

X5862

AD-A954278

File Copy

vek

UNANNOUNCED

UNCLASSIFIED

Copy No. 1

ORDTL-AR
FILE COPY

DTIC FILE COPY

~~SECRET~~

Watertown Arsenal

Rolled Armor Report No. 39

November 25, 1941

A Comparison of the Ballistic Efficiency
of Recent Face Hardened
and Homogeneous Armor Plates
(W.A. Report #710/356)

DTIC
ELECTE
FEB 19 1988
S H D

Purpose

The purpose of this investigation was to compare the performance of recently manufactured face hardened plate with the performance of homogeneous plate of corresponding thickness.

Introduction

This report is a survey of the ballistic limits of all the light armor plates, face hardened and homogeneous, whose ballistic properties are given in the Aberdeen reports of ballistic tests made in the period 1938 to March 18, 1940.* No attempt has been made to isolate the effects of depth of case, Brinell hardness, chemical composition, heat treatment or manufacturer's process on the ballistic properties. A similar survey for the period 1933 to 1938 was included in a more complete report titled, "Correlation of the Ballistic Properties of Light Armor Plate", W.A. #710/250, dated January 26, 1938.

* Aberdeen Partial Reports on Tests of Thin Armor Plate, Ordnance Program #4334, T.S.T.P. #1922-107, dated Jan. 1, 1938 to March 18, 1940, and Aberdeen Letter Reports on Tests of Experimental Plate submitted by various manufacturers, dated January 1938 to March 18, 1940.

UNCLASSIFIED
GOD SIN 000-9

~~SECRET~~

UNCLASSIFIED

88 2 19 022

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

UNCLASSIFIED

Conclusions

1. The survey shows that face hardened plate of all thicknesses is ballistically superior to homogeneous plate of corresponding thickness, see Figure 1.

2. The data for homogeneous plate is so meagre that the curves representing homogeneous plate must be considered as merely indicating a probable trend. However, the few tests made in 1938-40 indicate that the ballistic limits of homogeneous plate have not materially increased since the 1933-38 period. There is no reason to believe that there should be any radical change.

3. Recent face hardened plate averages from 175 to 300 ft/sec. higher than face hardened plate of the period 1933-38 when caliber .50 shot is used, although only 75 ft/sec. higher when caliber .30 A.P. shot is employed. This improved performance is probably the result of the change, which was introduced about 1938, in the type of steel base used for carburizing. An approximate composition of the steel base is 0.17% C, 5.0% Ni, 0.20% Mo, .10% V.

It is understood that a bonus for acceptable plates of exceptionally high ballistic limits has been regularly offered since July 31, 1934. (See Specification AXS54-Rev. 2). The change in the type of steel base used was inaugurated during the year 1938.

-2-

UNCLASSIFIED

Distribution/	
Availability Codes	
Dist	Avail and/or Special
12	

UNCLASSIFIED

TABLE I

Thickness in Inches	% Variation from Limits of Specification	Ballistic	Spread in ft/sec. between Average Ballistic Limits of Face Hard. & Homogen. Plate	% Variation between Average B.L. of Face Hard. & Homogen. Plate
	AXS-54K-Rev.3			
	Face Hardened	Homogeneous		
	Caliber .30 A.P. M 1922			
1/4	10.5%	* -30.1%	*762 ft/sec	*40.6%
3/8	7.9%	* -19.5%	*603 "	*27.4%
7/16	7.8%			
1/2	7.2%	2.3%	125 "	4.9%
	Caliber .50 A. P. M1			
1/2	7.5% †	* -12.0%	*373 ft/sec	*19.5%
9/16	3.3%			
5/8	4.7%	* - 4.1%	*193 "	* 8.8%
11/16	5.5%			
3/4	5.3%	- 0.8%	143 "	6.1%
7/8	7.8%	* - 0.8%	*215 "	* 8.6%
1	4.0%	- 6.5%	304 "	10.5%

* No data available in 1938-40, therefore these values are for the period 1933-38.

† Determined by extrapolation of the specification curve.

UNCLASSIFIED

UNCLASSIFIED

TABLE II-A
Covering 1938 through March 18, 1940

Thickness in Inches	Specified Limits	Face Hardened Plate	Homogeneous Plate
	No. of Plates	Average Ballistic Limits of Acceptable Plates	No. of Plates
		Highest Ballistic Limit of Acceptable Plates	Average Ballistic Limits of Tested Plates
			Ductile* Plates
Caliber .30 A. P. M 1922			
1/4	1875	2072	2520
5/8	2200	2373	2769
7/16	2350	2534	2618
1/2	2550	2733	3059
Caliber .50 A. P. M 1			
1/2	[2050, (e)]	2203	2351
9/16	2130	2201	2234
5/8	2210	2313	2468
11/16	2290	2415	2415
3/4	2375	2500	2601
7/8	2520	2715	2979
1	2900	3015	3138
			2357
			2361
			2711
			2794

* With the exception of the 1/2" plate, no homogeneous plate attained the ballistic values specified in AXS-54K-Rev. 3. Therefore, for the other thicknesses, all plates which were ballistically ductile (i.e., no spalling, cracking, etc.) had to be used to determine the average value.

[—, (e)] Value determined by extrapolation of specification curve.

UNCLASSIFIED

TABLE II-B

Covering 1933 to 1938.

W.A. Report No. 710/250.

Thickness in Inches	Face Hardened Plate		Homogeneous Plate	
	Weight [#]	Ballistic Limit (Weighted Means)	Weight [#]	Ballistic Limit (Weighted Mean)
Caliber .30 A.P. M 1922				
3/16	1	1921	37	920
1/4	196	1988	45	1310
3/8"	31	2219	59	1770
7/16	68	2525	0	—
1/2	25	2493	102	2550
Caliber .50 A.P. M 1				
1/2	9	1941	1	1830
5/8	17	2148	33	2120
3/4	1	2310	20	2360
7/8	0	—	1	2500
1	22	2673	0	—

[#] Weighted means of these ballistic limits had been determined, see W. A. Report No. 710/250. The weight of each mean is recorded here.

Results

The results are shown graphically in Figures I, II and III, and are given in tabular form in Tables I and II.

Procedure

All ballistic data was taken from Aberdeen reports and classified according to type, (i.e., face hardened or homogeneous), thickness, and caliber of ammunition used in testing. In the case of face hardened plate only the most modern plate, (i.e., tested 1938-40), which passed Specification AIS-54K-Rev. 3, were considered. However, in the case of homogeneous plate, so few plates had been tested in that period that in order to obtain any values at all the ballistic limits of all ductile* homogeneous plate had to be used regardless of their failure to meet specifications.

From this data the average ballistic limit for each type of plate and for each thickness was computed. These averages, together with the number of plates used in determining the average, are given in Table II-A. In addition, the highest ballistic limit recorded for a non-brittle plate of each thickness and the specified ballistic limit for that thickness are given in this Table.

Differences between the average ballistic limits of each type of plate and the specified ballistic limit were computed for each thickness, and from these differences the per cent variation, above or below specification AIS-54K-Rev. 3, was determined. These percentages are shown graphically in Figure I and numerically in Table I.

The per cent variation between face hardened and homogeneous plates of the same thickness was found by taking the percentage that the face hardened plate was above specification and subtracting from it the percentage that the homogeneous was above specification, or adding to it the percentage that the homogeneous plate was below specification. In addition, the actual spread in feet per second between the average limits of the face hardened plate and those of the homogeneous plate was calculated. The percent variations and spread are given in Table I.

* Plate which did not spall, button, or crack.

Curves were then drawn to show the trends for each type of plate. The average values of the ballistic limits are plotted against thickness of plate, the values obtained with caliber .30 A.P. being shown in Figure II, those obtained with caliber .50 A.P. in Figure III. In addition, the mean ballistic limits for the period 1933-38 are plotted in each Figure for comparison purposes. The values used in plotting these curves were taken from W. A. Report No. 710/250, and are given in Table II-B.

Discussion

Because of the manufacturers' reluctance to produce homogeneous plate in competition with face hardened plate when both must meet identical specifications, very few homogeneous plates are made available for testing. If a serious attempt to develop good quality homogeneous plate is contemplated, it would be advisable to draw up less stringent specifications for homogeneous plate as an inducement to the manufacturer.

The reliability of the plotted points in Figures II and III is indicated by the number in parentheses beside each point. For the curves representing the period from 1938 to 1940 these numbers are the total number of plates averaged in the determination of that ballistic average. In the case of the period 1933 to 1938, the numbers are the weights of the weighted mean values of the ballistic limits.

It must be emphasized that the curves representing homogeneous plate are not nearly so accurate as those representing the face hardened plate of any period, since there were so few plates contributing to the average. The addition of only one homogeneous plate would be sufficient to change the average value by an appreciable amount, whereas the inclusion of a considerable number of additional face hardened plate would change the average values but slightly.

Respectfully submitted,

E. L. Reed

E. L. Reed
Research Metallurgist

S. L. Kruegel

S. L. Kruegel
Jr. Phys. Science Aide

APPROVED:

G. L. Cox,
Major, Ord. Dept.,
Acting Director of
Laboratory.

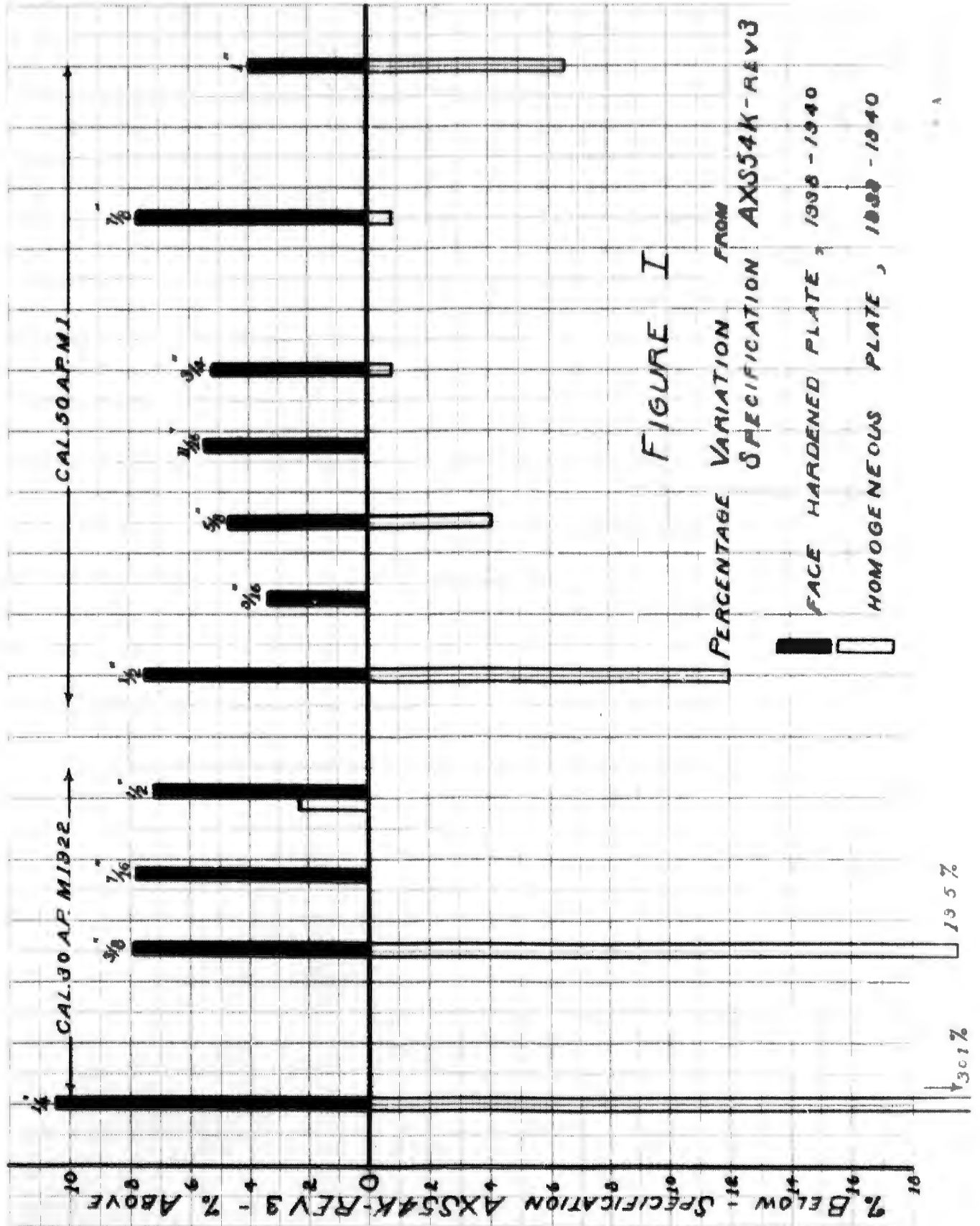


FIGURE I

PERCENTAGE VARIATION FROM SPECIFICATION AXS54K-REV 3

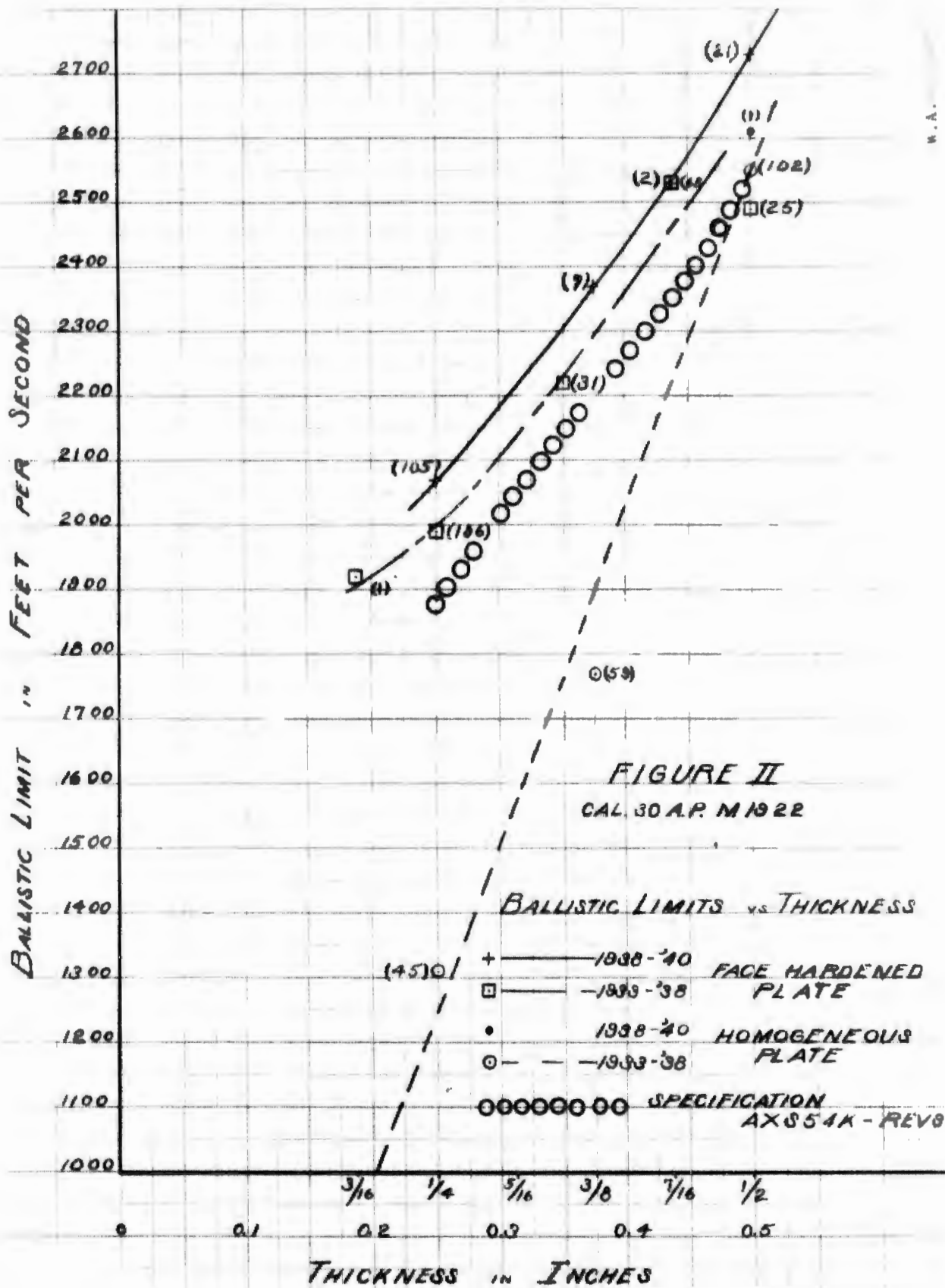
FACE HARDENED PLATE, 1938 - 1940
 HOMOGENEOUS PLATE, 1938 - 1940

19.5%

3.01%

FIGURE II

The reliability of each plotted point is indicated by the number in parentheses beside it. For curves of the period 1938 to 1940, these numbers show the total number of plates used in determining the average ballistic limit which is plotted. For the curves of the period 1933 to 1938, these numbers are the weights of the weighted means of the ballistic limits.



W.A.

UNCLASSIFIED

UNCLASSIFIED

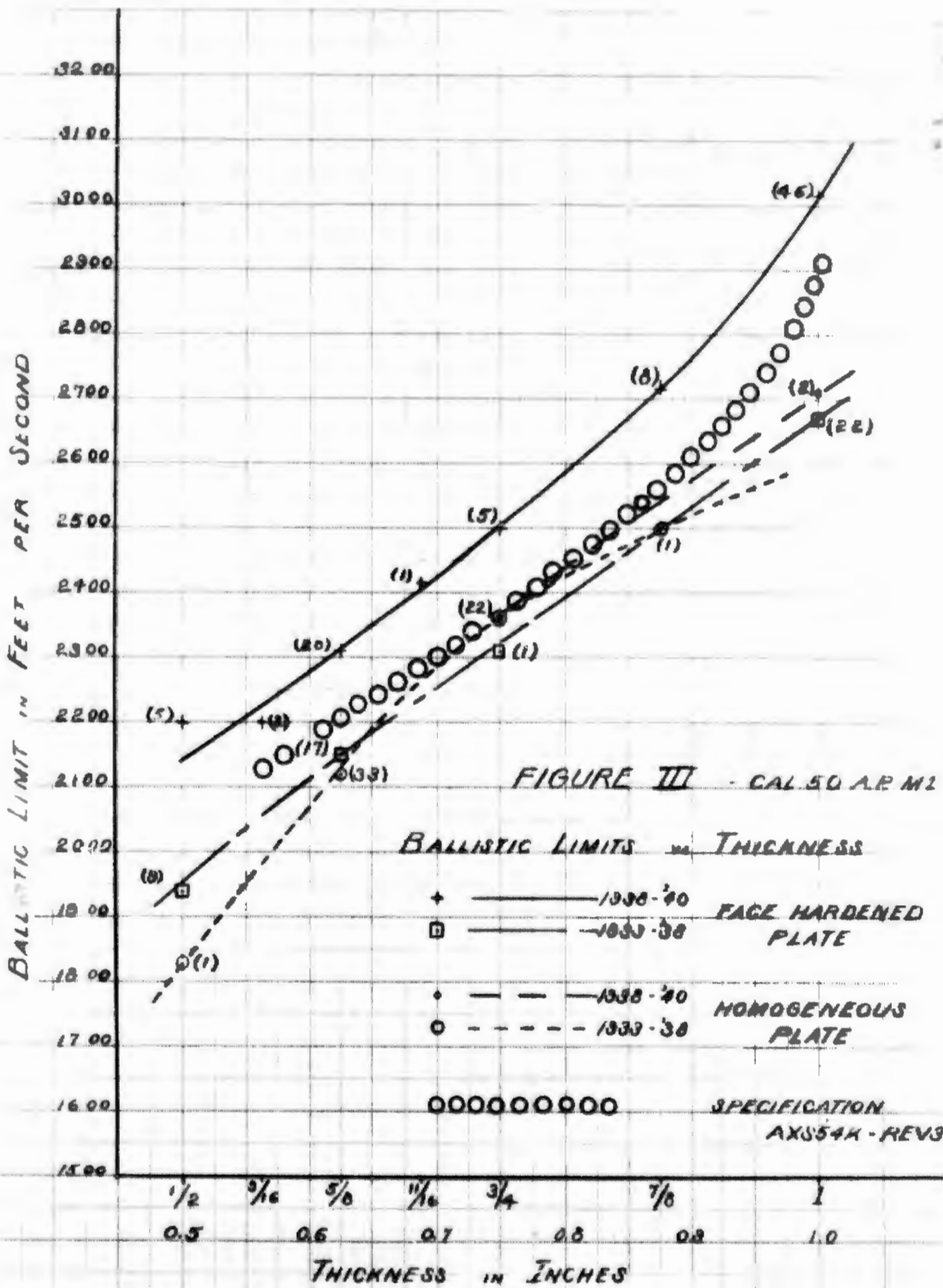
FIGURE III

The reliability of each plotted point is indicated by the number in parentheses beside it. For curves of the period 1938 to 1940, these numbers show the total number of plates used in determining the average ballistic limit, which is plotted. For the curves of the period 1933 to 1938, these numbers are the weights of the weighted means of the ballistic limits.

UNCLASSIFIED

UNCLASSIFIED

UNCLASSIFIED



UNCLASSIFIED