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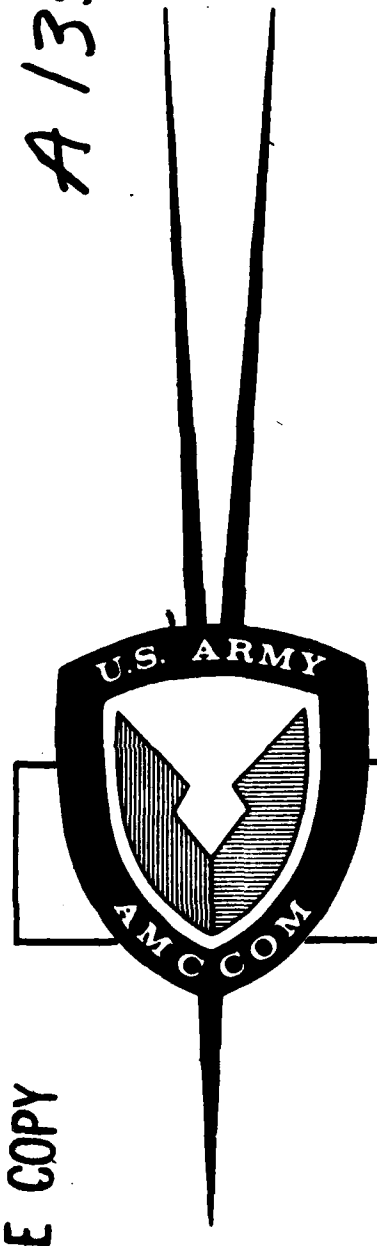
INJECTION MOLDING OF RUBBER OBTURATOR PADS

FRANK TESTROET

AUGUST 1982



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2. Obturator Pad, 155mm
3. Neoprene Rubber

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this effort was to reduce production costs for fabricating 155mm rubber obturator pads by using the injection molding process. A neoprene rubber compound specified for molding 155mm rubber obturator pads was tested to determine its processability using the injection molding technique. This compound was shown to be compatible with the injection molding process and an injection mold was fabricated for molding 155mm obturator pads. The 155mm rubber obturator pad can be vulcanized in 8 minutes by injection molding as

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20. ABSTRACT (cont)

compared to 2 hours for compression molded pads. Injection molded pads met the dimensional requirements of Drawing No 11578862 and were successfully test fired in the M109 Self Propelled Howitzer and the M198 Howitzer.

FOREWORD

This work was authorized as part of the Manufacturing Methods and Technology Program of the US Army Materiel Development and Readiness Command and was administered by the US Army Industrial Base Engineering Activity.

TABLE OF CONTENTS

INTRODUCTION

The purpose of this effort was to reduce production costs for fabricating rubber obturator pads for 155mm weapon systems by use of the injection molding technique. This technique is a continuous high temperature process that is capable of increasing production output and lowering manufacturing costs because of reduced stock preparation time, no physical handling of molds, shorter cure times and lower finishing costs.

Rock Island Arsenal (RIA) has been manufacturing rubber obturator pads by conventional compression molding for over 20 years. Compression molding of obturator pads involves milling the mixed stock to slab form, extruding the rubber, accurately weighing the rubber, and forming the rubber into preforms in the form of a donut. The preform is then loaded into a hot mold and manually placed onto a steam heated platen of a hydraulic press. Pressure is applied to close the mold for final forming and excess rubber is forced out of the mold as flash during the curing process. For thick items such as obturator pads, lengthy cure times are required because of the low thermal conductivity of rubber. Compression molding time of 2 hours is specified for 155mm obturator pads.

When using the compression molding process, only 3 molds can be used simultaneously at RIA; consequently, production is limited to 12 pads per 8-hour shift.

Conversely, the injection molding process requires no weighing or preform preparation. In this process, extruded rubber is fed directly into the heated injection cylinder where it is preheated and then forced through runners and gates where additional heat is generated by friction prior to entry into a preheated closed mold. A much shorter cure time is required because all of the rubber is at an elevated temperature when it enters the mold. In addition, virtually no flash is produced. Some items, depending on their volume and configuration, can be cured in three minutes or less.

The ram-type injection molding technique has been used at RIA for the production of barrier bags for 152mm caseless ammunition, various shaped bellows, grommets, retaining straps, gaskets and numerous other items. However, none of these items have the bulk or the rigid dimensional requirements of the 155mm obturator pad. The configuration and dimensional requirements of the obturator pad are shown on Drawing No 11578862, "Pad", in Figure 1.

PROCEDURE

A neoprene compound for all 155mm obturator pads, as specified by Drawing No 11578862, "Pad", in Figure 1 was used throughout this study. This compound was developed specifically for fabricating obturator pads and could not be altered by the addition of processing aids or other compounding ingredients that would enhance flow of the rubber during injection molding. A Banbury internal mixer, size No. 1, was used to mix the neoprene compound.

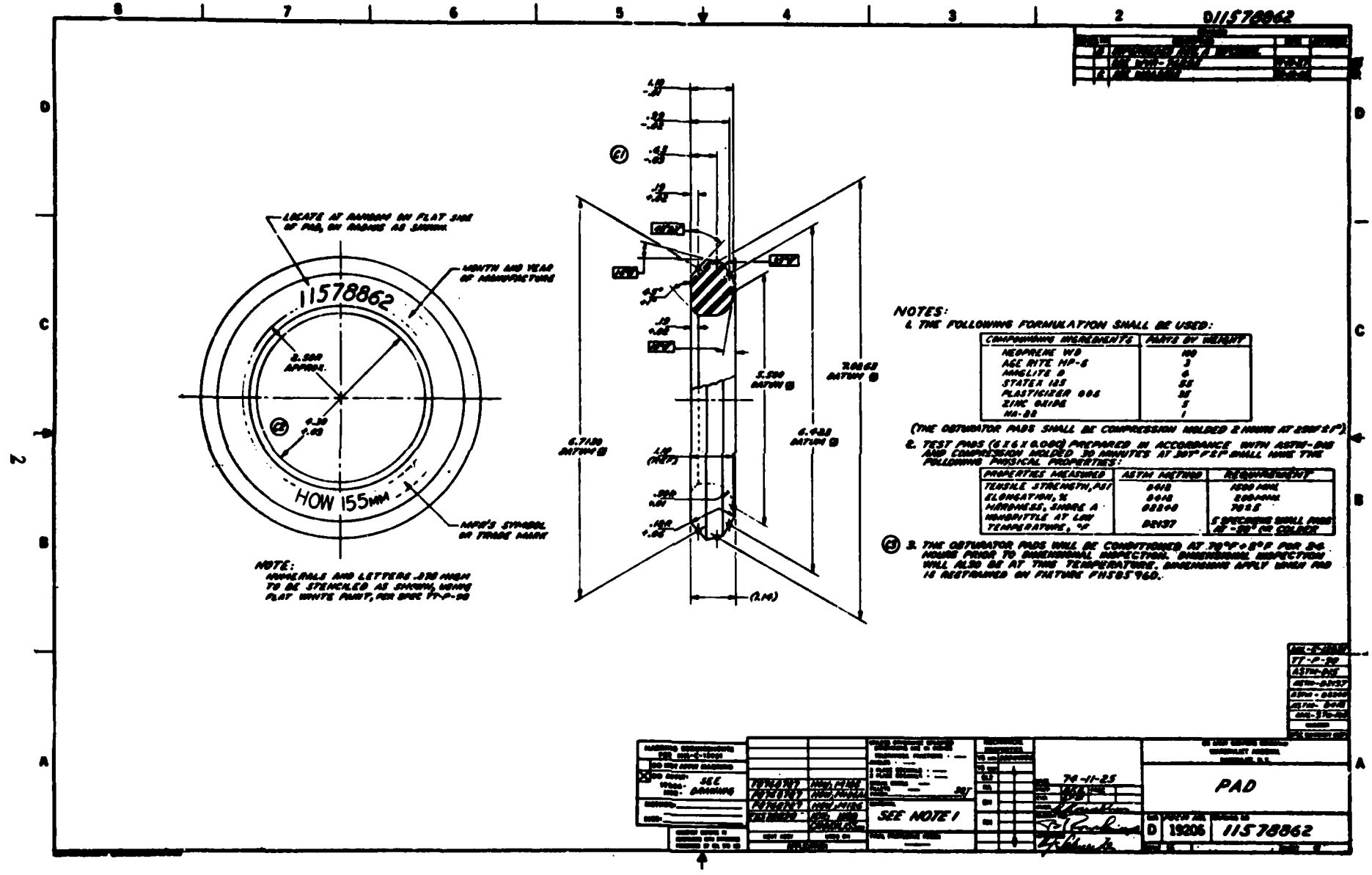

FIGURE 1. DIMENSIONS AND RUBBER FORMULATIONS FOR 155mm OBTURATOR PAD

Molding was performed with the Lewis ram-type vertical injection molding machine, shown in Figure 2. This machine is a Model 200V-Ram that has a filling capacity of 48 ounces, a 200 ton clamping capacity, a 2.5" diameter ram, and an effective plunger displacement of 65.4 cubic inches per shot. The machine is controlled with limit switches, timing relays and hydraulic valves. Valves, pressure and temperature regulators were operated manually to adjust injection temperature, pressure and speed. Mold temperature and clamping times were also varied to find the best conditions for injecting and curing the rubber.

Initial trials were conducted using an on-hand T142 track pad mold and a filler ring mold, PN 8427067, to observe whether the rubber would flow well enough to be successfully injection molded in thick and circular sections.

A three-plate injection mold 15.245" x 15.245" with a stack height of 4.375" was fabricated with a two-runner system with two gates and two vents to produce obturator pads within dimensional tolerances cited on the aforementioned drawing. Initially, gates and vents measured 0.125" in diameter and operating parameters such as cylinder temperature, mold temperature, dwell time, injection time and pressure were varied in an attempt to produce physical properties which meet drawing requirements and equal or exceed the performance of pads that are compression molded 2 hours at 290°F.

Test pads measuring 6" x 6" x 0.075" were compression molded 30 minutes at 307°F for purposes of quality control.

The injection mold was later modified from a two-runner to a four-runner system to allow for a more even distribution of the rubber during injection of the rubber. The gates and vents of the two-runner system measured 0.125" in diameter and were alternated equidistantly on the flat surface of the mold. Final retooling of the mold reduced the vent size to 0.0625" in diameter.

Obturator pads were checked for dimensional accuracy on an optical comparator using instructions for optical chart 11585963 which is used for quality assurance inspection of compression molded obturator pads. Physical properties of the injection molded obturator pads were measured from slices taken from the periphery of the pads.

Additional pads were sent to Watervliet Arsenal for similar optical inspection. These pads were then sent to Aberdeen Proving Grounds (APG) for test firing.

RESULTS AND DISCUSSION

Track pads, T142, were injection molded with a mold temperature of 350°F and injection pressure of 1000 psi while cylinder temperature, injection time and dwell time shown in Table I varied.

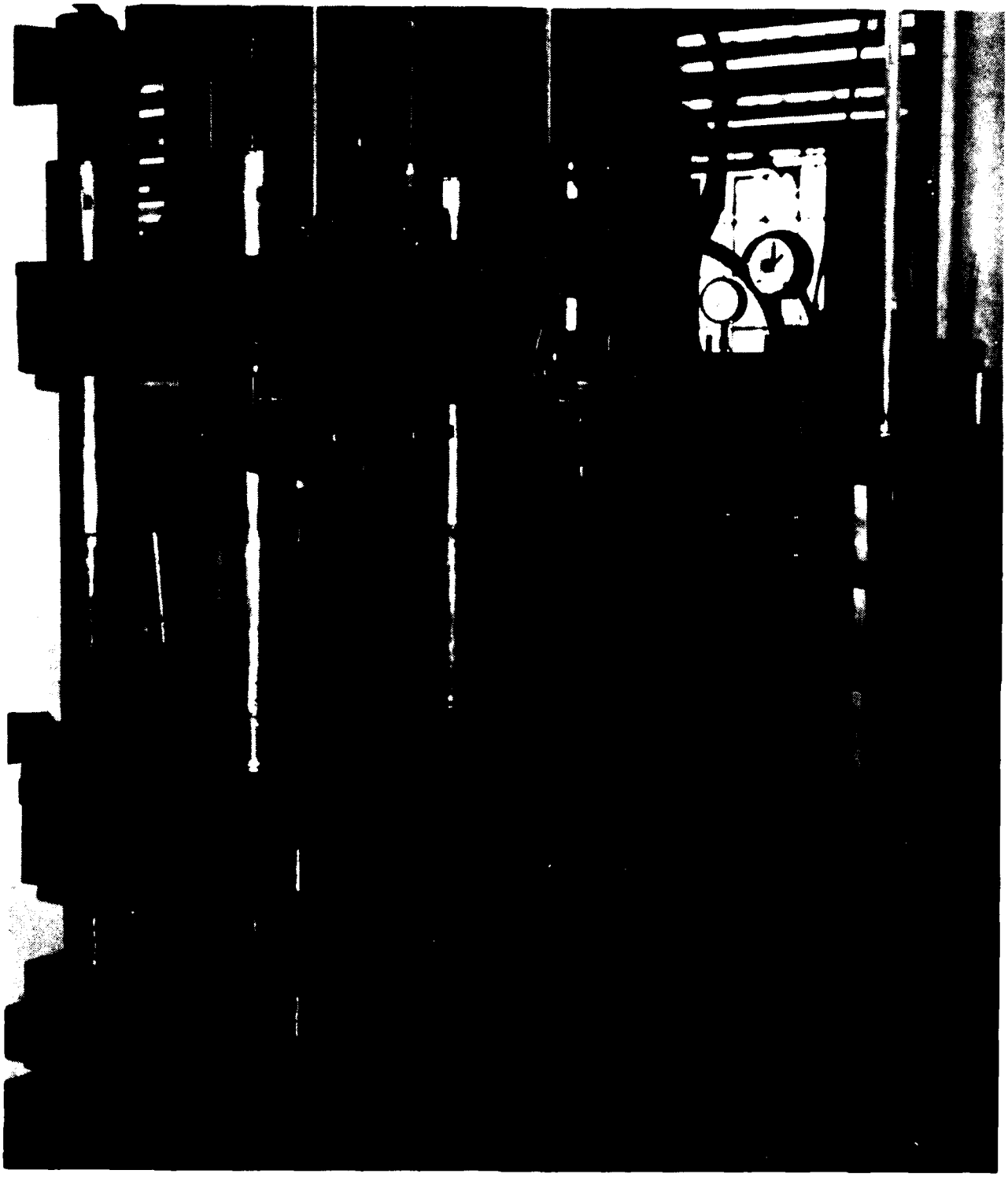

FIGURE 2. VERTICAL RAM-TYPE
INJECTION MOLDING MACHINE

TABLE I

TIME AND TEMPERATURE PARAMETERS
FOR INJECTION MOLDING TRACK PADS

Pad No.	Cylinder Temp., °F	Injection Time, Sec.	Dwell Time, Min.
1	150	48	5
2	150	48	10
3	150	48	15
4	180	60	10
5	200	60	10

The rubber flowed well for all of the pads but started to prec : at a cylinder temperature of 200°F. Test specimens were cut from the t : pads numbered two and four, and the physical properties shown in Table were measured.

TABLE II

PHYSICAL PROPERTIES OF INJECTION MOLDED TRACK PADS

Property Measured	Pad No. 2	Pad No. 4	Drawing No. 11578862 Requirement
Tensile Strength, psi	2280	2360	1500 Min.
Modulus @ 100%E, psi	770	710	none
Elongation, %	250	260	200 Min.
Hardness, Shore A	69	67	70 ± 5

These stress strain properties indicate that the rubber was properly cured throughout the 1.5" thickness of the pads within 10 minutes.

The filler rings, PN 8427067, which measure 5.754" in O.D. and 0.430" thick were injection molded with a cylinder temperature of 140°F, injection pressure of 1000 psi, injection time of 30 seconds, dwell times of 2.5 and 3 minutes and with mold temperature of 350°F. Physical properties of an injection molded filler ring that was cured 2.5 minutes at 350°F are given in Table III.

TABLE III

PHYSICAL PROPERTIES OF INJECTION MOLDED FILLER

Property Measured	Result
Tensile Strength, psi	2270
Elongation, %	250
Hardness, Shore A	69

Conformance to drawing tolerances was confirmed by measurement with a micrometer and caliper. Thus, the feasibility of injection molding of thick sectioned and round items using the specified compound was demonstrated. Based on these results, the two-runner system injection mold was subsequently fabricated.

The injection mold was then placed in the Lewis injection press and obturator pads were molded to test the mold. Injection cylinder temperature was set at 150°F, as it was shown earlier that the rubber stock was precuring in the cylinder at 200°F. Mold temperature of 320°F with injection time ranging from 15 to 36 seconds and injection pressure of 1500 psi with a cure time of 3, 5 and 7 minutes were selected for initial test. Injection times of 15 and 20 seconds were not long enough to fill the mold, but 24, 30 or 36 seconds were sufficient. Rubber was observed to flow well during the injection cycle; however, the obturator pads were out of round. The pads were determined to be undersize on the O.D. dimension in the area of the vents. Increasing injection temperature to 175°F and injection pressure to 2000 psi failed to alleviate the problem. The 0.125" diameter vents allowed excessive pressure drop and uneven filling of the mold between gates and vents during the cure time which resulted in pads that were undersize at the vents.

Two additional runners were added to the mold producing a four-runner system with four gates and four vents, each measuring 0.125" in diameter, alternating equidistantly around the mold.

Preliminary attempts to injection mold obturator pads were made using 24 seconds injection time with cylinder temperature at 130°F, injection pressure of 1700 psi and mold time of 8 minutes at 330°F. Again it was shown that the O.D. dimensions in the area of the vents were undersize in the vent area, producing pads that were not truly round. Dimensions of the pads were measured on an optical comparator at the 7.0263" datum line of Drawing 11578862.

The four-runner system allowed good loading and retention of the rubber in the area of the gates, but pressure drop-off at the vents permitted the rubber to shrink back from the vents during curing of the rubber, causing the undersize radius dimensions in that area. Therefore, the vents were reduced to 0.0625" and injection molding parameters were examined in an

effort to mold dimensionally stable obturator pads. The final parameters selected for injection molding obturator pads were an injection cylinder temperature of 160°F, an injection time of 30 seconds at 1800 psi injection pressure, and a cure time of 8 minutes at 320°F. These conditions proved to be the optimum ones for producing obturator pads that displayed the required dimensions. Typical measurements at the four gates and four vents are provided in Table IV. Variance of the radius is indicated by these measurements.

TABLE IV

TYPICAL MEASURED VARIANCE OF 7.0263 INCHES DATUM DIAMETER INJECTION MOLDED OBTURATOR PAD

Position	Gate/Vent	Specified Datum Diameter (Inches)	Molded Using Preliminary Parameters		Molded Using Final Parameters	
			Measured Datum Diameter (Inches)	Variance of Radius Dimension (Inches)	Measured Datum Diameter (Inches)	Variance of Radius Dimension (Inches)
#1	Gate	7.0263	7.0263	0.000	7.0263	0.000
#2	Vent	7.0263	7.0133	-0.013	7.0263	0.000
#3	Gate	7.0263	7.0263	0.000	7.0263	0.000
#4	Vent	7.0263	7.0153	-0.011	7.0263	0.000
#5	Gate	7.0263	7.0263	0.000	7.0263	0.000
#6	Vent	7.0263	7.0173	-0.009	7.0263	0.000
#7	Gate	7.0263	7.0263	0.000	7.0263	0.000
#8	Vent	7.0263	7.0163	-0.010	7.0263	0.000

The physical properties given in Table V were obtained with specimens cut from injection and compression molded obturator pads and a standard ASTM compression molded test pad for comparison with drawing requirements.

TABLE V

PHYSICAL PROPE. 'ES OF
INJECTION AND COMPRESSION MOLDED PADS

Property Measured	Injection Molded Obturator Pad	Compression Molded Obturator Pad	Compression Molded Test Pad	Requirements of Dwg.No.11578863
Tensile strength, psi	2250	2100	2200	1500 Min
Modulus @ 100%E, psi	530	480	630	-
Elongation, %	250	210	220	200 Min
Hardness, Shore A	69	67	68	70 $\pm$ 5
Brittleness at low Temperature	Pass	Pass	Pass	5 specimens shall pass @-50°F or colder

To illustrate the sequence of operations for producing injection molded obturator pads, the injection mold in the open position is shown in Figure 3. Figure 4 shows the closed mold during curing of the rubber and Figure 5 shows the cured obturator pad being removed from the mold.

A series of twelve obturator pads were subsequently fabricated, using the same conditions, i.e., 160°F injection cylinder temperature, 30 seconds injection time with 1800 psi injection pressure and an 8 minute cure time at 320°F. Three of these twelve pads were inspected by the RIA Quality Assurance Directorate, SMCRI-QAO-P, using optical inspection procedures per Drawing No 11578862. All three pads met the drawing requirements. Two of these three pads marked 7A and 12B were sent to Watervliet Arsenal for inspection. Both pads conformed to specifications as listed in the Watervliet Arsenal Inspection Activity Sheet shown in Table VI. These pads were then forwarded to Aberdeen Proving Ground for live firing tests.

Obturator pad 12B was installed in a M109 Self Propelled Howitzer. Sixty-five rounds were fired using zone 8 charges without any problems. This pad was reported to be in "fine" condition after 65 rounds had been fired.

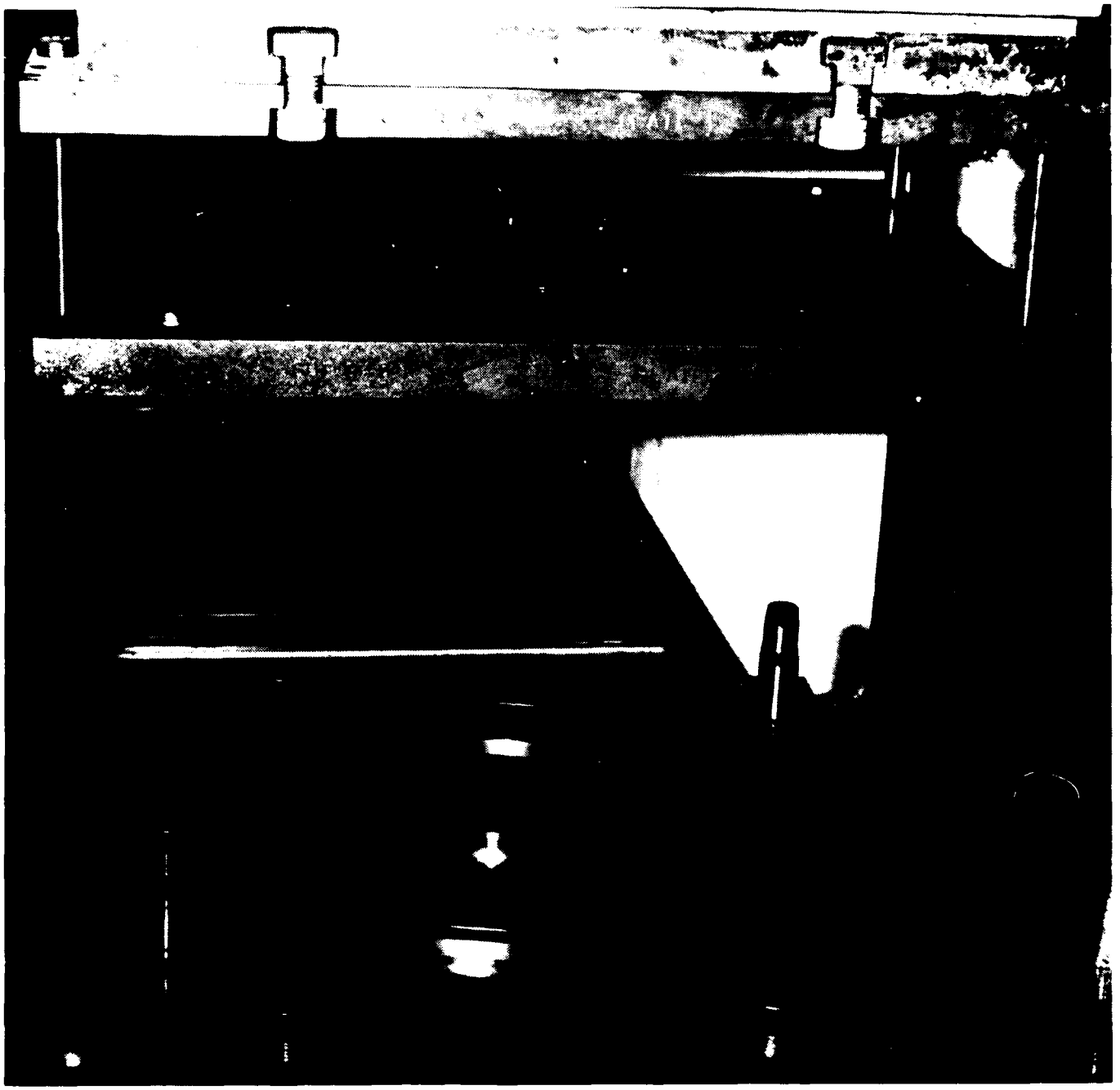

FIGURE 3. INJECTION MOLD FOR 155mm
OBTURATOR PAD (OPEN POSITION)

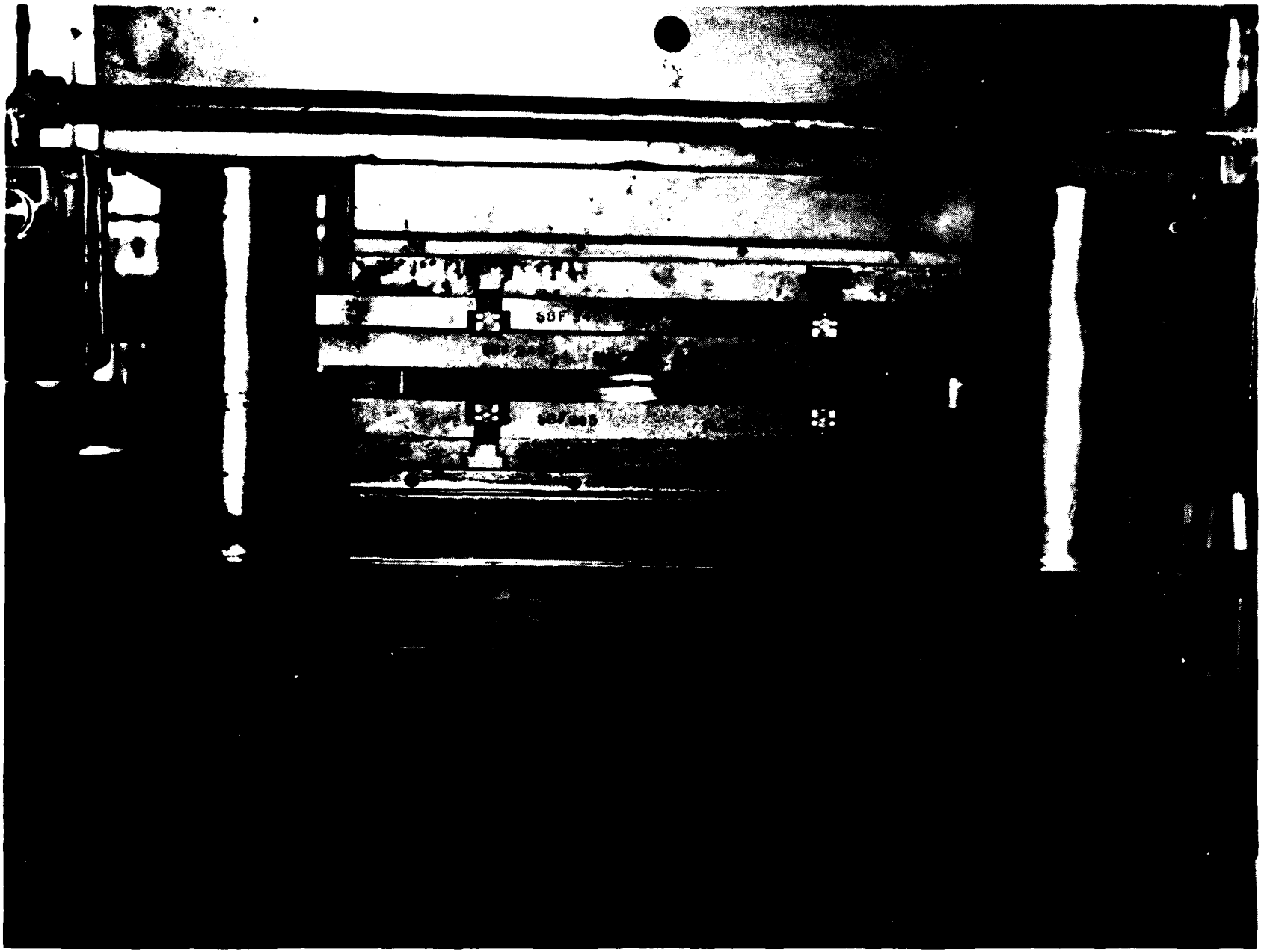

FIGURE 4. INJECTION MOLD FOR 155mm
OBTURATOR PAD (CLOSED POSITION)

FIGURE 5. REMOVAL OF OBTURATOR PAD
FROM THE INJECTION MOLD

TABLE VI

OBTURATOR PAD INSPECTION REPORT

INSPECTION ACTIVITY SHEET

DATE	MANUFACTURER	O.O.	DWG. NO. 11578862 REV. E	WEAPON	COMPONENT
12/16/81	WVT. ARSENAL	027047	SOAP NO. DATED	155mm M185	PAD

TOTALS OF COMPONENT TO DATE: PART NO. 7A AND 12B

LOT DETAIL: RECEIVED FROM ROCK ISLAND

RECEIVED ACCEPTED CONTRACT NO. 2 SIZE 2 RANGE

SINGLE-DOUBLE-MULTIPLE ——TYPE OF INSPECTION—— LEVEL I, II, III, _____

TIGHT NORMAL REDUCED REWORK SPARES G.P.

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2				.99 -.02	.968	.972
3				.63 -03	.604	.615
4				19 +02	.181	
5				[43°22']	—	[43°22] —
6				[33°0']	—	[33°0'] —
7				7.0263 DATUM	—	7.0263 Ø —
8				5.5 DATUM	—	5.5 Ø —
9				6.423 DATUM	—	6.423 Ø —
10				.12R +06	.12R	.125R
11				SQR +01	.50R	.50R
12				6.713Ø DATUM	—	6.713Ø —
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14				.19 +.02	.19	.20
15				45° +1°	45°	45°
16				[14°0']		[14°0']

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Obturator pad 7A was installed in a M198 Howitzer. Subsequently, 430 rounds were test fired using zone 8 charges. The pad was found to be in normal condition as compared to a compression molded pad. Additional rounds could have been fired using either pad since they were removed from the Howitzers only because of culmination of other testing.

CONCLUSIONS

The neoprene compound specified by Drawing No 11578862 can be successfully injection molded to form thick sectioned, multifaced rubber items with very tight dimensional tolerances.

Stress-Strain properties are equivalent to or better than those of compression molded specimens.

Injection molded 155mm obturator pads can function satisfactorily as indicated by the firing test at APG.

Molding time of obturator pads was substantially reduced using the injection molding technique. Forty-eight obturator pads can be injection molded as compared to 12 compression molded pads during an eight-hour shift.

RECOMMENDATION

It is recommended that:

a. 155mm obturator pads be injection molded.

b. The injection molding process be considered for other thick sectioned rubber items, especially for high volume orders.

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by Frank Testroet

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INJECTION MOLDING OF RUBBER OBTURATOR PADS,
by Frank Testroet

Report EN-82

The purpose of this effort was to reduce production costs for fabricating 155mm rubber obturator pads by using the injection molding process. A neoprene rubber compound specified for molding 155mm rubber obturator pads was tested to determine its processability using the injection molding technique. This compound was shown to be compatible with the injection molding process and an injection mold was fabricated for molding 155mm obturator pads. The 155mm rubber obturator pad can be vulcanized in 8 minutes by injection molding as compared to 2 hours for compression molded pads. Injection molded pads met the dimensional requirements of Drawing No 11578862 and were successfully test fired in the M109 Self Propelled Howitzer and the M198 Howitzer.

UNCLASSIFIED

1. Injection Molding
2. Obturator Pad, 155mm
3. Neoprene Rubber

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