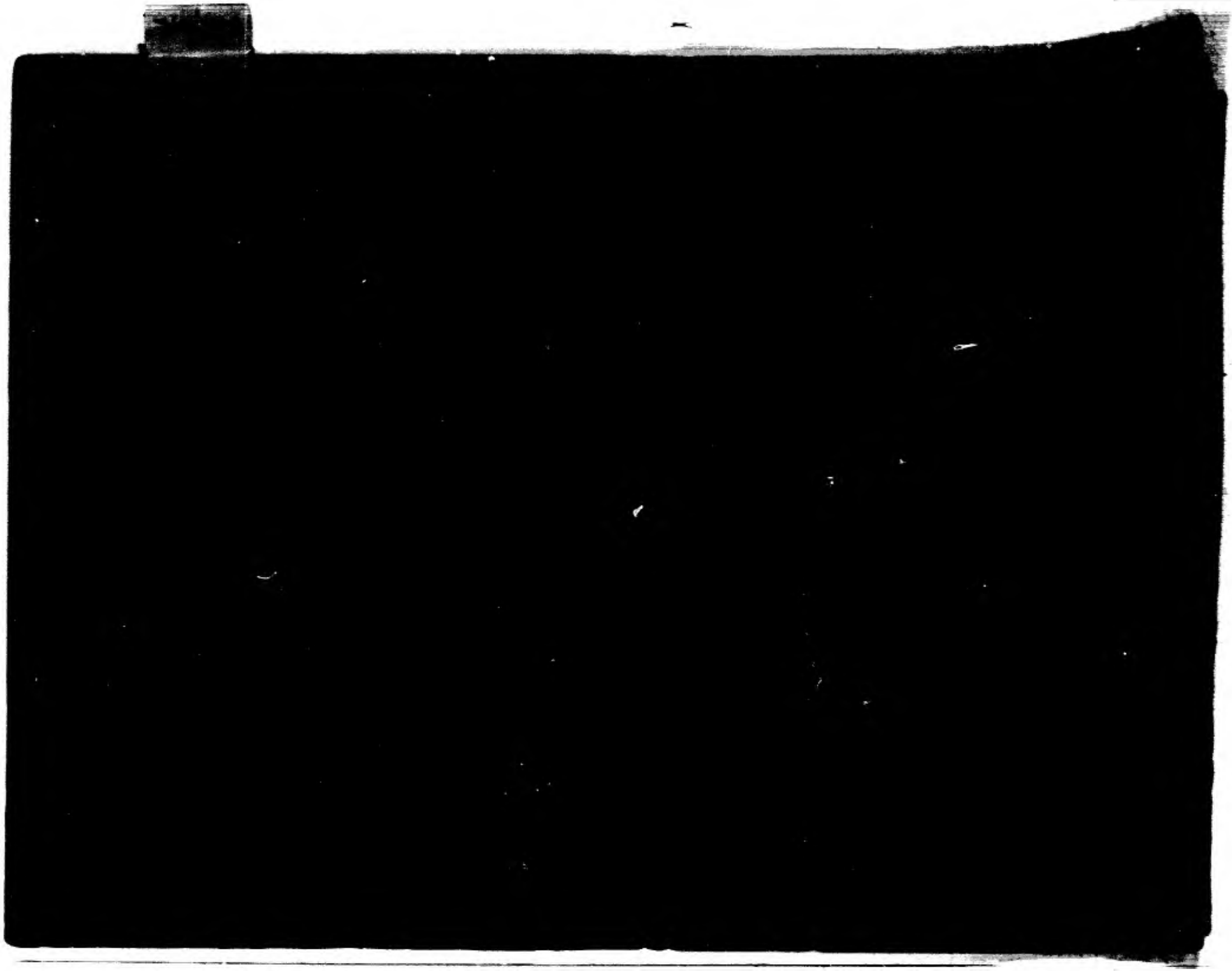

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Watertown Arsenal Laboratory
Report No. WAL 710/561
Problem No. A-2.3

2 February 1944

Armor Plate - Rolled

Correlation between Notched Tensile Impact Properties and

Static Tensile Properties across the Gauge and Back Spalling

Tendencies in Homogeneous Rolled Armor

OBJECT

To determine the relation between the notched tensile impact properties in conjunction with the static tensile properties across the gauge of 1½" thick rolled homogeneous armor plate and its spalling characteristics under the standard projectile-through-plate test.

CONCLUSIONS

1. In general, the notched tensile impact properties and the ductility as measured by the static tensile test across the gauge of 1½" thick rolled armor plate correlated with the spalling characteristics under the standard projectile-through-plate test. However, the differences in these properties as determined on satisfactory and poor quality plate were not pronounced.

2. Back spalling characteristics in armor have been more effectively revealed by the fracture test for steel soundness than the physical tests made across the gauge of plate. The advantages of the fracture test for steel soundness are its low cost, simplicity, lack of complicated apparatus and its ability to determine the presence of laminations over a suitable area.

3. Directional properties of the "straight-away" rolled plates were revealed by the notched tensile impact properties determined in the longitudinal and transverse directions of the plates.

4. Directional properties of [redacted] were not correlated with static ten[redacted]

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5. The static tensile tests made in the longitudinal and transverse directions of the plates were not correlated with spalling characteristics.

6. Shock failures which were correlated with crystallinity in the fractures were not correlated with the physical tests described herein.

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INTRODUCTION

This investigation is a continuation of the project initiated at this arsenal several years ago on the correlation of physical properties and ballistic properties of armor plate.

In this connection, recent investigations have shown that a satisfactory correlation exists between the ballistic shock properties and V-notch Charpy[1] values and also between the steel quality and ductility as measured on a special type of tensile bar machined from across the gauge of the armor.[2][3] The present study was made in order to determine if the notched tensile impact test made across the gauge of plate showed possibilities as an indicator of the ballistic quality of rolled plate. Additional tests were made in the course of this investigation for the purpose of establishing any correlation which might exist between static and dynamic properties and ballistic properties.

These tests included static tensile tests across the gauge, static tensile tests in the longitudinal and transverse directions and notched tensile impact tests in the longitudinal and transverse directions. The latter tests were made especially since it was determined that the unnotched[4] tensile impact tests were inadequate as an indicator of the ballistic quality of rolled armor.

During the past several years cooperative programs have been conducted between this arsenal and industry on the improvement of the quality of rolled armor. As already indicated, certain physical tests have shown a good relationship between steel quality and ballistic properties, but it is evident that these tests are tedious and costly to conduct. Within the past year the fracture test for steel soundness has been developed and recommended by this arsenal for controlling the steel quality of rolled armor. Standards for rating steel quality are given in Specification AXS-488, Revision 2.

The advantages of the fracture test are simplicity and sensitivity of test, low cost, the use of no special equipment; and the ability to reveal the quality of the steel in the whole section under investigation.

(1) Watertown Arsenal Report No. 710/500, 17 May 1943.

(2) First Quarterly Progress Report, NDRC Project NRC-6. Non-ballistic Test for Armor Plate Quality, 18 July 1942, R. F. Mehl, M. Gensamer, C. S. Barrett.

(3) Progress Report on Non-ballistic Test for Armor Plate, NRC Research Project NRC-6, 7 April 1943, M. Gensamer, C. S. Barrett, R. F. Mehl.

(4) See reference (1).

Samples measuring 6"x10"x1½" were obtained from Erie Proving Ground for this investigation and are listed below:

Satisfactory Plates

E.P.G. No.	Manufacturer	Plate No.
200-A	Carnegie-Farrell	3037B-4-60
201-A	Jones & Laughlin - S.S.S.	J608-1M1
202-A	Republic	R3420-1
203-A	Republic	RH678-9
204-A	Carnegie-Gary	GAP-199
205-A	Carnegie-Gary	GAP-198
206-A	Republic	R3429-9
207-A	Republic	R3686-9
208-A	Jones & Laughlin - S.S.S.	J606-1T1
209-A	Jones & Laughlin - S.S.S.	J608-1T1

Rejected Plates

			Type of Failure
210-F	Republic	RC-011-9-2	PTP
211-F	Great Lakes - S.S.S.	G-1064-1B1	PTP
212-F	Great Lakes - S.S.S.	G-1064-1M1	PTP
213-F	Great Lakes - S.S.S.	G-684-1B2	PTP, Shock, B.L.
214-F	Great Lakes - S.S.S.	G-788-1M3	75 mm. shock cracking-B.L.
215-F	Carnegie-Gary	GAP-109-R	PTP
216-F	Carnegie-Gary	GAP-240	PTP
217-F	Carnegie-Gary	GAP-110-R	PTP
218-F	Carnegie-Farrell	3015-B-10-60	75 mm. shock cracking
219-F	Great Lakes - S.S.S.	G-1087-1B1	75 mm. shock cracking

The type of notched tension Charpy bar and also the tensile test specimen are illustrated in Figure 1 - Inclosure A. Notched tensile impact and static tensile test data are given in Inclosure A.

Correspondence pertaining to this investigation is inclosed in Appendix A.

TEST PROCEDURE

1. Physical Tests

a. Notched Tensile Tests and Static Tensile Tests Made across Gauge

Three .312" diameter notched tension impact bars and three .113" diameter tensile bars were machined across the gauge of each plate, care being taken not to include areas which bordered the rolled edge.

b. Notched Tensile Tests and Static Tensile Tests Made Halfway between the Center and Surface, Both in the Longitudinal and Transverse Directions

Three bars of each type as described above were machined from the plates. The notched tensile bars were broken at 16.5 feet per second. All tests were made at +70°F.

2. Fracture Tests

Fracture tests were made on each plate. Sections approximately 2½" square and 6 inches in length were cut through the thickness of the plates, both in the longitudinal and transverse directions, nicked in the middle to a depth of approximately 3/8 inch and broken slowly under the press.

3. Ballistic Tests

The ballistic tests are recorded in Erie Proving Ground firing records to which reference is made in Table I.

RESULTS AND DISCUSSION

1. Metallurgical Examination

a. Chemical Analyses

The chemical analyses of the plates as reported by the manufacturers are given in Table I.

b. Physical Tests

A summary of the correlation of the tensile impact values and also the ductility as measured by the static tensile test with the ballistic properties and fracture test is given in Table I and graphically presented in Figure 1. In addition, a summary is given in Table II of the notched tensile impact data and tensile tests determined halfway between the center and surface of the plates both in the longitudinal and transverse directions, and also the tensile tests across the gauge. Tables A, B, C, and D in Appendix B contain the individual test results.

(1) Notched Tensile Impact Tests across the Gauge

In general, these values are relatively lower in plates which failed the PTP test by spalling as compared to the plates which passed the PTP test. With the exception of plate No. 204A, plates which satisfactorily passed the PTP test had impact values varying from 18 to 26.8 foot pounds. The notched tensile impact values of plates which spalled under the PTP test varied from 6 to 18 foot pounds. The relatively low impact values of satisfactory plates Nos. 204A and 205A are probably due to the high hardness reported for these plates, namely 302-311 Brinell.

The two plates 218F and 219F, which were only subjected to the shock test and showed evidence of cracking, had relatively high notched tensile impact values. It appears from these few tests conducted that there is no correlation between the notched tensile impact values and cracking under the shock test.

(2) Static Tensile Tests across the Gauge

The percentage elongation of the satisfactory plates varied from 5.8% to 15.8% while the percentage reduction of area varied from 10.2% to 34.0%. The percentage elongation of the poor quality plates varied from 0% to 13.3% while the percentage reduction of area varied from 0% to 26.5%. There was only a slight trend for correlation between these ductility values and the spalling characteristics. The low percentage of elongation obtained on the satisfactory plates, Nos. 204A and 205A, is undoubtedly due to the relatively high hardness of these plates. No correlation was made between the ductility as determined by the static tensile test and cracking promoted by the shock test.

There was a slight trend for a correlation between the ballistic limit, hardness and tensile and yield strengths of good quality plate. This relationship was not so apparent in the case of poor quality plate. In the cases of plates, Nos. 211F, 212F and 213F, which were "straight-away" rolled Great Lakes plates, the tensile strength was relatively low. These low values are correlated with the poor steel quality revealed by the fracture test, see Table I.

(3) Notched Tensile Impact Tests in the Longitudinal and Transverse Directions

In general, no definite correlation was made between these determinations and the PTP failures. In the case of the Great Lakes "straight-away" rolled plates, however, the directional properties were revealed by the noticeable differences between the longitudinal and transverse values, see Table II.

(4) Static Tensile Tests in the Longitudinal and Transverse Directions

No particular correlation was definitely established between these tests and the ballistic properties. The yield and tensile strengths varied according to the hardness of the plates as noted in Table II.

c. Fracture Tests for Steel Quality

The fracture test standards for soundness of rolled homogeneous armor plate as given in Specification AXS-465 Revision 2 - Appendix I are attached in Inclosure A. The photographic standards are shown in Inclosure A, Figures 2 and 3 for armor plate 1/4" to 1-1/8" thick and for armor plate from 1-1/4" to 4" thick inclusive. These standards cover B, C, D, and E types of fractures, the path of fracture being broken in the final direction of rolling. The B and C fractures are indicative of good quality plate while D and E fractures show excessive laminations and reveal a poor quality material.

The plates which satisfactorily passed the FTP test had fractures which were typical of good quality, namely, C or B ratings. With the exception of two poor ballistic plates, Nos. 210F and 217F, which had a passable C fracture, the balance of this series of poor quality plates was of poor steel quality, exhibiting D and E fractures. These results are summarized in Table I.

In most cases, the notched tensile impact properties across the gauge correlated with poor steel quality. In Figure 2, several broken notched tensile impact bars are shown illustrating the impact values and the type of fracture of the bars. It is noted that in the fracture of bar No. 213F which was taken from a poor ballistic plate, laminations were evident. The fracture of this bar was typical of the E fracture noted in the steel quality test referred to in Table I. A low notched tensile impact value in this case was correlated with poor steel quality and spalling tendencies.

The fractures of samples 213F and 214F showed the presence of streaks of crystallinity associated with a partially ductile fracture. Sample No. 215F had a totally crystalline fracture. It is difficult to estimate steel quality when the fracture is totally crystalline; since, laminations, if present in the steel, are masked due to the mechanism of rupture in this type of material. Hence no steel quality rating was given this sample. See Table I and Figure 1.

Shock failures are associated with crystallinity which in turn indicates that the material is improperly quenched hardened. It is noted that samples, Nos. 213F, 214F and 215F which show crystallinity in the fractures failed under the shock test. Crystallinity was revealed

in these fractures under the slow application of load by the press. The test for revealing whether a ductile (fibrous) or brittle (crystalline) fracture is obtained is known as the fibre test which demands that the samples be broken by a sharp blow. Due to the lack of material the fibre test was not made on this series of samples.

2. Ballistic Tests

Ballistic tests were made at Erie Proving Ground in accordance with Specification AXS-48, the results of which are summarized in Table I.

Plates, Nos. 200A - 209A inclusive passed satisfactorily the resistance to penetration test and projectile-through-plate using 37 mm. AP M51 APC shot. This series of plates had satisfactory resistance to shock when subjected to 75 mm. T21 projectiles.

The ballistic properties of plates, Nos. 210F - 219F were unsatisfactory. Plate No. 214F failed under the shock test and therefore was not subjected to the resistance to penetration test and the projectile-through-plate test. Plate No. 213F failed due to a low ballistic limit. Plates, Nos. 210F, 211F, 212F, 213F, 215F, 216F, 217F spalled badly under the projectile-through-plate test. Plates, Nos. 213F, 214F, 218F and 219F cracked under the shock test.

SUMMARY

A survey of the results of this investigation shows that there is evidence of a correlation between the notched tensile impact values and the ductility as measured by the tensile test across the gauge of 1½" thick plate and spalling characteristics. The low yield and tensile strengths across the gauge of several of the "straight-away" rolled plates were correlated with the poor steel quality revealed by the fracture test. Directional properties were revealed by the notched tensile impact properties in the longitudinal and transverse directions. On the other hand, directional properties were not correlated with the static tensile tests made in these same directions of rolling.

It is apparent that if a sufficient number of physical tests of the types described herein are taken across the gauge of 1½" thick plate in order to obtain the average properties of the steel, this method may be of value in establishing a correlation between steel quality and ballistic properties. On the other hand, it is evident that the preparation of a sufficient number of test samples and the performing of the tests is both a cumbersome and costly procedure. Furthermore, physical tests must be applied after heat treatment thereby introducing variables in the test results.

In this connection, the fracture test for steel soundness which has recently been incorporated in Specification AXS-488 Revision 2 and accepted by the manufacturers of rolled armor, has been found to be a simple and sensitive method for determining the steel quality. The advantages of the fracture test are enumerated as follows: elimination of heat treatment variables, the simplicity and low cost of the test; the use of no special equipment; and finally the ability of the investigator to study the whole section of the sample under observation.

The fracture test is now used effectively by industry in establishing the quality of each heat at each respective plant.

The fracture test is applied to armor of 1/4" to 3" in thickness. Physical tests across the gauge are limited to plates about 1½" and greater in thickness.

TABLE I

Summary of Ballistic Tests, Physical Properties across the Gauge, and Fracture Test[illegible]

Plate No.	Thickness	Manufacturer	C	Mn	Si	S	P	Cr	Ni	Mo	Zr	BHN	R.F.O. Firing Record No.	Ballistic Limit - f/s 37 mm. M51 APC	PTP 37 mm. M51 APC	Shock 75 mm. T21	Notched Tensile Impact Tests Ft/lbs.
200A 30372-4-60	1.51"	Carnegie Farrell	.27	1.33	.21	.022	.021	.80	.90	.17	-	269	76,[illegible]	1684 (+176)*	Satisfactory	Satisfactory Str. Vel. 1695 f/s	26.8
201A J608-1-HI	1.48"	J&L Standard SSS	.28	1.71	.22	.013	.018	-	-	.30	-	260-269	65,902	1678 (+194)	Satisfactory	Satisfactory Str. Vel. 1694 f/s	19.1
202A RH420-1	1.50"	Republic	.265	.93	.32	.023	.007	.79	.95	.39	-	248	-	-	Satisfactory	Satisfactory	18.9
203A RH678-9	1.51"	Republic	.264	1.17	.29	.020	.019	.68	.92	.35	-	269	65,097	[illegible] (+1[illegible])	Satisfactory	Satisfactory Str. Vel. 1687 f/s	21.3
204A GAP-199	1.53"	Carnegie Gary	.30	1.25	.22	.028	.018	.85	1.01	.44	-	311	64,881	1713 (+189)	Satisfactory	Satisfactory Str. Vel. 1684 f/s	12.9
205A GAP-198	1.54"	Carnegie Gary	.30	1.25	.22	.028	.018	.85	1.01	.44	-	302	64,881	1690 (+158)	Satisfactory	Satisfactory Str. Vel. 1689 f/s	18.9
206A RH689-9	1.51"	Republic	.284	.85	.27	.015	.020	.96	.98	.45	-	269	65,096	1671 (+163)	Satisfactory	Satisfactory Str. Vel. 1585 f/s	23.1
207A RH686-9	1.50"	Republic	.286	1.24	.31	.018	.022	.73	.89	.34	-	269	65,095	1684 (+184)	Satisfactory	Satisfactory Str. Vel. 1682 f/s	24.5
208A J-606-1H1	1.49"	J&L SSS	.27	1.62	.21	.014	.019	-	-	.20	-	260-269	65,902	1697 (+165)	Satisfactory	Satisfactory Str. Vel. 1683 f/s	24.3
209A J-608-1H1	1.48"	J&L SSS	.28	1.71	.22	.013	.018	-	-	.30	-	260-269	[illegible]	1698 (+174)	Satisfactory	Satisfactory Str. Vel. 1657 f/s	18.0
210F RH-011-9-2	1.49"	Republic	.28	1.10	.22	.023	.016	.73	.75	.22	-	250	72,[illegible]	1634 (+142)*	Failed 3-1/32x3-5/16" R.R.	Satisfactory Str. Vel. 1585 f/s	14.4
211F G-1064-1H1	1.49"	Great Lakes SSS	.29	.92	.21	.031	.013	.54	-	.30	.09	[illegible]-285	72,727	1636 (+144)	Failed 3-4/[illegible]-5/8" R.R.	Satisfactory Str. Vel. 1686 f/s	15.2
212F G-1064-1H1	1.49"	Great Lakes SSS	.29	.92	.21	.031	.013	.54	-	.30	.09	269-277	72,727	1615 (+123)	Failed 3-5/[illegible]-5/16" R.R.	Satisfactory Str. Vel. 1682 f/s	18.3
213F G-684-1H2	1.49"	Great Lakes SSS	.28	1.00	.68	.034	.021	.57	-	.17	.08	277-285	65,900	1392 (-100) Failed	Failed 4-1/[illegible]-5/8" R.R.	Failed [illegible]" R.R.	8.0
214F G-788-1H3	1.49"	Great Lakes SSS	.29	.86	.85	.038	.022	.62	-	.16	.09	285	65,900	—	—	Failed [illegible]" R.R. [illegible] Cracks	6.1
215F GAP-1098	1.52"	Carnegie Gary	.25	1.05	.26	.024	.016	.60	1.02	.37	-	302	75,377	1578 (+ 56)	Failed 3-15/[illegible] R.R.	Satisfactory Str. Vel. 1686 f/s	7.5
216F GAP-[illegible]	1.5[illegible]"	Carnegie Gary	.25	.[illegible]	.[illegible]	.0[illegible]	.013	.[illegible]	1.02	.39	-	[illegible]-285	75,3[illegible]	[illegible] ([illegible]) [illegible] 3-3/[illegible]	Failed 3-3/[illegible]-3/8" R.R.	Satisfactory Str. Vel. 1650 f/s	7.5
217F GAP-[illegible]	1.50"	Carnegie Gary	.25	1.05	.26	.02[illegible]	.016	.60	1.02	.37	-	293-302	75,377	[illegible] ([illegible]) [illegible] 3 [illegible] 3-3/8" [illegible]	Failed 3-3/[illegible]/8" R.R.	Satisfactory Str. Vel. [illegible] f/s	8.0
218F [illegible]	1.50"	Carnegie [illegible]	.[illegible]	.[illegible]	.[illegible]	.0[illegible]	.0[illegible]	.[illegible]	.93	.19	-	269	-	—	—	Failed-Cracks	[illegible].0
219F G-[illegible]-1H[illegible]	1.49"	Great Lakes SSS	.[illegible]	.[illegible]	.[illegible]	.0[illegible]	.0[illegible]	.[illegible]	-	.23	.07	[illegible]-285	75,[illegible]	1603 (+111)	Satisfactory	Failed [illegible] cracks Str. Vel. [illegible] f/s	[illegible].0

[illegible]

TABLE I

...llistic Tests, Physical Properties across the [illegible], and Fracture Tests

Mo	Zr	BHN	R.F.G. Firing Record No.	Ballistic Limit - f/s 37 mm. M51 APC	PTP 37 mm. M51 APC	Shock 75 mm. T21	Notched Tensile Impact Tests Ft/Lbs.	Yield Strength Lbs./Sq.In.	Tensile Strength Lbs./Sq.In.	% Elong.	% R.A.	Steel Quality	Fibre Test
			Ballistic Properties				Physical Properties across [illegible]	Static Tensile Tests				Fracture Test	
.17	-	269	76,[illegible]	1664 (+176)*	Satisfactory	Satisfactory Str. Vel. 1[illegible] f/s	26.8	103,200	122,400	15.8	34.0	B	Fibre
.30	-	26[illegible]-269	65,90[illegible]	1678 (+194)	Satisfactory	Satisfactory Str. Vel. 1[illegible]4 f/s	19.1	101,000	117,200	13.3	33.1	C	Fibre
.39	-	248	-	-	Satisfactory	Satisfactory	18.9	90,400	113,300	10.8	17.3	C	Fibre
.35	-	269	65,097	[illegible] (+141)	Satisfactory	Satisfactory Str. Vel. [illegible] f/s	21.3	96,700	116,150	9.2	19.6	B	Fibre
.44	-	311	64,881	1713 (+189)	Satisfactory	Satisfactory Str. Vel. [illegible] f/s	12.9	124,800	140,400	5.8	10.2	B	Fibre
.44	-	302	64,881	1690 (+158)	Satisfactory	Satisfactory Str. Vel. [illegible] f/s	18.9	123,000	142,300	5.8	16.6	B	Fibre
.45	-	269	65,096	1671 (+163)	Satisfactory	Satisfactory Str. Vel. [illegible] f/s	23.1	100,500	120,300	10.8	19.9	C	Fibre
.34	-	269	65,095	1664 (+184)	Satisfactory	Satisfactory Str. Vel. [illegible] f/s	24.5	99,800	121,000	12.5	22.5	B	Fibre
.20	-	26[illegible]-269	65,90[illegible]	1657 (+18[illegible])	Satisfactory	Satisfactory Str. Vel. [illegible] f/s	24.3	97,700	114,100	14.2	32.0	B	Fibre
.30	-	[illegible]-269	[illegible]	165[illegible] (+174)	Satisfactory	Satisfactory Str. Vel. 1[illegible]7 f/s	18.0	101,800	117,400	9.2	32.0	B	Fibre
.22	-	259	72,8[illegible]	1634 (+142)*	Failed 3-1/32"-5/16" B.S.	Satisfactory Str. Vel. [illegible] f/s	14.4	96,800	113,400	9.2	15.3	C	Fibre
.30	.09	[illegible]-285	72,717	1636 (+144)	Failed 3-[illegible]/[illegible]-[illegible]/8" B.S.	Satisfactory Str. Vel. [illegible] f/s	15.2	88,400	94,400	5.0	12.1	B	Fibre
.30	.09	269-277	72,717	1615 (+123)	Failed 3-5/[illegible]-5/16" B.S.	Satisfactory Str. Vel. 1[illegible] f/s	18.3	80,500	81,000	2.5	4.9	B	Fibre
.17	.08	277-285	65,900	1392 (-100) Failed	Failed 4-1/[illegible]-5/8" B.S.	Failed [illegible]" B.S.	8.0	67,300	67,300	0	0	B	Fibre and Crystalline
.16	.09	285	65,900	—	—	Failed [illegible]" B.S. [illegible]	6.1	114,800	133,000	13.3	16.5	B	Fibre and Crystalline
.37	-	302	75,177	1578 (+ 56)	Failed 3-15/[illegible]	Satisfactory Str. Vel. [illegible]	7.5	[illegible]	[illegible]	4.2	6.2	B	Fibre
.39	-	285-293	75,1[illegible]	[illegible] (+[illegible]) [illegible]	Failed 3-5/[illegible] B.S.	[illegible]	7.[illegible]	—	—	-	-	B	Fibre
.37	-	293-30[illegible]	75,177	[illegible]	Failed 3-3/[illegible] B.S.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.19	-	[illegible]	-	—		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
.23	.07	[illegible]	75,[illegible]	16[illegible] ([illegible])	Satisfactory	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	C	Fibre

[illegible]

[illegible]

TABLE II

Summary of Physical Test Data Including Static Tensile Tests across the Gauge

Notched Tensile Impact and Static Tensile Tests in the Longitudinal and Transverse Direc

Plate No.	Thickness	Manufacturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	Brinell Hardness	Notched Tensile Impact Tests Foot Pounds	Static Tensile Tests Y.S.P. .1% Set Lbs./Sq.In.	T.S. Lbs./Sq.In.	% Elong.	% R.A.	B.L. 37 m A.F. M
200A 3037B-4-60	1.51"	Carnegie Pearsall	.27	1.33	.21	.80	.90	.17	—	269	*Long. 55.1 *Trans. 40.3	Across Gauge 103,200 *Long. 109,200 *Trans. 103,200	1[illegible],400 131,100 1[illegible],[illegible]00	15.8 25.0 20.0	34.0 70.8 62.9	1684 (+176
201A J608-1-M1	1.48"	J&L SSS	.28	1.71	.22	—	—	.30	—	262-269	Long. 52.0 Trans. 42.8	Across Gauge 101,000 Long. 111,900 Trans. 105,100	117,200 126,400 125,100	13.3 22.5 20.0	33.1 68.3 67.0	1678 (+194
202A RM420-1	1.50"	Republic	.265	.93	.32	.79	.25	.39	—	248	Long. 60.4 Trans. 44.4	Across Gauge 90,400 Long. — Trans. —	113,300 — —	10.8 — —	17.3 — —	—
203A RM678-9	1.51"	Republic	.264	1.17	.29	.68	.92	.35	—	269	Long. 56.1 Trans. 41.1	Across Gauge 96,700 Long. 101,900 Trans. 102,200	116,150 126,500 125,600	9.2 24.2 22.5	19.6 69.5 57.6	1649 (+141
204A GAP-199	1.53"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	—	311	Long. 51.4 Trans. 43.1	Across Gauge 124,800 Long. 132,700 Trans. 131,800	140,400 152,700 151,800	5.8 20.0 19.2	10.2 62.7 56.1	1713 (+189
205A GAP-196	1.54"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	—	302	Long. 55.9 Trans. 43.8	Across Gauge 123,000 Long. 122,700 Trans. 127,400	141,300 148,900 149,800	5.8 20.4 20.0	16.6 66.0 58.2	1690 (+158
206A RM429-9	1.48"	Republic	.284	.85	.27	.96	.98	.45	—	269	Long. 59.0 Trans. 44.4	Across Gauge 100,500 Long. 106,400 Trans. 108,500	120,300 127,900 129,300	10.8 24.2 22.5	19.9 71.0 60.8	1671 (+163
207A RM686-9	1.50"	Republic	.286	1.24	.31	.73	.89	.34	—	269	Long. 58.0 Trans. 44.8	Across Gauge 99,800 Long. 105,400 Trans. 104,700	121,000 127,800 126,200	12.5 24.2 20.0	28.5 66.9 56.7	1684 (+184
208A J-606-1T1	1.49"	J&L SSS	.27	1.62	.21	—	—	.20	—	262-269	Long. 49.8 Trans. 50.2	Across Gauge 97,700 Long. 103,000 Trans. 104,400	116,200 123,800 122,800	14.2 21.1 20.0	32.0 62.4 60.9	1657 (+165
209A J-608-1T1	1.48"	J&L SSS	.28	1.71	.22	—	—	.30	—	262-269	Long. 52.8 Trans. 52.1	Across Gauge 101,800 Long. 106,000 Trans. 104,300	117,400 123,000 [illegible]	9.2 22.5 20.0	32.0 63.7 60.8	1658 (+17[illegible]
210F RS-011-9-2	1.49"	Republic	.28	1.10	.22	.73	.75	.22	—	259	Long. 44.1 Trans. 43.3	Across Gauge 96,800 Long. 101,800 Trans. 101,800	113,800 125,700 121,700	9.2 20.8 22.5	15.3 62.2 61.5	1634 (+142
211F G-1064-1B1	1.49"	Great Lakes SSS	.29	.92	.81	.54	—	.30	.09	277-285	Long. 53.8 Trans. 30.8	Across Gauge 88,400 Long. — Trans. —	94,400 — —	5.0 — —	12.1 — —	163[illegible] (+14[illegible]
212F G-1064-1B1	1.49"	Great Lakes SSS	.29	.92	.81	.54	—	.30	.09	269-277	Long. 60.8 Trans. 39.1	Across Gauge 80,900 Long. 108,800 Trans. 108,300	81,000 [illegible] [illegible]	2.5 20.8 20.0	4.9 63.3 57.7	161[illegible] (+12[illegible]
213F G-654-1B2	1.49"	Great Lakes SSS	.28	1.00	.66	.57	—	.17	.08	277-285	Long. 52.0 Trans. 39.0	Across Gauge 67,300 Long. 107,700	67,300 [illegible]	0 [illegible]	0 63.0	139[illegible] (-10[illegible]
[illegible]	[illegible]	[illegible]	[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]													

TABLE II

...of Physical Test Data Including Static Tensile Tests across the Gauge

...e Impact and Static Tensile Tests in the Longitudinal and Transverse Directions

Armor Hardness	Notched Tensile Impact Tests Foot Pounds	Static Tensile Tests	Y.S.P. .1% Set Lbs./Sq.In.	T.S. Lbs./Sq.In.	% Elong.	% R.A.	Ballistic Properties B.L. 37 mm. A.P. M51 APC	Remarks on PTP and Shock Tests
269	•Long. ...1 •Trans. ...3	Across Gauge	103,200	1[illegible],400	15.[illegible]	34.0	1684 (+176)**	Satisfactory PTP and shock.
		•Long.	109,300	131,100	15.	30.8		
		•Trans.	103,300	13[illegible],[illegible]00	22.	62.2		
262-269	Long. 38.6 Trans. 42.8	Across Gauge	111,000	11[illegible],700	13.5	33.1	1678 (+194)	Satisfactory PTP and shock.
		Long.	111,900	126,400	22.	68.3		
		Trans.	105,100	125,100	20.0	67.0		
248	Long. 40.4 Trans. 44.4	Across Gauge	90,400	113,500	10.8	17.3	—	Satisfactory PTP and shock.
		Long.	—	—	—	—		
		Trans.	—	—	—	—		
269	Long. 40.1 Trans. 41.1	Across Gauge	96,700	116,150	9.2	19.6	1649 (+141)	Satisfactory PTP and shock.
		Long.	101,900	128,500	24.2	69.5		
		Trans.	102,200	12[illegible],600	22.5	57.6		
311	Long. 31.4 Trans. 43.1	Across Gauge	124,800	140,400	5.2	10.2	1713 (+189)	Satisfactory PTP and shock.
		Long.	132,700	152,700	20.0	62.7		
		Trans.	111,800	12[illegible],800	19.2	56.1		
302	Long. 39.9 Trans. 43.8	Across Gauge	123,000	141,300	5.8	16.6	1690 (+158)	Satisfactory PTP and shock.
		Long.	122,700	148,900	20.4	66.0		
		Trans.	127,400	14[illegible],800	20.0	58.2		
269	Long. 59.0 Trans. 54.4	Across Gauge	100,500	120,300	10.8	19.9	1671 (+163)	Satisfactory PTP and shock.
		Long.	106,400	127,900	24.2	71.0		
		Trans.	108,500	12[illegible],800	22.5	60.8		
269	Long. 58.0 Trans. 44.8	Across Gauge	99,800	121,000	12.5	22.5	1684 (+184)	Satisfactory PTP and shock.
		Long.	105,400	127,300	24.2	66.9		
		Trans.	104,700	12[illegible],200	20.0	56.7		
262-269	Long. 49.8 Trans. 50.2	Across Gauge	97,700	11[illegible],800	14.2	32.0	1657 (+165)	Satisfactory PTP and shock.
		Long.	103,000	123,800	21.1	62.4		
		Trans.	104,400	122,800	20.0	60.9		
262-269	Long. 52.8 Trans. 52.1	Across Gauge	101,800	117,400	9.2	32.0	1658 (+174)	Satisfactory PTP and shock.
		Long.	106,000	123,000	22.5	63.7		
		Trans.	104,300	12[illegible],[illegible]00	20.0	60.8		
259	Long. 44.1 Trans. 43.3	Across Gauge	96,800	113,[illegible]00	9.2	15.3	1634 (+142)	Failed PTP - BS - Satisfactory Shock
		Long.	101,800	125,700	20.8	62.2		
		Trans.	101,800	121,700	22.5	61.5		
277-285	Long. 53.8 Trans. 30.8	Across Gauge	88,400	94,400	5.0	12.1	1636 (+144)	Failed PTP - BS - Satisfactory Shock
		Long.	—	—	—	—		
		Trans.	—	—	—	—		
269-277	Long. 60.0 Trans. 39.1	Across Gauge	80,500	81,000	2.5	4.9	1615 (+123)	Failed PTP - BS - Satisfactory Shock
		Long.	108,500	12[illegible],[illegible]00	20.8	63.3		
		Trans.	108,300	12[illegible],000	20.0	57.7		
277-285	Long. 52.0 Trans. 29.0	Across Gauge	67,300	67,300	0	0	1392 (-100)	Failed PTP and Shock - BS
		Long.	107,700	131,300	23.7	63.0		
		Trans.	108,800	130,500	17.5	48.6		
285	Long. 46.3 Trans. 31.5	Across Gauge	114,200	133,000	13.3	26.3	—	Failed shock only. B.S.Aerocks.
		Long.	116,700	140,500	20.4	70.8		
		Trans.	121,500	140,100	16.3	47.7		
302	Long. 42.4 Trans. 36.7	Across Gauge	116,600	126,500	5.2	6.2	1572 (+ 56)	Failed PTP - BS - Satisfactory Shock
		Long.	123,500	140,100	20.0	62.6		
		Trans.	125,700	140,900	20.0	57.6		
285-293	Long. 45.6 Trans. 41.7	Across Gauge	—	—	—	—	16[illegible] (+157)[illegible]	Failed PTP - BS - Satisfactory Shock
		Long.	120,900	138,500	20.0	64.3		
		Trans.	122,800	137,500	16.2	47.7		
293-302	Long. 46.5	Across Gauge	123,700	139,900	8.5	7.8	1518 (+2)	Failed PTP - BS - Satisfactory Shock
	Trans. [illegible]	Long.	127,200	145,100	20.0	59.6		

												Trans. 43.1	Long. 132,700	138,700	20.0	
													Trans. 133,800	143,800	19.2	
205A GAP-198	1.54*	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	—	302	Long. 56.9 Trans. 43.8	Across Gauge	123,000	140,300	5.8	1
												Long.	122,700	148,900	20.4	6
												Trans.	127,400	145,200	20.0	5
206A RE429-9	1.47*	Republic	.284	.85	.27	.96	.98	.45	—	269	Long. 59.0 Trans. 44.4	Across Gauge	100,500	120,300	10.8	1
												Long.	100,400	127,500	24.2	
												Trans.	108,500	129,300	22.5	
207A RE686-9	1.50*	Republic	.286	1.24	.31	.73	.89	.34	—	269	Long. 58.0 Trans. 44.8	Across Gauge	99,800	121,000	12.5	2
												Long.	105,400	127,800	24.2	6
												Trans.	104,700	125,200	20.0	5
208A J-606-1T1	1.49*	J&L SSS	.27	1.62	.21	—	—	.20	—	262-269	Long. 49.8 Trans. 50.2	Across Gauge	97,700	114,200	14.2	3
												Long.	103,000	123,800	21.1	6
												Trans.	104,400	122,800	20.0	5
209A J-608-1T1	1.48*	J&L SSS	.28	1.71	.22	—	—	.30	—	262-269	Long. 52.8 Trans. 52.1	Across Gauge	101,800	117,400	9.2	3
												Long.	106,000	123,000	22.5	6
												Trans.	104,300	[illegible]	20.0	5
210F RO-611-9-2	1.49*	Republic	.38	1.10	.22	.73	.75	.22	—	259	Long. 48.1 Trans. 43.3	Across Gauge	96,800	113,800	9.2	1
												Long.	101,800	125,700	20.8	6
												Trans.	101,800	121,700	22.5	6
211F G-1064-1B1	1.49*	Great Lakes SSS	.29	.92	.81	.54	—	.30	.09	277-285	Long. 53.8 Trans. 30.8	Across Gauge	88,400	94,400	5.0	1
												Long.	—	—	—	
												Trans.	—	—	—	
212F G-1064-1M1	1.49*	Great Lakes SSS	.29	.92	.81	.54	—	.30	.09	269-277	Long. 60.0 Trans. 39.1	Across Gauge	80,500	81,000	2.5	
												Long.	108,500	[illegible]	20.8	6
												Trans.	101,300	125,000	20.0	5
213F G-684-1B2	1.49*	Great Lakes SSS	.28	1.00	.68	.57	—	.17	.08	277-285	Long. 52.0 Trans. 29.0	Across Gauge	67,300	67,300	0	
												Long.	107,700	131,300	21.7	5
												Trans.	102,800	130,400	17.5	4
214F G-788-1M3	1.49*	Great Lakes SSS	.29	.86	.85	.62	—	.16	.09	285	Long. 46.3 Trans. 31.5	Across Gauge	114,200	133,000	13.3	7
												Long.	116,700	140,500	20.4	6
												Trans.	121,500	140,100	18.3	6
215F GAP-109R	1.52*	Carnegie Gary	.25	1.05	.86	.60	1.02	.37	—	302	Long. 42.4 Trans. 36.7	Across Gauge	118,600	130,500	4.2	
												Long.	123,500	140,100	20.0	6
												Trans.	125,700	140,900	20.0	5
216F GAP-240	1.48*	Carnegie Gary	.26	.95	.25	.44	1.02	.39	—	285-293	Long. 45.8 Trans. 41.7	Across Gauge	—	—	—	
												Long.	130,900	138,500	20.0	6
												Trans.	122,800	137,700	19.2	5
217F GAP-110R	1.52*	Carnegie Gary	.25	1.05	.26	.60	1.02	.37	—	293-302	Long. 46.5 Trans. 41.6	Across Gauge	123,700	126,900	2.5	
												Long.	127,200	145,100	20.0	5
												Trans.	120,200	143,600	19.7	5
218F 3015-B-10-60	1.50*	Carnegie Farrell	.245	.92	.25	.87	.93	.19	—	269	Long. 41.9 Trans. 38.4	Across Gauge	103,100	123,200	10.0	2
												Long.	113,200	131,100	18.3	5
												Trans.	114,500	132,900	17.5	5
219F G-1087-1B1	1.49*	Great Lakes SSS	.29	.94	.81	.61	—	.23	.07	262-269	Long. 59.0 Trans. 39.2	Across Gauge	86,300	113,800	15.0	8
												Long.	92,500	116,700	25.8	6
												Trans.	95,200	118,300	20.8	5

Note: Above values are an average of three tests.
**Numbers in parentheses indicate feet per second in excess of Specification AMS-466.
The longitudinal and transverse notched tensile impact tests and static tensile tests were made on test bars machined halfway

311	Long. 41.4 Trans. 43.1	Across Gauge Long. Trans.	132,700 133,900	138,700 141,800	5. 20.	12.7 58.1	1713 (+189)	Satisfactory PTP and shock.
302	Long. [illegible] Trans. 43.8	Across Gauge Long. Trans.	133,000 122,700 127,400	141,400 140,300 140,200	5. 20.4 20.0	16.6 66.0 58.2	1690 (+158)	Satisfactory PTP and shock.
286	Long. 59.0 Trans. 44.3	Across Gauge Long. Trans.	104,500 106,900 109,800	135,300 137,[illegible] [illegible]	10.8 [illegible] [illegible]	19.9 71.0 60.8	1671 (+163)	Satisfactory PTP and shock.
269	Long. 58.0 Trans. 44.5	Across Gauge Long. Trans.	99,800 105,400 104,700	121,000 137,400 128,200	13.5 20.2 20.0	22.5 66.9 56.7	1684 (+184)	Satisfactory PTP and shock.
286-269	Long. 41.8 Trans. 50.[illegible]	Across Gauge Long. Trans.	97,700 [illegible] 104,400	114,200 133,800 128,800	[illegible] 21.1 20.0	32.0 62.4 60.9	1657 (+165)	Satisfactory PTP and shock.
286-269	Long. [illegible] Trans. 52.1	Across Gauge Long. Trans.	1 1,800 10[illegible],000 104,[illegible]	117,400 123,000 [illegible]	[illegible] [illegible] [illegible]	32.0 63.7 60.8	1658 (+171)	Satisfactory PTP and shock.
269	Long. 44.1 Trans. 43.3	Across Gauge Long. Trans.	96,800 101,800 [illegible],[illegible]0	113,800 125,700 [illegible],700	[illegible].2 20.8 [illegible].5	15.3 62.2 61.5	1634 (+142)	Failed PTP - BS - Satisfactory Shock
277-285	Long. 33.8 Trans. 30.8	Across Gauge Long. Trans.	88,400 — —	94,400 — —	5.0 — —	12.1 — —	1636 (+144)	Failed PTP - BS - Satisfactory Shock
285-277	Long. 60.0 Trans. 33.1	Across Gauge Long. Trans.	80,500 102,500 101,300	81,000 125,700 121,000	2.5 20.8 20.0	4.9 63.3 57.7	1615 (+123)	Failed PTP - BS - Satisfactory Shock
277-285	Long. 32.0 Trans. 29.0	Across Gauge Long. Trans.	67,300 107,700 102,800	67,300 131,300 130,400	0 21.7 17.5	0 63.0 62.6	1392 (-100)	Failed PTP and Shock - BS
285	Long. 40.3 Trans. 31.5	Across Gauge Long. Trans.	114,200 115,700 121,200	133,000 130,500 140,100	13.3 20.4 16.3	26.5 50.8 [illegible].7	—	Failed shock only. B.S.4cracks.
302	Long. 42.4 Trans. 38.7	Across Gauge Long. Trans.	118,600 123,500 125,700	138,500 144,100 140,200	4.2 20.0 20.0	6.2 61.6 57.6	1572 (+ 56)	Failed PTP - BS - Satisfactory Shock
285-293	Long. 45.8 Trans. 41.7	Across Gauge Long. Trans.	— 120,[illegible]00 122,800	— 13[illegible],500 137,700	— 20.0 19.2	— 61.3 57.7	1641 (+157)BS	Failed PTP - BS - Satisfactory Shock
293-302	Long. 45.5 Trans. 41.0	Across Gauge Long. Trans.	123,700 127,200 120,200	12[illegible],500 145,100 143,000	2.5 20.0 16.7	7.2 59.6 56.6	1518 (+2) BS	Failed PTP - BS - Satisfactory Shock
269	Long. 41.9 Trans. 38.4	Across Gauge Long. Trans.	103,100 113,200 114,500	123,200 131,100 132,900	0.0 18.3 17.5	29.0 51.8 51.5	—	Failed Shock - Cracks
262-269	Long. 59.0 Trans. 39.2	Across Gauge Long. Trans.	86,300 92,500 95,200	113,800 116,700 118,300	15.0 25.8 20.8	28.4 65.3 51.0	1603 (+111)	Satisfactory PTP - Failed Shock Cracks

Specification AXS-405.
and static tensile tests were made on test bars machined halfway between center and surface of plates.

PHYSICAL PROPERTIES ACROSS GAUGE OF 1½" THICK SATISFACTORY & POOR QUALITY PLATE

NOTCHED TENSILE IMPACT VALUES, PERCENT REDUCTION AREA & PERCENT ELONGATION AS DETERMINED BY THE STATIC TENSILE TEST

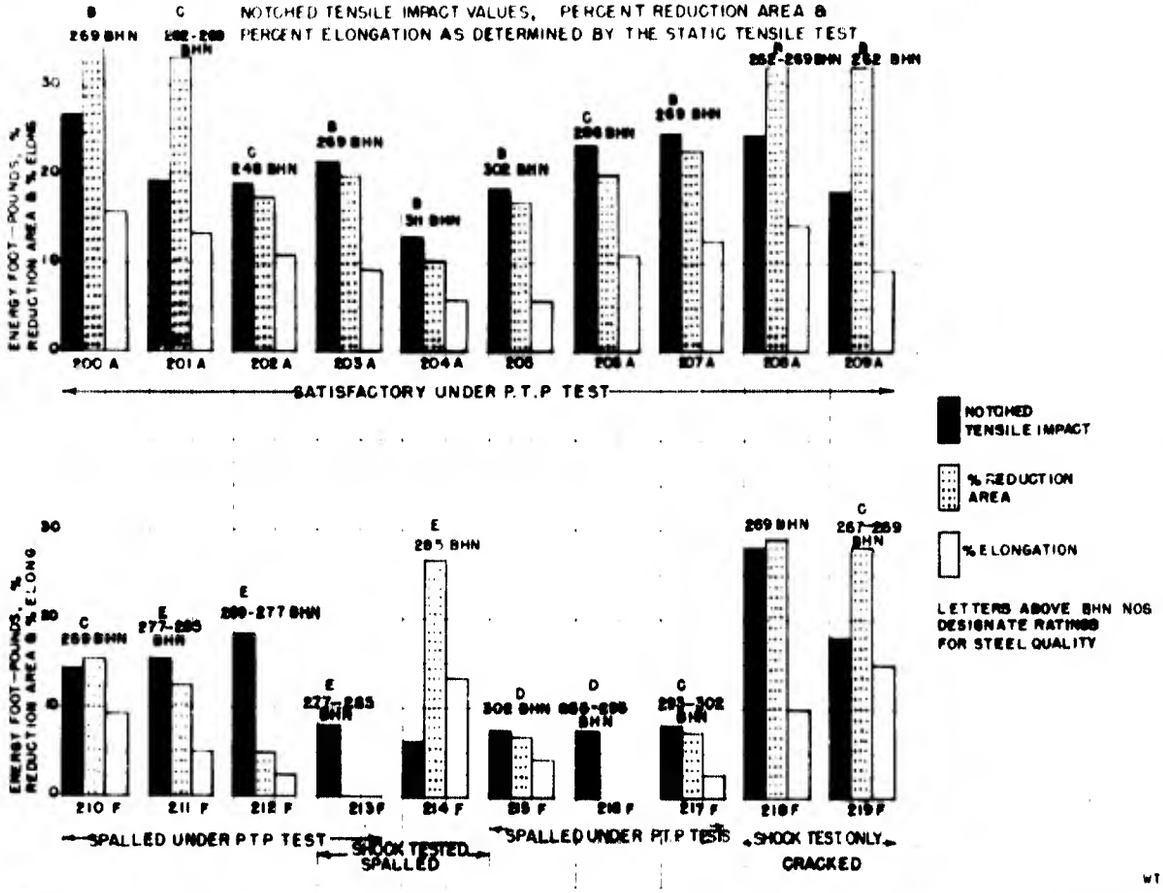
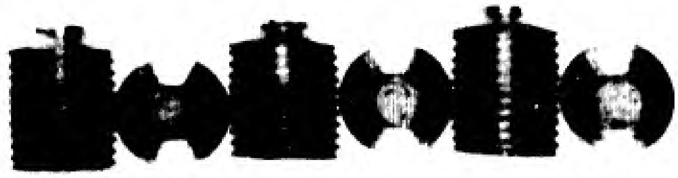


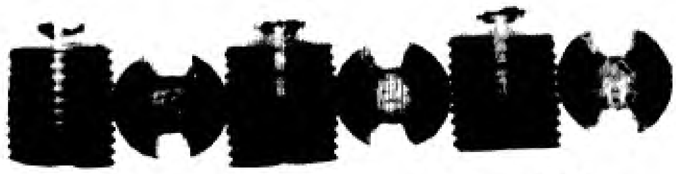
FIG 1

WTN.639-6182



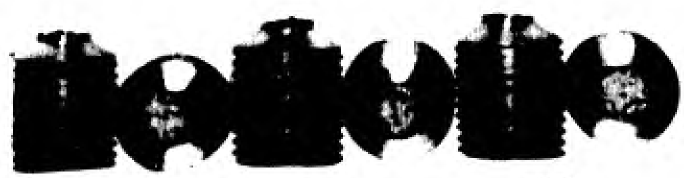
[illegible]A1 — [illegible] FT/LBS · [illegible]A2 — [illegible].7 FT/LBS · [illegible]A3 — [illegible] FT/LBS

SATISFACTORY PTP TEST



207A1 — 14.3 FT/LBS · 207A2 — 19.7 FT/LBS · 207A3 — 25.5 FT/LBS

SATISFACTORY PTP TEST



210F1 — 11.8 FT/LBS · 210F2 — 15.9 FT/LBS · 210F3 — 15.5 FT/LBS

FAILED PTP TEST

213F1 — 7.0 FT/LBS · 213F2 — 8.0 FT/LBS · 213F3 — 9.1 FT/LBS

FAILED PTP TEST

1 2 3

ORDNANCE DEPT U.S.A.
WATERTOWN ARSENAL

PHOTOGRAPH OF BROKEN NOTCHED TENSION CHARPY BARS TAKEN ACROSS GAGE OF SATISFACTORY AND POOR QUALITY 1½" ROLLED HOMOGENEOUS ARMOR PLATE.
25 AUGUST 1943 — MAG. X 1 — WTN. 710-1141

FIG. 2

ENCLOSURE A

Word Description of Fracture Standards

A Fracture - Acceptable

1. Devoid of visible laminations.

B Fracture - acceptable

1. Small laminations present but well distributed and not concentrated in any one plane.
2. No lamination exceeding 1/2 T in length.

C Fracture - Borderline Acceptable

1. No continuous lamination in any one plane.
2. No single lamination exceeding 2 T in length.
3. No single lamination exceeding 1½ T in length in conjunction with another disconnected lamination in the same plane.
4. No laminations in any one plane the sum of whose lengths exceeds 75% of the length of the fracture.

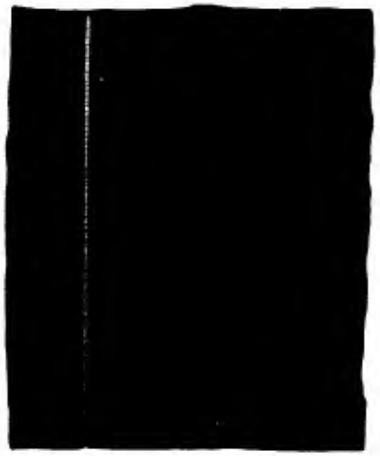
D Fracture - Borderline Rejectable

1. Continuous laminations in one to three planes.
2. Laminations in any one plane whose combined lengths exceed 75% of the length of the fracture.
3. Lamination in any one plane whose length exceeds 2 T.
4. Lamination in any one plane whose length exceeds 1-1/2 T in conjunction with another disconnected lamination in the same plane.

E Fracture - Rejectable

1. Continuous or essentially continuous (over 75% of length of fracture) laminations in more than three planes.

T = Thickness



B FRACTURE – ACCEPTABLE

D FRACTURE – REJECTABLE

WTN.710-2098

ENCLOSURE A FIG. 2

APPENDIX A

BASIC CORRESPONDENCE

COPY

WA-470.5/6058
EPG-470.5/6957 1st Ind. ABRAM/vmr

Erie Proving Ground, LaCarne, Ohio. 1 March 1943. To: War Department Watertown Arsenal, Watertown, Mass.

1. The twenty (20) samples requested in paragraph 1 of basic letter were shipped to your station from Erie Proving Ground, 26 February 1943.

2. Attached sheet of data lists the information requested in paragraph 3 of basic letter.

For the Commanding Officer:

(S/T) LEVI C. EDDY
Lt.Col., Ord. Dept.
Assistant

Incls. - 1
List of Samples of Good and Poor Ballistic 1-1/2" Rolled Homogeneous Armor Plate

COPY

COPY

ELR/amv

WAR DEPARTMENT

WATERTOWN ARSENAL

WATERTOWN 72, MASS. December 30, 1942

Attention of
Laboratory(NAA)

Subject: Samples of Good and Poor Ballistic Rolled Homogeneous Armor Plate

To: The Commanding Officer
Erie Proving Ground
Ingarne, Ohio

1. It is requested that ten (10) samples each of good and poor ballistic rolled homogeneous production armor plate measuring approximately 6"x12"x1½" be sent this arsenal for experimental purposes by freight collect.

2. It is suggested that these samples be flame cut from the test plates and accumulated at his station and when the sufficient number of test pieces are obtained the shipment be made. It is particularly desired that samples be submitted which have failed the PTP test because of back spalling.

3. Please identify the plates and in the letter of transmittal indicate whether the plate passed or failed and the type of failure involved.

For the Commanding Officer:

H. H. ZORNIG
Colonel, Ordnance Dept.
Director of Laboratory

COPY

SUBJECT: SAMPLES OF GOOD AND POOR BALLISTIC 1-1/2" ROLLED HOMOGENEOUS ARMOR PLATE FOR H. H. ZORNIG

E.P.G. NO.	HEAT TREATER ACCEPTED PLATES	PLATE NO.
200-A	Carnegie, Farrell	3037B-4-60
201-A	Standard, Coraopolis	J608-1T1
202-A	Republic	PE-420-1
203-A	Republic	RH-678-9
204-A	Carnegie, Gary	GAP-199
205-A	Carnegie, Gary	GAP-198
206-A	Republic	RE-429-9
207-A	Republic	RH-686-9
208-A	Standard, Coraopolis	J-606-1T1
209-A	Standard, Coraopolis	J-608-1T1

REJECTED PLATES

			TYPE OF FAILURE
210-F	Republic	RC-011-9-2	PTP
211-F	Standard, Coraopolis	G-1064-1B1	PTP
212-F	Standard, Coraopolis	G-1064-1M1	PTP
213-F	Standard, Coraopolis	G-684-1B2	PTP, Shock, BL
214-F	Standard, Coraopolis	G-788-1M3	75mm. Shock-Cracking-BS
215-F	Carnegie, Gary	GAP-109-R	PTP
216-F	Carnegie, Gary	GAP-240	PTP
217-F	Carnegie, Gary	GAP-110-R	PTP
218-F	Carnegie, Farrell	3015-R-10-60	75mm. Shock Cracking
219-F	Standard, Coraopolis	G-1067-1B1	75mm. Shock Cracking

APPENDIX B

Data

TABLE A - Appendix B

Physical Properties across Gauge

Notched Tensile Impact Tests

Plate No.	Thick-ness	Manu-facturer	Chemical Composition C	Mn.	Si	Cr	Ni	Mo	Zr	Brinell Hardness	Notched Impact R. Foot Po (1)	(2)
200A 3037B-4-60	1.51"	Carnegie Farrell	.27	1.33	.21	.80	.90	.17	-	269	25.8	24.7
201A J606-1M1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	262-269	19.1	18.1
202A RH420-1	1.50"	Republic	.265	.93	.32	.79	.95	.39	-	248	18.1	18.1
203A RH678-9	1.51"	Republic	.264	1.17	.29	.68	.92	.35	-	269	19.4	23.3
204A GAP-199	1.53"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	311	14.0	12.7
205A GAP-198	1.54"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	302	21.5	23.2
206A RH429-9	1.51"	Republic	.284	.85	.27	.96	.98	.45	-	269	24.6	25.3
207A RH686-9	1.50"	Republic	.286	1.24	.31	.73	.89	.34	-	269	24.3	19.7
208A J606-1T1	1.49"	J&L SSS	.27	1.62	.21	-	-	.20	-	262-269	26.2	23.6
209A J606-1T1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	262-269	14.8	23.6
210F RC-011-9-2	1.49"	Republic	.28	1.10	.22	.73	.75	.22	-	259	11.8	15.9
211F G-1064-1B1	1.49"	Great Lakes SSS	.29	.92	.81	.54	--	.30	.09	277-285	25.0	13.0
212F G-1064-1M1	1.49"	Great Lakes SSS	.29	.92	.81	.54	-	.30	.09	269-277	26.0	7.4
213F G-684-1B2	1.49"	Great Lakes SSS	.28	1.00	.68	.57	-	.17	.08	277-285	7.0	8.0

293-302 [illegible] Long 137,200 135,100 20.0 59.6 (+2)

L. A - Appendix B

Properties across Gage

Tensile Impact Tests

tion				Notched Tensile Impact Results Foot Pounds				
	Mo	Zr	Brinell Hardness	(1)	(2)	(3)	Ave.	Ballistic Properties
.90	.17	-	265	25.8	24.7	29.8	26.8	Satisfactory - PTP
-	.30	-	262-269	19.1	18.1	20.0	19.1	Satisfactory - PTP
.95	.39	-	248	18.1	18.1	20.5	18.9	Satisfactory - PTP
92	.35	-	269	19.4	23.3	21.1	21.3	Satisfactory - PTP
01	.44	-	311	14.0	12.7	11.9	12.9	Satisfactory - PTP
01	.44	-	302	21.5	23.2	12.0	18.9	Satisfactory - PTP
98	.45	-	269	24.6	25.3	19.4	23.1	Satisfactory - PTP
89	.34	-	269	24.3	19.7	29.5	24.5	Satisfactory - PTP
-	.20	-	262-269	26.2	23.6	23.0	24.3	Satisfactory - PTP
-	.30	-	262-269	14.8	23.6	15.5	18.0	Satisfactory - PTP
75	.22	-	259	11.8	15.9	15.5	14.4	Failed - PTP - B.S.
-	.30	.09	277-285	25.0	13.0	7.5	15.2	Failed - PTP - B.S.
-	.30	.09	269-277	28.0	7.4	19.4	18.3	Failed - PTP - B.S.
-	.17	.08	277-285	7.0	8.0	9.1	8.0	Failed - PTP - All B Failed Shock - B.S.

1

2

TABLE A - Appendix B (Cont'd)

Plate No.	Thickness	Manufacturer	Chemical Composition							Brinell Hardness	Notched Tensile Impact Results Foot Pounds		
			C	Mn	Si	Cr	Ni	Mo	Zr		(1)	(2)	(3)
214F G788-1M3	1.49"	Great Lakes SSS	.29	.86	.85	.62	-	.16	.09	285	5.8	7.2	5.3
215F GAP-109R	1.52"	Carnegie Gary	.25	1.05	.26	.60	1.02	.37	-	302	7.7	7.7	7.2
216F GAP-240	1.48"	Carnegie Gary	.26	.95	.25	.44	1.02	.39	-	285-293	7.2	7.0	8.3
217F GAP-110R	1.52"	Carnegie Gary	.25	1.05	.26	.60	1.02	.37	-	293-302	8.6	7.4	8.1
219F G-1067-1F1	1.49"	Great Lakes SSS	.29	.94	.81	.61	-	.23	.07	262-269	20.8	20.1	13.2
218F 3015-B-1C-6C	1.5"	Carnegie Farrell	.245	.92	.25	.87	.93	.19	-	269	34.5	25.8	23.6

TABLE A - Appendix B (Cont'd)

Composition Cr	Ni	Mo	Zr	Brinell Hardness	Notched Tensile Impact Results Foot Pounds (1)	(2)	(3)	Ave.	Ballistic Properties
.62	-	.16	.09	285	5.8	7.2	5.3	6.1	Failed Shock Only - B.S. and Cracks
.60	1.02	.37	-	302	7.7	7.7	7.2	7.5	Failed - PTP - B.S.
.44	1.02	.39	-	285-293	7.2	7.0	8.3	7.5	Failed - PTP - B.S.
.60	1.02	.37	-	293-302	8.6	7.4	8.1	8.0	Failed - PTP - B.S.
.61	-	.23	.07	262-269	20.8	20.1	13.2	18.0	Satisfactory - PTP - Failed Shock - Cracks
.87	.93	.19	-	269	34.5	25.8	23.6	28.0	Failed Shock - Cracks

TABLE B - APPENDIX B

Physical Properties - Longitudinal and Transverse Directions

Notched Tensile Impact Tests

Plate No.	Thick-ness	Manu-facturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	Brinell Hardness	Notched Tensile Im Foot Pou Longitudinal			Ave.	
200A 3037B-4-60	1.51"	Carnegie Farrell	.27	1.33	.21	.80	.90	.17	-	269	53.5	54.6	57.1	55.1	4
201A J608-1M1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	262-269	53.7	51.0	51.3	52.0	4
202A RH420-1	1.50"	Republic	.265	.93	.32	.79	.95	.39	-	248	60.8	60.0	-	60.4	1
203A RH678-1	1.51"	Republic	.264	1.17	.29	.68	.92	.35	-	269	55.1	56.4	56.9	56.1	4
204A GAP-199	1.53"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	311	54.6	49.8	49.8	51.4	1
205A GAP-198	1.54"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	302	55.1	56.4	56.2	55.9	4
206A RH429-9	1.51"	Republic	.284	.85	.27	.96	.98	.45	-	269	57.6	61.3	58.2	59.0	4
207A RH686-9	1.50"	Republic	.286	1.24	.31	.73	.89	.34	-	269	58.2	58.2	57.5	58.0	4
208A J-606-1T1	1.49"	J&L SSS	.27	1.62	.21	-	-	.20	-	262-269	52.8	45.8	52.8	49.8	5
209A J-608-1T1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	262-269	53.5	52.1	52.9	52.8	5
210F RC-011-9-2	1.49"	Republic	.28	1.10	.22	.73	.75	.22	-	259	47.0	47.5	41.7	44.1	4
211F G-1064-1B1	1.49"	Great Lakes SSS	.29	.92	.81	.54	-	.30	.09	277-285	52.2	51.0	58.2	53.8	3

TABLE B - APPENDIX B

s - Longitudinal and Transverse Directions

tched Tensile Impact Tests

ition			Brinell	Notched Tensile Impact Results Foot Pounds							
i	Mo	Zr	Hardness	Longitudinal			Ave.	Transverse			Ave.	Ballistic Properties
30	.17	-	269	53.5	54.6	57.1	55.1	45.8	46.0	47.2	46.3	Satisfactory - PTP
-	.30	-	262-269	53.7	51.0	51.3	52.0	44.1	48.4	35.8	42.8	Satisfactory - PTP
95	.39	-	248	60.8	60.0	-	60.4	45.3	43.2	44.6	44.4	Satisfactory - PTP
92	.35	-	269	55.1	56.4	56.9	56.1	41.5	40.7	-	41.1	Satisfactory - PTP
01	.44	-	311	54.6	49.8	49.8	51.4	42.9	41.0	45.3	43.1	Satisfactory - PTP
01	.44	-	302	55.1	56.4	56.2	55.9	43.2	45.8	42.4	43.8	Satisfactory - PTP
98	.45	-	269	57.6	61.3	58.2	59.0	45.8	42.4	44.9	44.4	Satisfactory - PTP
89	.34	-	269	58.2	58.2	57.5	58.0	47.5	41.5	50.1	44.8	Satisfactory - PTP
-	.20	-	262-269	52.8	45.8	52.8	49.8	50.7	50.7	49.2	50.2	Satisfactory - PTP
-	.30	-	262-269	53.5	52.1	52.9	52.8	50.7	52.6	53.1	52.1	Satisfactory - PTP
75	.22	-	259	47.0	47.5	41.7	44.1	45.8	44.1	40.2	43.3	Failed - PTP - B.S.
-	.30	.09	277-285	52.2	51.0	58.2	53.8	30.3	32.6	29.5	30.8	Failed - PTP - B.S.

TABLE B - Appendix B (Cont'd)

Plate No.	Thick-ness	Manu-facturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	Brinell Hardness	Notched Tensile Im Foot Pound Longitudinal			Ave.	
212F G-1064-1M1	1.49"	Great Lakes SSS	.29	.92	.81	.54	-	.30	.09	269-277	61.9	60.0	57.1	60.0	3
213F G-684-1B2	1.49"	Great Lakes SSS	.28	1.00	.68	.57	-	.17	.08	277-285	51.3	51.5	53.1	52.0	23
214F G-788-1M3	1.49"	Great Lakes SSS	.29	.86	.85	.62	-	.16	.09	285	49.2	43.4	46.3	30.0	30
215F GAP-109R	1.52"	Carnegie Gary	.25	1.05	.26	.60	1.02	.37	-	302	40.7	42.4	44.1	42.4	37
216F GAP-240	1.48"	Carnegie Gary	.26	.95	.25	.44	1.02	.39	-	285-293	45.8	44.9	44.6	45.8	41
217F GAP-110R	1.52"	Carnegie Gary	.25	1.05	.26	.60	1.02	.37	-	293-302	47.5	45.8	43.1	45.5	41
218F 3015-B-10-60	1.50"	Carnegie Gary	.245	.92	.25	.87	.93	.19	-	269	39.4	40.4	45.8	41.9	42
219F G-1087-1B1	1.49"	Great Lakes SSS	.29	.94	.81	.61	-	.23	.07	262-269	63.7	55.2	58.0	59.0	39

3 - Appendix B (Cont'd)

	Zr	Brinell Hardness	Notched Tensile Impact Results Foot Pounds Longitudinal	Ave.	Transverse	Ave.	Ballistic Properties
6	.09	269-277	61.9 60.0 57.1	60.0	34.4 43.2 39.7	39.1	Failed - PTP - B.S.
7	.08	277-285	51.3 51.5 53.1	52.0	23.6 29.5 33.9	29.0	Failed - PTP - Also Failed Shock - B.S.
6	.09	285	49.2 43.4 46.3	30.0	30.0 35.8 28.8	31.5	Failed Shock Only - B.S. and Cracks
7	-	302	40.7 42.4 44.1	42.4	37.7 39.7	38.7	Failed - PTP - B.S.
6	-	285-293	45.8 44.9 44.6	45.8	41.0 44.2 40.0	41.7	Failed - PTP - B.S.
7	-	293-302	47.5 45.8 43.1	45.5	41.0 42.3 41.6	41.6	Failed - PTP - B.S.
9	-	269	39.4 40.4 45.8	41.9	42.2 35.8 37.1	38.4	Failed Shock - Cracks
3	.07	262-269	63.7 55.2 58.0	59.0	39.1 39.4 39.1	39.2	Satisfactory - PTP - Failed Shock - Cracks

TABLE C - APPENDIX B

Physical Properties across Gauge

Static Tensile Tests

Plate No.	Thick-ness	Manu-facturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	Brinell Hardness	Static Tensile Test Results Unnotched .113" Diameter Y.S.P. Lbs./Sq.In. .1% Set	T.S. Lbs./Sq.In.	% Elo
200A 3037B-4-60	1.51"	Carnegie Farrel	.27	1.33	.21	.80	.90	.17	-	269	101,400	121,200	15
											104,300	123,000	17
											103,900	123,000	1
										Av.	103,200	122,400	15
201A J608-1M1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	222-269	100,000	117,700	1
											100,500	117,300	1
											102,500	116,700	10
										Av.	101,000	117,200	13
202A RH420-1	1.50"	Republic	.265	.93	.32	.79	.95	.39	-	248	90,000	113,000	13
											90,680	112,750	12
											90,500	114,000	12
										Av.	90,400	113,300	10
203A RH678-9	1.51"	Republic	.264	1.17	.29	.68	.92	.35	-	269	97,050	116,150	7
											97,050	116,150	10
											96,070	116,150	10
										Av.	96,700	116,150	9
204A GAP-199	1.53"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	311	124,500	139,700	7
											126,500	142,000	5
											123,500	139,500	5
										Av.	124,800	140,400	5
205A GAP-198	1.54"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	302	124,000	141,000	5
											122,000	141,000	5
											123,000	143,000	7
										Av.	123,000	141,300	5

TABLE C - APPENDIX B

Mechanical Properties across Gauge

Results of Static Tensile Tests

Static Tensile Test Results
Unnotched .113" Diameter Bar

Cr	Brinell Hardness	Y.S.P. Lbs./Sq.In. .1% Set	T.S. Lbs./Sq.In.	% Elong.	% R.A.	Ballistic Properties
-	269	101,400	121,200	15.0	33.6	Satisfactory - PTP
		104,300	123,000	17.5	42.3	
		103,900	123,000	15.0	26.0	
		Av. 103,200	122,400	15.8	34.0	
-	222-269	100,000	117,700	15.0	32.4	Satisfactory - PTP
		100,500	117,300	15.0	42.3	
		102,500	116,700	10.0	24.5	
		Av. 101,000	117,200	13.3	33.1	
-	248	90,000	113,000	10.0	16.7	Satisfactory - PTP
		90,680	112,750	12.5	18.6	
		90,500	114,000	10.0	16.7	
		Av. 90,400	113,300	10.8	17.3	
-	269	97,050	116,150	7.5	18.6	Satisfactory - PTP
		97,050	116,150	10.0	22.5	
		96,070	116,150	10.0	17.6	
		Av. 96,700	116,150	9.2	19.6	
-	311	124,500	139,700	7.5	8.8	Satisfactory - PTP
		126,500	142,000	5.0	13.4	
		123,500	139,500	5.0	8.4	
		Av. 124,800	140,400	5.8	10.2	
-	302	124,000	141,000	5.0	11.7	Satisfactory - PTP
		122,000	141,000	5.0	21.5	
		123,000	143,000	7.5	16.7	
		Av. 123,000	141,300	5.8	16.6	

TABLE C - APPENDIX B (Cont'd)

Plate No.	Thick-ness	Manu-facturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	Brinell Hardness	Static Tensile Test Results Unnotched .113" Diameter Y.S. Lbs./Sq.In. .1% Set	T.S. Lbs./Sq.In.	El
206A R2429-9	1.51"	Republic	.284	.8[illegible]	.27	.96	.93	.[illegible]	-	269	97,000	121,000	[illegible]
											103,000	121,000	12
											101,000	117,000	10
										Av.	100,[illegible]	120,300	[illegible]
207A R1686-9	1.50"	Republic	.28[illegible]	1.24	.31	.73	.89	.34	-	269	99,000	120,000	12
											100,000	123,000	12
											99,200	120,000	12
										Av.	99,800	121,000	12
208A J606-1T1	1.49"	J&L SSS	.27	1.62	.21	-	-	.20	-	262-269	95,000	114,000	[illegible]
											97,500	113,700	13
											97,500	114,700	15
										Av.	97,700	114,100	13
209A J606-1T1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	262-269	101,500	117,000	12
											101,900	117,600	5
											101,800	117,600	10
										Av.	101,800	117,400	9
210F RC-011-9-2	1.49"	Republic	.28	1.10	.22	.73	.75	.22	-	269	97,600	113,700	7
											96,600	114,700	10
											96,100	111,700	10
										Av.	96,800	113,400	9
211F G-1064-1B1	1.49"	Great Lakes SSS	.29	.92	.81	.54	-	.30	.09	277-285	96,100	96,100	2
											66,600	66,600	2
											102,500	120,600	10
										Av.	88,400	94,400	5

APPENDIX F (Cont'd)

Static Tensile Test Results
[illegible] .113" Diameter Bar

Projectile Number	Y.S. Lbs./Sq.In. (.2%)	T.S. Lbs./Sq.In.	% Elong.	% R.A.	Ballistic Proportion
[illegible]	[illegible]	121,000	[illegible]	19.1	
[illegible]	103,000	122,000	12.5	21.9	Satisfactory - PTP
	[illegible]	119,000	10.0	19.1	
	Av. [illegible]	[illegible]	[illegible]	19.9	
	[illegible]	120,000	12.5	24.6	
284	[illegible]	123,0[illegible]	12.5	19.9	Satisfactory - PTP
	[illegible]	120,000	12.5	23.0	
	Av. 99,800	121,000	12.5	22.5	
	[illegible]	114,0[illegible]	12.5	30.6	
	97,500	113,700	15.0	31.9	
262-269	97,200	114,700	15.0	33.4	Satisfactory - PTP
	Av. 97,[illegible]	114,100	14.2	32.0	
	101,[illegible]	117,000	12.5	30.6	
	101,900	117,600	15.0	33.4	
262-269	101,[illegible]	117,600	15.0	32.1	Satisfactory - PTP
	Av. 101,[illegible]	117,400	14.2	32.0	
	97,600	113,700	7.5	14.7	
	96,600	114,700	10.0	14.7	
289	96,100	111,700	10.0	16.5	Failed - PTP BS
	Av. 96,800	113,400	9.2	15.3	
	96,100	96,100	2.5	9.8	
	66,600	66,600	2.5	4.9	
277-285	102,500	120,600	10.0	21.6	Failed - PTP BS
	Av. 88,400	94,400	5.0	12.1	

2

TABLE 3 - APPENDIX B (Cont'd)

Plate No.	Thickness	Manufacturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	Brinell Hardness		Static Tensile Test Unnotched .113" Diam. Y.S.P. Lbs./Sq.In. .1% Set	T.S. Lbs./Sq.In.	% Elon.
212F G-1064-1M1	1.49"	Great Lakes SSS	.29	.92	.81	.54	-	.30	.09	269-277		74,500	74,500	0
												84,300	84,300	0
												82,800	84,300	2.5
											Av.	80,500	81,000	2.5
213F G-664-182	1.49"	Great Lakes SSS	.28	1.00	.60	.57	-	.17	.08	277-285		98,000	98,000	0
												41,200	41,200	0
												62,700	62,700	0
											Av.	67,300	67,300	0
214F G-788-1M3	1.49"	Great Lakes SSS	.29	.86	.85	.62	-	.16	.09	285		114,000	134,000	15.0
												114,500	132,000	12.5
												114,000	133,000	12.5
											Av.	114,200	133,000	13.
215F GAP-109R	1.52"	Carnegie Gary	.25	1.05	.26	.60	1.02	.39	-	302		119,500	127,000	5.
												118,600	127,500	5.0
												117,600	125,000	2.
											Av.	118,600	126,500	4.
217F GAP-110R	1.52"	Carnegie Gary	.25	1.05	.26	.60	1.02	.37	-	293-302		123,000	128,400	2.
												125,500	132,000	2.
												122,500	129,400	2.
											Av.	123,700	129,900	2.
218F 3015-B-10-60	1.50"	Carnegie Farrel	.245	.92	.25	.87	.93	.19	-	269		106,000	124,000	10.0
												103,300	123,500	10.0
												100,000	122,000	10.0
											Av.	103,100	123,200	10.0
219F G-1067-1B1	1.49"	Great Lakes SSS	.29	.94	.81	.61	-	.23	.07	262-269		87,200	118,600	15.0
												88,200	113,700	15.0
												83,500	109,000	15.0
											Av.	86,300	113,800	15.0

APPENDIX F (Cont'd)

Static Tensile Test Results
Unnotched .113" Diameter Bar

Heat Treatment	Y.S.P. Lbs./Sq.In. .1% Set	T.S. Lbs./Sq.In.	% Elong.	% R.A.	Ballistic Properties
	74,500	74,500	0	0	
-277	84,300	84,300	0	0	Failed - PTP
	82,800	84,300	2.5	4.9	BS
Av.	80,500	81,000	2.5	4.9	
	98,000	98,000	0	0	
-285	41,200	41,200	0	0	Failed - PTP
	62,700	62,700	0	0	Also Failed Shock
Av.	67,300	67,300	0	0	BS
	114,000	134,000	15.0	35.0	
	114,500	132,000	12.5	21.5	Failed Shock Only -
	114,000	133,000	12.5	23.0	BS and Cracks
Av.	114,200	133,000	13.3	26.5	
	119,500	127,000	5.0	6.7	
	118,600	127,500	5.0	6.9	Failed - PTP
	117,600	125,000	2.5	4.9	BS
Av.	118,500	126,500	4.2	6.2	
	123,000	128,400	2.5	6.9	
-302	125,500	132,000	2.5	7.7	Failed - PTP
	122,500	129,400	2.5	6.9	BS
Av.	123,700	129,900	2.5	7.2	
	106,000	124,000	10.0	35.0	
	103,300	123,500	10.0	30.4	Failed - Shock
	100,000	122,000	10.0	21.5	Cracks
Av.	103,100	123,200	10.0	29.0	
	87,200	118,600	15.0	26.1	
-269	88,200	113,700	15.0	26.1	Satisfactory - PTP
	83,500	109,000	15.0	33.1	Failed - Shock
Av.	86,300	113,800	15.0	28.4	Cracks

TABLE I - APPENDIX B

Mechanical Properties - Longitudinal and Transverse Directions

Static Tensile Test

Plate No.	Thickness	Manufacturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	B.H.	Static Tensile Res. Unnotched .113" Dia. Y.S.P. Lbs./Sq.In. .1% Set Long.	Trans.	T.S. Lbs./Sq.In. Long.	Trans.
201A 3037-4-10	1.51"	Carnegie Farrell	.21	1.48	.21	.80	.30	.17	-	269	108,800	101,800	130,000	130,700
											110,000	104,900	132,000	131,000
											108,800	102,900	131,200	130,000
										Av.	109,200	103,200	131,100	130,600
201A 3003-1A1	1.48"	J&L SSS	.28	1.71	.22	-	-	.30	-	262	111,900	102,000	127,000	123,400
										269	111,900	108,200	126,300	125,300
											111,900	105,000	127,000	125,500
										Av.	111,900	105,100	126,800	125,100
203A RB678-9	1.51"	Republic	.284	1.17	.29	.68	.32	.39	-	248	102,600	102,000	127,000	126,000
											101,200	102,600	126,500	126,400
											102,000	102,000	126,000	125,400
										Av.	101,900	102,200	126,500	125,600
204A GaP-199	1.53"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	311	135,000	133,500	154,100	154,100
											131,500	134,000	152,000	152,500
											131,500	134,000	152,000	153,000
										Av.	132,700	133,800	152,700	153,200
205A GaP-198	1.54"	Carnegie Gary	.30	1.25	.22	.85	1.01	.44	-	302	115,700	126,200	149,000	149,000
											120,800	127,800	147,000	149,000
											131,700	128,300	150,700	149,700
										Av.	122,700	127,400	148,900	149,200
206A RB429-9	1.51"	Republic	.284	.85	.27	.96	.98	.45	-	269	108,100	107,800	128,900	129,200
											102,900	107,800	124,900	129,200
											108,300	109,900	129,900	129,200
										Av.	106,400	108,500	127,900	129,200

Static Tensile Results
[illegible] .113" I.D. Bar

Y.S.I. Lbs./Sq.In. .1% Set		T.S. Lbs./Sq.In.		% Elong.		% R.A.		Ballistic Properties
Long.	Trans.	Long.	Trans.	Long.	Trans.	Long.	Trans.	
108,800	101,500	130,000	130,000	20.0	20.0	70.5	52.2	
111,000	104,900	132,000	131,000	20.0	20.0	71.0	53.2	Satisfactory
110,800	102,900	131,200	130,600	20.0	20.0	71.0	53.2	PTP
Av. 110,200	103,300	131,100	130,600	20.0	20.0	70.8	52.9	
111,900	102,000	127,000	123,400	22.5	20.0	69.0	62.0	
111,300	103,200	126,300	125,300	22.5	20.0	67.0	66.0	Satisfactory
111,300	105,000	127,000	125,900	22.5	20.0	69.0	66.0	PTP
Av. 111,500	105,100	126,800	125,100	22.5	20.0	68.3	67.0	
102,500	102,000	127,000	126,000	20.0	22.5	70.2	56.8	
101,200	102,500	126,500	125,400	22.5	22.5	68.2	56.8	Satisfactory
102,000	102,000	126,000	125,400	20.0	22.5	70.2	59.1	PTP
Av. 101,900	102,200	126,500	125,600	24.2	22.5	69.5	57.6	
133,000	133,500	154,100	154,100	20.0	20.0	63.8	59.4	
131,900	134,000	152,000	152,500	20.0	20.0	62.7	56.7	Satisfactory
131,200	134,000	152,000	153,000	20.0	17.5	61.5	52.2	PTP
Av. 132,700	133,800	152,700	153,200	20.0	19.2	62.7	56.1	
115,700	126,200	149,000	149,000	20.0	20.0	65.8	58.2	
120,800	127,800	147,000	149,000	21.3	20.0	68.4	58.2	Satisfactory
131,700	128,300	150,700	149,700	20.0	20.0	63.8	58.2	PTP
Av. 122,700	127,400	148,900	149,200	20.4	20.0	66.0	58.2	
108,100	107,800	128,900	129,200	22.5	22.5	71.0	61.5	
102,900	107,800	124,900	129,200	25.0	22.5	73.0	60.5	Satisfactory
108,300	109,900	129,900	129,200	25.0	22.5	68.9	60.5	PTP
Av. 106,400	108,500	127,900	129,200	24.2	22.5	71.0	60.8	

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TABLE I – APPENDIX B (Cont'd)

Plate No.	Thickness	Manufacturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	BHN	Static Tensile Results Unnotched .113" Dia. Y.S.P. Lbs./Sq.In. .1% Set Long.	Trans.	T.S. Lbs./Sq.In. Long.	Trans.
207A R4686-9	1.50"	Republic	.286	1.24	.31	.73	.8[illegible]	.34	–	269	106,000	104,100	128,400	127,800
											105,800	106,000	127,800	129,000
											104,400	104,100	127,200	127,800
											Av. 105,400	104,700	127,800	128,200
208A J606-1T1	1.48"	J&L SSS	.27	1.62	.21	–	–	.20	–	262	99,300	105,100	124,000	123,400
										269	104,100	105,100	124,000	122,500
											105,100	103,000	123,400	122,500
											Av. 103,000	104,400	123,800	122,800
209A J608-1T1	1.48"	J&L SSS	.28	1.71	.22	–	–	.30	–	262	106,000	102,500	123,000	125,000
										269	106,000	105,500	123,000	125,000
											106,000	105,000	123,000	124,000
											Av. 106,000	104,300	123,000	124,700
210F RC-011-9-2	1.49"	Republic	.28	1.10	.22	.73	.75	.22	–	259	98,500	102,000	124,000	123,000
											102,000	101,500	125,000	123,000
											105,000	102,000	128,000	122,000
											Av. 101,800	101,800	125,700	121,700
212F G-1064-1M1	1.49"	Great Lakes SSS	.29	.92	.81	.54	–	.30	.09	269	102,000	97,500	127,000	125,000
										277	103,000	100,500	125,000	123,000
											102,500	106,000	125,000	127,000
											Av. 102,500	101,300	125,700	125,000
213F G-684-1B2	1.49"	Great Lakes SSS	.28	1.00	.68	.57	–	.17	.08	277	111,000	102,000	132,000	128,000
										285	108,000	104,000	132,000	134,000
											104,000	102,500	129,900	129,200
											Av. 107,700	102,800	131,300	130,400
214F 0788-1M3	1.49"	Great Lakes SSS	.29	.86	.85	.62	–	.16	.09	285	116,000	120,000	140,200	140,800
											118,000	122,500	140,400	140,600
											116,000	122,000	140,800	138,800
											Av. 116,700	121,500	140,500	140,100

APPENDIX B (Cont'd)

Static Tensile Results
Unnotched .113" Dia. Bar

	Y.S.P. Lbs./Sq.In. .1% Set		T.S. Lbs./Sq.In.		% Elong.		% R.A.		Ballistic Properties
	Long.	Trans.	Long.	Trans.	Long.	Trans.	Long.	Trans.	
	106,000	104,100	128,400	127,800	25.0	20.0	68.0	56.7	
	105,800	105,000	127,800	129,000	25.0	20.0	64.8	56.7	Satisfactory
	104,400	104,100	127,200	127,800	22.5	20.0	67.8	56.7	PTP
Av.	105,400	104,700	127,800	128,200	24.2	20.0	66.9	56.7	
	95,300	105,100	124,000	123,400	22.5	20.0	61.3	60.2	
	104,100	105,100	124,000	122,500	20.0	20.0	61.3	61.3	Satisfactory
	105,100	103,000	123,400	122,500	22.5	20.0	64.6	61.3	PTP
Av.	103,000	104,400	123,800	122,800	21.7	20.0	62.4	60.9	
	106,000	102,500	123,000	125,000	22.5	20.0	63.7	61.5	
	106,000	103,500	123,000	125,000	22.5	20.0	63.7	60.4	Satisfactory
	106,000	105,000	123,000	124,000	22.5	20.0	63.7	60.4	PTP
Av.	106,000	104,300	123,000	124,700	22.5	20.0	63.7	60.8	
	98,500	102,000	124,000	123,000	22.5	22.5	63.7	61.5	
	102,000	101,500	125,000	123,000	20.0	22.5	61.5	61.5	Failed - PTP
	105,000	102,000	128,000	122,000	20.0	22.5	61.5	61.5	BS
Av.	101,800	101,800	125,700	121,700	20.8	22.5	62.2	61.5	
	102,000	97,500	127,000	125,000	20.0	20.0	62.6	58.1	
	103,000	100,500	125,000	123,000	22.5	20.0	64.7	59.3	Failed - PTP
	102,500	106,000	125,000	127,000	20.0	20.0	62.6	55.8	BS
Av.	102,500	101,300	125,700	125,000	20.8	20.0	63.3	57.7	
	111,000	102,000	132,000	128,000	22.5	17.5	62.7	47.2	
	108,000	104,000	132,000	134,000	22.5	15.0	65.8	32.1	Failed - PTP
	104,000	102,500	129,900	129,200	20.0	20.0	61.2	48.5	Also Failed
Av.	107,700	102,800	131,300	130,400	21.7	17.5	63.2	42.6	Shock - BS
	116,000	120,000	140,200	140,800	20.0	17.5	52.1	47.2	
	118,000	122,500	140,400	140,600	20.0	20.0	60.4	50.0	Failed - PTP
	116,000	122,000	140,800	138,800	21.3	17.5	50.0	45.9	BS
Av.	116,700	121,500	140,500	140,100	20.4	18.3	50.8	47.7	

Table I APPENDIX B (Cont'd)

Plate No.	Thick-ness	Manu-facturer	Chemical Composition C	Mn	Si	Cr	Ni	Mo	Zr	B:N		Static Tensile Results Unnotched .113" Dia. Y.S.P. Lbs./Sq.In. .1% Set Long.	Y.S.P. Trans.	T.S. Lbs./Sq.In. Long.	T.S. Trans.	Lo
216F GaP-104R	1.52"	Carnegie Gary	.2[illegible]	1.0[illegible]	.20	.60	1.02	.37	-	302		126,000	127,000	143,300	141,500	20.
												124,000	125,000	135,400	140,800	20.
												120,500	125,000	138,600	140,400	20.
											av.	123,500	125,700	140,100	140,900	20.
216F GaP-240	1.48"	Carnegie Gary	.26	.[illegible]	.25	.44	1.02	.39	-	285 293		121,500	124,500	139,200	138,400	20.
												121,100	122,800	139,500	138,000	20.
												120,200	121,000	136,800	136,600	20.
											av.	120,900	122,800	138,500	137,700	20.
217F GaP-110R	1.52"	Carnegie Gary	.25	1.05	.20	.60	1.02	.37	-	293 302		129,000	113,500	145,400	144,200	20.
												127,500	118,500	144,800	142,400	20.
												125,000	128,500	145,000	144,800	20.
											av.	127,200	120,200	145,100	143,800	20.
218F 30[illegible]-R-10-60	1.50"	Carnegie Farrel	.245	.92	.25	.87	.93	.19	-	263		114,000	116,500	133,200	131,400	20.
												112,500	112,000	129,200	133,400	17.
												113,000	115,000	131,000	133,800	17.
											av.	113,200	114,500	131,100	132,900	18.
219F G-1087-1F1	1.49"	Great Lakes SSS	.29	.94	.81	.61	-	.23	.07	262 269		92,000	96,500	118,000	117,800	27.
												92,500	94,500	117,200	118,400	25.
												93,000	94,500	115,000	118,400	25.
											av.	92,500	95,200	116,700	118,300	25.

Static Tensile Results
Quenched .113" Dia. Bar

	Y.S.I. Lbs./Sq.In. .1% Set		T.S. Lbs./Sq.In.		% elong.		% R.A.		Ballistic Properties
	Long.	Trans.	Long.	Trans.	Long.	Trans.	Long.	Trans.	
	126,000	127,000	143,300	141,500	20.0	20.0	61.1	57.8	
	124,000	125,000	139,400	140,800	20.0	20.0	60.0	59.3	Failed - PTP
	126,500	125,400	138,600	142,400	20.0	20.0	63.7	55.8	BS
av.	125,500	125,700	140,100	140,900	20.0	20.0	61.6	57.6	
	121,500	124,500	139,200	137,400	20.0	20.0	61.6	56.1	
	121,100	122,800	139,500	138,000	20.0	17.5	59.0	57.8	Failed - PTP
	120,900	121,600	136,800	136,600	20.0	20.0	63.3	59.3	BS
av.	120,500	122,800	138,500	137,700	20.0	19.2	61.3	57.7	
	129,000	113,500	145,400	144,200	20.0	17.5	58.1	55.8	
	127,500	118,500	144,800	142,400	20.0	15.0	58.1	56.0	Failed - PTP
	128,000	128,500	145,000	144,800	20.0	17.5	62.6	58.1	BS
av.	127,200	120,200	145,100	143,800	20.0	16.7	59.6	56.6	
	114,000	116,500	133,200	131,400	20.0	17.5	53.5	52.3	
	112,500	112,000	129,200	133,400	17.5	17.5	51.0	52.3	Failed-Shock
	113,000	115,000	131,000	133,800	17.5	17.5	51.0	49.8	Cracks
av.	113,200	114,500	131,100	132,900	18.3	17.5	51.8	51.5	
	92,000	96,500	118,000	117,800	27.5	20.0	66.9	49.8	
	92,500	94,500	117,200	118,400	25.0	22.5	64.8	52.3	Satisfactory PTP
	93,000	94,200	115,000	116,400	25.0	20.0	65.8	51.0	Failed-Shock
av.	92,500	95,200	116,700	118,300	25.8	20.8	65.3	51.0	Cracks