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WATERTOWN ARSENAL
WATERTOWN, MASS.

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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 710/633

Effect of Hardness on Resistance of a Thin-Gauge
(.039" to .042") Modified SAE 4340 Steel
to Perforation by Fragment-Simulating Projectiles

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BY

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Arsenal.
Paul O. Mann
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WATERTOWN ARSENAL LABORATORY

Memorandum Report No. WAL 710/633

Seventh Partial Report on Problem B-8.2

17 May 1944

Effect of Hardness on Resistance of a Thin-Gauge

(.039" to .042") Modified SAE 4340 Steel

to Perforation by Fragment-Simulating Projectiles

1. In conjunction with a program of development of improved body armor components which is being conducted at this arsenal in response to a request of the Office, Chief of Ordnance¹, tests have recently been completed on samples of a modified SAE 4340 steel in three conditions of hardness.

2. No substantial difference in the perforation resistance of samples of this steel at 29/31 Rockwell "C" and samples at 52 Rockwell "C" was evident. The plates tended to fail because of directional weaknesses probably due to non-metallic inclusions present in stringer form. The resistance of none of these samples was comparable with that of Hadfield manganese steel of equivalent weight.

3. Samples of each condition of hardness were clamped rigidly to a wooden ballistic frame which allows an 8"x8" area to remain unsupported from the rear and impacts of caliber .45 ball projectiles and three types of fragment-simulating projectiles developed at this arsenal^{2,3} were directed into these areas. The results are summarized in Table I.

1. O.O. 422.3/71(c) - Wtn 470.5/7443(c) dated 28 September 1943.
2. WAL Memorandum Report No. 762/274(c) - "Development of Projectiles to Be Used in Testing Body Armor to Simulate Flak and 20 mm. H.E. Fragment" - 17 December 1943.
3. 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 the caliber .45 ball projectile and of the light-weight fragment simulator, G-2, the resistance of the samples in the intermediate hardness condition (38/40 Rockwell "C") was considerably lower (PTP at 493 feet-per-second and ballistic limit at 1043 feet-per-second, respectively) than that of either of the samples at the extremes in hardness (28/31 Rockwell "C" and 47/52 Rockwell "C") which were comparable with each other (592 feet-per-second and 626/646 feet-per-second and 1104 feet-per-second and 1129 feet-per-second, respectively). All values were substantially lower than those typical of Hadfield manganese steel (900 feet-per-second and 1600 feet-per-second).

5. Under impact of the caliber .30 light-weight fragment simulator, G-1-S, the resistance of samples in the three hardness conditions was substantially identical (820, 817 and 810 feet-per-second) and inferior to that of average Hadfield steel (900 feet-per-second).

6. Under impact of the heavy weight caliber .30 projectile G-1-A the resistance of the softer material (405 feet-per-second) was superior to that of the harder types (342 and 325 feet-per-second) but inferior to that of Hadfield which (on the basis of a limited number of tests) is estimated at about 500 feet-per-second.

7. The general resistance of this steel in any of the hardness conditions represented was so inferior to Hadfield manganese steel as to discourage its further consideration as a prospective body armor component although some of its inferiority may be attributable to directional weaknesses which were doubtless induced by non-metallic inclusions present in stringer form.

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Table I

Summary of Ballistic Tests Conducted at Watertown Arsenal
on Thin-gauge Samples of a Modified SAE 4340 Steel
in Three Conditions of Hardness

Nominal Chemical Composition								
C	Mn	P	S	Si	Ni	Cr	Mo	V
.30/.40	.50/.80	.025 max.	.025 max.	.20/.35	1.50/2.00	.70/.90	.25/.50	.15 min.

Sample	Hardness	Gauge	Ballistic Limit			
			G-1-A ¹	G-1-S ²	G-2 ³	Cal. .45 ⁴
Item 4	28 Rc	.042"	405	---	---	---
Normalized, oil quenched and tempered	29 Rc	.040"	---	820	1104	---
	31 Rc	.041"	---	---	---	592
Item 5	38 Rc	.040"	342	---	---	---
Normalized, oil quenched and tempered	39 Rc	.040"	---	817	1043	---
	40 Rc	.039"	---	---	---	493 (PTP)
Item 6	47 Rc	.039"	325	---	---	626
Normalized, oil quenched and tempered	52 Rc	.039"	---	810	1129	646

For comparison:

Hadfield manganese steel	88 Bb	.040"	---	900	1600	900
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¹Caliber .30 fragment simulating projectile - 150 grains

²Caliber .30 fragment simulating projectile 34 grains

³Caliber .22 fragment simulating projectile - 17 grains

⁴Caliber .45 steel jacketed ball projectile - 230 grains