REPORT NO. 314/66

Gun Steel - - Centrifugal Castings

Watertown Arsenal Gun Tubes Processed Without Normalizing

By
N. A. Birch
1st Lt., Ordnance Dept.

V. T. Bender
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30 June 1943

WATERTOWN ARSENAL
WATERTOWN, MASS.

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72

24 July 1943

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4. Copies of this report have been sent to Watervliet Arsenal, and The Proving Center.

5. This report covers the processing through proof-firing of fourteen 40mm M1, thirteen 3-inch M5, fifteen 90mm M1, and two 105mm Howitzer M.Al centrifugally cast gun tubes produced without the usual normalizing (2200°F for 16 hours) treatment. Further investigation is under way on one tube (a 90mm M1) which was rejected because two small cracks were discovered upon boroscoping after proof-firing. Seventeen 90mm M1 gun tubes also were produced with an anneal replacing the normalize treatment.

For the Commanding Officer:

G. L. COX
Lt. Col., Ord. Dept.
Assistant

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Report No. 314/66
Watertown Arsenal
Problem No. G-6
Prod. X.O.-1605 A 23 & 24
X.O.-1595 A 13
X.O.-1151 A 68 & 72

(11) 30 June 1943

(6) GUN STEEL --- CENTRIFUGAL CASTINGS,

Watertown Arsenal Gun Tubes Processed Without Normalizing,

OBJECT

To determine the feasability of omitting the normalizing (2200°F for 16 hours) treatment in the production of centrifugally cast gun tubes at Watertown Arsenal.

SUMMARY

Fourteen 40 mm. M1 and thirteen 3-inch M5 gun tubes (heat-treated to strength) were produced without the normalize treatment (2200°F for 16 hours and air cooled), proof-fired and accepted for Field Service.

Fifteen 90 mm. M1 and two 105 mm. Howitzer M2A1 gun tubes (cold-worked to strength) were produced without the normalize treatment, proof-fired, and all but one were accepted for service. Tube 7024 (90 mm. M1) was rejected because two small cracks were discovered upon boroscoping after proof firing. Further investigation of this tube is under way.

Seventeen 90 mm. M1 gun tubes (cold-worked to strength) were produced with an anneal replacing the normalize treatment. The tubes were rough machined in the annealed condition prior to quenching and drawing treatment. All seventeen tubes were proof fired and accepted for service. Improvement in machinability due to the anneal on this size, analysis and strength of gun tube were minor, if any.

(12) 46

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INTRODUCTION

Watertown Arsenal Report No. 314/61* concludes, "Based upon the results obtained in this limited investigation, standard castings without the high-temperature treatment can be processed satisfactorily into cold worked guns that meet the requirements of the specifications up to proof-firing. Proof-firing has not yet been attempted." This conclusion was reached after processing through cold work two production 105 mm. Howitzer tubes with complete omission of the standard high temperature normalize (16 hours at 2200°F and air cool).

To determine the feasability of omitting completely this high temperature normalizing treatment in the routine production of centrifugally cast gun tubes, pilot lots of 40 mm. M1, 3" M5 and 90 mm. M1 tubes were authorized to be processed and proof-fired.

RESULTS AND DISCUSSIONS

40 mm. M1 Tubes

Fourteen 40 mm. M1 tubes were produced without the normalize treatment. These tubes were melted and cast according to present shop practice. They were slow cooled in ashes (to prevent flakes), water quenched from 1650°F and drawn for 6 hours at 1165°F/1190°F, according to standard procedure except that the normalize treatment was omitted. Testing, straightening, stress-relieving and machining operations were done in the standard manner and with no unusual behavior apparent.

The gun tubes were proof-fired according to U. S. Army tentative specification AXS-635 for the first tube manufactured under a contract plus two additional rounds loaded for 115% of maximum rated pressure. Stargauging and boroscopic examinations after firing failed to reveal any unusual bore condition as compared with similar tubes receiving normal processing. All tubes were released to Field Service.

Table I lists the W. A. casting number, Army gun number, chemical analyses, heat treatment, physical properties, macrostructure, proof-firing data and disposition of these 40 mm. gun tubes.

* Evaluation of the Normalize Treatment, 12/17/42.

3" M5 Tubes

Thirteen 3" M5 gun tubes were produced without the normalizing treatment. These tubes were melted, cast and slow cooled according to present shop practice. They were then annealed (7 hours at 1600°F) straightened and rough machined according to standard procedure except that the normalize treatment was omitted. The gun tubes were water quenched from 1650°F and drawn for 6 hours at 1130°F/1170°F. Three of the tubes were requenched and redrawn to bring their physical properties within the required range. Testing and final machining were done in the usual manner. No irregularities were observed during processing.

These gun tubes were proof-fired in accordance with U. S. Army current specification for the first gun tube manufactured under a contract. The tubes were stargauged and boroscoped after firing a minimum of eight rounds, two of which developed powder pressures in excess of 115% rated pressure. All passed proof-firing tests. By 7 June 1943 one gun, Serial Number 727 (3J-181) had been fired 319 rounds, firing A.P. and A.P.C. projectiles at Jefferson Proving Grounds.

Table II lists the W. A. casting number, Army serial number, chemical analyses, heat treatments, physical properties, macrostructure, proof-firing data and disposition of these 3" M5 gun tubes.

90 mm. M1 Tubes (Group A)

Fifteen 90 mm. M1 gun tubes were produced without the normalize treatment. These tubes were melted, cast and slow cooled (to prevent flakes) according to present shop practice. They were then water quenched from 1650°F and drawn for 6 hours at 1305°F/1325°F, according to standard procedure except that the normalize treatment was omitted. No irregularities developed during the testing, straightening, machining for cold work, cold work, soaking (5 hours at 570°F and air cool) and final machining which followed in the usual manner.

The tubes were proof-fired in accordance with the procedure specified for first production tubes — nine rounds of which four were at or in excess of 115% maximum rated pressure. Each tube was stargauged and boroscoped after proof-firing. All tubes except Army Gun Number 7024 (W. A. Casting 3K-186) passed proof test. Tube Number 7024 was rejected because boroscoping after firing revealed the existence of two small cracks in the grooves at 4 o'clock position 33 1/2 inches from the rear face of the tube. This rejected tube was returned to Watertown Arsenal for examination.

Table III lists the W. A. casting number, Army gun number, chemical analyses, heat treatments, physical properties, macrostructure, cold work data, proof-firing data and disposition of the 90 mm. M1 gun tubes (Group A) produced without the normalize treatment.

90 mm. M1 Tubes (Group B)

Seventeen 90 mm. M1 gun tubes were produced with an anneal (1675°F for 7 hours and furnace cool) replacing the usual normalize treatment. These tubes were melted, cast and slow cooled according to present shop practice. They were then annealed (7 hours at 1675°F and furnace cool) and rough machined prior to quench and draw. This procedure is not normal for this type gun tube, but was tried to learn whether the improved machinability (if any) of the annealed tube (Group B) over the heat treated tube (Group A) would warrant such an additional heat treatment. Both groups were machined in routine shop practice; differences in machinability were minor and not consistent. It was concluded that annealing prior to rough machining did not appreciably affect the machining time.

After rough machining, the tubes (Group B) were water quenched from 1650°F and drawn for 6 hours at 1320°F/1335°F. No irregularities developed during the testing, straightening, machining for cold work, cold work, soaking and final machining which followed.

The tubes were proof-fired with nine rounds, four of which were at or in excess of 115% rated pressure. The tubes were boroscoped after firing and no defects were found.

Table IV lists the W. A. casting number, Army serial number, chemical analyses, heat treatments, physical properties, macrostructure, cold work data, proof-firing data and disposition of the 90 mm. M1 gun tubes (Group B) produced with an anneal replacing the normalize treatment.

105 mm. Howitzer M2A1

Four special 105 mm. Howitzer M2A1 gun tubes were processed; two without the normalize treatment and two with a special 64 hour (at 2200°F) normalize treatment. A complete history up to proof-firing of these tubes is covered in detail in W. A. Report No. 314/61 "Evaluation of the Normalize Treatment". These tubes were proof-fired with 10 rounds, four of which were

at pressures at or in excess of 115% rated pressure. Proof-firing data are as follows:

W.A. Casting Number	Army Gun Number	Normalize	Maximum Powder Pressure PSI	or % Service
2L-1125	7855	None	34700	115%
2N-1268	7856	64 hr.	34600	115%
2N-1431	7857	None	35400	118%
2N-1271	7858	64 hr.	34900	116%

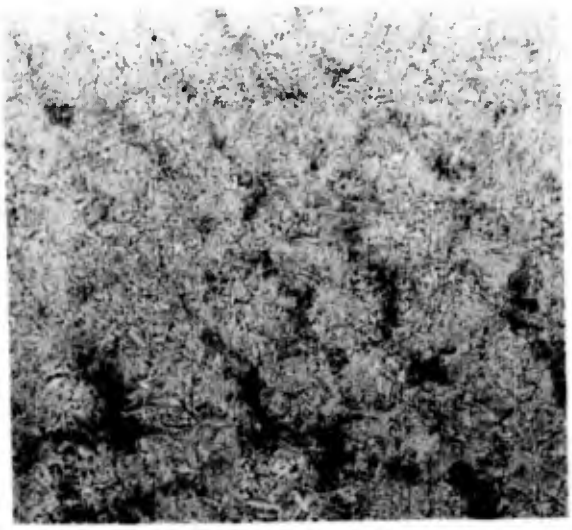
No bore irregularities were noted on stargauging and boroscope inspection after proof-firing.

Howitzer number 7855 (2L-1125), in service testing cartridge cases at Jefferson Proving Grounds, has been declared unserviceable on 24 June 1943 after 2901 rounds. This gun tube is being returned to Watertown Arsenal for further investigation. Howitzer number 7856 (2N-1268), at Southwestern Proving Grounds, had been fired 2000 rounds by 24 June 1943. Complete service records for both howitzers will be made available to this Arsenal.

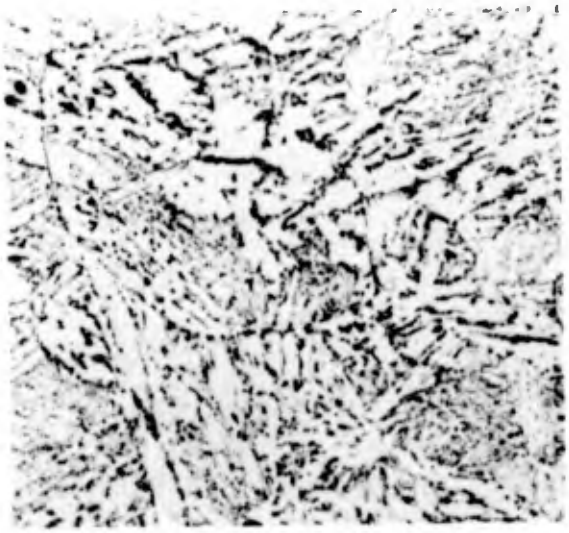
Microstructures

For record purposes, breech and muzzle photomicrographs (after quench and draw) of one gun tube from each treatment group are submitted in Appendix A as Figure 1 to 4. These photomicrographs yield no additional information but agree generally with the findings of the microscopic studies in W. A. Report No. 314/61.

APPENDIX A



BREECH 100X NITAL

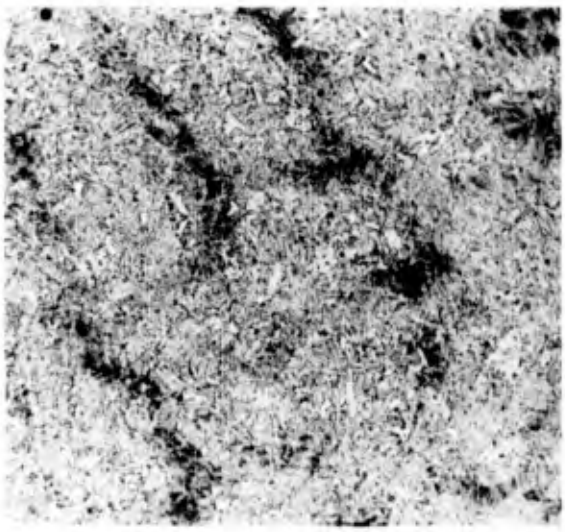


BREECH 1000X NITAL

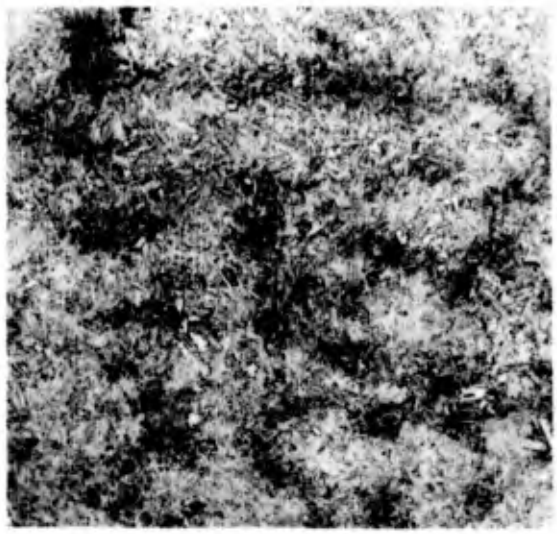
MICROSTRUCTURES OF 40 MM GUN TUBE 3H330 HEAT TREATED TO STRENGTH

WTN.639-5265

Fig 1



BREECH 100X NITAL



MUZZLE 100X NITAL

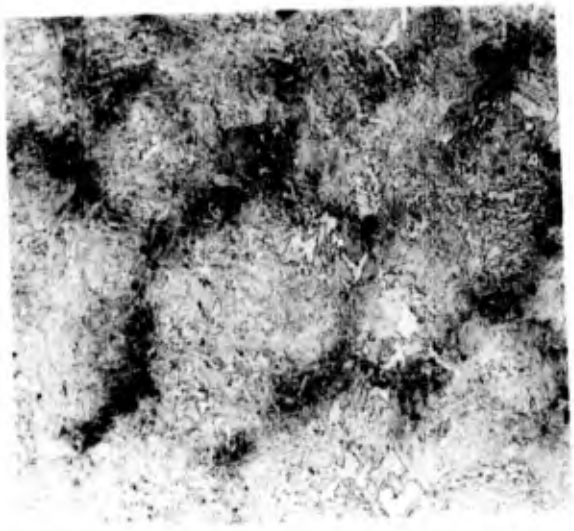
BREECH 1000X NITAL

MUZZLE 1000X NITAL

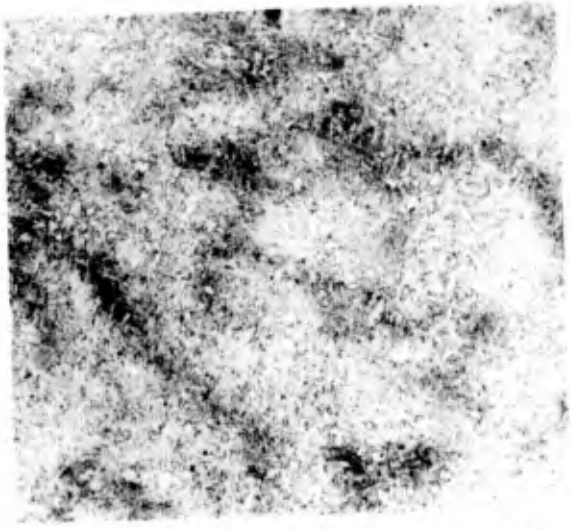
MICROSTRUCTURES OF 3-INCH M5 GUN TUBE 3J181 HEAT TREATED TO STRENGTH

WTN.639-5266

Fig 2



BREECH 100X NITAL



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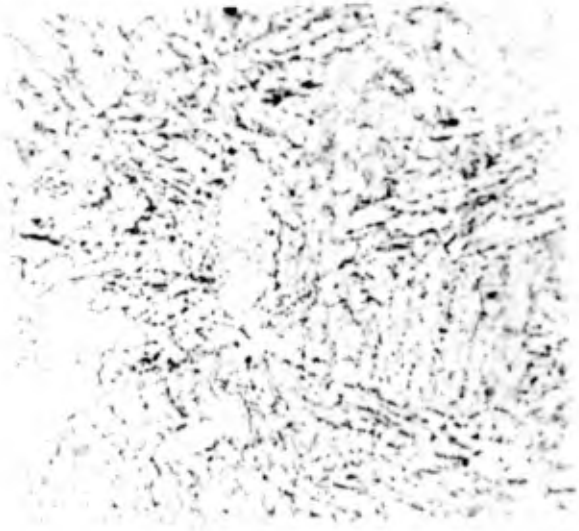


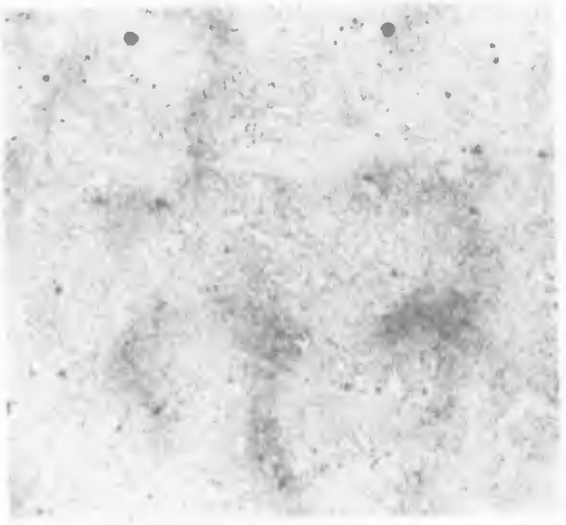
BRLECH 1CCOX NITAL

MUZZLE 1000X NITAL

MICROSTRUCTURES OF 90 MM GUN TUBE 3T193 NO NORMALIZE – GROUP A

WTN.639-5263

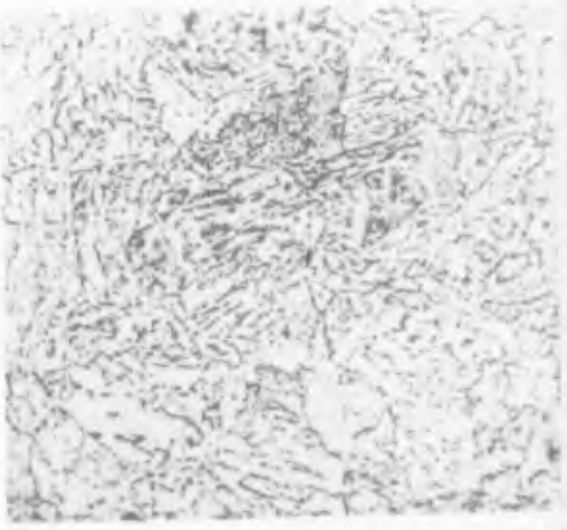
Fig 3



BREECH 100X NITAL

MUZZLE 100X NITAL

BREECH 1000X NITAL



MUZZLE 1000X NITAL

MICROSTRUCTURES OF 90 MM GUN TUBE 3K189 ANNEALED – GROUP B

WTN.639-5264

Fig 9

TABLE I TEST DATA 40 MM M1

IDENTIFICATION		CHEMICAL ANALYSES						HEAT
WA CASTING NUMBER	ARMY GUN NUMBER	C %	MN %	SI %	Cr %	Mo %	V %	NORMALIZE
REQUIRED								
3P246	21,840	.25	.93	.31	48	46	.095	NONE
3H354	21,847	.24	.93	.29	42	47	.085	NONE
3Q276	21,856	.27	.93	.32	47	49	.08	NONE
3Q273	21,886	.26	.89	.31	45	46	.085	NONE
3D285	21,893	.24	.89	.33	48	48	.10	NONE
3Q278	21,935	.26	.91	.32	.57	45	.085	NONE
3H330	21,947	.25	.89	.29	.50	46	.09	NONE
3Q269	21,955	.25	.93	.34	45	44	.09	NONE

0 M/M M1 GUN TUBES PRODUCED WITHOUT TREATMENT

V %	HEAT TREATMENT			PHYSICAL PROPERTIES						
	NORMALIZE	WATER QUENCH FROM °F	DRAWN 6 HRS. °F	LOCATION *	Y.S. P.S.I.	T.S. P.S.I.	R.A. %	FRACTURE	BRINELL HARDNESS NUMBER	MACRO ETCH
				95,000/120,000		40.0 MIN.				
.095	NONE	1650	B-1170 M-1185	BREECH	100,000	139,000	53.7	C-P		SATIS FACTO
				"	104,000	136,000	52.9	C-P		
				MUZZLE					302	
.085	NONE	1650	B-1170 M-1185	BREECH	98,000	129,800	55.6	C-P		SATI FACTO
					95,500	128,200	57.0	C-P		
				MUZZLE					269	
.08	NONE	1650	B-1175 M-1190	BREECH	100,500	135,000	53.7	C-P		SAT FAC
					101,500	134,500	55.9	C-P		
				MUZZLE					285	
.085	NONE	1650	B-1170 M-1185	BREECH	99,000	131,600	54.1	C-P		SAT FAC
					97,000	131,600	54.1	C-P		
				MUZZLE					302	
.10	NONE	1650	B-1165 M-1180	BREECH	95,000	130,500	45.3	C-P		SAT FAC
					100,200	129,500	47.0	C-P		
				MUZZLE					311	
.085	NONE	1650	B-1175 M-1190	BREECH	98,500	129,000	54.8	C-P		SA FA
					96,000	129,000	56.7	C-P		
				MUZZLE					277	
.09	NONE	1650	B-1165 M-1180	BREECH	97,000	130,200	53.3	C-P		SA FA
					97,000	130,800	51.0	C-P		
				MUZZLE					277	
.09	NONE	1650	B-1170 M-1185	BREECH	98,000	133,000	50.6	C-P		SA FA
					101,000	133,500	49.0	C-P		
				MUZZLE					285	

RODUCED WITHOUT NORMALIZING

VT

PHYSICAL PROPERTIES					PROOF FIRING	DISPOSITION
	T.S. P.S.I.	R.A. %	FRACTURE	BRINELL HARDNESS NUMBER	MACRO-ETCH	MAXIMUM POWDER PRESSURE P.S.I. BEHAVIOR	
L							
	40.0 MIN.					13,000 KK	
000	139,000	53.7	C-P		SATIS-FACTORY	115% NORMAL	ACCEPT for Field Service
000	136.000	52.9	C-P	302			
00	129,800	55.6	C P		SATIS-FACTORY	115% NORMAL	ACCEPT for Field Service
500	128 200	57.0	C P	269			
500	135,000	53.7	C-P		SATIS-FACTORY	115% NORMAL	A F S
500	134,500	55.9	C-P	285			
000	131,600	54.1	C-P		SATIS-FACTORY	115% NORMAL	A. F S.
000	131,600	54 1	C-P	302			
000	130,500	45.3	C-P		SATIS-FACTORY	115% NORMAL	A F S
0,200	129,500	47.0	C-P	311			
500	129,000	54.8	C-P		SATIS-FACTORY	115% NORMAL	A. F. S
000	129,000	56.7	C-P	277			
000	130 200	53.3	C-P		SATIS-FACTORY	115% NORMAL	A F S.
000	130,800	51.0	C-P	277			
000	133,000	50.6	C-P		SATIS-FACTORY	115% NORMAL	A. F. S.
000	133,500	49.0	C-P				

3Q278	21,935	.26	.91	.32	.57	49	.065	NONE	1650
3H330	21,947	.25	.89	.29	.50	46	.09	NONE	1650
3Q269	21,955	.25	.93	34	.45	44	.09	NONE	1650
3H352	21,995	26	.94	.28	45	42	.085	NONE	1650
3H362	22,024	23	93	.29	43	45	.075	NONE	1650
3H369	22,036	.25	.90	.37	.55	45	.09	NONE	1650
3H365	22,057	.24	.88	.32	49	48	.08	NONE	1650
3D282	22,137	24	.86	34	46	49	.065	NONE	1650
3Q277	22,163	26	.89	.35	.50	.53	.07	NONE	1650

*ALL TESTS TAKEN IN THE TRANSVERSE
** STANDARD PRESSURE

Y.S. = YIELD STRENGTH .01% OFFSET
T.S. = TENSILE STRENGTH

0	B-1175	BREECH	98,500	129,000	54.8	C-P		SATIS-FACTORY	115% NORMAL
			96,000	129,000	56.7	C-P			
	M-1190	MUZZLE					277		
50	B-1165	BREECH	97,000	130,200	53.3	C-P		SATIS-FACTORY	115% NORMAL
			97,000	130,800	51.0	C-P			
	M-1180	MUZZLE					277		
50	B-1170	BREECH	96,000	133,000	50.6	C-P		SATIS-FACTORY	115% NORMAL
			101,000	133,500	49.0	C-P			
	M-1185	MUZZLE					285		
50	B-1175	BREECH	95,000	127,400	55.2	C-P		SATIS-FACTORY	115% NORMAL
			95,000	126,400	52.5	C-P			
	M-1190	MUZZLE					269		
50	B-1160	BREECH	95,000	129,500	55.2	C-P		SATIS-FACTORY	115% NORMAL
			95,500	130,000	55.9	C-P			
	M-1175	MUZZLE					262		
50	B-1170	BREECH	97,000	129,500	54.4	C-P		SATIS-FACTORY	115% NORMAL
			99,000	128,500	55.2	C-P			
	M-1185	MUZZLE					269		
50	B-1165	BREECH	96,000	123,500	54.8	C-P		SATIS-FACTORY	115% NORMAL
			96,000	129,500	53.7	C-P			
	M-1180	MUZZLE					269		
50	B-1165	BREECH	96,000	125,500	57.4	C-P		SATIS-FACTORY	115% NORMAL
			99,500	129,000	56.7	C-P			
	M-1180	MUZZLE					277		
50	B-1170	BREECH	100,000	132,000	53.0	C-P		SATIS-FACTORY	115% NORMAL
			99,500	131,000	51.4	C-P			
	M-1185	MUZZLE					277		

GE DIRECTION

ST METHOD)

R.A.=REDUCTION IN AREA
P.S.I = POUNDS PER SQUARE INCH

C-CUPPED
P-PITTED

				311			
500	129,000	54.8	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
000	129,000	56.7	C-P				
				277			
000	130,200	53.3	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
000	130,800	51.0	C-P				
				277			
000	133,000	50.6	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
000	133,500	49.0	C-P				
				285			
500	127,400	55.2	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
000	126,400	52.5	C-P				
				269			
000	129,500	55.2	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
500	130,000	55.9	C-P				
				262			
000	129,500	54.4	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
000	126,500	55.2	C-P				
				269			
000	129,500	54.8	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
000	129,500	53.7	C-P				
				269			
000	129,500	54.4	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
500	129,000	56.7	C-P				
				277			
000	132,000	53.0	C-P		SATIS-FACTORY	115% NORMAL	A.F.S.
500	131,000	57.4	C-P				
				277			

R.A=REDUCTION IN AREA

P.S.I = POUNDS PER SQUARE INCH

C-CUPPED

P-PITTED

TABLE II - TEST DATA - 3 INCH M-5 G

IDENTIFICATION		CHEMICAL ANALYSES						HEAT TREATM		
W.A. CASTING NUMBER	ARMY GUN NUMBER	C %	Mn %	Si %	Cr %	Mo %	V %	NORMALIZE	ANNEAL THRS. °F.	HD QU FROM
REQUIRED										
3J 77	711	.27	.78	.23	.66	.49	.08	NONE	1600	165
3J 205	717	.25	.80	.35	.77	.46	.075	NONE	1600	1650
3J 103	720	.27	.85	.29	.67	.46	.085	NONE	1600	1650
3J 200	721	.26	.75	.34	.75	.45	.08	NONE	1600	1650
3J 108	722	.26	.74	.25	.76	.45	.07	NONE	1600	1650
3J 109	724	.26	.82	.25	.74	.46	.07	NONE	1600	1650

INCH M-5 GUN TUBES PRODUCED WITHOUT NOR

HEAT TREATMENT				PHYSICAL PROPERTIES					
NORMALIZE	ANNEAL 7 HRS. °F	H.D QUENCH FROM °F	DRAWN 6 HR AT °F	LOCATION *	Y.S. P.S.I.	T.S. P.S.I.	R.A. %	FRACTURE	MACRO ETCH
					95000/120000		40.0 MIN		
NONE	1600	1650	B-1135	BREECH	99,000	129,000	50.6	C-P	SATIS.
					101,000	128,000	50.6	C-P	
			M-1165	MUZZLE	120,000	142,500	42.8	CP-SQC	
					120,000	141,600	48.6	C-P	
NONE	1600	1650	B1140	BREECH	102,500	130,000	49.8	C-P	SATIS.
					102,500	130,000	50.6	C-P	
			M1170	MUZZLE	112,500	131,000	49.0	C-P	
					111,250	130,500	53.7	C-P	
NONE	1600	1650	B1145	BREECH	104,000	131,500	44.9	C-P	SATIS.
					99,000	137,500	44.9	C-P	
			M1175	MUZZLE	98,000	118,500	48.2	C-P	
					97,000	117,500	47.3	C-P	
NONE	1600	1650	B1130	BREECH	102,500	129,500	51.4	C-P	SATIS
					100,000	129,000	44.9	C-P	
			M1160	MUZZLE	116,250	134,000	50.2	C-P	
					112,500	135,000	40.7	CP,SQC	
NONE	1600	1650	B1130	BREECH	92,500	125,000	51.7	C-P	SATIS
					92,500	124,500	52.4	C-P	
			M1160	MUZZLE	106,250	129,500	49.4	C-P	
					103,750	129,000	52.1	C-P	
NONE	1600	1650	B1140	BREECH	95,000	124,000	47.4	C-P	SATIS
					96,000	124,000	48.2	C-P	
			M1170	MUZZLE	98,000	121,000	47.8	C-P	

S PRODUCED WITHOUT NORMALIZING TREATMENT

PHYSICAL PROPERTIES					MACRO ETCH	PROOF FIRING		DISPOSITION
OCATION	Y.S.	T.S.	R.A.	FRACTURE		MAX. POWD. PRESS. PSI.	BEHAVIOR	
*	P.S.I.	P.S.I.	%					
	[illegible]		40.0 MIN.			36,000**		
BREECH	98,000	129,000	51.6	C-P	SATIS.	42,200	NORMAL	ACCEPT-FIELD SERV.
	101,000	128,000	50.6	C-P				
MUZZLE	120,000	142,500	42.8	CR-SQC				
	129,000	141,600	48.6	C-P				
BREECH	102,500	130,000	49.8	C-P	SATIS.	42,400	NORMAL	ACCEPT FIELD SERV.
	102,500	130,000	50.6	C-P				
MUZZLE	112,500	131,000	49.0	C-P				
	111,250	130,500	53.7	C-P				
BREECH	104,000	131,500	44.9	C-P	SATIS.	43,300	NORMAL	ACCEPT-FIELD SERV.
	99,000	132,500	44.9	C-P				
MUZZLE	98,000	118,500	48.2	C-P				
	97,000	117,500	47.3	C-P				
BREECH	102,500	129,500	51.4	C-P	SATIS.	42,800	NORMAL	ACCEPT-FIELD SERV.
	100,000	128,000	44.9	C-P				
MUZZLE	116,250	134,000	50.2	C-P				
	112,500	135,000	40.7	CP, SQC				
BREECH	92,500	125,000	51.7	C-P	SATIS.	43,300	NORMAL	ACCEPT-FIELD SERV.
	92,500	124,500	52.4	C-P				
MUZZLE	116,250	129,500	49.4	C-P				
	103,750	128,000	52.1	C-P				
BREECH	96,000	124,000	47.4	C-P	SATIS.	42,600	NORMAL	ACCEPT-FIELD SERV.
	96,000	124,000	48.2	C-P				
MUZZLE	99,000	121,000	47.9	C-P				

3J 104	724	.26	.82	.25	.74	.46	.07	NONE	1600	1650	B
											M
3J 187	725	.27	.84	.41	.70	.44	.07	NONE	1600	1650	B
											M
3J 190	726	.27	.82	.35	.77	.47	.07	NONE	1600	1650	B
											M
3J 181	727	.25	.77	.35	.80	.49	.07	NONE	1600	1650	B
											M
3J 105	729	.26	.78	.27	.65	.51	.08	NONE	1600	1650	B
											M
3J 55	831	.28	.80	.21	.75	.41	.07	NONE	1600	1650	B
											M
										1650	B
											M
		.27	.78	.35	.76	.46	.08	NONE	NONE	1650	B

		M 1160	MUZZLE	126,250	129,500	40.9	C-P
				103,750	112,000	52.1	C-P
1600	1650	B1140	BREECH	96,000	124,000	47.9	C-P
				96,000	129,000	48.2	C-P
		M1170	MUZZLE	92,000	121,000	47.8	C-P
				97,000	120,000	51.0	C-P
1600	1650	B1140	BREECH	110,000	130,500	44.5	C-P, SBC
				103,000	126,000	42.8	C-P, SBC
		M1170	MUZZLE	103,000	122,500	50.6	C-P
				105,000	125,000	54.1	C-P
1600	1650	B1145	BREECH	99,000	130,000	43.2	C-P, SBC
				100,000	133,000	50.2	C-P
		M1175	MUZZLE	102,000	129,000	52.5	C-P
				100,500	129,000	48.2	C-P, SBC
1600	1650	B1140	BREECH	99,000	126,500	51.0	C-P
				99,000	126,500	51.0	C-P
		M1170	MUZZLE	98,000	129,000	50.2	C-P
				105,000	129,000	51.1	C-P
E 1600	1650	B1130	BREECH	95,000	125,000	52.9	C-P
				96,000	129,000	54.8	C-P
		M1160	MUZZLE	116,000	146,000	50.2	C-P
				120,000	146,000	49.9	C-P, SBC
NE 1600	1650	B1140	BREECH	91,250	129,000	43.2	C-P, SBC
				93,500	129,000	49.9	C-P, SBC
		M1170	MUZZLE	96,250	123,500	53.7	C-P, SBC
				98,500	116,000	56.0	C-P, SBC
			RETREAT				
	1650	B1125	BREECH	102,500	139,000	44.5	C-P, SBC
				105,000	145,000	46.6	C-P, SBC
		M1155	MUZZLE	102,500	128,000	60.6	C-P
				100,000	121,500	59.8	C-P
			BREECH	73,000	99,500	44.6	C-P, SBC

SATIS.	48,600
SATIS.	45,800
SATIS.	42,400
SATIS.	45,600
SATIS.	48,400
SATIS.	
SATIS.	
	46,2
SATIS.	

ECH	97,500	125,000	[illegible]	C-P	SATIS	[illegible]	NORMAL	
	97,500	124,500	57.4	C-P				
ZZLE	106,250	129,500	49.4	C-P				
	103,750	128,000	52.1	C-P				
					SATIS.	42,600	NORMAL	ACCEPT-FIELD SERV.
BREECH	96,000	124,000	47.4	C-P				
	96,000	124,000	48.2	C-P				
MUZZLE	99,000	121,000	47.8	C-P				
	97,000	120,000	51.0	C-P				
					SATIS.	43,800	NORMAL	ACCEPT-FIELD SERV.
BREECH	104,000	130,500	41.5	C-P,SBC				
	103,000	128,000	42.8	C-P,SBC				
MUZZLE	103,000	128,500	50.6	C-P				
	105,000	125,000	39.1	C-P				
					SATIS.	42,400	NORMAL	ACCEPT-FIELD SERV.
BREECH	99,000	130,000	43.2	C-P,SBC				
	100,000	133,000	50.2	C-P				
MUZZLE	106,000	124,000	52.5	C-P				
	100,500	124,000	48.2	C-P,SBC				
					SATIS.	45,600	NORMAL	ACCEPT-FIELD SERV.
BREECH	99,000	126,500	51.0	C-P				
	99,000	126,500	51.0	C-P				
MUZZLE	98,000	124,000	50.2	C-P				
	104,000	124,000	51.4	C-P				
					SATIS.	42,100	NORMAL	ACCEPT-FIELD SERV.
BREECH	95,000	125,000	52.9	C-P				
	96,000	124,000	54.8	C-P				
MUZZLE	116,000	141,000	50.2	C-P				
	120,000	146,000	44.9	C-P,SBC				
					SATIS.			RETREAT
BREECH	91,250	129,000	43.2	C-P,SBC				
	93,500	129,000	49.4	C-P,SBC				
MUZZLE	96,250	113,500	53.7	C-P,SBC				
	92,500	116,000	56.0	C-P,SBC				
		RETREAT				46,700	NORMAL	ACCEPT-FIELD SERV.
BREECH	102,500	138,500	44.5	C-P,SBC				
	105,000	145,000	46.6	C-P,SBC				
MUZZLE	102,500	128,000	60.6	C-P				
	100,000	121,500	57.8	C-P				

3K 184C	843	.27	.78	.35	.85	.16	.08	NONE	NONE	1650	B
											M
										1650	B
											M
J-J-54	845	.27	.80	.21	.15	.47	.07	NONE	1610	1650	B
											M
										1650	B
											M

* ALL TESTS TAKEN

** STANDARD PRESS

Y.S. - YIELD STRENGTH. (.01% OFFSET METHOD)
T.S - TENSILE STRENGTH.
P.S.I. - POUNDS PER SQUARE INCH.

SGC-

1600	1650	B1140	BREECH	91,250	129,000	43.2	C-P,SGC	SATIS.		
				93,500	129,000	49.4	C-P,SGC			
		M1170	MUZZLE	96,250	133,500	53.7	C-P,SGC			
				98,500	116,000	56.0	C-P,SGC			
					RETREAT					
	1650	B1125	BREECH	102,500	139,500	44.5	C-P,SGC		46,700	N
				105,000	130,000	76-6	C-P,SGC			
		M1155	MUZZLE	102,500	128,000	60.6	C-P			
				106,000	121,500	52.8	C-P			
NONE	1650	B1310	BREECH	73,000	95,500	48.6	I,P,SGC	SATIS.		
				72,500	96,500	52.9	I,P,SGC			
		M1310	MUZZLE	81,000	81,000	60.3	C-P			
	1650	B1140	BREECH	105,400	135,000	44.1	C-P,SGC		43,300	N
				106,250	137,500	71.5	C-P,SGC			
		M1170	MUZZLE	113,750	133,500	47.8	C-P			
				116,750	141,500	46.1	C-P			
1600	1650	B1145	BREECH	88,150	123,000	38.0	I,P,SGC	SATIS.		
				93,750	125,000	46.5	C-P,SGC			
		M1170	MUZZLE	88,750	112,000	66.0	C-P			
				93,500	122,000	52.1	C-P-SGC			
	1650	B1120	BREECH	96,250	128,500	49.0	C-P		45,200	N
				100,000	129,000	45.7	C-P			
		M1150	MUZZLE	115,000	132,000	56.3	C-P			
				102,500	133,000	56.7	C-P			

TESTS TAKEN IN THE TRANSVERSE DIRECTION

ARD PRESSURE.

B - BREECH
M - MUZZLE
P - PITTED
C - CUPPED

SGC - SMALL GAS CAVITY

REECH	91,250	129,000	43.2	C-P,SBC	SATIS.			RETREAT
	93,500	129,000	49.9	C-P,SBC				
UZZLE	96,250	113,500	59.7	C-P,SBC				
	92,500	116,000	56.0	C-P,SBC				
		RETREAT						
REECH	108,500	139,500	44.6	C-P,SBC		46,700	NORMAL	ACCEPT-FIELD SERV.
	105,000	149,000	46.6	C-P,SBC				
UZZLE	102,500	128,000	60.6	C-P				
	100,000	121,500	59.8	C-P				
REECH	73,000	95,900	46.6	I,P,SBC	SATIS.			RETREAT
	72,500	96,500	52.9	I,P,SBC				
MUZZLE	81,000	81,000	60.3	C-P				
BREECH	105,000	135,000	44.1	C-P-SBC		43,300	NORMAL	ACCEPT. FIELD SERV.
	106,250	137,500	41.5	C-P-SBC				
MUZZLE	113,750	137,500	47.8	C-P				
	116,750	148,500	46.7	C-P				
BREECH	93,750	123,000	38.0	I,P,SBC	SATIS.			RETREAT
	93,750	125,000	46.5	C-P,SBC				
MUZZLE	68,750	112,000	66.0	C-P				
	92,500	122,000	52.1	C-P-BC				
BREECH	96,250	128,500	19.0	C-P		45,200	NORMAL	ACCEPT-FIELD SERV.
	100,000	129,000	45.7	C-P				
MUZZLE	115,000	132,000	56.3	C-P				
	102,500	138,000	56.7	C-P				

THE TRANSVERSE DIRECTION

B - BREECH
M - MUZZLE
P - PITTED
C - CUPPED

4

LL GAS CAVITY

9

TABLE III. 90MM M1 GUN TUBES

IDENTIFICATION		CHEMICAL ANALYSES						HEAT TREATMENT			
W.A. CASTING NUMBER	ARMY GUN NUMBER	C %	MN %	SI %	CR %	MO %	V %	NORMALIZE	ANNEAL 7HRS °F	H_2O QUENCH FROM °F	DRAW AT
REQUIRED											
3G-171	7012	.25	.81	.37	.30	.46	.08	NONE	NONE	1650	13
3K-191	7013	.27	.79	.41	.72	.47	.09	NONE	NONE	1650	13
3T-173	7014	.25	.83	.40	.82	.46	.085	NONE	NONE	1650	13
3K 201	7015	.27	.81	.37	.70	.46	.07	NONE	NONE	1650	13
3K 196	7016	.27	.83	.38	.75	.45	.07	NONE	NONE	1650	13
3G 182	7017	.25	.82	.41	.74	.48	.075	NONE	NONE	1650	13

UBES PRODUCED WITHOUT NORMALIZING TR

TREATMENT			PHYSICAL PROPERTIES						C.W. PRESS.	
EAL	H_2O QUENCH	DRAW (HR	LOCATION	Y.S.	T.S.	R.A.	FRACTURE	MACRO	CALC.	ACTUA
°F	FROM °F	AT °F		P.S.I.	P.S.I.	%		ETCH	P.S.I	P.S.
				***		45.0 MIN				
NE	1650	1315	BREECH	73500	96000	51.5	C-P-SGC	SATIS	109500	11600
				73500	96000	59.9	C-P			
			MUZZLE	72000	94800	66.1	C-P			
				72500	94800	60.8	C-P			
NE	1650	1310	BREECH	73000	97200	56.3	C-P-SGC	SATIS.	108500	1160
				73000	96200	54.8	C-P-SGC			
			MUZZLE	78500	99400	65.0	C-P			
				76000	98200	58.5	C-P-SGC			
NE	1650	1315	BREECH	81000	101900	40.2	I,B,P,GC	SATIS	120000	1180
				80000	101900	47.8	C-P-SGC			
			MUZZLE	76000	96400	52.9	C-P-SGC			
				75500	95800	43.3	C-P-SGC			
NE	1650	1315	BREECH	70000	96000	56.3	C-P	SATIS.	105500	1155
				72000	94800	51.0	C-P			
			MUZZLE	77500	94800	57.8	C-P			
				78500	96400	58.5	C-P			
E	1650	1315	BREECH	75000	97500	49.8	C-P-GC	SATIS.	111000	1160
				74000	96400	50.2	C-P-SGC			
			MUZZLE	79000	97400	57.0	C-P-SGC			
				79500	99300	59.2	C-P-SGC			
NE	1650	1310	BREECH	73000	96300	58.5	C-P	SATIS	110260	1160
				75000	98000	58.9	C-P			
			MUZZLE	75500	97500	62.3	C-P			

LIT NORMALIZING TREATMENT

3

OPERTIES			C.W. PRESS. PSI		PROOF FIRING		DISPOSITION
R.A. %	FRACTURE	MACRO ETCH	CALC. P.S.I	ACTUAL P.S.I.	MAX. PWDR PRESS. PSI	BEHAVIOR	
45.0 MIN					38000**		
51.5	C-P-SLC	SATIS	109500	116000	115% X	NORMAL	ACCEPT-FIELD SERVICE
59.9	C-P						
66.1	C-P						
60.8	C-P						
56.3	C-P-SGC	SATIS.	108500	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
54.8	C-P-SGC						
65.0	C-P						
58.5	C-P-SGC						
40.2	I.P.P.G.C	SATIS	120000	118000	115 %	NORMAL	ACCEPT-FIELD SERVICE
47.8	C-P-SGC						
52.9	C-P-SGC						
43.3	C-P-SGC						
56.3	C-P	SATIS.	105500	115500	115%	NORMAL	ACCEPT-FIELD SERVICE
51.0	C-P						
57.8	C-P						
58.5	C-P						
49.8	C-P-GC	SATIS.	111000	116000	115%	NORMAL	ACCEPT-FIELD SERVICE
50.2	C-P-SGC						
57.0	C-P-SGC						
59.2	C-P-SGC						
58.5	C-P	SATIS.	110260	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
58.9	C-P						
59.7	C-P						

3G 182	7017	.25	.82	.41	.74	.48	.075	NONE	NONE	1650	1310
3U 162	7018	.24	.83	.37	.86	.47	.085	NONE	NONE	1650	1315
3T 171	7019	.25	.79	.35	.84	.47	.085	NONE	NONE	1650	1310
3T 190	7020	.25	.74	.31	.88	.45	.075	NONE	NONE	1650	1310
3K 202	7021	.26	.81	.37	.76	.47	.075	NONE	NONE	1650	1315
3T 181	7022	.26	.86	.37	.87	.45	.095	NONE	NONE	1650	1325
3G 173	7023	.27	.76	.37	.67	.42	.075	NONE	NONE	1650	1305
3K 186	7024	.28	.87	.44	.70	.42	.075	NONE	NONE	1650	1325

			[illegible]	[illegible]	[illegible]	[illegible]			
1650	1310	BREECH	73000	96300	58.5	C-P	SATIS.	110260	116000
			75000	98000	58.9	C-P			
		MUZZLE	75500	97500	62.3	C-P			
			79000	98200	51.7	Ir,Br,P,SGC			
1650	1315	BREECH	80500	97400	52.1	C-P-SGC	SATIS.	120200	119000
			81000	99300	52.1	C-P-SGC			
		MUZZLE	76000	96000	60.3	C-P-SLC			
			78500	101000	48.6	C-P-GC			
1650	1310	BREECH	73500	95300	45.3	Ir,Br,P,GC	SATIS.	107000	116000
			70000	95800	49.8	Ir,Br,P,Gc			
		MUZZLE	72000	90200	67.6	C-P			
			77000	98200	65.4	C-P			
1650	1310	BREECH	74500	96800	48.6	Ir,P,PGC	SATIS.	110500	116000
			74000	96600	45.3	Ir,Br,PGC			
		MUZZLE	76000	93600	67.6	C-P			
			76000	95800	47.4	Ir,Br,P,GC			
1650	1315	BREECH	70500	92900	56.7	C-P	SATIS.	106000	116000
			72000	92600	57.4	C-P			
			79500	96100	60.6	C-P			
			77500	97400	62.0	C-P			
1650	1325	BREECH	68500	93700	45.7	Ir,Br,P,GC	SATIS.	102000	116000
			69500	94600	47.4	Ir,Br,P,GC			
		MUZZLE	78000	95700	62.7	C-P			
			76500	95200	68.6	C-P			
1650	1305	BREECH	74500	97600	48.2	Ir,Br,P,SGC	SATIS.	111000	116000
			74500	98000	48.6	Ir,Br,P,SGC			
		MUZZLE	79000	97200	51.7	Ir,Br,P,SGC			
			79000	100400	47.8	Ir,Br,P,SGC			
1650	1325	BREECH	72000	97700	54.1	C,P,SGC	SATIS.	108000	116000
			73000	97700	51.7	C,P,SGC			
		MUZZLE	77500	95900	53.7	C,P,SGC			

57.0	C-P SGC						
59.2	C-P-SGC						
58.5	C-P	SATIS.	110260	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
58.9	C-P						
62.3	C-P						
51.7	Iy,By,P,SGC						
52.1	C-P-SGC	SATIS.	120200	119000	115 %	NORMAL	ACCEPT-FIELD SERVICE
52.1	C-P-SGC						
60.3	C-P-SLC						
48.6	C-P-GC						
45.3	Iy,By,P,GC	SATIS.	107000	116000	115 %	NORMAL	ACCEPT FIELD SERVICE
49.8	Iy,By,P,GC						
67.6	C-P						
65.4	C-P						
48.6	Iy,By,P,GC	SATIS.	110500	116000	115 %	NORMAL	ACCEPT FIELD SERVICE
45.3	Iy,By,P,GC						
67.6	C-P						
47.4	Iy,By,P,GC						
56.7	C-P	SATIS.	106000	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
57.4	C-P						
60.6	C-P						
62.0	C-P						
45.7	Iy,By,P,GC	SATIS.	102000	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
47.4	Iy,By,P,GC						
62.7	C-P						
68.6	C-P						
48.2	Iy,By,P,SGC	SATIS.	111000	116000	115 %	NORMAL	ACCEPT - FIELD SERVICE
48.6	Iy,By,P,SGC						
51.7	Iy,By,P,SGC						
47.8	Iy,By,P,SGC						
54.1	C,P,SGC	SATIS.	108000	116000	115 %	XXX	REJECT

3T 181	7022	.26	.86	37	.87	45	.095	NONE	NONE	1650	13
3G 173	7023	.27	.76	37	.67	.42	.075	NONE	NONE	1650	13
3K 186	7024	.28	.87	44	.70	.42	.075	NONE	NONE	1650	13
3T 193	7025	.26	.79	32	.77	.44	.09	NONE	NONE	1650	13
3K 192	7026	.26	81	40	.76	.44	.08	NONE	NONE	1650	13

* ALL TESTS

** STANDARD

*** BREECH 65
ALLOWABLE

Y.S. YIELD STRENGTH (.01% OFFSET METHOD)
T.S. TENSILE STRENGTH.
R.A. REDUCTION IN AREA.
P.S.I. POUNDS PER SQUARE INCH.
X PERCENT AT NORMAL PRESSURE

1

1325	BREECH	68500	93700	45.7	Ir,Br,P,GC	SATIS.	102000	116000
		69500	94600	47.4	Ir,Br,P,GC			
	MUZZLE	78000	95700	62.7	C-P			
		76500	95200	68.6	C-P			
1305	BREECH	74500	97600	48.2	Ir,Br,P,SGC	SATIS.	111000	116000
		74500	98000	48.6	Ir,Br,P,SGC			
	MUZZLE	79000	97200	51.7	Ir,Br,P,SGC			
		79000	100400	47.8	Ir,Br,P,SGC			
1325	BREECH	72000	97700	54.1	C,P,SGC	SATIS.	108000	116000
		73000	97700	51.7	C,P,SGC			
	MUZZLE	77500	95900	53.2	C,P,SGC			
		76500	95000	51.1	C,P,SGC			
1310	BREECH	71500	97600	59.2	C-P	SATIS.	108200	116000
		74000	99200	55.3	C-P			
	MUZZLE	76000	99300	54.8	C-P			
		81000	99300	56.3	C-P			
1315	BREECH	71000	94000	51.7	Ir,Br,P,GC	SATIS	105500	116000
		71000	94600	45.5	Ir,Br,P,GC			
	MUZZLE	73000	91700	66.1	C-P			
		74500	92400	67.6	C-P			

STS TAKEN IN THE TRANSVERSE DIRECTION
ARD PRESSURE
H 65000/81000, MUZZLE 60000/95000 - MAXIMUM
ABLE DIFFERENCE B & M 15000 P.S.I.

GC GAS CAVITIES

C CUPPED
P PITTED
SLC SMALL L
SGC SMALL
XXX BOROSCOPING
2 SMALL

0	45.7	Ir,Br,P,GC	SATIS.	102000	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
00	47.4	Ir,Br,P,GC						
0	62.7	C-P						
00	68.6	C-P						
00	48.2	Ir,Br,P,SGC	SATIS.	111000	116000	115 %	NORMAL	Accept - Field Service
00	48.6	Ir,Br,P,SGC						
00	51.7	Ir,Br,P,SGC						
00	47.8	Ir,Br,P,SGC						
00	54.1	C,P,SGC	SATIS.	108000	116000	115 %	XXX	REJECT
00	51.7	C,P,SGC						
00	53.2	C,P,SGC						
00	51.1	C,P,SGC						
00	59.2	C-P	SATIS.	108200	116000	115 %	NORMAL	ACCEPT-FIELD SERVICE
00	55.3	C-P						
00	54.8	C-P						
00	56.3	C-P						
00	51.7	I-Br P,SC	SATIS	105500	116000	115%	NORMAL	ACCEPT-FIELD SERVICE
00	45.5	Ir,Br,P,GC						
00	64.7	C-P						
00	67.6	C-P						

NSVERSE DIRECTION

000/95000 – MAXIMUM
& M 15000 P.S.I.

C CUPPED
P PITTED
SLC SMALL LUSTROUS CAVITIES
SGC SMALL GAS CAVITIES
XXX BOROSCOPING AFTER FIRING REVEALED 2 SMALL CRACKS.

TABLE IV: 90 MM MI GUN TUBES PRODUCED

IDENTIFICATION		CHEMICAL ANALYSES						HEAT TREATME			
W.A. CASTING	ARMY GUN	C	Mn	Si	Cr	Mo	V	NORMALIZE	ANNEA.	H.D QUENCH	DR
NUMBER	NUMBER	%	%	%	%	%	%		7 HRS. °F	FROM °F	A
REQUIRED											
37158	7027	.25	.84	.38	.87	.43	.105	NONE	1675	1650	B
3K 190	7028	.27	.87	.44	.73	.46	.08	NONE	1675	1650	
3T-177	7029	.27	.81	.35	.81	.43	.08	NONE	1675	1650	
3G 176	7030	.27	.78	.35	.81	.47	.07	NONE	1675	1650	
3T 192	7031	.26	.78	.40	.81	.44	.055	NONE	1675	1650	
3G 191	7032	.27	.88	.38	.73	.44	.07	NONE	1675	1650	

UCED WITH AN ANNEAL REPLACING THE NORMALIZING

TREATMENT			PHYSICAL PROPERTIES							
	HQ QUENCH	DRAW 6HR	LOCATION	Y.S.	T.S.	R.A.	FRACTURE	MACRO ETCH	C.V.P. CALC P.S.I.	C.V.P. ACTUAL P.S.I.
	FROM °F	AT °F	*	P.S.I	P.S.I.	%				
			* * *			45.0 MIN				
5	1650	B1320	BREECH	71000	94300	61.0	C-P	SATIS.	107500	116000
				73000	94500	59.9	C-P			
		M1330	MUZZLE	72000	92300	63.0	C-P			
				77000	97100	59.9	C-P			
5	1650	B1325	BREECH	71000	97800	62.0	C-P	SATIS.	106300	118000
				72000	99000	56.3	C-P			
		M1335	MUZZLE	77000	99400	61.0	C-P			
				74500	95500	69.5	C-P			
5	1650	B1325	BREECH	75500	101700	56.1	CP LC	SATIS.	112000	116000
				75000	100000	58.1	C-P-LC			
		M1335	MUZZLE	76500	98200	65.0	C-P			
				77500	98200	66.9	C-P			
75	1650	B1320	BREECH	73500	98400	53.2	C-P	SATIS.	108500	11900
				72500	96800	54.8	C-P			
		M1330	MUZZLE	77000	98700	65.7	C-P			
				71000	94800	65.0	C-P			
75	1650	B1320	BREECH	70000	94600	55.9	C-P-GC	SATIS	103500	1160
				69000	94400	54.8	C-P-GC			
		M1330	MUZZLE	74000	95200	52.1	C-P-GC			
				76000	96000	52.9	C-P-GC			
75	1650	B1325	BREECH	73500	99000	56.7	C-P	SATIS	110000	1160
				74000	98500	57.6	C-P			
		M1335	MUZZLE	74000	99300	56.7	C-P			
				73000	98100	63.4	C-P			

PLACING THE NORMALIZING TREATMENT

PROPERTIES								
R.A. %	FRACTURE	MACRO ETCH	CALC P.S.I.	ACTUAL P.S.I.	PROOF TESTING MAX FORG PRESS PSI	BEHAVIOR	DISPOSITION
45.0 MIN.					38000 PT		
61.0	C-P	SATIS.	107500	116000	44400	NORMAL	ACCEPT FOR FIELD SERVICE
59.9	C-P						
63.0	C-P						
59.9	C-P						
62.0	C-P	SATIS.	106300	118000	45300	NORMAL	A. F. S.
56.3	C-P						
61.0	C-P						
69.5	C-P						
56.1	CP LC	SATIS.	112000	116000	45600	NORMAL	A F S
58.1	C-P-LC						
65.0	C-P						
68.9	C-P						
53.2	C-P	SATIS.	ICE500	119000	44200	NORMAL	A. F. S.
54.8	C-P						
65.7	C-P						
65.0	C-P						
55.9	C-P-GC	SATIS	103500	116000	44500	NORMAL	A. F. S.
54.8	C-P-GC						
52.1	C-P-GC						
52.9	C-P-GC						
56.7	C-P	SATIS	110000	116000	44100	NORMAL	A. F. S.
57.0	C-P						
56.7	C-P						
63.4	C-P						

3G 191	7032	.27	.88	.38	.73	.44	.07	NONE	1675	1650	B132
											M1335
3K 155	7033	.27	.83	.40	.71	.46	.07	NONE	1675	1650	B1320
											M1330
3T 187	7034	.27	[illegible]	.34	.83	.49	.08	NONE	1675	1650	B1325
											M1325
3U 172	7035	.26	.76	.40	.83	.45	.09	NONE	1675	1650	B1320
											M1330
3G 177	7036	.27	.82	.37	.81	.47	.08	NONE	1675	1650	B1325
											M1325
3K 187	7037	.26	.82	.41	.77	.51	.08	NONE	1675	1650	B1320
											M1330
3K 189	7038	.26	.81	.41	.72	.41	.08	NONE	1675	1650	B1320
											M1320
3K 183	7039	.27	.81	.45	.70	.46	.09	NONE	1675	1650	B1320
											M1320

	M1330	MUZZLE	74000	95200	52.1	C-P-GC		
			76000	96000	52.9	C-P-GC		
650	B1325	BREECH	73500	99000	56.7	C-P	SATIS	110000 116000
			74000	98500	57.4	C-P		
	M1335	MUZZLE	74000	99300	56.7	C-P		
			72000	93900	67.4	C P		
650	B1320	BREECH	75500	95200	51.0	I-B-P-GC	SATIS	112100 119000
			75000	97600	57.0	C P		
	M1330	MUZZLE	75500	97300	65.0	C P		
			74000	98000	62.0	C P		
650	B1325	BREECH	74000	96000	56.7	C-P-GC	SATIS	110500 116000
			76000	96000	57.4	C-P-GC		
	M1335	MUZZLE	74000	97000	62.7	C-P		
			76000	98000	65.0	C-P		
650	B1320	BREECH	70000	97500	56.3	C-P-SGC	SATIS	105000 116000
			71000	98000	59.2	C-P-SGC		
	M1330	MUZZLE	73500	97000	56.7	C-P-SGC		
			75000	97000	65.7	C-P-C		
650	B1325	BREECH	72500	97000	57.4	C-P	SATIS	108500 116000
			73500	96200	53.3	C-P		
	M1335	MUZZLE	72500	97000	63.7	C-P		
			70000	97000	61.7	C-P		
1650	B1320	BREECH	73500	95000	56.7	C-P	SATIS	110500 116000
			75000	97000	57.4	C-P		
	M1330	MUZZLE	76500	98000	63.7	C-P		
			74000	97000	61.0	C-P		
1650	B1320	BREECH	7500	9.000	62.0	C-P	SATIS	112500 116000
			7000	96400	60.4	C-P		
	M1330	MUZZLE	7650	9520	68.0	C-P		
			7200	94200	67.6	C-P		
650	B1320	BREECH	74000	95000	51.4	I-B-P-GC	SATIS	110000 119000

54.5	C-P-GC					
52.1	C-P-GC					
52.9	C-P-GC					
56.7	C-P	SATIS	110000	116000	44100	NORMAL
51.0	C-P					
56.7	C-P					
67.4	C P					
51.0	IrBr-P-GC	SATIS	112100	119000	44700	NORMAL
57.0	CP					
65.0	CP					
62.0	CP					
[illegible]	[illegible] LC	SATIS	110500	116000	45100	NORMAL
54	[illegible] P LC					
62.7	C P					
65.[illegible]	[illegible] P					
56.3	C-P-GC	SATIS	105000	116000	44400	NORMAL
50.2	C-P-GC					
[illegible]	C-P-GC					
45.7	C-P-GC					
57.4	C-P	SATIS	103500	116000	45100	NORMAL
53.3	C-P					
62.7	C-P					
61.7	C-P					
56.7	C-P	SATIS	110500	111000	44700	NORMAL
57.4	C-P					
63.7	C-P					
64.0	C-P					
62.0	C-P	SATIS	112500	116000	47600	NORMAL
60.[illegible]	C-P					
69.0	C-P					
67.6	C-P					
[illegible]	[illegible] P GC	SATIS	110000	119000	45400	NORMAL

A.F.S.

A.F.S.

A.F.S

A F.S.

A.F.S.

A.F.S

A.F.S.

A F S.

EK 175	7031	.27	.81	.45	.10	.46	.09	NONE	1675	1650	B132
										M13
3U 176	7010	.26	.73	.35	.89	.41	.07	NONE	1675	1650	B132
										M133
3T 183	1041	.25	.78	.35	.90	.46	.01	NONE	1675	1650	B132
										M133
3S 175	7042	.27	.80	.38	.00	.47	.075	NONE	1675	1650	B132
										M133
3T 184	1043	.27	.81	.35	.90	.46	.09	NONE	1675	1650	B132
										M133

* ALL TESTS TAKEN IN THE TRA
** STANDARD PRESSURE.
*** BREECH 65000/81000, MUZZLE

Y.S. YIELD STRENGTH
(.01% OFFSET METHOD.)
T.S. TENSILE STRENGTH.

R.A. REDUCTION IN AREA

7

P.S.I. PO

0	MUZZLE	76500	95200	68.0	C-P				
		72000	94200	67.6	C-P				
0	BREECH	74000	95000	51.4	Ir.Br.P.GC	SATIS	110000	119000	45600
		73500	97500	60.6	C-P				
0	MUZZLE	7450	92500	6.0	C-P				
		7150	100500	61.3	C-P				
0	BREECH	70000	94000	56.3	C.P.S.GC	SATIS	105500	116000	45000
		72000	96000	58.6	C.P.S.GC				
0	MUZZLE	77000	101000	54.1	C.P. GC				
		72500	98000	59.6	C.P.S.GC				
0	BREECH	69000	97500	58.9	C.P.S.GC	SATIS	101500	113000	45000
		67500	97500	56.7	C.P.S.GC				
0	MUZZLE	68000	91500	70.1	C-P				
		70500	94000	66.0	C-P				
2.5	BREECH	73000	101500	57.8	C-P	SATIS	113000	115000	45800
		75500	101500	59.9	C-P				
5	MUZZLE	70000	97500	65.7	C-P				
		70000	101000	62.0	C-P				
325	BREECH	72000	97500	60.3	C-P	SATIS.	108000	116000	45800
		73000	98300	61.7	C-P				
35	MUZZLE	72000	92300	70.7	C-P				
		74000	94800	68.9	C-P				

ANSVERSE DIRECTION.

LE 60000/95000 — MAX. ALLOWABLE DIFFERENCE B & M — 15000 P.S.I.

C CUPPED GC G

P PITTED SGC S

Ir Br IRREGULAR BREAK LC L

OUNDS PER SQUARE INCH

	69.0	C-P					
	67.6	C-P					
	51.4	I.E.P.GC	SATIS	110000	119000	45600 NORMAL	A. F. S.
	60.6	C-P					
	[illegible]	C-P					
	61.2	C P					
	5[illegible]	C.P.SGC	SATIS	105500	116000	45000 NORMAL	A. F. S.
	5[illegible]	[illegible]					
	54.1	CP, SC					
	59.6	CP, SC					
	58.9	CP.SC	SATIS	101500	113000	45000 NORMAL	A. F. S.
	56.7	CP.SC					
	70.1	C-P					
	66.0	C-P					
	57.8	C-P	SATIS	113000	115000	45800 NORMAL	A. F. S.
	59.9	C-P					
	65.7	C-P					
	62.0	C-P					
	60.3	C-P	SATIS.	108000	116000	45800 NORMAL	A. F. S.
	61.7	C-P					
	70.7	C-P					
	68.9	C-P					

C.NABLE DIFFERENCE B&M – 15000 P.S.I.

GC GAS CAVITIES

SGC SMALL GAS CAVITIES

LC LUSTROUS CAVITIES.

EAK

UARE INCH