the plate was recorded by means of a chromel-alumel thermocouple (#28 wire) attached to a standard potentiometer. The thermocouple tip was inserted through two small insulated holes (see sketch below) and flash-welded to the plate by a discharge of condensers.



The cooling test was conducted in a cold room capable of attaining a temperature of -23° F. The plate was placed on small supports in order to lift the bottom face from the concrete flooring and so allow air contact to be made on all six sides.

The results are shown on time-temperature graphs and from these are derived Cooling Rate-Temperature Difference reference curves. An explanation of these latter charts may be

(Method of Investigation, cont'd) -

found in Report of Investigation No. 1555 (December 14th, 1943), which determined the cooling rates of small arms ammunition. By application of these cooling-rate charts, one may find the cooling period to any desired cold temperature.

Results:

Plate A. - Figure 1.

The 2-inch plate cooled to the temperature of the surrounding cold air medium in 2 hours 5 minutes.

The cooling rate curve (chart, Figure 2) is shown as a band in order to cover the experimental errors. It will be noted, however, that the width of this band is much narrower than in the case of small arms ammunition. This is credited to the homogeneity of the test specimen.

Plate B. - Figure 3.

The 1½-inch plate cooled to the temperature of the surrounding cold air medium in 1 hour 40 minutes. It may be noted that the cooling rate curve obtained (Figure 4) diverges slightly from the straight-line relationship shown in Figure 2 for Plate A. This may be attributed to the fact that the specimen was cooled in a different position in the cold chamber. The air is circulated by a small fan, and it is likely that Plate B was more directly affected by flowing air than was Plate A.

CONCLUSIONS:

The times recorded are only approximate and vary somewhat when the specimen to be cooled is subject to varying air currents in the cold chamber.

A general rule could be adopted, that steel cools from room temperature to sub-zero temperature at a rate of 1 inch of diameter per hour. However, a safety factor of 50 per cent should be added, to ensure that there has been complete cold penetration and to cover a range of final low temperatures.

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Figure 1.

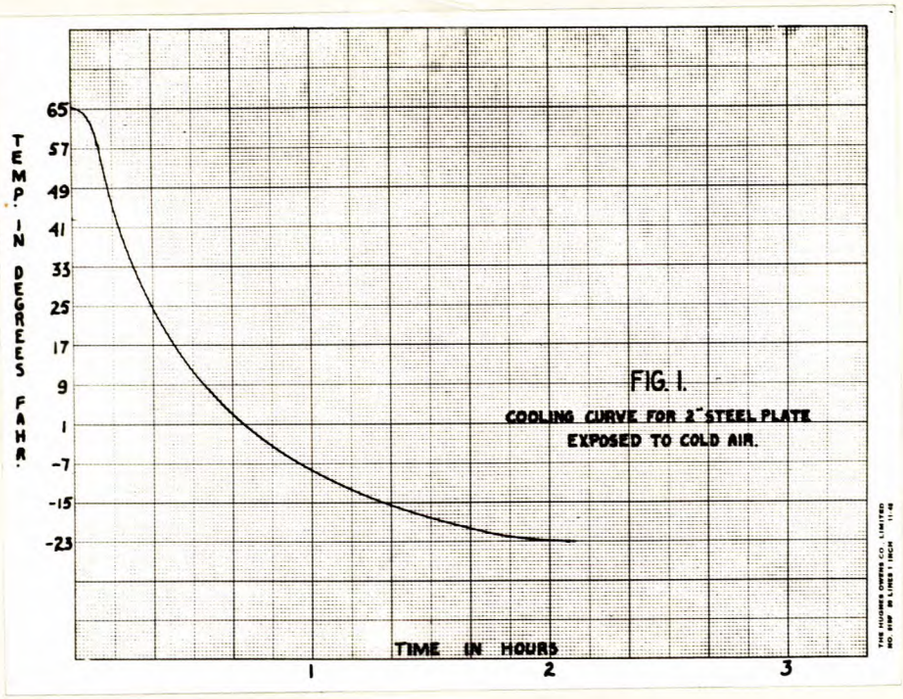

FIG. 1.
COOLING CURVE FOR 2" STEEL PLATE EXPOSED TO COLD AIR.

Figure 2.

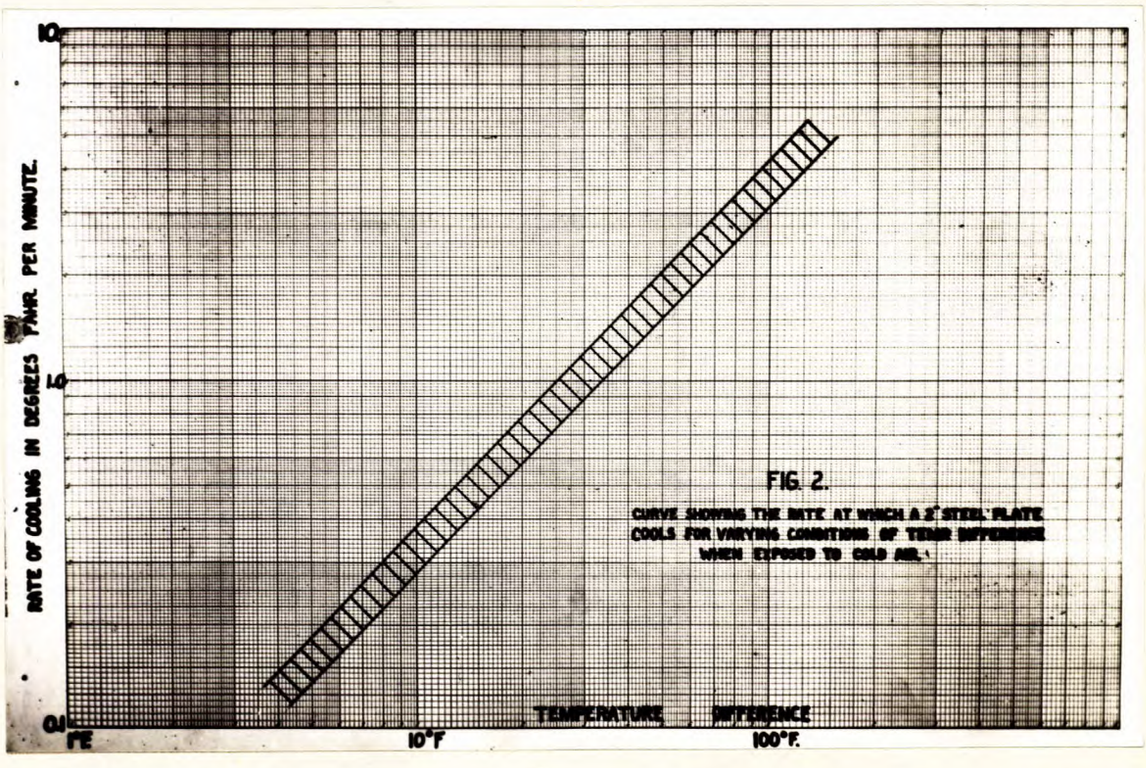

FIG. 2.
CURVE SHOWING THE RATE AT WHICH A 2" STEEL PLATE COOLS FOR VARYING CONDITIONS OF TEMP. DIFFERENCE WHEN EXPOSED TO COLD AIR.

Figure 3.

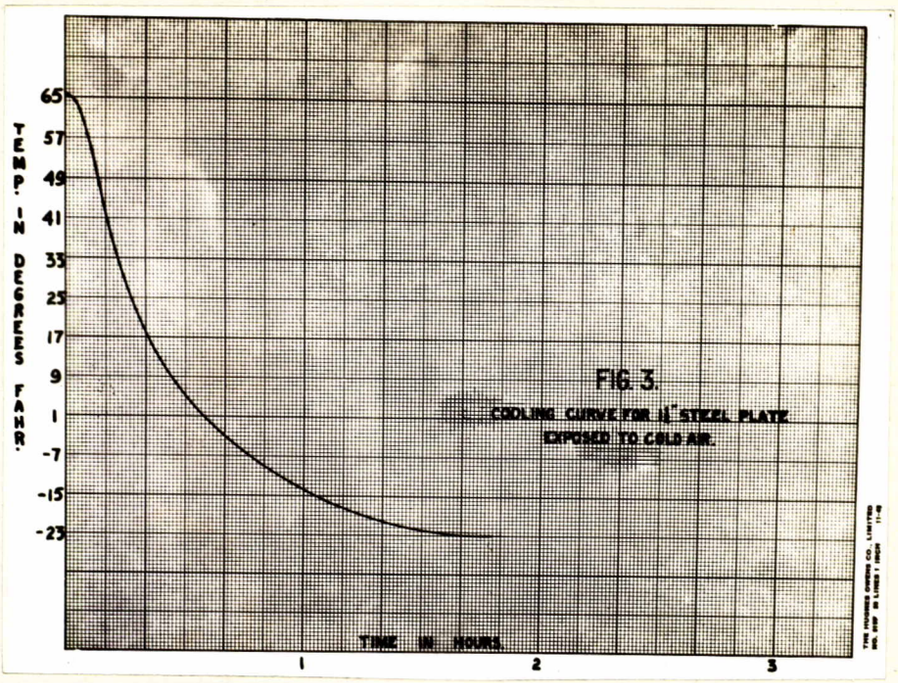

FIG. 3.
COOLING CURVE FOR 1½" STEEL PLATE EXPOSED TO COLD AIR.

Figure 4.

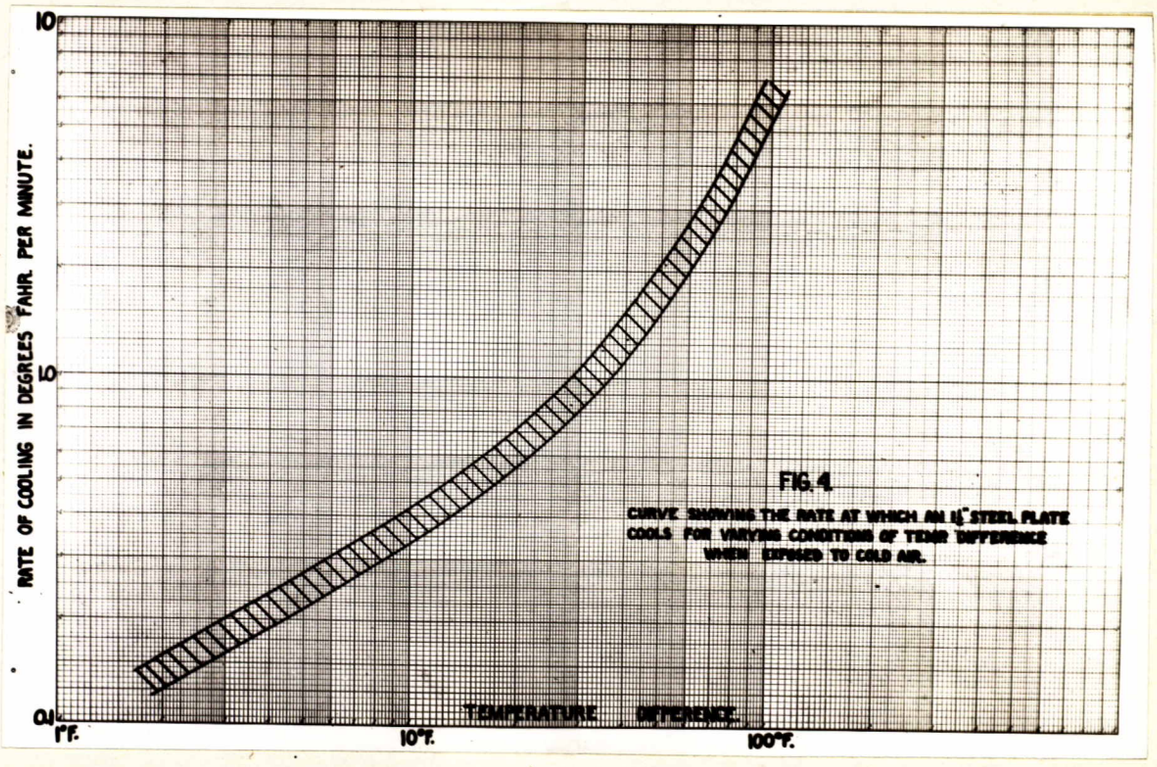

FIG. 4.
CURVE SHOWING THE RATE AT WHICH AN 1½" STEEL PLATE COOLS FOR VARYING CONDITIONS OF TEMP. DIFFERENCE WHEN EXPOSED TO COLD AIR.

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