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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1362.

An Investigation of the Ballistic Properties of High Test Cast Iron.

(Test 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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Purpose of Investigation:

From time to time this Department has received inquiries concerning the behaviour of high test cast iron when exposed to rifle fire or to flying shell fragments. In order to give an intelligent answer to these inquiries, this investigation was carried out.

Two high test cast iron plates, dimensions 24"x12"x5/8", were obtained from a foundry producing high test cast iron by a patented inoculation process. The grade obtained will respond to heat treatment.

These plates were analysed and then cut in half, giving four plates 12 inches square. Three of these plates

(Purpose of Investigation, cont'd) -

were oil-quenched from 1550° F. and drawn at 600°, 700° and 800° F., respectively. These plates were then submitted to ballistic tests. Following this, test bars were obtained to determine mechanical properties.

Chemical Analysis:

The chemical analyses of the two plates supplied were found to be identical. The composition is given in Table I.

Table I.

		Per cent
Carbon	-	2.81
Manganese	-	1.03
Silicon	-	1.69
Phosphorus	-	0.059
Sulphur	-	0.082
Nickel	-	Not detected.
Chromium	-	Not detected.
Molybdenum	-	Trace.
Copper	-	0.05

Heat Treatment:

The four plates cut out of the two plates supplied were numbered "1" to "4" and received the following treatment:

Plate No. 1. - Oil quench - 1550° F.
Draw - 600° F. for 30 minutes.
Air cool from draw.

Plate No. 2. - Oil quench - 1550° F.
Draw - 700° F. for 30 minutes.
Air cool from draw.

Plate No. 3. - Oil quench - 1550° F.
Draw - 800° F. for 30 minutes.
Air cool from draw.

Plate No. 4. - As cast.

Ballistic Tests:

Ballistic tests were carried out at the National Research Council in Ottawa. C.303" calibre A/P. shot were used. With the facilities available it was not feasible to vary the striking velocity. It was therefore decided to vary the angle of attack. The results of these tests are given in Table II.

Table II. - Ballistic Tests of Cast Iron.

Plate Number	Shot Number	Angle of Attack, in degrees	Striking Velocity, feet per second	Result
1	1	70	2460	Defeated shot.
	2	80	2442	Broke plate.
	3	80	2454	Spalled back of plate.
2	1	90	2464	Defeated plate.
	2	70	2434	Defeated shot.
	3	70	2448	Defeated shot.
	4	80	2442	Spalled back of plate.
3	1	60	Not obtained.	Defeated shot.
	2	90	Not obtained.	Defeated plate.
	3	70	2470	Spalled back of plate.
4	1	60	2442	Defeated plate.
	2	30	2444	Defeated shot.
	3	45	2428	Defeated shot.

The results of these tests are summarized in Table III. The critical angle of attack is that angle at which the plate is defeated under the conditions of test.

Table III. - Summary of Ballistic Tests.

Plate No.	Critical angle of attack at a striking velocity of 2450 feet per second for .303 A/P. shot, in degrees.
1	80
2	80
3	70
4	60

(Continued on next page)

(Ballistic Tests, cont'd) -

The ballistically tested plates were photographed. These photographs are presented in Figures 1 to 8 inclusive. It should be noted that in Plate No. 1, Shot No. 1 broke the corner out and in Plate No. 2, Shots Nos. 1 and 4 cracked the plate badly. Plates Nos. 3 and 4 were not cracked.

Mechanical Properties:

Standard cast iron test bars, made in accordance with A.S.T.M. Specification A-48-36, Bar A, were machined from these plates and used to determine the tensile properties of these plates. Hardness values were also obtained using a standard Brinell testing machine with a 10-mm. ball and a 3,000 kg. load. The results of these tests are given in Table IV.

Table IV. - Mechanical Properties.

Plate No.		Tensile strength, p. s. i.	Brinell hardness number
1	-	59,800	477
2	-	56,400	461
3	-	61,500	388
4	-	47,000	248

Discussion of Results and Conclusions:

The data collected in this investigation would indicate that a material of this nature should not be considered for any vital structural part that will be exposed to rifle or machine-gun fire. The optimum ballistic properties were obtained from Plate No. 3 but even with this plate it is highly probable that a cluster of three or four shots could seriously shatter the plate. Such structures should be fabricated from steel. It is true that the steel may be

(Discussion of Results and Conclusions, cont'd) -

pierced, but if in the proper condition it should not shatter.

It should be mentioned here that this quality of cast iron behaved much better in the ballistic tests than had been anticipiated. This good behaviour might be interpreted to mean that the iron possesses the ability to absorb shocks to an appreciable degree; that is, as compared to ordinary grey iron, it is tough. However, the tensile bars showed no measurable elongation or reduction in area and it is not recommended that high test cast iron of any type be used as structural parts of ordnance equipment when such members are subject to shock loading.

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Figure 1.

Front of Plate.

Figure 2.

Back of Plate.

Photographs of Plate No. 1 after firing trials.
Note pieces broken out of corner and spalling
on the back of the plate.

Figure 3.

Back of Plate, Shot No. 1.
Front of Plate, Shots 2, 3 and 4.

Figure 4.

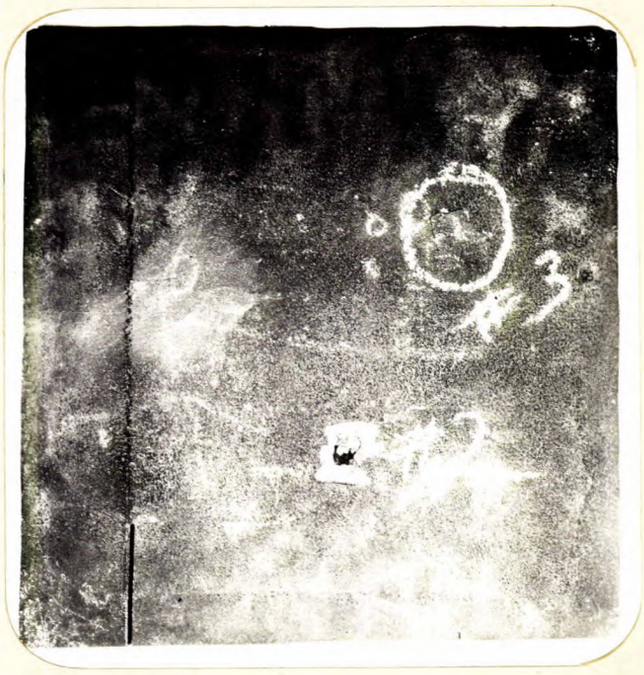
Front of Plate, Shot No. 1.
Back of Plate, Shots Nos. 2, 3 and 4.

Photographs of Plate No. 2 after firing trials.
Note cracks in plate around Shots Nos. 1 and 4.
Also note spalling at back of Shots Nos. 1 and 4.

Figure 5.

Front of Plate.

Figure 6.



Back of Plate.

Photographs of Plate No. 3 after firing trials.
Note spalling at back of Shot No. 1 and commencement of spalling at back of Shot No. 3.

Figure 7.

Front of Plate.

Figure 8.

Back of Plate.

Photographs of Plate No. 4 after firing trials.
Note small amount of spalling at back of Shot No. 1.

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