O T T A W A   May 14th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1223.

Examination of Lookout Block #20958 for
Valentine Tanks.

(Copy No. 14.)

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 Object of Investigation:

Early in April, 1942, a lookout block (#20958, Valentine tanks) was received from the Inspectorate of Tanks, Inspection Board of the United Kingdom and Canada, 58 Lyon Street, Ottawa, Ontario, for examination. The letter reproduced below, which accompanied the original four blocks sent to Ottawa from Montreal, will set forth the purpose of the investigation:

(Continued on next page)

(Origin of Request and Object of Investigation, cont'd) -

(COPY) -

File - 4/10/14 CPR/3.

March 31st, 1942.

1. Tanks - Ottawa.

1. O. (Tanks) - Montreal.

Lookout Blocks #20958 - Valentine Tanks.

When A.D.I. (h) was last in this office, I showed him four of these blocks which have been used to assist the ballistic test of our Duplate Blocks (Glass) at Hamilton.

He expressed a desire to have them sent to Ottawa in view of the somewhat disastrous effect from .30 ball ammunition.

I have, therefore, shipped these four blocks to your attention by C.P. freight, prepaid.

For your information, these blocks were strictly in accordance with the Specification 5005/502, and therefore, are quite acceptable. From exhaustive tests we found that this steel would produce its best ballistic qualities against this service ammunition at a Brinell hardness of 350, and you will note that on each of these blocks the B.H.N. is indicated, within a reasonable tolerance of the above figure.

These blocks are representative of those which are accompanying all tanks destined to Russia, and I know that after examination you will realize how I feel about the matter. As you have already been advised, future orders for this steel specify a molybdenum modification up to 0.5%, with inherently fine grained steel, and these two refinements in the specification will improve the impact resistance very considerably.

B. O. Heron,

BOH:K. I.O. (Tanks) - Montreal.

Nature of Blocks:

Figure 1.

FRONT VIEW OF LOOKOUT BLOCK,
SHOWING BALLISTIC FAILURE.
(Approximately 1/2 size).

Figure 2.

REAR VIEW OF LOOKOUT BLOCK.
(Approximately 1/2 size).

Hardness Tests:

One end of the block was sectioned and hardness readings were taken from the outside to the centre. The hardness ranged from 322 to 349 V.H.N.

Chemical Analysis:

		Per cent
Carbon	-	0.29
Manganese	-	0.67
Silicon	-	0.30
Phosphorus	-	0.011
Sulphur	-	0.008
Nickel	-	4.22
Chromium	-	1.40
Molybdenum	-	0.14
Vanadium	-	None

Microstructure:

Figure 3. Figure 4.

Original document missing information

Le document original est manque d'informations

NEAR SLIT.
X1000, nital etch.

NEAR CENTRE.
X1000, nital etch.

Physical Tests:

The machine shop reported that standard test pieces could not be machined from the lookout block without a drawing operation. This would change the properties so that physical tests would be of little value.

Discussion:

In the absence of any specification information on ballistic performance expected of peep sights, it is assumed that the failure shown in Figure 1 does not usually occur, or that better performance is required. There are two possibilities for getting maximum ballistic resistance, each one of which will be discussed separately:

(a) Change the analysis of the steel used, or

(b) Work out optimum heat-treatment method for steel used.

Change Analysis -

The chemical analysis of the peep sight is an unusual one in that it contains 4.22 per cent nickel and little molybdenum. A saving in the strategic alloy nickel could be made by reducing it considerably and substituting molybdenum. Jones* stated that a 3.00% nickel 1.00% molybdenum steel was found to be similar to one containing 4.50% nickel and 0.50% molybdenum.

The phenomenon of temper brittleness is quite pronounced in alloys similar to the peep sight examined. Molybdenum additions have proven very effective in eliminating this condition. It is characteristic of nickel alloys that:

(a) When tempered in a certain range of temperature they become quite brittle;

(b) When slowly cooled after tempering they frequently become brittle.

Thus, at a given hardness and with no apparent change in microstructure, a wide range of impact strengths may be obtained. It is generally recommended for this material, therefore, that the vicinity of 500° C. be avoided for tempering, and that the

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* "The Influence of Molybdenum on Medium Carbon Steel Containing Nickel and Chromium," by J. A. Jones, MECH. ENG., v. 49, 1927.

(Discussion, cont'd) -

parts should be water-quenched on coming out of the draw. In order to avoid this sensitive condition, a molybdenum addition to the steel is widely used. The following table shows how effective this is:

IZOD IMPACT VALUES OF STEELS COOLED AT DIFFERENT VELOCITIES FROM TEMPERING TEMPERATURE AT 650° C. (1200° F.)
(Specimens quenched in oil from 900° C. (1650° F.))

Steel	Composition, per cent				Cooling Rate			
	C	Ni	Cr	Mo	In water	$2\frac{1}{2}$° C. per min.	1° C. per min.	0.3° C. per min.
A	0.43	1.96	2.15	--	45	4	3	3
B	0.42	2.02	1.04	--	57	8	5	4
C	0.37	1.93	0.62	--	49	20	11	7
D	0.35	3.00	1.49	--	43	4	3	2
E	0.23	3.72	0.92	--	44	13	7	6
K	0.28	2.45	0.65	0.43	58	--	--	57
K1	0.25	2.84	0.85	0.48	37	--	--	35

Although 5 per cent nickel steel can be heat-treated so as to be free from brittleness, there would be some advantage to substituting lower nickel steel containing molybdenum.

Optimum Heat Treatment -

Izod impact is generally assumed to be a measure of structural homogeneity. It does not necessarily indicate anything about ballistic limit, since ballistic impact occurs at much greater velocities and resistance to impact varies with the speed of the striking body. However, it is generally assumed that the higher the impact strength for a given hardness, the more homogeneous is the structure. Structural homogeneity is thought to be desirable for high test armour plate.

According to a letter (March 31st, 1942) from Mr. B. O. Heron, the best ballistic performance of lookout blocks similar to the one examined in this report is obtained with a hardness

(Discussion, cont'd) -

of 350 B.H.N. It is quite possible to have a great variation in impact values at this hardness value. We would suggest that sufficient material be obtained so that experimental heat treatments can be carried out in order to determine the best times and temperatures for the alloy used.

Recommendations:

1. Change alloy to include molybdenum, 0.5 to 0.6 per cent.

2. Obtain material for experimental heat treatment and determine by ballistic tests the optimum heat-treating procedure.

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HHF:GHB.