

WAL 710/619

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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 710/619

Resistance of Light Gauge (.041" to .046")

Samples of .070% Carbon Armco Steel to

Perforation by Fragment-Simulating Projectiles

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BY

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DATE 17 May 1944

WATERTOWN ARSENAL
WATERTOWN, MASS.

WATERTOWN ARSENAL LABORATORY

Memorandum Report No. WAL 710/619

Fourth Partial Report on Problem B-8.2

17 May 1944

Resistance of Light Gauge (.041" to .046")

Samples of 0.70% Carbon Armco Steel to

Perforation by Fragment-Simulating Projectiles

1. In accordance with a request from the Office, Chief of Ordnance, a program of development of improved body armor components is in progress at this arsenal. In conjunction with this program tests have recently been conducted on several light-gauge samples of 0.70% carbon Armco steel, submitted by Carnegie-Illinois Steel Corporation.

2. The resistance of a normalized, oil-quenched sample, tempered to 41/42 Rockwell "C" was inferior to that of a normalized, oil-quenched sample tempered to 49/51 Rockwell "C" under impact of standard (steel jacketed) caliber .45 ball ammunition and that of a sample austempered to 53/54 Rockwell "C" was considerably greater than either. Under impact of the caliber .22 fragment-simulating projectile, G-2, however, the hardest plate offered less resistance than either of the softer plates. The fact that a fourth sample which had been austempered to 49/50 Rockwell "C" was out of gauge with the other three samples precluded a precise evaluation of its resistance.

3. Samples of the steel in each heat treated condition were mounted on wooden ballistic frames which allow an 8"x8" area to be unsupported from the rear. Duplicate test samples were impacted with caliber .45 ball projectiles (steel jacketed) and with projectile, G-2, a fragment simulator. The results are tabulated in Table I.

1. O.O. 422.3/71(c), Wtn 470.5/7443(c) dated 28 September 1943.

2. WAL Memorandum Report No. 762/253(c) - "Development of a Projectile, to Be Used in Testing Body Armor, to Simulate Fragments of a 20 mm. H.E. Projectile" - 7 January 1944.

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4. Under impact of standard caliber .45 ball ammunition the resistance to perforation of the sample which had been normalized, oil-quenched and tempered to 42 Rockwell "C" (514 feet-per-second) was inferior to that of the sample which had been similarly normalized and quenched but had been drawn to 51 Rockwell "C" (615 feet-per-second). Both of these samples were considerably inferior to one which had been austempered to 54 Rockwell "C" (827 feet-per-second). Although the resistance of the fourth type which had been austempered to 50 Rockwell "C" was comparable (830 feet-per-second) with that which had been similarly treated to 54 Rockwell "C" some of its resistance must be attributed to its greater gauge. Applying a correction factor which has been found to be applicable to Hadfield manganese steel (10 feet-per-second per .001"), its "in-gauge" resistance would be 800 feet-per-second which is considerably greater than the normalized, quenched and drawn sample of the same hardness. However, all samples were inferior to Hadfield manganese steel which averages 900 feet-per-second resistance in this gauge.

5. Under impact of the light weight (17 grains) fragment-simulating projectile, G-2, the resistance of all samples is fairly comparable (when a correction factor of 15 feet-per-second per .001" has been applied to the over-gauge austempered sample) and considerably inferior (less than 1100 feet-per-second) to that of run-of-the-mill Hadfield steel (1600 feet-per-second).

6. The behavior of the austempered samples under impact of the caliber .45 projectile tended to be brittle. This tendency corroborated previous experience with this alloy which indicated that brittleness is introduced when it is austempered to hardnesses greater than 47/48 Rockwell "C".

7. The low resistance of all samples of this steel to perforation by projectile G-2 discourages farther consideration of 0.70% carbon Anola steel as a substitute for Hadfield manganese steel which continues to appear supreme as a projectile resistor in the thickness range .040" to .050".

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APPROVED:

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Table I

Summary of Ballistic Tests Conducted at Watertown Arsenal
on Light Gauge (.041" to .046") Samples of
0.70% Carbon Armco Steel Submitted by
Carnegie-Illinois Steel Corporation

Nominal Chemical Composition

<u>C</u>	<u>Mn</u>	<u>P</u>	<u>S</u>	<u>Si</u>	<u>Mo</u>
.60/.70	.70/.90	.040 max.	.040 max.	.20/.35	.20/.30

<u>Sample</u>	<u>Gauge</u>	<u>Hardness</u>	<u>Ballistic Limit</u>	
			<u>G-2¹</u>	<u>Cal. .45²</u>
<u>Item 9</u>				
Normalized, oil	.039"	41 Rc	1053	---
quenched and tempered	.039"	42 Rc	--	514
<u>Item 10</u>				
Normalized, oil	.040"	49 Rc	1057	---
quenched and tempered	.039"	51 Rc	--	615
<u>Item 11-A</u>				
Austempered	.044"	50 Rc	--	830
	.046"	49 Rc	1165	---
<u>Item 11-B</u>				
Austempered	.041"	53 Rc	1020	---
	.041"	54 Rc	--	827
<u>For Comparison</u>				
Hadfield	.040"	88 Rb	1600	900
Manganese Steel	.045"	88 Rb	1675	950