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O T T A W A August 23, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1923.

(Further to Report of
(Investigation No. 1842,
(dated April 18, 1945.

Low-Temperature Impact Tests on 60-mm. British Armour Plate.

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Origin of Material and Object of Investigation:

On April 18, 1945, Report of Investigation No. 1842, entitled "Preliminary Report on Metallurgical Examination of 60-mm. British Armour Plate," was issued by these Laboratories. This preliminary report dealt with some British armour plate which had been received, for examination, from Mr. E. W. Shaw, Inspecting Officer, Directorate of Tanks, Inspection Board of United Kingdom and Canada, Ottawa, Ontario.

The present further report deals with the low-temperature impact tests carried out on through-plate specimens cut from the samples submitted.

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

The following table gives some data concerning the plates under test:

TABLE I.

Plate Nos.	Manufacturer	Nominal Composition	Melting Practice
	ROLLED PLATES		
1-6	English Steel Co.	1½ Cr-Mo	Acid Open Hearth
7-12	Colvilles	1½Cr-Mo	Basic Open Hearth
13-18	Firth Brown	1½ Cr-Mo	Basic Electric
19-24	Firth Brown	Low Alloy	Acid Open Hearth
25-30	Colvilles	Low Alloy	Basic Open Hearth
31-36	English Steel Co.	Low Alloy	Basic Electric
	CAST PLATES		
43-48	Hadfields	Vibrac 45	Basic Electric
55-60	Hadfields	1½ Cr-Mo	Basic Electric
67-72	Hadfields	Low Alloy	Basic Electric

TEST RESULTS:

The test results are shown in tabular form in Tables II and III and are given graphically in Figures 1 to 8.

(Tables II and III comprise Pages 3 and 4.)
(Text follows on Page 5.)

(Test Results, cont'd) -

TABLE II. - 60-mm. British Armour Plate Impact Tests.

ROLLED PLATES.

Specimen No.	Type of Plate	Izod impact at room temperature, ft-lb.	Izod impact at 32° F. temperature, ft-lb.	Izod impact at -42° F. temperature, ft-lb.	W/R Limit at normal temperature, i.e. 65°-85° F., corrected to 60 mm.
1	English Steel Co., 1½Cr-Mo A.O.H.	20.0	21.0	20.0	1839
2		17.7	14.0	9.0	1776
3		21.5	23.0	18.7	1871
4		21.2	20.0	13.0	1787
5		18.7	18.0	11.5	1768
6		19.5	16.0	13.5	1862
7	Colvilles, 1½Cr-Mo B.O.H.	16.7	16.0	14.0	1825
8		16.5	15.0	17.0	1758
9		16.2	--	--	--
10		15.0	15.0	13.0	--
11		17.2	18.0	11.0	1772
12		15.2	15.0	10.5	1767
13	Firth Brown, 1½Cr-Mo Basic Electric	43.5	--	--	1908
14		39.0	47.0	43.0	1822
15		44.5	28.0	25.5	--
16		37.7	40.0	34.5	1960
17		49.0	49.0	45.5	1841
18		20.7	47.0	52.5	--
19	Firth Brown, Low Alloy A.O.H.	11.0	11.0	7.5	1694
20		16.0	12.0	8.5	1730
21		8.0	6.0	4.0	1753
22		14.0	9.0	8.0	--
23		13.0	12.0	8.0	1747
24		12.0	13.0	8.0	--
25	Colvilles, Low Alloy B.O.H.	22.2	22.0	19.5	--
26		21.0	22.0	16.5	1762
27		15.2	16.0	13.0	--
28		16.2	13.0	12.0	1752
29		14.5	12.0	13.5	1689
30		11.5	9.0	5.5	1681
31	English Steel Co., Low Alloy B.E.	30.0	24.0	16.0	--
32		21.0	16.0	8.0	1738
33		41.0	20.0	14.5	1736
34		31.7	20.0	10.0	1810
35		42.2	21.0	7.0	1769
36		19.5	13.0	12.5	--

(Tests Results, cont'd) -

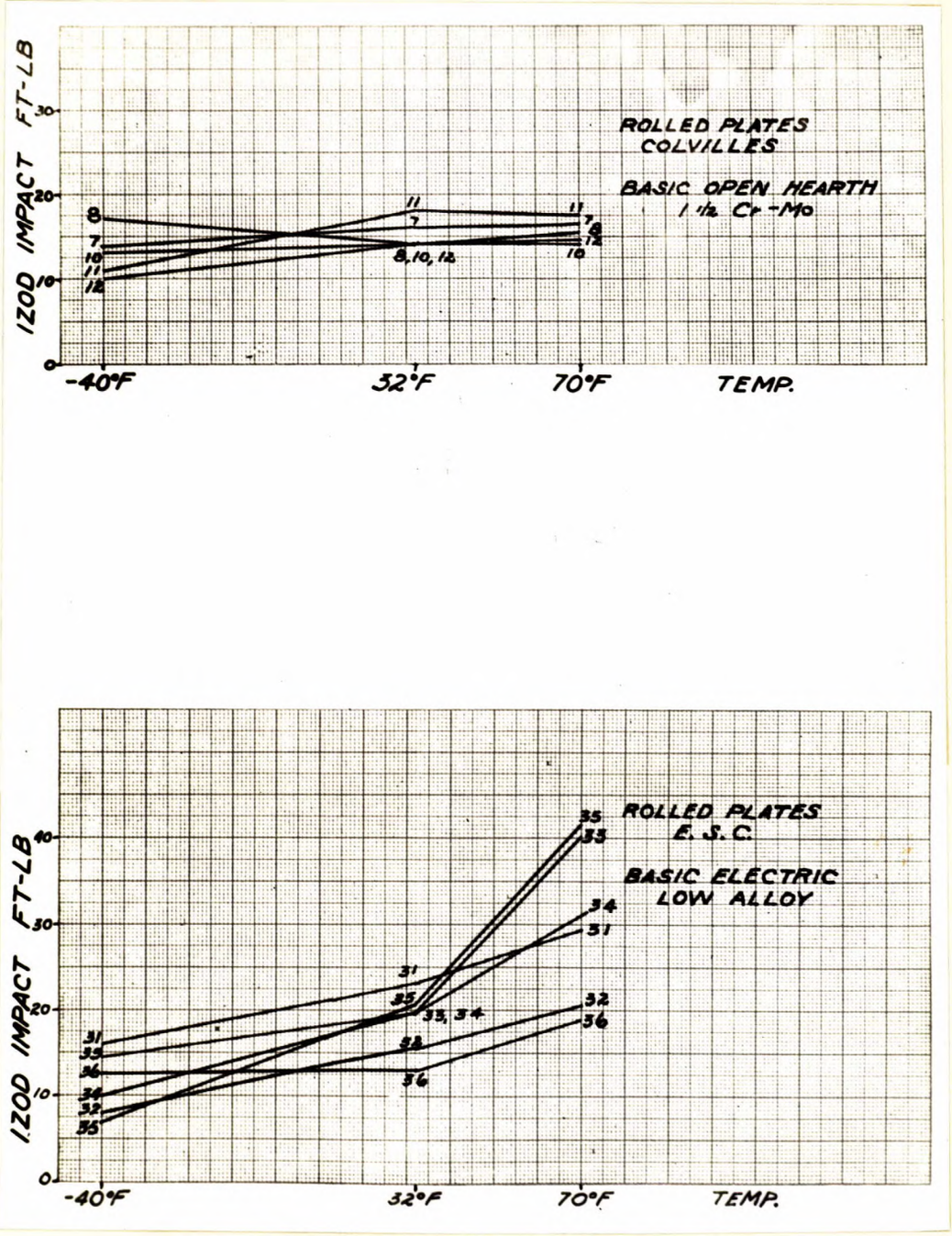
TABLE III. - 60-mm. British Armour Plate Impact Tests.

CAST PLATES.

Specimen No.	Type of Plate	Izod impact at room temperature, ft-lb.	Izod impact at 32° F. temperature, ft-lb.	Izod impact at 42° F. temperature, ft-lb.	W/R Limit at normal temperature, i.e. 65°-85° F., corrected to 60 mm.
43A	Hadfields, Vibrac 45 Basic Electric	45.0	45.0	38.5	1739
43B		31.5	34.0	29.0	--
44A		58.5	43.0	27.5	1620
44B		40.0	37.0	29.0	--
45A		37.5	40.0	22.0	1611
45B		50.5	42.0	49.0	--
46A		40.0	41.0	35.5	1630
46B		38.0	37.0	31.0	--
47A		31.0	25.0	19.0	1630
47B		29.0	22.0	14.0	--
48A		48.0	47.0	43.0	1635
48B		31.5	34.0	23.5	--
55A	Hadfields, 1¼ Cr-Mo B.E.	25.5	19.0	9.0	1645
55B		29.0	24.0	16.0	--
56A		30.0	27.0	18.5	1680
56B		29.0	29.0	15.0	--
57A		43.0	43.0	41.0	1756
57B		44.0	44.0	38.5	--
58A		42.5	39.0	29.5	1602
58B		45.0	36.0	28.0	--
59A		55.5	30.0	18.0	1661
59B		49.5	36.0	20.5	--
60A		33.5	24.0	14.5	1620
60B		36.0	36.0	36.0	--
67A	Hadfields, Low Alloy B.E.	57.5	50.0	30.0	1692
67B		57.0	54.0	34.0	--
68A		57.0	56.0	31.5	1642
68B		61.5	66.0	33.0	--
69A		54.0	56.0	30.5	1647
69B		67.5	68.0	38.0	--
70A		69.0	58.0	39.5	1583
70B		64.5	68.0	47.0	--
71A		69.0	42.0	24.0	1663
71B		--	64.0	45.0	--
72A		--	--	--	1755
72B		54.2	--	--	--

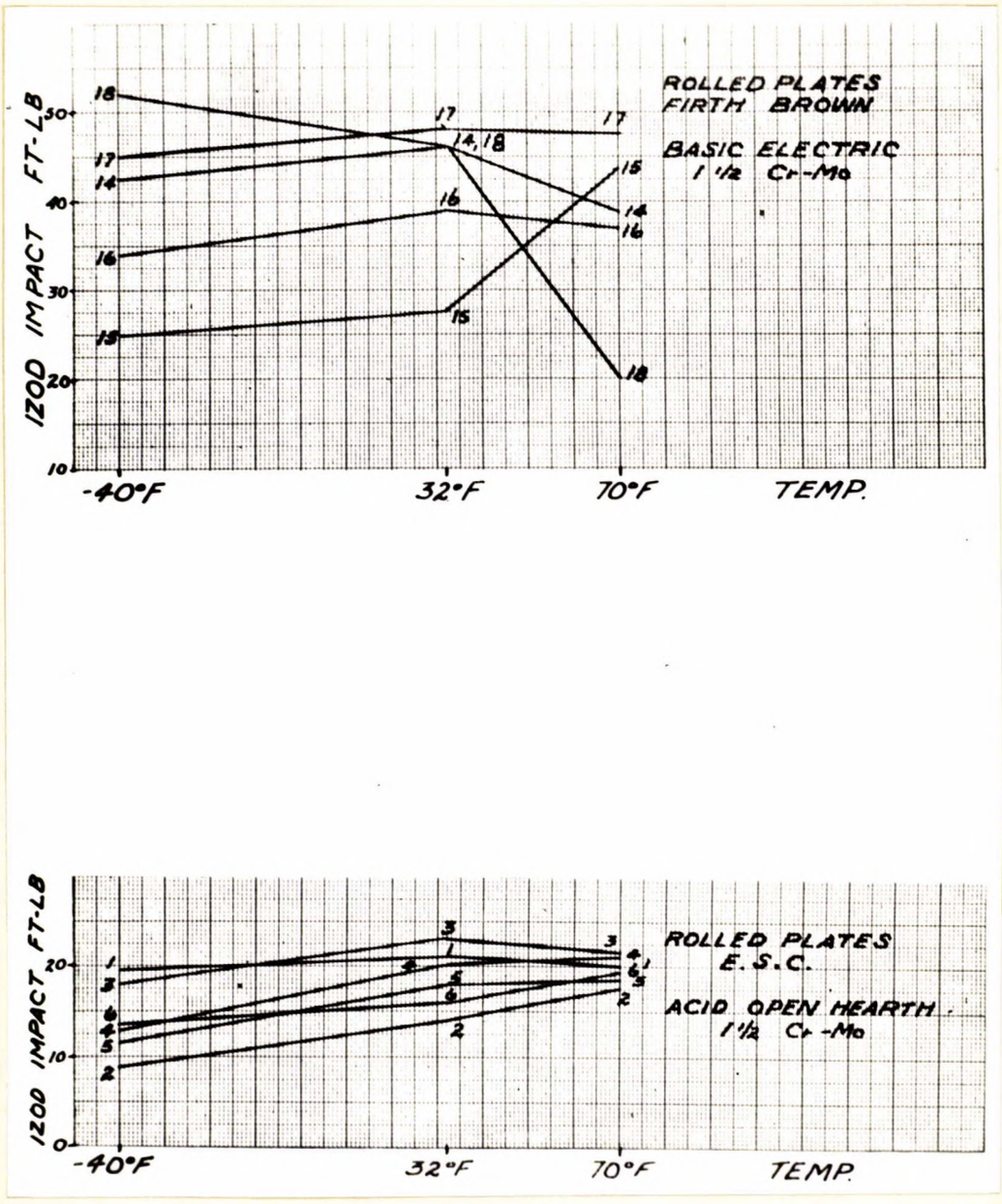
(Test Results, cont'd) -

Figure 1.



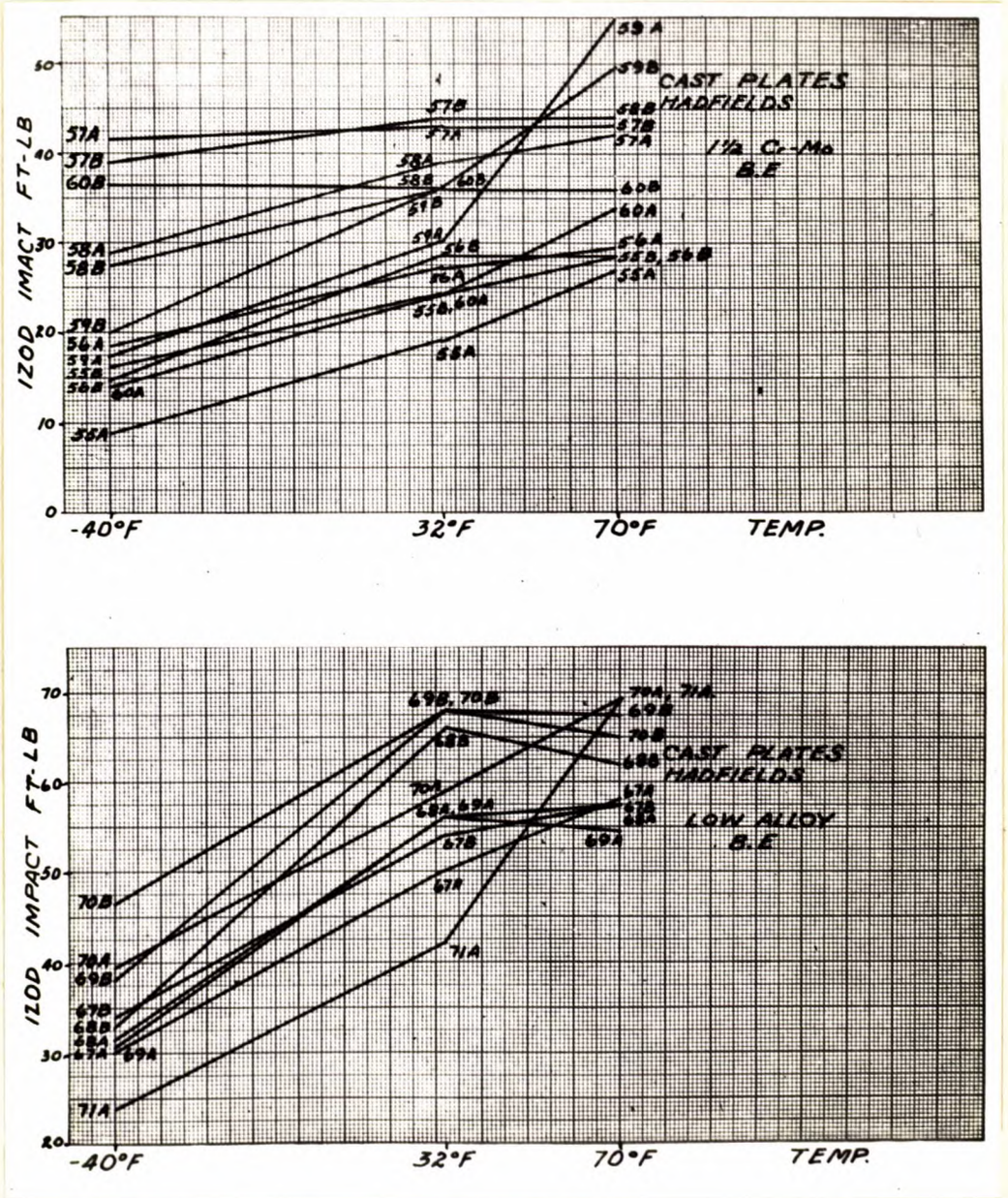
(Test Results, cont'd) -

Figure 2.



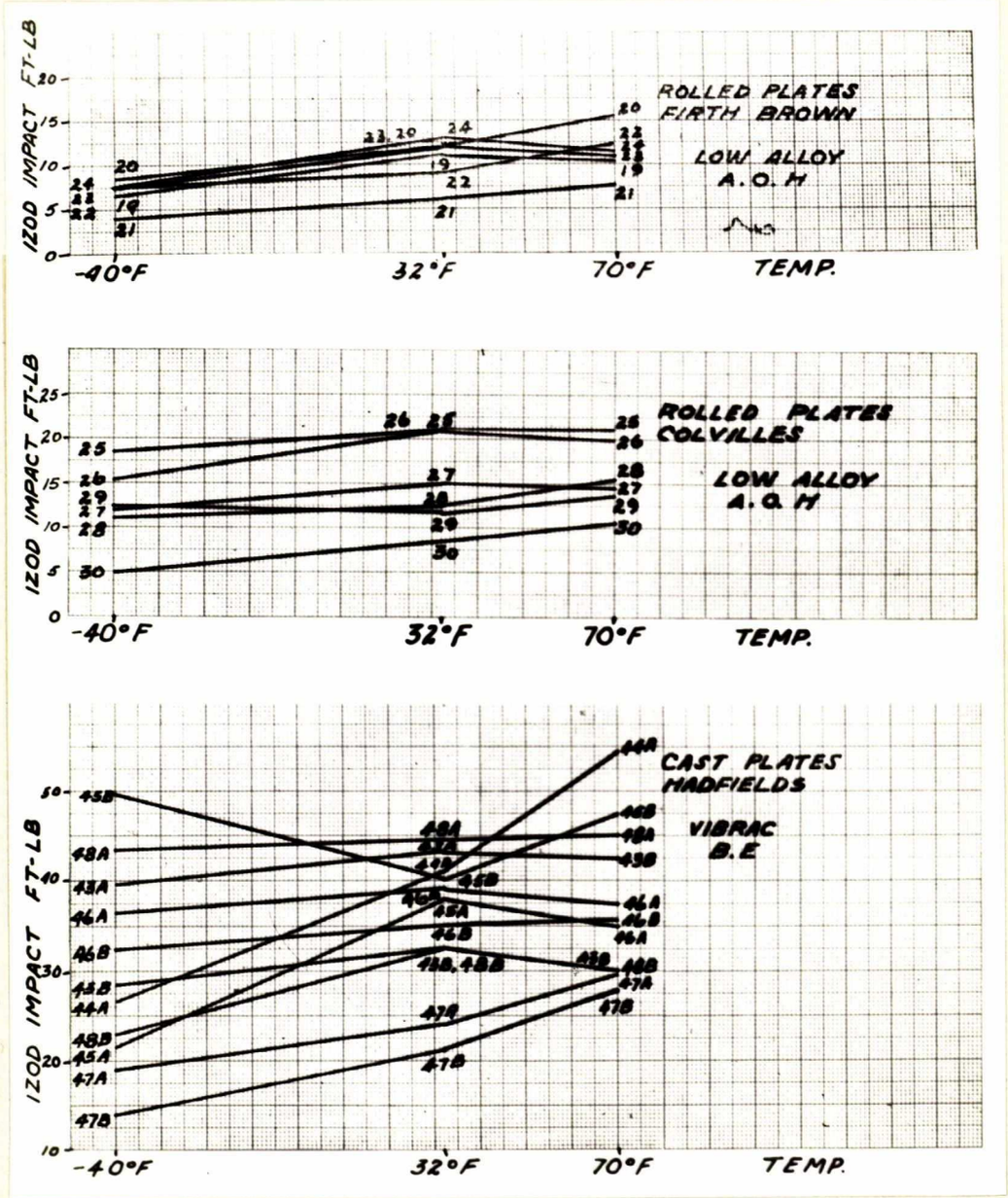
(Test Results, cont'd) -

Figure 3.



(Test Results, cont'd) -

Figure 4.



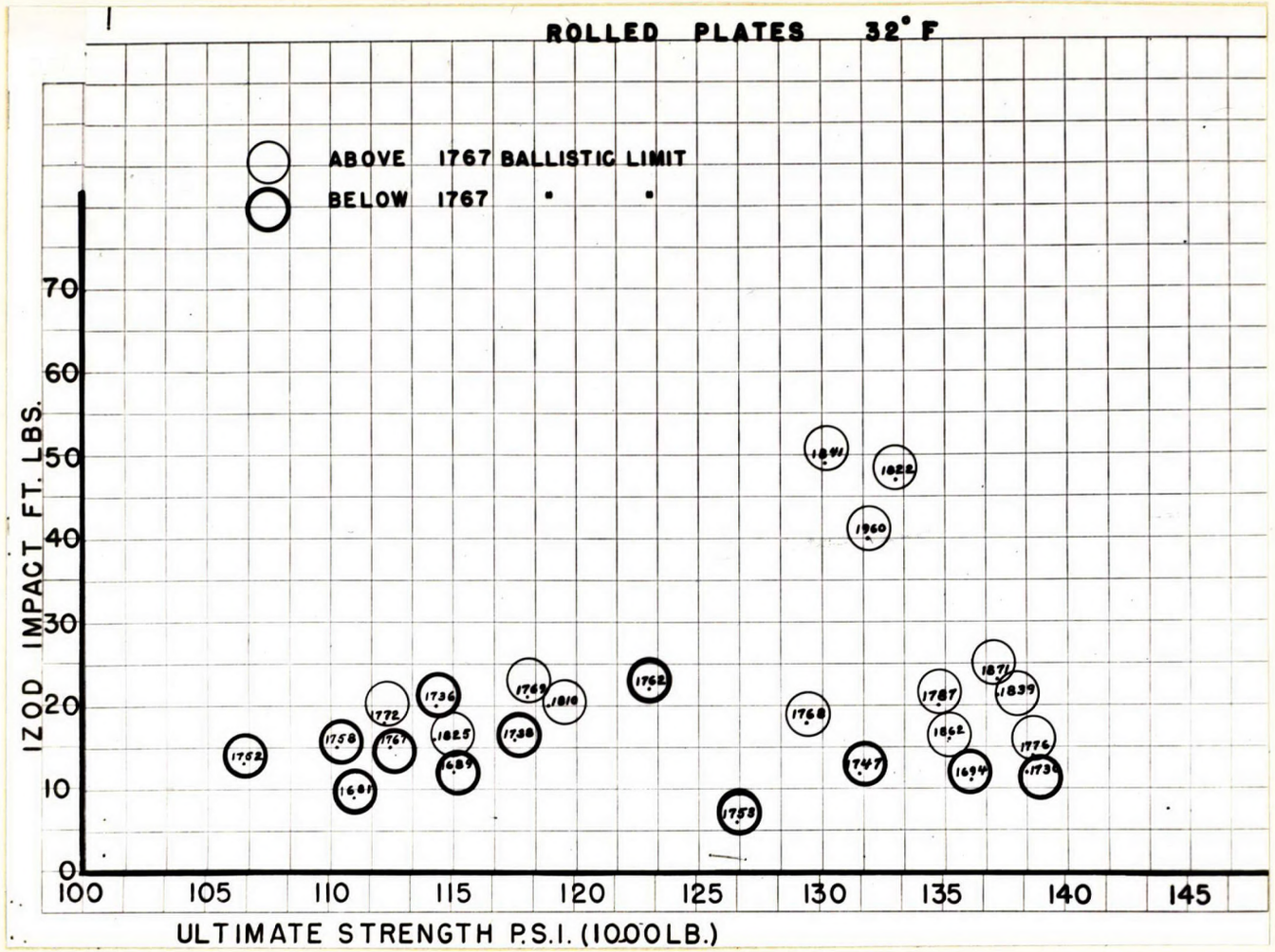

ROLLED PLATES 32° F
ABOVE 1767 BALLISTIC LIMIT
BELOW 1767 " "
IZOD IMPACT FT. LBS.
0
10
20
30
40
50
60
70
100
105
110
115
120
125
130
135
140
145
ULTIMATE STRENGTH P.S.I. (1000 LB.)
1752
1758
1601
1772
1767
1736
1825
1689
1769
1816
1738
1762
1758
1768
1941
1822
1960
1747
1871
1839
1787
1662
1694
1776
1736

Figure 5.

(Test Results, cont'd) -

Figure 6.

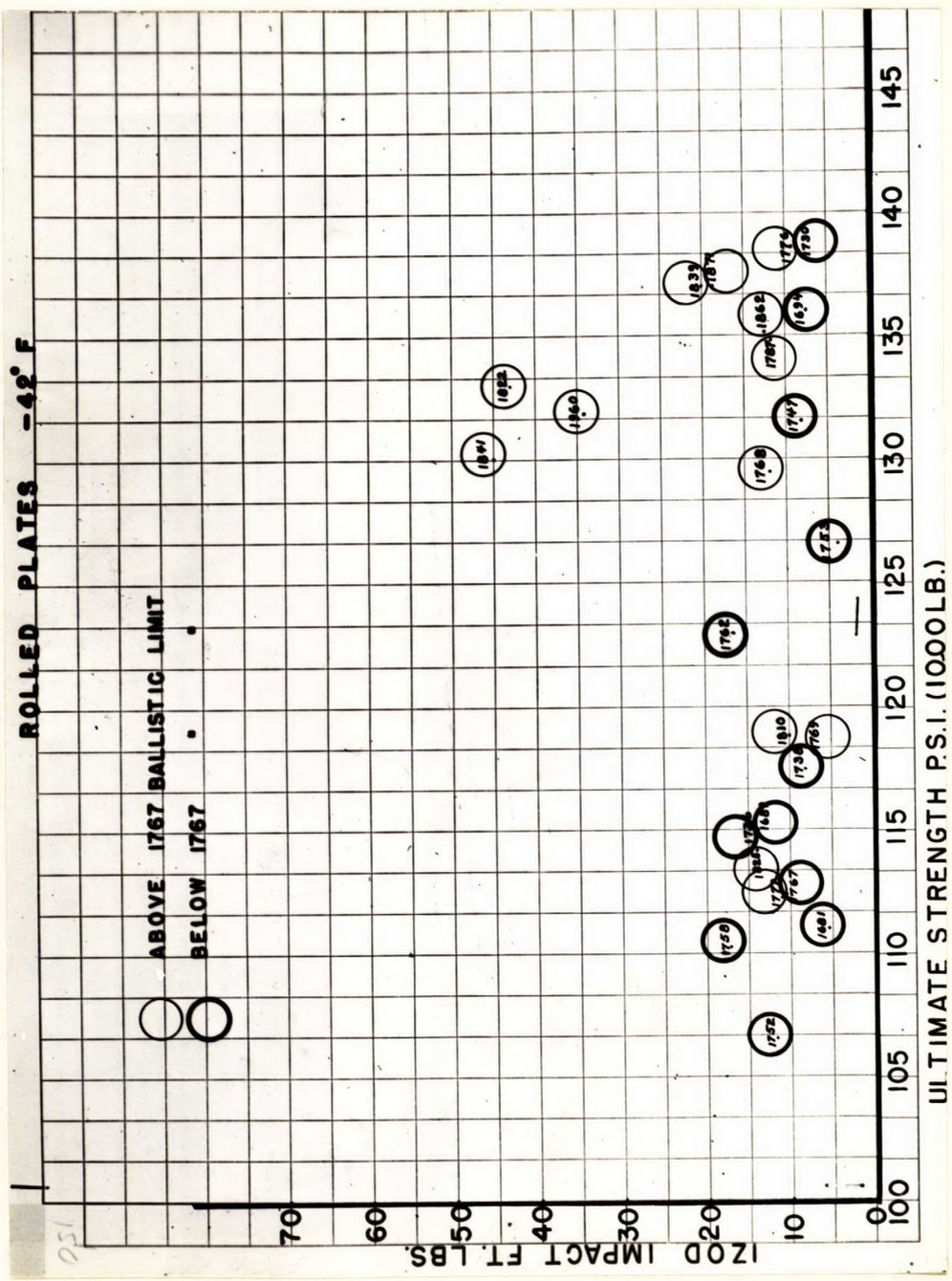
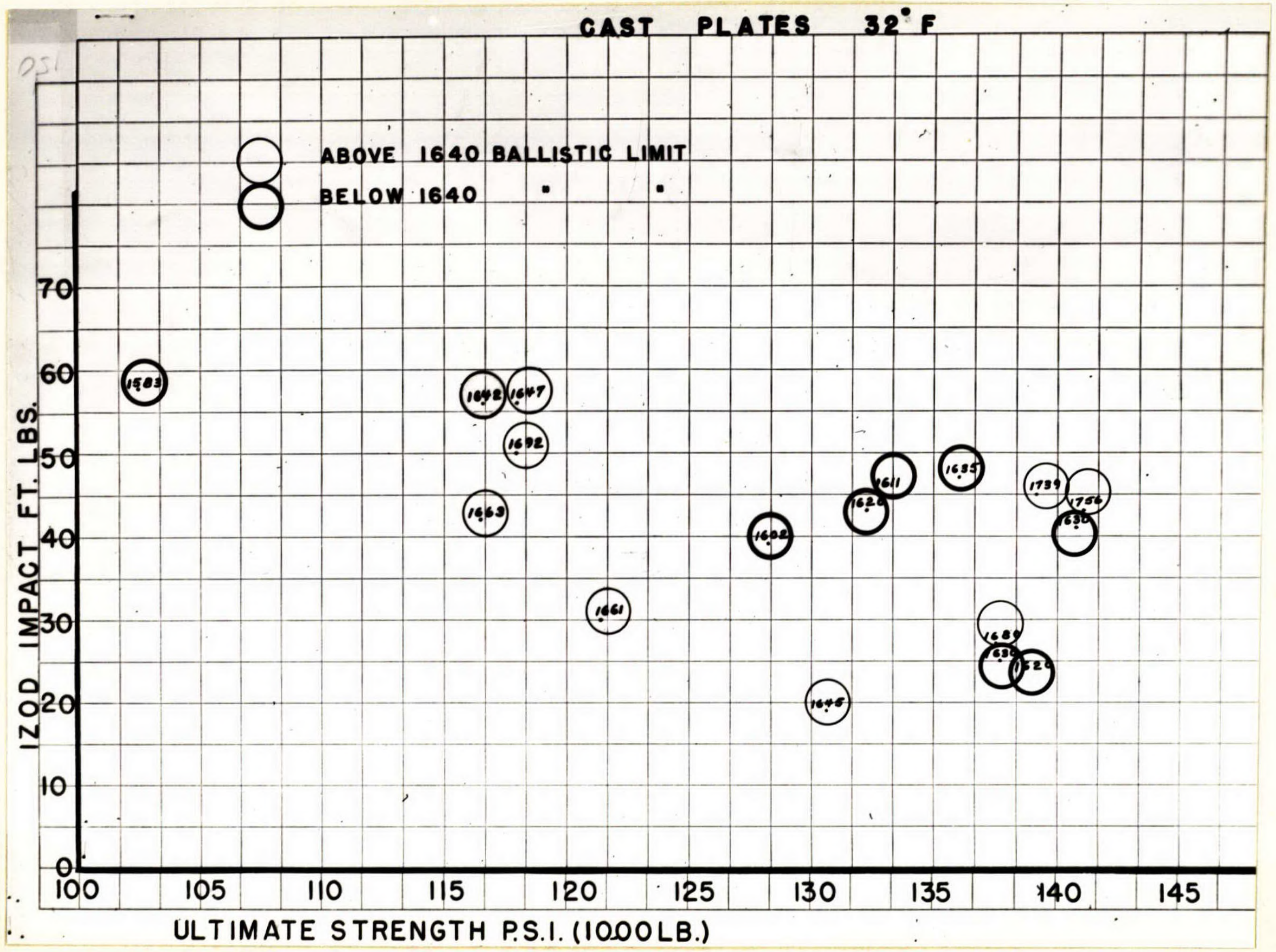


Figure 7.


CAST PLATES 32° F
ABOVE 1640 BALLISTIC LIMIT
BELOW 1640
IZOD IMPACT FT. LBS.
ULTIMATE STRENGTH P.S.I. (1000 LB.)
0
10
20
30
40
50
60
70
100
105
110
115
120
125
130
135
140
145
1583
1642
1647
1692
1663
1661
1602
1645
1620
1611
1635
1739
1756
1630
1689
1630
1624

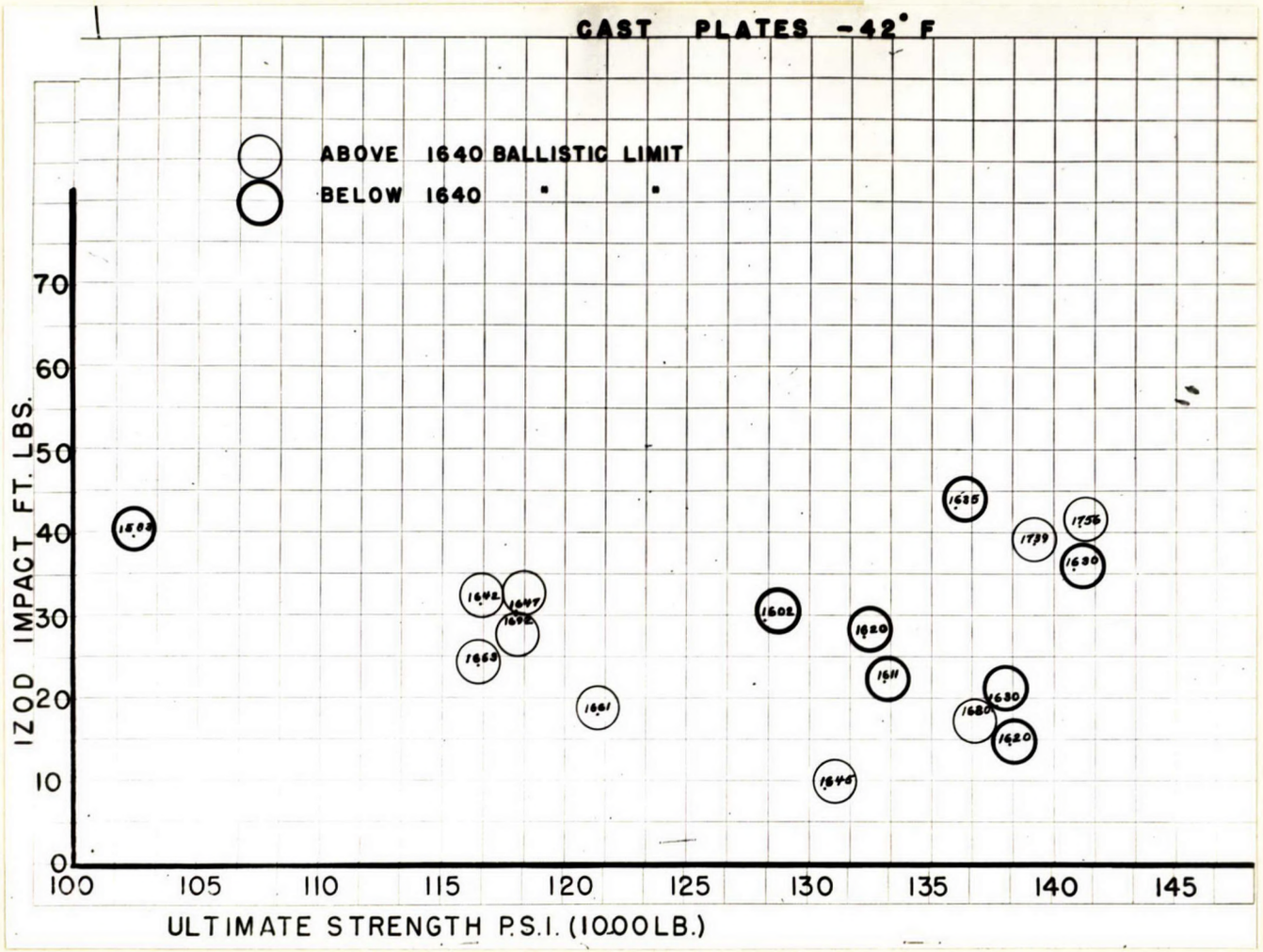

CAST PLATES -42° F
ABOVE 1640 BALLISTIC LIMIT
BELOW 1640
IZOD IMPACT FT. LBS.
0
10
20
30
40
50
60
70
100
105
110
115
120
125
130
135
140
145
ULTIMATE STRENGTH P.S.I. (1000 LB.)
1502
1642
1647
1698
1663
1601
1502
1620
1611
1645
1635
1739
1756
1630
1680
1630
1620

Figure 8.

Comments:

1. All impact specimens mentioned herein were cut with their axis at right angles to the surface of the plate. The fracture line of the specimen parallels the plate surface.

2. Variation in impact strength at low temperatures is greater in cast than in rolled plate.

3. The cast plates have, in general, higher Izod values than the rolled plates.

4. For most producers the variation between plates is greater than the variation caused by low temperatures.

5. The plates which seem the most sensitive to temperature are:

Hadfield's Cast 1½Cr-Mo, Basic Electric.
Hadfield's Cast Low Alloy, Basic Electric.
English Steel Co.'s Low Alloy Basic Electric.

6. The cast plates examined tended to have lower ballistic limits at tensile strengths over 125,000 p.s.i.

7. The rolled plates examined tended to have higher ballistic limits at tensile strengths over 125,000 p.s.i.

8. The rolled plates show tendency of ballistic limit to increase with a rise of impact strength.

9. It is obvious that the impact strength decreases with fall in temperature, both in rolled and in cast plates.

10. The through-plate Izod test results on the rolled plates are quite low compared with those of the cast plates. This is probably due to the fact that the fracture parallels the plate surface and any laminations in the plate may affect the Izod.

Specimens Nos. 14, 16 and 17, produced by Firth Brown, have the highest impact strength at -42° F. and also have high ballistic properties. The satisfactory results on the above plates might be attributed to there being fewer laminations in these specimens.

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