O T T A W A August 4th, 1942.

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of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1276.

Examination of .303 inch Mk VIIIz (Streamline) Bullets.

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Origin of Problem:

In a letter dated July 16th, 1942, Colonel E. M. Ransford, for Inspector General, Directorate of S. A. & A., Inspection Board of United Kingdom & Canada, Ottawa, requested the examination of bullets from .303 inch Mk VIIIz ammunition submitted from the initial Canadian production, started by Defence Industries Limited, Verdun, Quebec.

Origin of Problem, (cont'd.) -

It was stated that owing chiefly to the short parallel and boat-tail of the Mk Vlll (streamline) bullet which distinguishes it from the longer parallel and cylindrical base of the Mk Vll bullet, barrel wear, bullet design and hardness of bullet envelope and core are critical features in the maintenance of accuracy with Mk Vlll ammunition. Each of these factors has a bearing on "set-up" which, compared with that of Mk Vll is small. The ammunition is fired only in Vickers Mk 1 watercooled M.G.s.

In the United Kingdom some makes of Mk Vlll, from recent production, have been found to give very unsatisfactory results in respect of accuracy within the first few thousand rounds of barrel life. This situation has led to extensive investigations as to the cause and a possible remedy. The reports of these investigations have been published in Ordnance Board Proceedings. The hardness of the core and of the envelope has received attention and it appears from tests, which have been made that the margin between satisfactory limits of hardness is not very great.

An extract from Ordnance Board Proceedings 18,279, Appx. lll, which deals with this subject was attached for information.

It was stated that Messrs. Defence Industries Limited, Verdun, Quebec, recently commenced initial Canadian production of .303" Mk Vlllz ammunition. In view of the problems referred to above, which have arisen in the United Kingdom, it has been arranged that some samples from early batches from D. I. L. production will be subjected to full experimental trials.

Origin of Problem, (cont'd.) -

It was requested to carry out an examination of, and certain physical tests with, sample bullet cores and envelopes, as described in the attached copy of Appx. 111 to O. B. Proc. 18,279.

In a subsequent letter, dated July 27th, 1942, Colonel E. M. Ransford requested the additional examination of some Mk V111 bullets made by Imperial Chemical Industries, United Kingdom, for comparison with those manufactured in Canada.

Nature of Samples:

For the examination 50 sample bullets and 50 cores made by Defence Industries Limited, Verdun, Quebec, were submitted.

Additional 23 sample bullets manufactured by Imperial Chemical Industries, United Kingdom, were received.

Fig. 1 shows the shape of the samples as received. The design of the English made bullets is a little different from the Canadian made bullets.

a b c

Figure 1. Samples as received (approx. natural size)

a - Canadian made core,
b - Canadian made bullet,
c - English made bullet.

Chemical Analysis:

	Canadian made bullet	English made bullet
	per cent	
a) Envelopes		
Copper	89.93	89.56
Zinc	9.97	10.27

Chemical Analysis (cont'd.) -

	Canadian made bullet	English made bullet
	per cent	
b) Cores		
Lead	89.54	91.32
Antimony	10.11	9.16
Tin	0.36	none detected

Examination of the Envelopes:

a) Wall thickness of the envelopes was determined on five Canadian made bullets and three English made bullets. Following results are the averages from these determinations⊠:

Wall thickness in inches:	Canadian	English
0.15 inch from the base	0.0280	0.0296
0.35 " " " "	0.0291	0.0292
0.65 " " " "	0.0274	0.0292
0.90 " " " "	0.0294	0.0286

⊠ The measurements were made by the Gauge Laboratory, National Research Council, Ottawa.

b) Hardness of the envelopes was determined by the Vickers method, using a 5 kg. load. The hardness was tested on the outside and inside surfaces of five Canadian and three English bullet envelopes.

Canadian bullet envelopes:

Sample No.	1	2	3	4	5	Average
Outside Surface			V. H. N.			
0.35" from the base	133	120	107	115	117	118
0.65" " " "	128	118	124	123	123	123
0.90" " " "	135	123	110	124	113	121
Inside Surface						
0.35" from the base	119	126	107	123	117	118
0.65" " " "	108	117	117	122	131	119
0.90" " " "	113	120	117	117	122	118

Enblish bullet envelopes:

Sample No.	1	2	3	Average
Outside Surface				
0.35" from the base	111	124	118	118
0.65" " " "	109	121	109	113
0.90" " " "	105	110	116	108
Inside Surface				
0.35" from the base	113	110	114	112
0.65" " " "	119	124	119	121
0.90" " " "	122	124	121	122

Examination of Envelopes (cont'd.)

The above hardness tests results are subject to certain inaccuracies owing to the nature of the specimen tested (rounded surface) and the natural lack of perfection in the testing method. It is felt that the hardness of the two materials are to all practical purposes similar.

c) Reverse bend tests over a bending radius of 0.100" were carried out on pieces taken from the parallel parts of the envelopes rear of the cannelure. Five Canadian and three English bullet envelopes were tested. A ring was cut, split longitudinally and opened out flat. Two tests were made on each sample. Bending was repeated until a crack appeared.

Complete bends before the appearance of a crack:

	Canadian	English
Sample No. 1	4 - 5	3 - 3
" " 2	2 - 3	3 - 5
" " 3	4 - 4	4 - 4
" " 4	3	
" " 5	3 - 3	
Average	3.5 bends	3.7 bends

Rigidity of the Bullets.

Compression tests were carried out on five Canadian and four English bullets. Samples of 0.36 inch length were cut out from the parallel part of the bullets and compressed using two different rates of loading. The loads which produced a shortening of 0.03 inch were as follows:

Rate of loading	1000 lb/min.	2500 lb/min.
Canadian bullets:	2100	2130
	2140	2160
	2100	
English bullets:	2100	2100
	2095	2040

Examination of Bullet Cores (before assembly):

Only Canadian made cores were examined, since no English cores were submitted.

Examination of Bullet Cores (before assembly) (cont'd.) -

a) Outside diameter of the cores before assembly were measured by the Gauge Laboratory of the National Research Council, Ottawa.

Five cores were examined with following results:

Core No.	1	-	0.2502 to 0.251 inch
" "	2	-	0.2505 to 0.251 "
" "	3	-	0.2505 to 0.251 "
" "	4	-	0.2507 to 0.251 "
" "	5	-	0.2505 to 0.251 "
Average		-	0.2505 to 0.251 inch

Variations on diameter probably due to burrs.

b) Hardness tests were carried out on transverse and longitudinal sections of the cores using the Vickers pyramid intenter and a 1-kg. load.

Transverse sections were cut through the middle of the cylindrical portions (about 0.65" from the base) of five cores. On each of these sections five hardness determinations were made along a diameter. In the results given below, No. 3 position of test was in the centre of the section:

	Sample No.					
Position	A	B	C	D	E	Average
1	8.5	8.2	8.8	8.1	8.8	8.5
2	9.0	8.7	9.5	9.2	8.4	9.0
3	9.1	9.0	9.6	8.9	9.2	9.2
4	9.4	9.5	9.4	9.2	9.0	9.3
5	8.9	9.0	9.6	8.7	9.6	9.2

Hardness on longitudinal axial sections was determined on six cores with the following results:

Sample No.	1	2	3	4	5	6	Average
0.15" from the base	8.7	8.9	8.1	8.8	9.3	9.0	8.8
0.30" " " "	9.7	8.0	8.4	9.5	9.8	9.9	8.8
0.45" " " "	8.8	8.6	8.5	9.3	8.9	8.5	8.8
0.60" " " "	9.2	8.3	8.5	8.8	9.8	9.8	9.2
0.80" " " "	8.2	8.6	9.6	8.9	9.4	9.2	9.0

Examination of Bullet Cores (before assembly) (cont'd.)-

Hardness tests on longitudinal flats which, along the parallel part, were half-way between axis and surface on six cores:

Sample No.	1	2	3	4	5	6	Average.
0.15" from the base	9.4	9.6	9.4	9.0	9.6	9.6	9.4
0.30" " " "	10.5	10.4	9.1	9.9	10.0	9.9	10.0
0.45" " " "	9.6	10.3	9.4	10.0	10.2	9.9	9.9
0.60" " " "	10.4	10.3	10.1	10.3	10.4	10.5	10.3
0.80" " " "	9.6	10.0	9.6	10.2	10.3	10.0	10.0

Examination of Bullet Cores (after assembly):

Since the English-made bullets were submitted only in the finished condition, the cores of these bullets could be tested only in the bullet assembly. (see Fig. 2). For comparison also Canadian made bullet cores were tested in the same way. The hardness was determined by the Vickers method, using a 1-kg. load.

Figure 2. Arrangements showing the location of hardness tests on various sections of the bullets.

a) Hardness tests on the transverse section (approx. 0.65" from the base) were carried out on five Canadian and three English bullets. On each of these sections five hardness determinations were made along a diameter.

Canadian bullet cores:

Sample No.		A	B	C	D	E	Average.
Position	1	9.3	9.5	8.9	9.5	8.7	9.2
	2	8.4	9.8	8.9	9.2	8.7	9.0
	3	9.5	10.0	9.6	8.7	8.7	9.3
	4	9.1	10.4	6.9	8.7	9.4	8.9
	5	9.5	10.2	7.5	9.5	9.0	9.1

Examination of Bullet Cores (after assembly) (cont'd.)

English bullet cores:

Sample No.	A	B	C	Average
Position 1	7.6	8.4	8.8	8.3
2	8.9	8.5	8.3	8.6
3	8.4	8.7	7.2	8.1
4	9.2	8.8	7.1	8.4
5	8.3	8.6	7.4	8.1

b) Hardness tests on longitudinal axial sections were carried out on three Canadian and three English bullet cores with the following results:

Location from the base:	0.15"	0.30"	0.45"	0.60"	0.80"
Canadian samples					
No. 1	7.8	7.7	7.8	9.4	8.4
" 2	8.4	9.3	8.3	9.7	8.7
" 3	9.0	10.0	9.2	9.6	8.7
Average	8.4	9.0	8.4	9.6	8.6
English samples					
No. 1	7.9	7.7	8.4	10.2	8.4
" 2	7.7	8.2	8.5	8.7	8.4
" 3	8.2	9.0	8.7	9.5	8.9
Average	7.9	8.3	8.5	9.5	8.6

c) Hardness tests on longitudinal flats (half-way between axis and surface) were carried out on three Canadian and three English bullet cores with the following results:

Location from the base:	0.15"	0.30"	0.45"	0.60"	0.80"
Canadian samples					
No. 1	8.1	9.6	9.8	10.8	9.8
2	10.0	9.3	9.5	9.9	9.8
3	9.6	10.8	10.5	10.9	9.8
Average	9.2	9.9	9.9	10.5	9.8
English samples					
No. 1	6.7	7.2	8.8	6.4	9.0
2	8.1	7.6	7.6	8.7	8.6
3	7.2	6.2	6.3	6.7	7.9
Average	7.3	7.0	7.6	7.3	8.5

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JWM:RM
4th August, 1942.