File.

FILE COPY

O T T A W A July 6, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1870.

Metallurgical Examination of
2-Inch Mortar Signal Bombs.

===========

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA July 6, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1870.

Metallurgical Examination of 2-Inch Mortar Signal Bombs.

==========

Source of Material and Object of Investigation:

On May 2, 1945, Mr. J. M. Gilmartin, I.O.(M), for Inspector of Materials, Inspection Board of United Kingdom and Canada, 71 Lyon Street, Ottawa, Canada, submitted for examination a 2-inch mortar signal bomb which had failed in proof firing, and also an unfired bomb. The latter was stated to be from production which had passed the proof firing test. In addition to the above, three sets of seven, each representing a step in the processing of these bombs, were also submitted. The request for this investigation was covered in

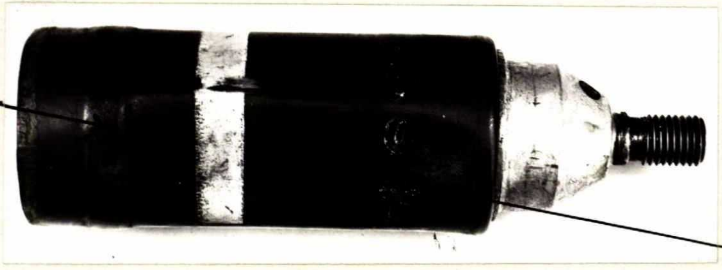
(Source of Material and Object of Investigation, cont'd) -

Analysis Requisitions Nos. O.T. 4351, dated May 2, 1945, and O.T. 4351-1, dated June 13, 1945. It was further stated that in addition to the above-mentioned trouble, cracking had been encountered in certain instances in expanding the tubing band.

Macro-Examination:

Figure 1 is a photograph showing the failed steel bomb as submitted.

Figure 1.



(Approximately 1/2 actual size).

The metal tube appeared to have collapsed in the proof firing test. However, no breaks were observed in the tubing body of the bomb. The tube was found to be 0.037 inch thick.

Mechanical Properties:

A tensile specimen was machined from the failed tube and tested in the Baldwin-Southwark tensile testing machine. In addition, microtensile specimens were prepared from all samples submitted and tested in the Hounsfield tensometer. The results of tensile and Vickers hardness tests are recorded in Table I.

(Continued on next page)

(Mechanical Properties, cont'd) -

TABLE I.

Sample Marked No.	Size of Test Piece, inches	Ultimate Stress, p.s.i.	Yield Stress, p.s.i.	Elongation, per cent	Vickers Hardness Number
Failed Proof	0.500 X 0.037	47,300	27,000	41.0*	117-151
" "	Micro	50,000	28,500	29.2	117-151
Passed Proof	"	53,500	33,400	26.8	134
No. 1, Blank	"	80,000	72,700	10.0	182
" "	"	75,300	67,200	17.5	195
" "	"	74,400	67,600	15.0	175
No. 2, 1st Draw	"	87,700	76,700	7.5	206
" "	"	82,700	82,700	10.0	197
" "	"	86,800	83,000	5.0	199
No. 3, 1st Anneal	"	49,800	28,400	30.0	98
" "	"	51,700	34,400	35.0	100
" "	"	55,400	27,700	32.5	109
No. 4, 2nd Draw	"	78,400	65,200	15.0	183
" "	"	75,100	67,600	15.0	182
" "	"	70,200	52,200	15.0	171
No. 5, 2nd Anneal	"	44,800	26,100	35.0	88
" "	"	47,800	24,000	32.5	99
" "	"	48,800	24,300	35.0	103
No. 6, 3rd Draw	"	67,900	54,000	17.5	160
" "	"	73,300	65,600	17.5	171
" "	"	80,200	66,800	17.5	175
No. 7, Tempered 1000° F.	"	75,000	64,300	22.5	168
" "	"	81,300	57,100	20.0	167
" "	"	83,700	71,700	15.0	175
HEAT-TREATED, B. of M.					
No. 6, Tempered 1000° F.	"	63,900	48,400	22.5	160
No. 7, Tempered 1000° F.	"	68,900	30,600	15.0	170
No. 7, Tempered 1100° F.	"	45,500	24,500	27.5	101
No. 7, Tempered 1200° F.	"	46,200	21,300	32.5	106
Sheet Specified		42,560	31,360	41.0**	

* Per cent in 2 inches.

** This value for a full-sized test specimen. The smaller values encountered are what one would expect in micro specimens.

Chemical Analysis:

A typical analysis of C.P. strip used in Canada for the the manufacture of signal bombs and the results obtained on the samples submitted are given in Table II.

TABLE II.

Sample	Carbon	Manganese	Silicon	Phosphorus	Sulphur
	- Per	Cent -			
Typical Analysis	0.09	0.32	-	0.010	0.032
Failed Bomb	0.09	0.36	0.01	0.022	0.047
From Passed Proof Stock	0.05	0.38	-	-	-
No. 1, Blank and Cup	0.08				
" " "	0.10				
" " "	0.11				
No. 2, 1st Draw	0.11				
" "	0.09				
" "	0.10				
No. 3, 1st Anneal	0.06				
" "	0.05				
" "	0.07				
No. 4, 2nd Draw	0.04				
" "	0.07				
" "	0.08				
No. 5, 2nd Anneal	0.04				
" "	0.04				
" "	0.05				
No. 6, 3rd Draw	0.05				
" "	0.03				
" "	0.11				
No. 7, Tempered 1000° F	0.07				
" " "	0.07				
" " "	0.11				

Microscopic Examination:

Specimens cut from the various samples submitted were mounted in bakelite, polished, and examined under the microscope in the unetched condition. The steels were found to be fairly clean. They were then etched in a solution of two per cent nitric acid in alcohol and re-examined. Figures 2 to 8 show the nital-etched structure of the specimens examined. The structure is typical of low-carbon steel. The

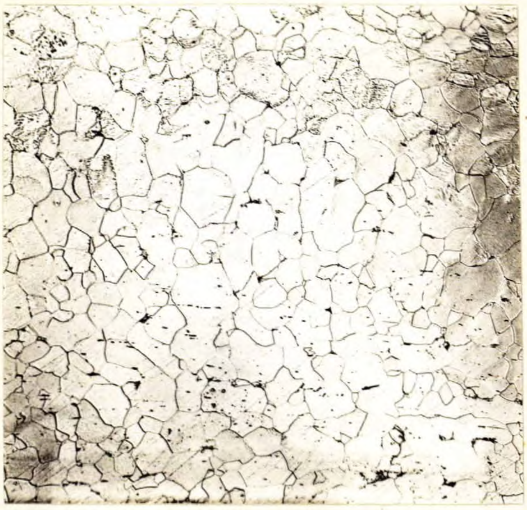
(Microscopic Examination, cont'd) -

steels were fairly fine-grained. However, some grain growth was observed in the heavily worked sections of the tubes. This condition is illustrated in Figure 6. The structure of the steel before and after annealing is shown in Figures 7 and 8. It will be observed that the steel was heavily decarburized in the annealing operation.

(Figures 1 to 8 follow,)
(on Pages 6 and 7.)
(Text resumes on Page 8.)

(Microscopic Examination, cont'd) -

Figure 2.



X100, etched in
2 per cent nital.

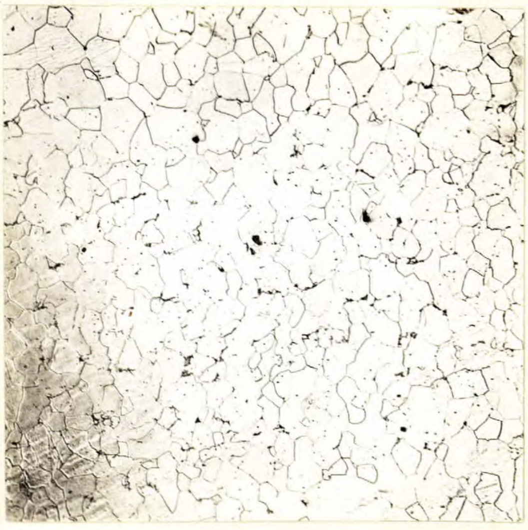
LONGITUDINAL SECTION, SIGNAL BOMB SAMPLED FROM STOCK WHICH PASSED PROOF FIRING TEST.

Figure 3.

X100, etched in
2 per cent nital.

LONGITUDINAL SECTION, SIGNAL BOMB FAILED IN PROOF FIRING.

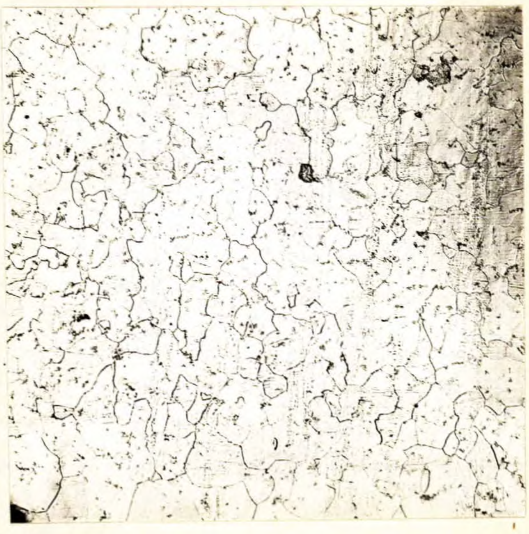
Figure 4.



X100, etched in
2 per cent nital.

TRANSVERSE SECTION, SIGNAL BOMB SAMPLED FROM STOCK WHICH PASSED PROOF FIRING TEST.

Figure 5.



X100, etched in
2 per cent nital.

TRANSVERSE SECTION, SIGNAL BOMB FAILED IN PROOF FIRING.

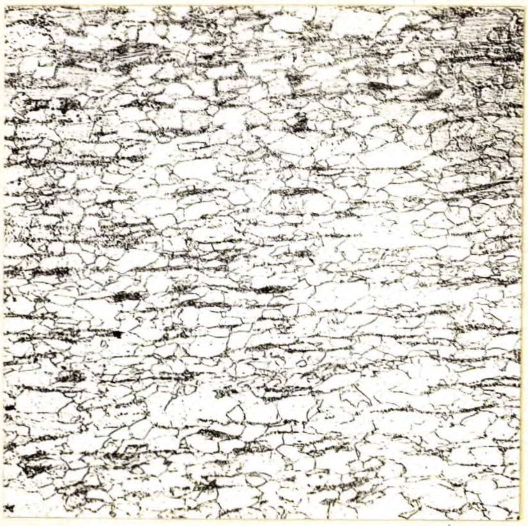
Figure 6.

X100, etched in
2 per cent nital.

SHOWING LARGE GRAIN STRUCTURE AT BENT SECTION OF TUBING AFTER 2ND DRAW.

Specimen No. 4. Carbon, 0.04 per cent.

Figure 7.



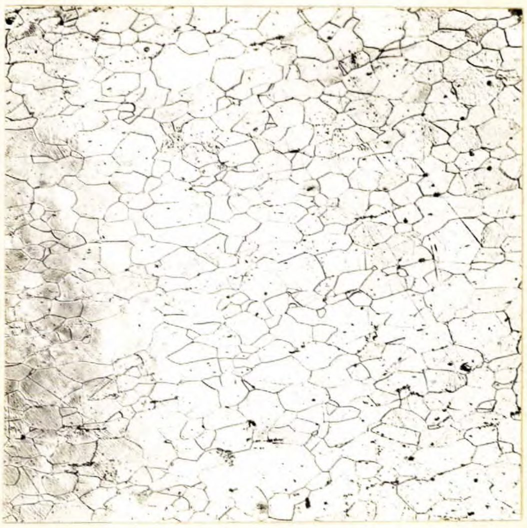
X100, etched in
2 per cent nital.

BEFORE ANNEAL.

Showing structure after 1st draw.

Carbon, 0.08 per cent.

Figure 8.



X100, etched in
2 per cent nital.

AFTER ANNEAL.

Showing structure after 1st anneal and 2nd draw.

Carbon, 0.04 per cent.

Discussion of Results:

The chemical composition of the steel used in the manufacture of the signal bombs submitted was similar to that of an SAE 1010 steel. Although there were two high carbon content values reported for two tubes in Operations Nos. 6 and 7, the average values after the annealing operation definitely indicate a marked drop in carbon. This was confirmed in the microscopic examination. Decarburization can be prevented by annealing in a controlled atmosphere.

The tensile strength and the per cent elongation of the steel conform to the requirements specified for the sheet steel from which these signal bombs are fabricated, making due allowance for the low elongation values which are to be expected on microtensile specimens. However, it will be noted that the yield point value was considerably lower than specified.

The hardness of the failed bomb was found to vary from 117 to 151 Vickers, while the hardness of the bomb taken from stock which had passed the proof firing test was quite uniform. The erratic values may be due to distortion which accompanied failure.

The microscopic examination showed little difference in grain size of the failed and satisfactory tubing. An X-ray examination, however, showed that the latter was somewhat finer-grained.

Experimental heat treatment tests carried out at different draw temperatures indicate that the mechanical properties are lowered below the specified value by drawing above 1000° F.

The results of this investigation would indicate that the failure of the tube was due to its low yield strength. The low mechanical properties of the failed tubing are probably due to drawing the material at too high a temperature

(Discussion of Results, cont'd) -

or to full annealing rather than tempering. It is recommended that the temperature of the draw should not exceed 1000° F. and that the annealing be carried out in a controlled atmosphere to prevent decarburization.

The cracking on expanding is another problem. The examination of the sets submitted would indicate that they had not been drawn for a sufficient time or had missed the draw in the final operation.

Summarizing the results of this investigation, it is concluded that the differences encountered in the proofing and manufacturing of this tubing are due to faulty heat treatment, and more care should be taken in the final drawing operation and in the protection of the tubing in the annealing cycle.

oooooooooooo
oooooooo
oo

NBB:LB.