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ASROC ROCKET MOTOR MARK 37 MOD 0 OVERVIEW

David Hernandez

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WEAPONS ENGINEERING DEPARTMENT

Indian Head Special Publication 97-416

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Indian Head Division
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FOREWORD

This report provides a description of the Asroc Rocket Motor Mk 37 Mod 0 and a general overview of its surveillance performance history, safety, and disposal options. This document shall be used for information purposes only.

Approved by:

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1.0 DESCRIPTION

1.1 Rocket Motor Mk 37 Mod 0

The Rocket Motor Mk 37 Mod 0 is the propulsion system on the Asroc missile (Figure 1). The rocket motor (Figure 2), drawing No. 1984043, consists of a cylindrically welded steel chamber containing two configurations of N-5 double-base, solventless extruded propellant (Figure 3). The two configurations are known as the shell and cruciform grains. Additionally, the rocket motor has a "thrust neutralizer." This is a metal disk attached to the motor nozzle plate by a self-locking nut. It is removed when the missile is placed in the launcher. In case of inadvertent ignition, this disk prevents the missile from thrusting forward. The rocket motor is packed for shipping and storage into a Mk 178 metal container (Figure 4). The motor's Igniter Mk 287 Mod 0 is stored and shipped separately from the motor. It is only installed for motor static firing or missile assembly.

1.2 Physical Characteristics

The physical characteristics of the rocket motor are given below.

Length (including thrust neutralizer) .... 58.451 in
Diameter
  Forward end .... 11.650 in
  Aft end .... 12.010 in
Center of gravity loaded .... 30.800 in
Weight
  Propellant (total average weight) .... 235 lb
  Shell grain propellant average weight .... 150 lb
  Cruciform grain propellant average weight .... 85 lb
  Inert weight .... 140 lb
Propellant
  Designation N-5
  Composition .... 50% nitrocellulose, 34.9% nitroglycerin
  Flame temperature at P_c = 1,000 psig isobaric .... 3,565 °F
  Nominal dimensions (inhibited grain):

Dimension	Shell	Cruciform
Length (in)	50.374	50.374
Diameter (in)	11.316	6.815
Web thickness (in)	1.700	Rib, 2.800; center hole, 0.880

Exhaust gas composition at 1,200 psia and 3,501 °F (mol%) = CO_2, 8.27; CO, 45.78; H_2O,17.36; H_2, 17.73; N_2, 10.83; H, 0.03.

Case
- Material (steel) .... MIL-S-18729, AISI 4130 or 4135
- Outside diameter .... 11.650 in
- Length (without thrust neutralizer) .... 56.375 in
- Thickness .... 0.200 in

Nozzle
- Material (steel-cadmium plated) .... AISI 1010–1020

1.3 Manufacturing Levels

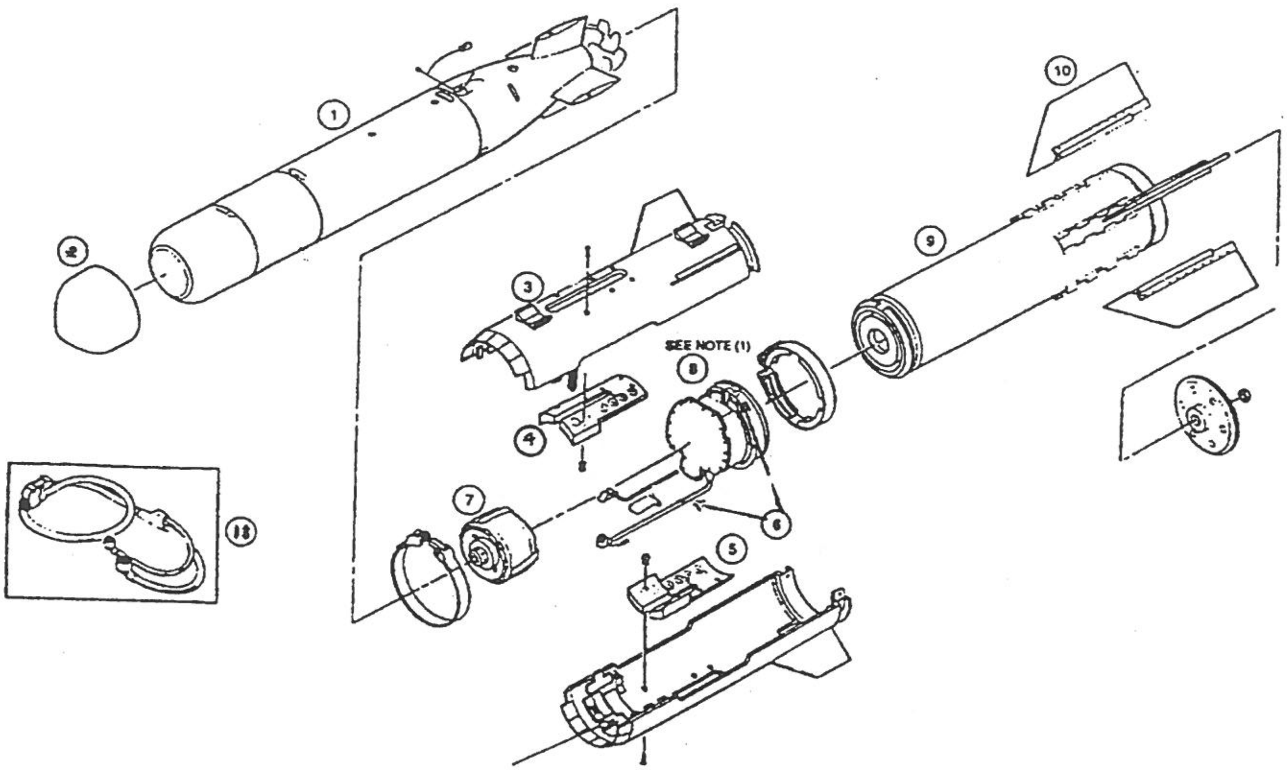
There are three levels at which the rocket motor is manufactured:

a. *New*—Both the inert hardware and propellant grains are new. An initial service life of 10 years is assigned to the rocket motor. The 10-year service life has been established and validated with over 33 years of surveillance data (Appendix A) and type life testing[1] conducted on the rocket motors.

b. *Regrain*—The propellant grain is removed from the motor and burned. A new propellant grain is loaded into the original motor metal chamber. Some of the original metal parts are reused (metal parts may be refurbished). The service life of the rocket motor with the new grain is 10 years.

c. *Rework*—The shell and cruciform propellant grains of the overage rocket motor (over 10 years old) are removed. Then they are machined and re-inhibited with ethylcellulose as necessary to meet the drawing length and outside diameter dimensional requirements. This process reinforces the strength of the grain structure at levels similar to the new grain. Also, the new and thicker inhibitor added helps to retard the normal shrinkage of the propellant grain with age. Once reworked, the propellant grain is reloaded into the original rocket motor metal parts. Reworked rocket motors are good for 10 more years. This process is done only once throughout the life of the rocket motor.

   The cut-off date for reworking the propellant grain is 13 years. At this age, the extensive shrinkage in most of the propellant grains and loss of propellant due to the potentially needed additional machining prevent reworking the grains in a reliable, economical, and safe manner.



Part No.	Asroc	Missile designator	RUR-5D-5/W	RUR-5D-NR/EX	RTR-5D-1
	HERO		Yes	Yes	N/A
	Launching system		16	16	
1	Warshot Mk 46 torpedo		1338		
1	Exercise Mk 46 torpedo	NALC		1367	
1	Training Mk 46 torpedo				MW42
2	Nose Cap Mk 8 Mod 2	T183	X	X	X
3	Airframe Mk 8 Mod 0	TA06	X	X	X
4	Counterweight, Upper Mk 46-1	TW11	X	X	X
5	Counterweight, Lower Mk 46-1	TW11	X	X	X
6	Explosive Blocks AFS/TCO	YW21, YW22	X	X	_[a]
7	Air Stabilizer Mk 27 Mod 0	TW07	X	X	_[a]
8	ISA Mk 4 Mod 0	WW77	_[b]	_[b]	_[a]
8	MISA	WW78	X	X	_[a]
8	RASP Mk 9 Mod 1	WW79	X	X	_[a]
9	Rocket Motor Mk 37 Mod 0	T683	X	X	_[a]
10	Fin Assembly Mk 4 Mod 0	TW18	X	X	X
11	Cable Assembly Mk 29 Mod 0	SW92	X	X	X

[a]Inert components.
[b] RASP Mk 9 combined with the MISA becomes the ISA Mk 4, WW77 = WW78 + WW79.

Figure 1. Asroc Missile Configurations, Exploded View

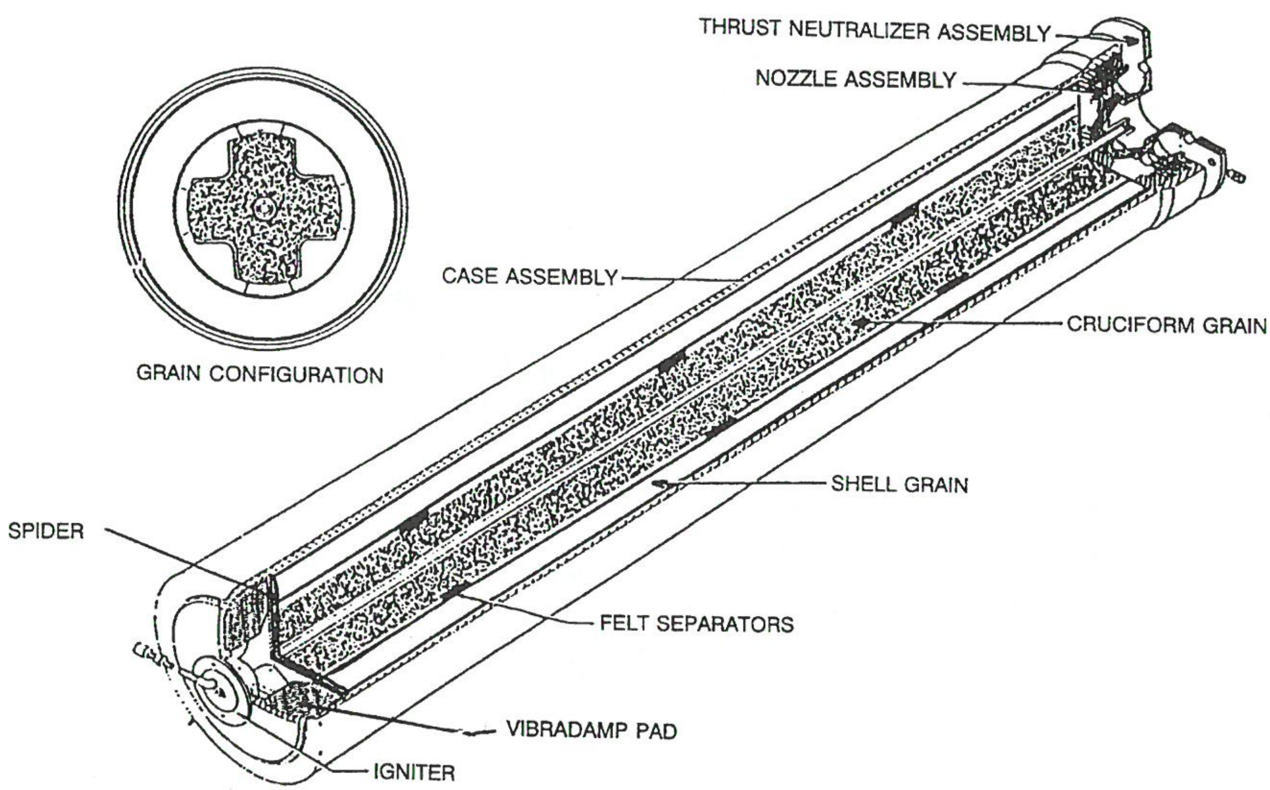


Figure 2. Asroc Mark 37 Mod 0 Parts Breakdown

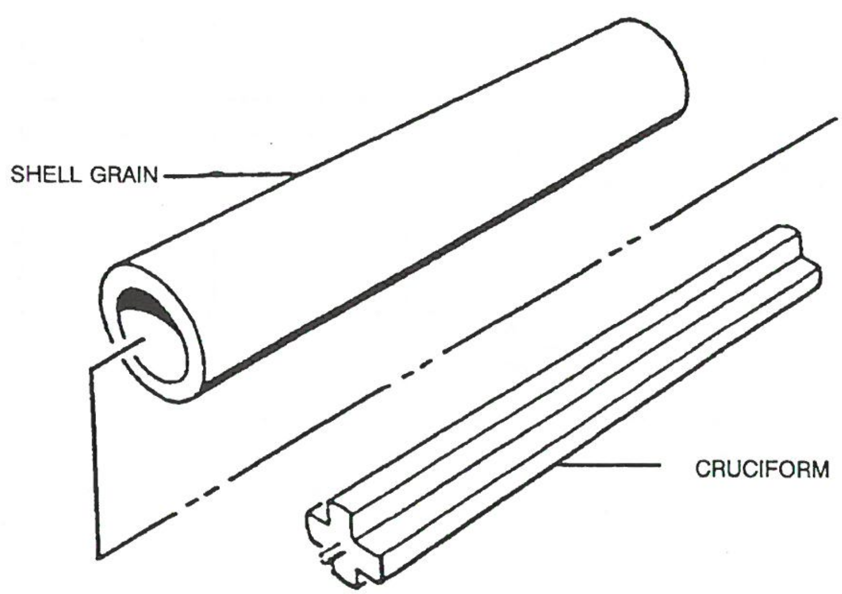
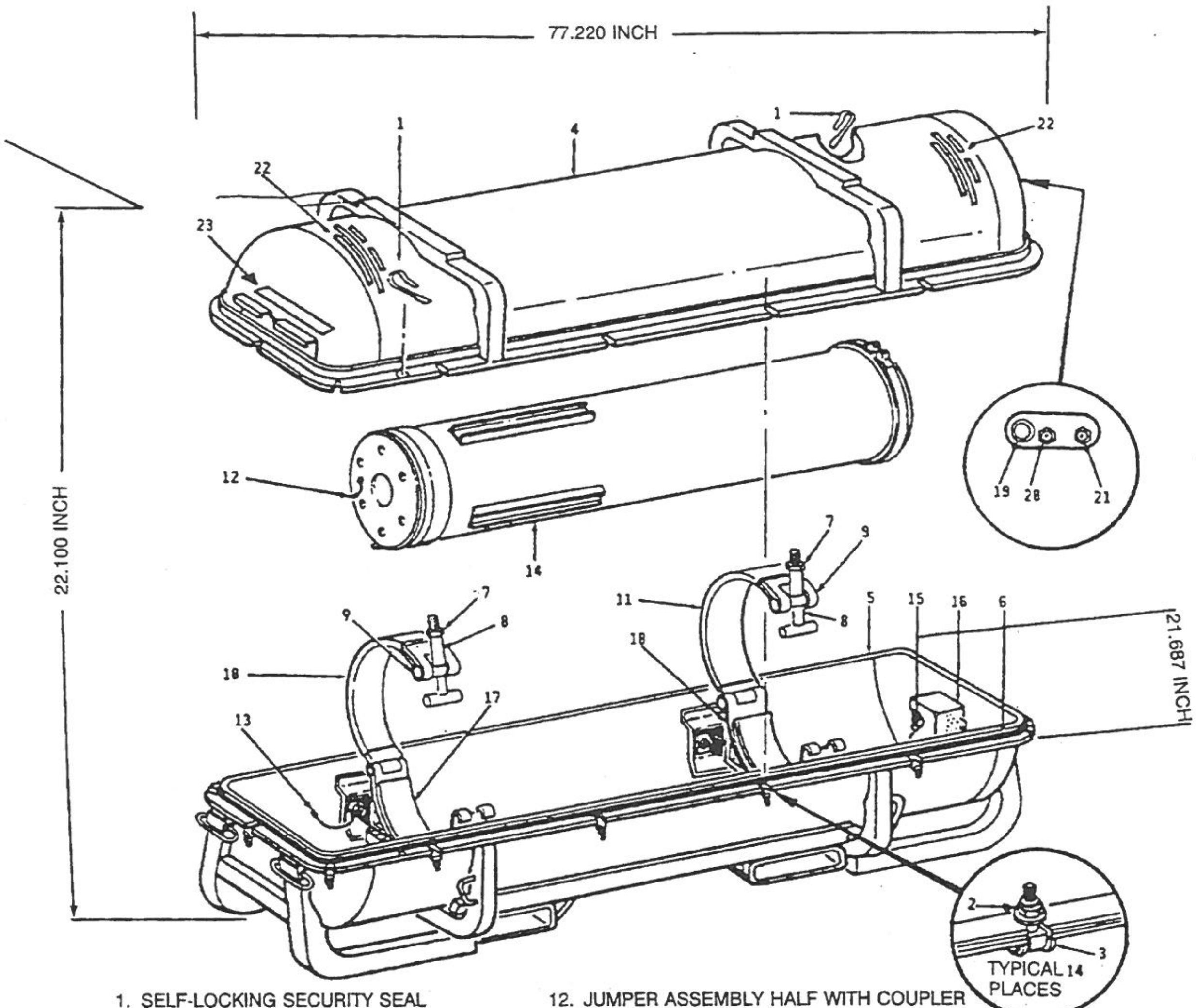


Figure 3. Rocket Motor Extruded Propellant Grain



1. SELF-LOCKING SECURITY SEAL
2. NUT
3. SWING BOLT
4. COVER
5. CONTAINER
6. GASKET
7. NUT
8. SWING BOLT
9. TRUNNION
10. UPPER STRAP (AFTER)
11. UPPER STRAP (FORWARD)
12. JUMPER ASSEMBLY HALF WITH COUPLER
13. JUMPER ASSEMBLY HALF LESS COUPLER
14. ROCKET MOTOR
15. DESICCANT BAGS
16. DESICCANT HOLDER
17. LOWER STRAP (AFTER)
18. LOWER STRAP (FORWARD)
19. HUMIDITY INDICATOR
20. 1/8-INCH PIPE PLUG
21. BREATHER VALVE
22. SHIPPING DATA
23. BAR CODE

Figure 4. Packaging Condition of Rocket Motor Mark 37 in Container Mark 178, Exploded View

2.0 PERFORMANCE

2.1 Performance Description

The Mk 37 Mod 0 rocket motor shall be capable of delivering the Mk 46 torpedo payload to a preset water entry point range. The rocket motor develops approximately 12,000 pounds of thrust for about 4 seconds. This gives the Asroc missile a maximum range of approximately 10,000 yards. The regrained and reworked rocket motors must meet the same ballistic performance requirement range of a new unit per MIL-DTL-82870A.

2.2 Propellant Characteristics

The shell grain normally shrinks as it ages. This condition reduces the inside diameter (ID) of the grain. A smaller grain ID will increase the gas port to nozzle area ratio. When this ratio increases, the gases generated by burning of the propellant will not have a large enough nozzle area to escape or vent. When fired, the gas pressure will rapidly exceed the rocket motor case rupture capacity and provoke an explosive reaction. A small shell grain ID is not expected to be a problem in grains up to 25 years old. However, grain dimensional inspection is required when the grain reaches 10 years. This inspection verifies the grain meets the minimum dimensions specified in MIL-DTL-82761A that are required for good performance and rework.

In addition to the shrinkage of the shell grain, nitroglycerine (NG) slowly migrates to the periphery of the grain and is absorbed by the grain inhibitor (ethylcellulose). One of the functions of the inhibitor is to add structural strength to the extruded propellant shell grain. As the inhibitor absorbs NG, it weakens, and the additional structural strength needed by the burning propellant grain to sustain axial stresses without cracking is gradually lost.

2.3 Rocket Motor Malfunctions

Historically, a high-pressure malfunction (motor nozzle is ejected) has been the worst malfunction experienced with the Asroc motors. This has only occurred during static-firing tests at temperatures over 110 °F.[2] Except for one 14-year-old, non-reworked motor that malfunctioned at 100 °F, all the surveillance rocket motor high-pressure malfunctions have occurred at temperatures of 110 °F or higher. The failures have been attributed to the undersized grain dimensions of the propellant combined with high static-firing temperatures. With this failure condition, the grain deforms due to axial stress, cracks, breaks up, and then closes off the nozzle ports, which produces the internal pressure that exceeds the nozzle-motor chamber locking wire strength. Thus, the nozzle is ejected (Figures 5 through 9). During static-firing the motor igniter assembly (weakest connection) is not ejected because it is externally restrained to the motor forward end. In theory, although it has not been determined by U.S. Navy investigations, the igniter, rather than the nozzle, is expected to be ejected prematurely during dynamic (launch) firing just after the missile has cleared the launcher.

According to surveillance type life (accelerating aging study) and "fleet-returned" unit inspection data, the majority of the grain shrinkage occurs within the first 3 to 4 years of service life and then continues in a quasi-steady low rate mode.[2] The typical type life (TL) shell grain length and inside diameter shrinkage profiles compared with 10-year-old motors from lot 141 are illustrated in Figures 10 and 11.

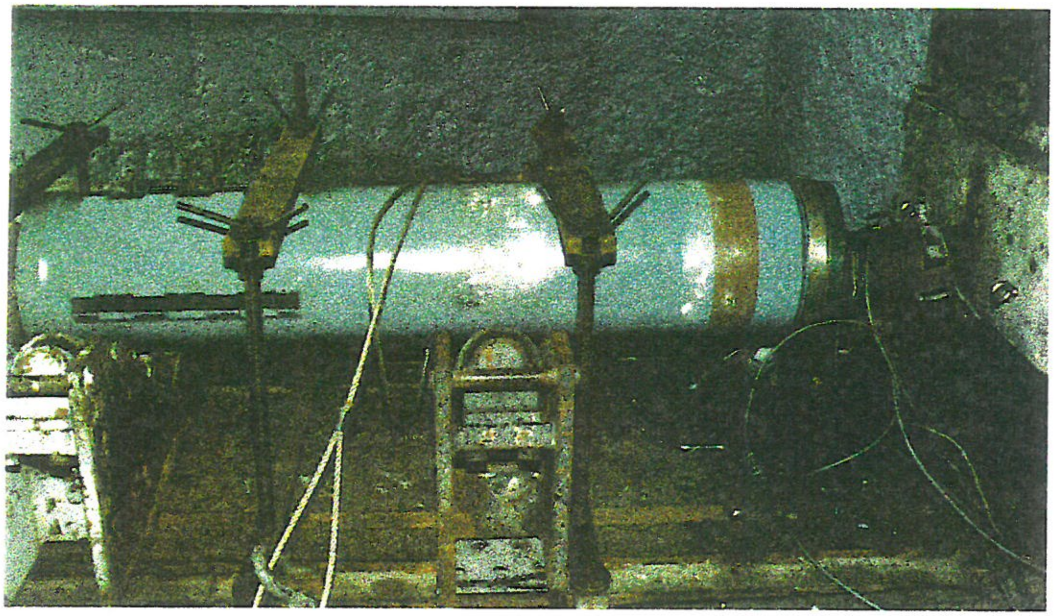


Figure 5. Rocket Motor Malfunction, Motor Chamber View

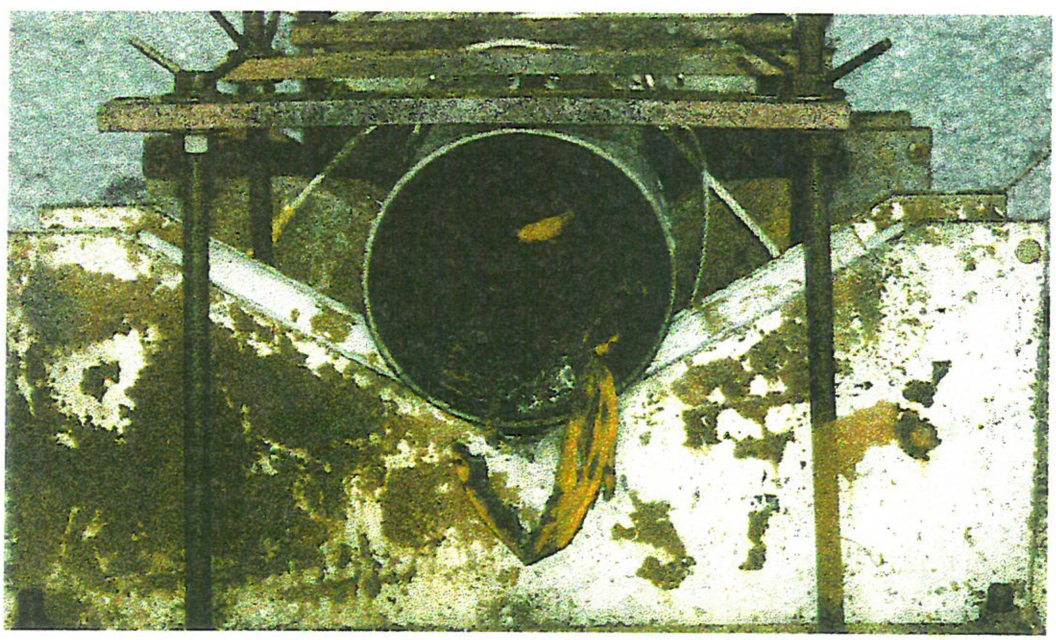


Figure 6. Rocket Motor Malfunction, Motor Aft End View

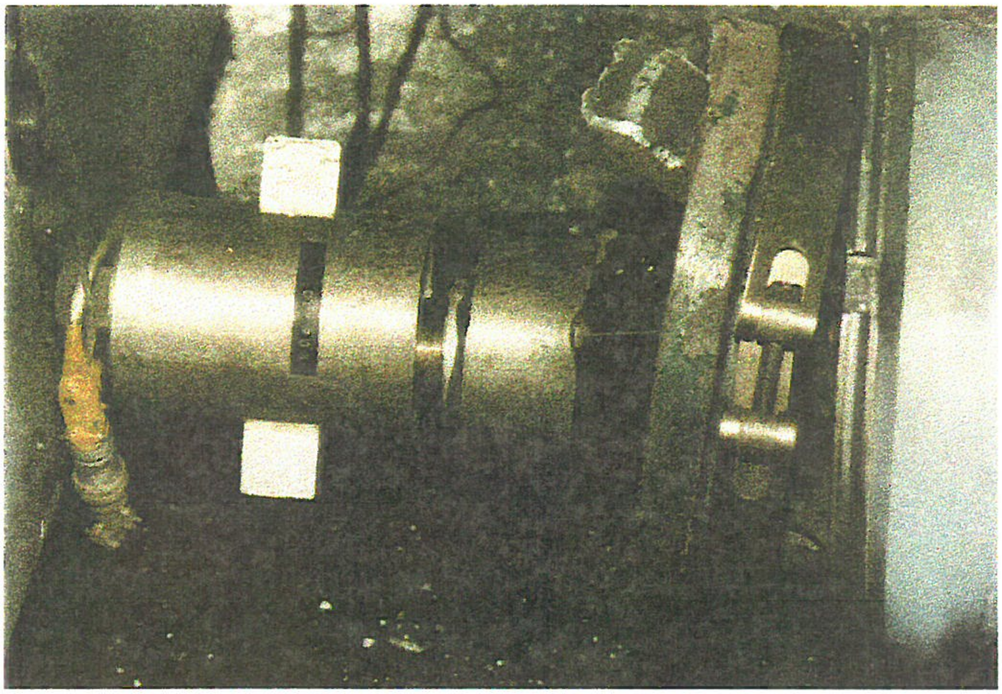


Figure 7. Rocket Motor Malfunction, Motor Forward End View

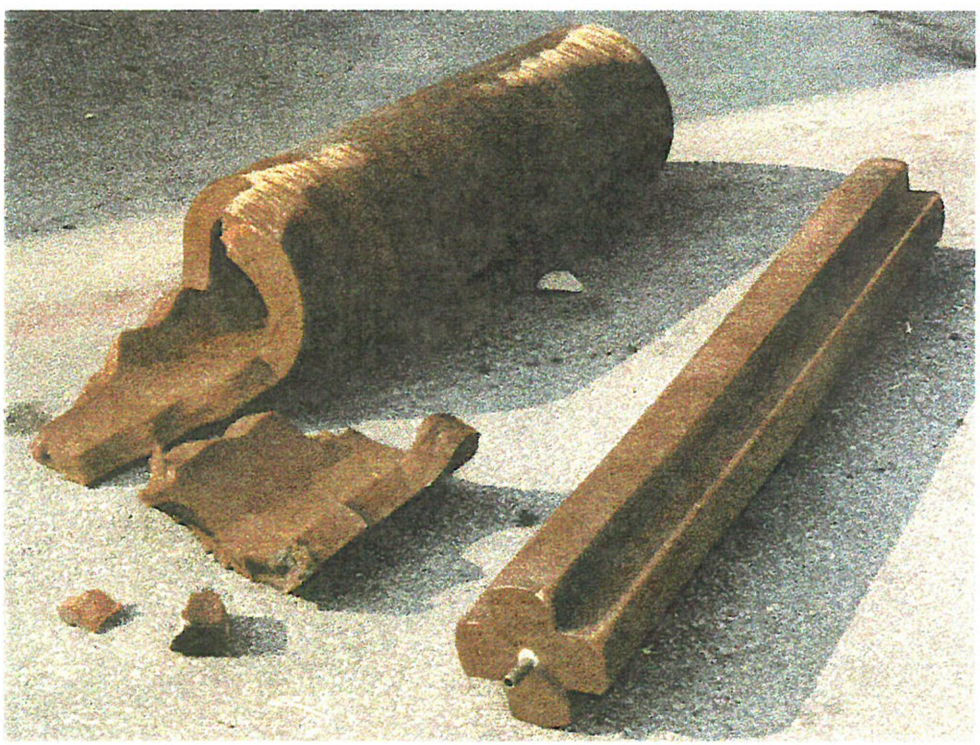


Figure 8. Rocket Motor Malfunction, Propellant Grains View

Figure 9. Rocket Motor Malfunction, Motor Nozzle View

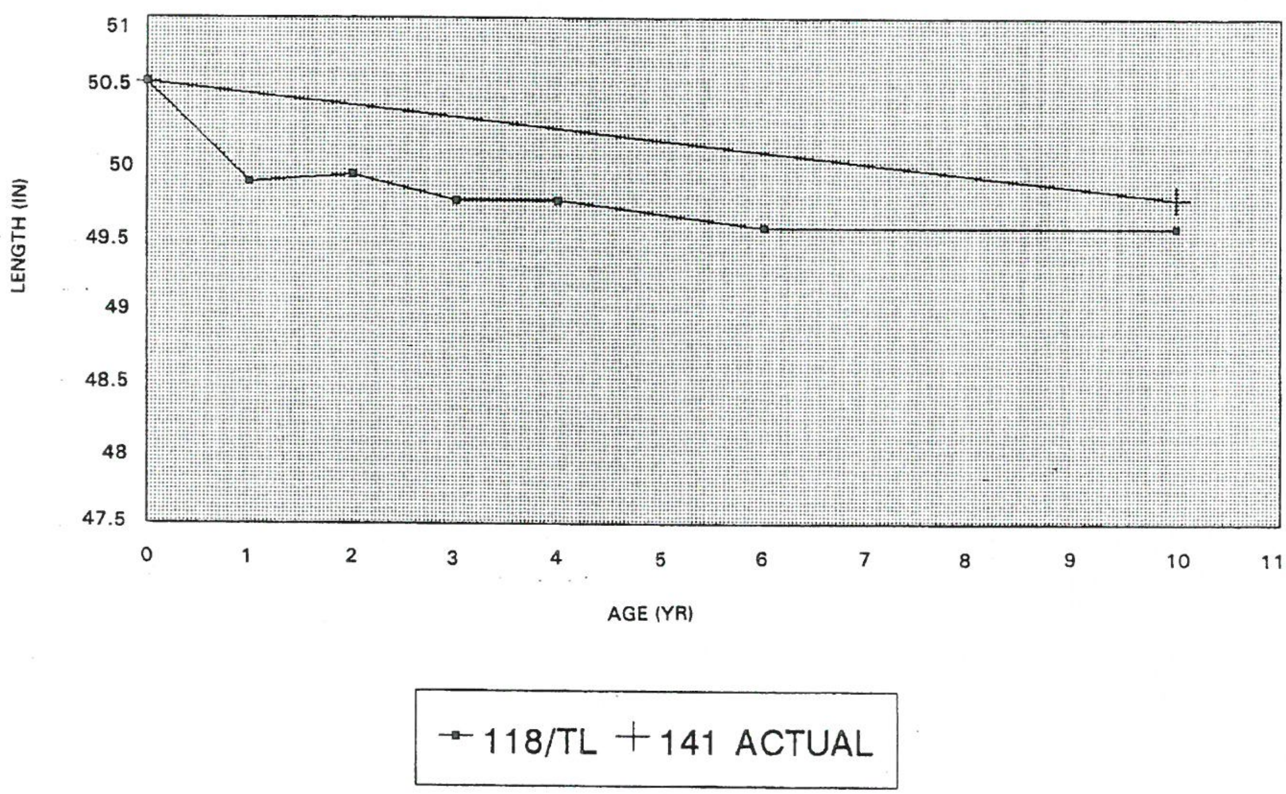


Figure 10. Shell Grain Length Shrinkage Profile

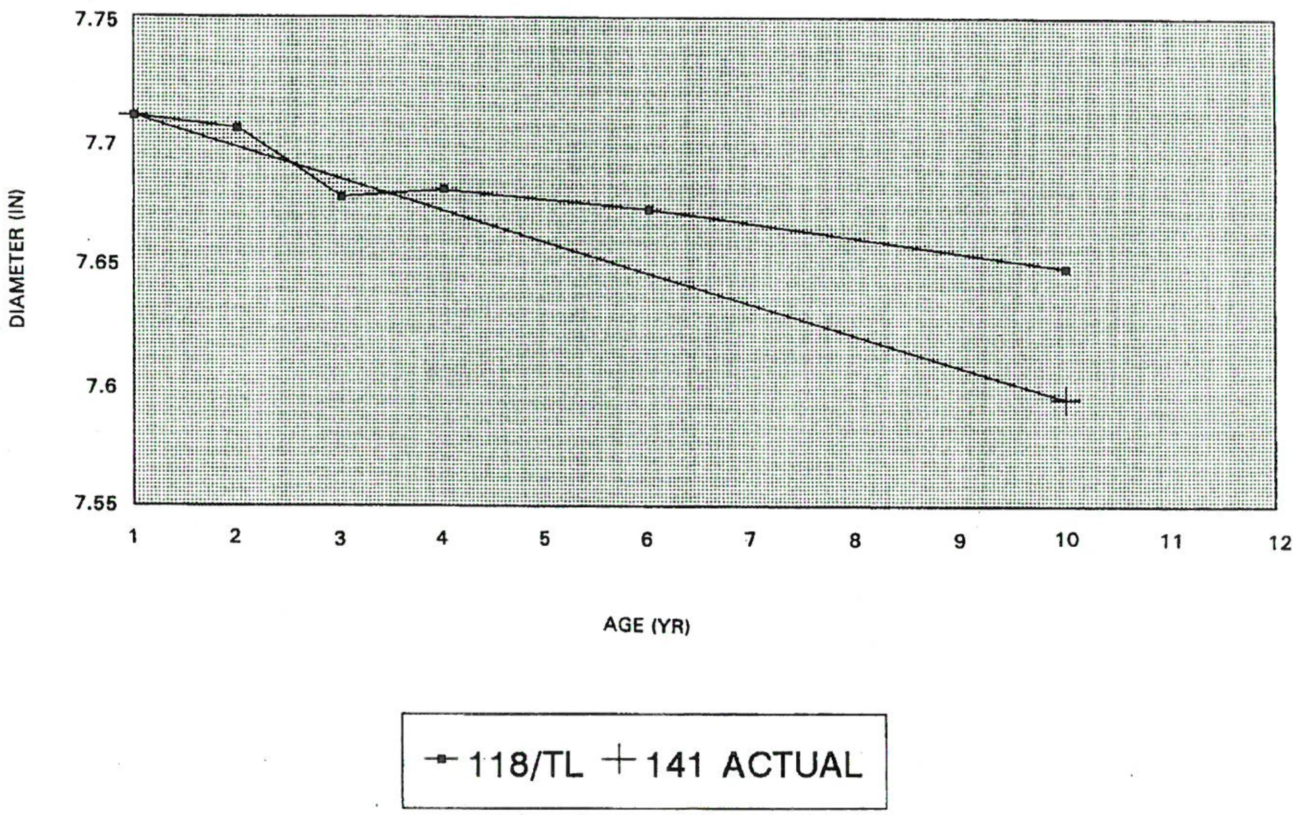


Figure 11. Shell Grain Inside Diameter Profile

Surveillance static-firing malfunctions indicate that the possibility of a high-pressure malfunction in rocket motors older than 4 years increases when the motors are conditioned and fired at temperatures above 100 °F. Table I shows all the Asroc motor static-firing malfunctions that have occurred since the inception of the production program.

Would a high-pressure malfunction occur in a reworked grain? The rework of grains with short length reinforces the shell grain strength on aged units. This is required on grains exceeding the first 10 years of service life. A summary of the surveillance reworked propellant grain shrinkage recorded from 1966 to 1988 shows the following:

- Shell grain maximum shrinkage 9 years after rework .... 0.750 inch
- Average shell grain shrinkage 8 years after rework .... 0.428 inch
- Cruciform grain shrinkage 9 years after rework .... 1.000 inch
- Average cruciform grain shrinkage 8 years after rework .... 0.613 inch

As seen above, the shrinkage continues in reworked grains. Therefore, the correlation of undersized grains with elevated firing temperatures still exists. A high-pressure malfunction on an 8-year-old, reworked unit (No. 127/184) fired at 110 °F occurred in 1986 as part of the surveillance program.[3] This was the only reworked unit that has ever failed. Motor rework has been proven throughout the years to be a very reliable method for extending by 10 years the life of the Asroc motor.

Table I. Asroc High-Pressure Malfunctions

Firing date	Lot	Age (yr)	Fire temp. (°F)	Length (in)		Shell diameter (in)		Cruciform rod extension (in)
				Shell	Cruciform	Inner	Outer	
Surveillances								
1965	1/1	5	120	—	—	—	—	—
1965	1/18	5	120	—	—	—	—	—
1968	5/84	6	120	—	—	—	—	—
1970	1/3	10	110	—	—	—	—	—
1976	60/57	10	110	—	—	—	—	—
1977	80/100	9	110	49.813	50.063	7.631	11.270	3.100
1980	60/9	14	100	49.688	50.000	7.635	11.270	2.123
1980	60/67	14	110	49.688	50.000	7.650	11.298	2.138
1981	110/012	8	110	49.688	50.063	7.627	11.259	2.085
1985	110/001	12	110	49.895	50.188	7.600	11.293	2.068
1986	127/184	8[a]	110	49.875	49.563	—	—	—
Lot Acceptance Tests								
1992	156/007	0	120	—	—	—	—	—
1993	156/014	1	120	49.963	50.438	7.591	11.206	1.780
Special Tests								
1993	156/RT1	1	120	49.905	50.438	7.509	11.258	1.767
1994	141/S1	10	120	49.750	50.063	7.570	—	1.767
Type Life Programs								
1962	P-5	1[b]	120	—	—	—	—	—
1962	1-59	4	120	49.938	50.282	—	11.272	—
1969	9-66	9	110	—	—	—	—	—
Specification limits:								
Maximum				50.559	50.439	7.770	11.376	1.781
Minimum				50.309	50.309	7.630	11.256	1.657
Rework				—	—	7.605 min	—	1.625 to 1.900

[a]Age after rework date.
[b]Stored for one year at 120 °F.

In summary, the fleet maximum firing temperature of 100 °F has been confirmed throughout over 33 years of surveillance and temperature performance testing.[4] The fact that there has been only one failure at elevated temperature and none at 100 °F or below has shown that reworking the propellant grains before the 13-year cutoff date is a reliable method of extending the motor service life 10 more years.

3.0 SAFETY

3.1 Propellant Stability

The chemical stabilizer 2-nitrodiphenylamine (2NDPA) is added to the N-5 propellant (MIL-P-17689) to absorb the nitrogen oxides (NO_2) released naturally from the nitrocellulose. The NO_2 reaction with nitrocellulose is exothermic. It could lead to autoignition if the stabilizer was depleted to a low level. The 2NDPA reduces the rate of decomposition of the nitrocellulose and NG. Propellant design typically uses from 1% to 2% of 2NDPA in a formulation. This amount of stabilizer has proven to be sufficient for double-base propellants, gun propellants, and high energy explosive (e.g., PBXN-103, the explosive used in the Mk 46 torpedo warhead utilizes a similar percentage that is effective for 50 to 100 years at temperatures of 75 to 90 °F).

The N-5 specification requires a minimum of 1.5% by weight of 2NDPA when first manufactured. However, in actuality a nominal 2.0% of 2NDPA is added. A type life study initiated with motors from lot 141 in 1983 indicated a decomposition rate of 0.2% by weight in 3 years after an accelerated aging condition.[5] Three years in type life is considered equivalent to 6 years in the fleet. Type life is not a test to accurately determine the stabilizer depletion rate, but it does provide a general idea of what should happen. After 11 years in service, two motors from lot 141 were tested again for stabilizer level in 1994.[2] The lowest stabilizer level detected was 1.4% in one motor. In past surveillances, the lowest stabilizer level detected in motors up to 14 years old was 1.79%. The cause of the unusual drop in stabilizer on this particular motor is unknown. Nevertheless, if a decomposition rate of 0.2% by weight is seen with a 2NDPA content of 1.4%, at the end of 10 additional years lot 141 will have 0.8% of 2NDPA. This is significantly greater than 0.2% acceptable limit for mandatory weapon disposal.

The stability of propellant and explosive depends on the exposure temperature versus time, the nature of the chemical composition, and the decomposition products. Periodical surveillance of stabilizer content is conducted to monitor the degree of decomposition of the material. Double-base propellants like the Asroc propellant have not shown a significant stabilizer depletion for at least 24 years (Appendix B). Since the Asroc is not expected to be in service longer than 20 years, the stabilizer content has not been a concern in surveillance as long as the motor storage conditions have been met. We cannot predict with certainty what minimum stabilizer level is required prior to recalling a unit from service. However, the U.S. Joint Ordnance Commanders, Quality Assurance Group has agreed that 0.2% by weight should be the minimum level for recalling a unit from service. With the Asroc stowage requirements, we do not expect to reach this level prior to a period of 40 years or more. If storage temperature controls are not available, the propellant stability is an area that deserves periodic surveillance testing.

Asroc motor energetic materials are sensitive to impact, heat, and electrostatic discharge and may react when in contact with other chemicals. The rocket motor propellant grain becomes exothermic and could self-ignite when exposed to temperatures higher than 165 °F.

The rocket motor storage temperature is −30 to 130 °F. The highest daily average storage temperature should not exceed 90 °F. Prolong storage temperatures over 120 °F will accelerate the stabilizer depletion rate of the propellant grain, thus shortening its service life. The firing temperature of 100 °F shall not be exceeded. Otherwise, motor malfunction may occur.

3.2 Hazard Classifications

Classification	Mk 37 rocket motor	Mk 55 propellant grain (Asroc N-5 propellant) (interim)
DOD hazard class/Div./SCG	1.3C	1.3C
UN serial number	0186	0272
DOT hazard class	J	1.3C
DOT marking	EM	—
Shipping name	Rocket Motor	Charges, Propelling, for Rocket Motors
National stock number	1356-00-962-0684	—

3.3 Hazardous Materials

3.3.1 Chemical Characteristics: The chemical characteristics of the N-5 double-base propellant (MIL-P-17689) are as follows:

Ingredient	Purpose	Composition (%)
Nitrocellulose	Binder-fuel	50.0
Nitroglycerin	Oxidizer-plasticizer	34.9
Diethylphthalate	Plasticizer	10.5
2-Nitrodiphenylamine	Stabilizer	2.0
Lead salicylate (S-202)	Burn rate modifier	1.2
Lead 2-ethylhexoate (H-101)	Burn rate modifier	1.2
Candelilla wax	Processing aid	0.2

3.3.2 Double Salt Complex: Two chemicals, lead-2-ethyl hexoate (H-101) and lead salicylate (S-202), are used to modify burning rates of N-5 propellant at various pressures and temperatures. H-101 is an extremely viscous liquid, which mixes poorly into the propellant matrix. It also presents a safety and health hazard due to the high temperatures required to achieve dispersion of the liquid and the generation of noxious fumes.

During 1990, the N-5 manufacturer, Radford Army Ammunition Plant, recommended the use of a powdered solid form of the two N-5 burn rate modifiers. After qualification testings, the new lead Double Salt Complex (DSC) was used to manufacture N-5 propellant in 1994. Asroc motor lot IH 94H-001-158 was the first and only lot manufactured using the new DSC. Surveillance tests were planned to determine the new DSC motor ballistic properties with age. Unfortunately, because of the retirement of the Asroc system from the U.S. Navy, the planned follow-up surveillance tests were not performed. Use of these motors for foreign military sales will require surveillance tests.

3.3.3 Other Chemical Materials: The following non-energetic chemical materials are present in the configuration:

- Antiseize compound (MIL-T-22361 and MIL-A-907)
- Silicone grease (G-697, MIL-C21567)
- Epoxies (MMM-A-134 and MIL-A-388)
- Adhesive (652148), Potting compound (Per MIL-DTL-82761A)

4.0 DISPOSAL OPTIONS

4.1 Rocket Motor Disposal

The Mk 37 rocket motor is of environmental concern to the U.S. because of the large volume of N-5 propellant and its lead content (2.5 % of total grain weight).[6] Before disposal of the rocket motor is effected, the disposal activity shall be familiar with the rocket motor's physical (explosive) characteristics and have taken all possible measurements to guarantee safety of personnel and limit environmental contamination to acceptable local government levels.

4.2 Disposal Options

The following are different options for disposal of the rocket motor:

- Download propellant grains and burn in a closed thermal treatment area. Decontamination of inert hardware by flashing is required before discarding. This is the preferred method for rocket motors older than 25 years old if environmental control is of consideration.

- Download propellant grains and burn in an open field area. Decontamination of inert hardware by flashing is required before discarding. This is the preferred method for rocket motors older than 25 years old if possible damage to the facilities is of consideration and environmental controls are not a concern.

- Detonate the rocket motor. This method is preferred if facility damage and environmental controls are not of consideration or a detonation facility is available.

- Static-fire the rocket motor. This method requires the restriction of the rocket motor from thrusting forward and a means to set off the propellant grain. Decontamination of the inert hardware by flashing is required before discarding. If environmental controls are a concern, then this method should not be used.

The Mk 37 rocket motor can be demilitarized for final disposal by static firing in an open area or firing range. The propellant can also be removed by certified explosive personnel from the metal casing and burned in a closed or open thermal treatment area. In the future, it also can be reprocessed for use in other explosive applications, e.g., mining.

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2. Hernandez, David, *Asroc Rocket Motor Mark 37 Propellant Grain Shrinkage Investigation,* IHTR 1745, 30 September 1994.

3. Surveillance report, NAVORDSTAIH ltr 8830/2 Ser 6320F/C28, Subj.: Report of the FY 86 Surveillance Evaluation of the Asroc Rocket Motor Mk 37 Mod 0, 22 July 1987.

4. Hernandez, David., and Glowacki, L., *Test Performance Results of Asroc Propellant Grains at 100 °F* (U), IHTR 1778, 21 April 1995. CONFIDENTIAL

5. NAVORDSTAIH ltr 8830/1-9 Ser 6320F/C173, Sub.: Report of the 3.0-Year Withdrawal of Asroc Rocket Motors Mk 33 Mod 0 from Lot 141, 17 March 1989.

6. *Demilitarization/Disposal Plan for the Asroc Missile Explosive Components,* IHSP 93-348, Revision 1, 31 May 1995.

Appendix A

ROCKET MOTORS MARK 37 FIRED IN SURVEILLANCE PROGRAMS

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ASROC NON-REWORKED ROCKET MOTORS SURVEILLANCE HISTORY

LOT/#	AGE (YRS)	FIRE TEMP. (oF)	LENGTH SHELL original		LENGTH CRUCIFORM original		SHELL DIAMETERS ID	SHELL DIAMETERS OD	CRUCIFORM ROD EXTENSION original		RESULTS
			original	at test	original	at test	at test	at test	original	at test	
5/34	1	0									SUCCESS
P5/15	1	120									SUCCESS
1/24	2	0									SUCCESS
P16/5	2	120									SUCCESS
7/8	2	0		50.001		50.186					SUCCESS
16/69	3	0									SUCCESS
2/30	3	120									SUCCESS
2/27	3	120									SUCCESS
2/8	3	120		50.054		50.319					SUCCESS
2/19	3	120		50.000		50.274					SUCCESS
15/22	3	120									SUCCESS
16/7	3	120									SUCCESS
3/29	3	0		50.036		50.223					SUCCESS
3/50	3	0		49.921		50.099					SUCCESS
30/40	3	120									SUCCESS
2/55	3	0									SUCCESS
2/52	3	120		49.978		50.246					SUCCESS
3/57	3	120									SUCCESS
1/22	3	120		49.710		50.246					SUCCESS
11/3	4	0									SUCCESS
30/78	4	110									SUCCESS
26/52	4	0									SUCCESS
26/88	4	0									SUCCESS
132/249	4	0	50.559	50.000	50.375	50.000					SUCCESS
132/025	4	40									SUCCESS
118/038RG	4	35	50.530	49.625	50.438	50.063			1.733	2.085	SUCCESS
26/45	4	110									SUCCESS
118/106RG	4	0	50.500	49.750	50.438	49.964			1.728	2.130	SUCCESS
117/070	4	35	50.558	49.875	50.375	50.125			1.744	2.100	SUCCESS
117/016RG	4	0	50.550	49.875	50.375	50.032			1.746	2.080	SUCCESS
117/062RG	4	0	50.530	50.000	50.438	50.031			1.737	2.141	SUCCESS
9/28	4	0									SUCCESS
7/15	5	100									SUCCESS
6/7	5	100									SUCCESS
4/45	5	120									SUCCESS
14/23	5	120									SUCCESS
14/18	5	120									SUCCESS
1/18	5	120									MALFUNCTION
1/1	5	120									MALFUNCTION
16/22	5	110									SUCCESS
11/50	5	120									SUCCESS
117/013	6	40	50.500	49.750	50.438	50.000					SUCCESS
7/63	6	120									SUCCESS
6/41	6	120									SUCCESS
7/59	6	120									SUCCESS
6/34	6	120									SUCCESS
5/54	6	120									MALFUNCTION
135/076	7	100		50.000		50.250				1.901	SUCCESS
4/39	7	120									SUCCESS
4/21	7	120									SUCCESS
3/44	7	120									SUCCESS
2/28	7	120									SUCCESS
135/187	7	100									SUCCESS
15/86	8	110		49.673		50.162	7.645	11.327			SUCCESS
16/86	8	110									SUCCESS
110/012RG	8	110		49.688		50.063	7.627	11.259		2.085	MALFUNCTION
84/116	8	0									SUCCESS
84/63	8	110									SUCCESS
132/045	8	100									SUCCESS
84/124	8	40		49.875		49.863	7.610	11.340		2.500	SUCCESS
13/75	8	110									SUCCESS
132/041	8	40									SUCCESS
118/054RG	8	100	50.500	49.938	50.400	50.188			1.720	2.025	SUCCESS
118/052RG	8	40	50.438	50.000	50.438	50.188			1.768	2.094	SUCCESS
117/017RG	8	0	50.500	49.938	50.375	50.125			1.746	2.095	SUCCESS
117/069RG	8	0									SUCCESS
23/26	8	110		49.938		50.125	7.640	11.326			SUCCESS
76/85	9	40		50.000		50.250	7.665	11.320			SUCCESS
76/77	9	0									SUCCESS
135/002	9	100		49.938		50.188					SUCCESS

ASROC NON-REWORKED ROCKET MOTORS SURVEILLANCE HISTORY (continue)

LOT/#	AGE (YRS)	FIRE TEMP. (oF)	LENGTH SHELL original	LENGTH SHELL at test	LENGTH CRUCIFORM original	LENGTH CRUCIFORM at test	SHELL DIAMETERS ID at test	SHELL DIAMETERS OD at test	CRUCIFORM ROD EXTENSION original	CRUCIFORM ROD EXTENSION at test	RESULTS
118/064RG	9	0									SUCCESS
106/253	9	110									SUCCESS
106/244	9	100									SUCCESS
118/076RG	9	100	50.500	49.813	50.438	50.000					SUCCESS
118/067RG	9	40	50.438	49.688	50.438	49.938					SUCCESS
18/79	9	110		49.750		50.125	7.633	11.331			SUCCESS
18/27	9	110		49.562		50.000	7.620	11.302			SUCCESS
132/135	9	100									SUCCESS
79/22	9	110									SUCCESS
79/85	9	110									SUCCESS
68/122	9	110									SUCCESS
77/119	9	0		49.875		49.875	7.614	11.300		2.275	SUCCESS
79/52	9	40									SUCCESS
102/183	9	110									SUCCESS
102/35	9	110									SUCCESS
80/100	9	110		49.813		50.063	7.631	11.270		3.100	MALFUNCTION
102/47	9	40									SUCCESS
102/50	9	100		49.875		50.250	7.657	11.282		1.855	SUCCESS
81/87	9	110									SUCCESS
81/91	9	110									SUCCESS
5/63	9	110		49.600		49.937	7.606	11.305			SUCCESS
16/9	9	110		49.938		50.250	7.640	11.330			SUCCESS
66/36	9	110									SUCCESS
105/119	9	0		49.563		49.938	7.632	11.280		2.210	SUCCESS
93/60	9	100									SUCCESS
106/124	9	40									SUCCESS
106/118	9	110									SUCCESS
93/123	9	110									SUCCESS
93/87	9	110		49.750		50.190	7.670	11.278		1.970	SUCCESS
4/1	9	110		49.650		49.957	7.665	11.321			SUCCESS
4/59	9	110									SUCCESS
92/14	9	40									SUCCESS
4/4	9	110									SUCCESS
92/81	9	110		49.875		50.188	7.620	11.288		1.962	SUCCESS
92/66	9	100									SUCCESS
92/37	9	100									SUCCESS
92/2	9	0									SUCCESS
92/71	9	110									SUCCESS
92/20	9	40									SUCCESS
3/19	9	110									SUCCESS
107/015	9	100		49.688		49.938	7.673	11.279		2.168	SUCCESS
107/038	9	0									SUCCESS
62/19	9	110									SUCCESS
60/57	10	110									MALFUNCTION
34/21	10	110		49.750		49.938	7.628	11.233			SUCCESS
34/11	10	110									SUCCESS
126/121RG	10	100		50.000		50.375					SUCCESS
126/136	10	40		49.875		50.309					SUCCESS
1/3	10	110									MALFUNCTION
1/15	10	110									SUCCESS
1/20	10	110									SUCCESS
1/25	10	110									SUCCESS
11/57	10	110		49.913		50.125	7.648	11.289			SUCCESS
55/95	10	110		49.813		50.125	7.688	11.315			SUCCESS
106/260RG	10	40									SUCCESS
93/111	10	40									SUCCESS
93/104	10	0		49.750		50.000	7.605	11.230		2.170	SUCCESS
118/037RG	10	40									SUCCESS
95/033	10	100									SUCCESS
93/121	10	110									SUCCESS
106/167	10	110		49.500		49.938	7.674	11.298		2.175	SUCCESS
101/67	10	100									SUCCESS
99/27	10	110		49.875		50.188	7.649	11.292		1.928	SUCCESS
9/64	10	110		49.695		50.000	7.593	11.297			SUCCESS
106/199	11	100		49.813		50.000	7.655	11.287		2.140	SUCCESS
106/205	11	100									SUCCESS
106/194	11	40		49.625		50.000	7.663	11.294		2.125	SUCCESS
42/12	11	40									SUCCESS

ASROC NON-REWORKED ROCKET MOTORS SURVEILLANCE HISTORY (continue)

LOT/#	AGE (YRS)	FIRE TEMP. (oF)	LENGTH SHELL original	LENGTH SHELL at test	LENGTH CRUCIFORM original	LENGTH CRUCIFORM at test	SHELL DIAMETERS ID at test	SHELL DIAMETERS OD at test	CRUCIFORM ROD EXTENSION original	CRUCIFORM ROD EXTENSION at test	RESULTS
42/21	11	110									SUCCESS
41/75	11	0									SUCCESS
18/64	11	110									SUCCESS
38/39	11	40									SUCCESS
105/030	11	110		49.500		49.938	7.618	11.283		2.195	SUCCESS
19/22	11	110									SUCCESS
18/77	11	110									SUCCESS
18/3	11	110		49.750		50.000	7.675	11.312			SUCCESS
18/1	11	110									SUCCESS
4/29	11	110		49.625		50.000	7.585	11.286			SUCCESS
18/50	11	110									SUCCESS
1/21	11	110		49.695		50.000	7.575	11.243			SUCCESS
3/37	11	110		49.938		50.125	7.623	11.288			SUCCESS
1/9	11	110		49.695		50.000	7.595	11.220			SUCCESS
1/41	11	110		49.975		50.250	7.600	11.260			SUCCESS
1/32	11	110		49.938		50.000	7.570	11.207			SUCCESS
104/183	12	0									SUCCESS
30/94	12	40									SUCCESS
118/063RG	12	40									SUCCESS
117/052RG	12	40		49.688		50.000					SUCCESS
110/001RG	12	110		49.895		50.188	7.600	11.293		2.068	MALFUNCTION
60/65	14	100		49.750		50.063	7.643	11.279		2.176	SUCCESS
60/67	14	110		49.688		50.000	7.650	11.298		2.138	MALFUNCTION
67/34	14	40		49.688		50.000	7.692	11.271		2.123	SUCCESS
60/9	14	100		49.688		50.000	7.635	11.270		2.123	MALFUNCTION

ASROC REWORKED ROCKET MOTORS SURVEILLANCE HISTORY

SPEC	AGE* YR.	FIRE TEMP. (oF)	LENGTH SHELL original	LENGTH SHELL at test	CRUCIFORM original	CRUCIFORM at test	SHELL DIAMETERS ID at test	SHELL DIAMETERS OD at test	ROD EXTENSION original	ROD EXTENSION at test	RESULTS
MAX				50.559		50.439	7.770	11.376		1.900	
MIN				50.309		50.309	7.605	11.256		1.625	
LOT/#											
1/33R	5	0	49.796	50.339						1.842	SUCCESS
9/71R	4	120	49.849	50.141						1.868	SUCCESS
13/4R	3	120	49.812	50.166						1.900	SUCCESS
8/32R	6	110	49.755	50.010			7.641	11.331			SUCCESS
119/088RW	1	40									SUCCESS
119/097RW	1	0	50.500	50.375	50.375	50.125			1.754	1.782	SUCCESS
119/098RW	1	110	50.375	50.250	50.438	50.375			1.727	1.806	SUCCESS
119/106RW	1	110	50.313	50.188	50.313	50.313			1.728	1.776	SUCCESS
119/110RW	1	110									SUCCESS
121/074RW	1	0									SUCCESS
121/077RW	1	40	50.313	50.063	50.313	49.875			1.725	1.800	SUCCESS
121/110RW	1	110	50.408	50.125	50.313	49.750			1.625	1.650	SUCCESS
123/002RW	1	110	50.438	50.188	50.438	49.938			1.749	1.875	SUCCESS
123/032RW	1	110									SUCCESS
119/009RW	3	0	50.438	50.000	50.375	49.875			1.625	1.810	SUCCESS
120/083RW	2	40	50.438	50.000	50.438	50.188			1.730	1.865	SUCCESS
123/163RW	2	110	50.375	50.000	50.375	49.813			1.725	1.835	SUCCESS
124/199RW	2	110									SUCCESS
119/044RW	4	0	50.375	50.000	50.309	49.938			1.625	1.831	SUCCESS
120/021RW	4	40									SUCCESS
123/153RW	3	110	50.438	50.063	50.313	49.813			1.780	1.912	SUCCESS
125/160RW	3	110	50.375	50.125	50.438	50.000			1.675	2.000	SUCCESS
119/022RW	6	110	50.500	49.938	50.343	50.062					SUCCESS
120/060RW	5	100	50.438	49.938	50.313	50.062					SUCCESS
122/038RW	5	40	50.375	49.822	50.313	50.062					SUCCESS
124/175RW	5	0									SUCCESS
120/092RW	6	110									SUCCESS
120/096RW	6	100	50.500	49.938	50.375	49.750			1.747	1.732	SUCCESS
121/014RW	6	40	50.438	49.813	50.313	49.938			1.680	1.707	SUCCESS
122/088RW	6	0	50.375	49.750	50.375	49.938			1.630	1.710	SUCCESS
119/028RW	8	110									SUCCESS
120/089RW	8	100	50.500	50.188	50.375	49.875			1.668	1.770	SUCCESS
121/033RW	8	40	50.375	50.250	50.313	50.000			1.720	1.675	SUCCESS
122/006RW	8	0	50.313	49.938	50.313	49.813			1.690	2.010	SUCCESS
125/092RW	9	100									SUCCESS
130/167RW	8	100		50.000		49.750					SUCCESS
130/070RW	8	40		50.063		50.063					SUCCESS
131/169RW	8	40		50.063		49.688					SUCCESS
122/069RW	10	100		49.845		49.815					SUCCESS
130/165RW	9	100									SUCCESS
131/166RW	9	100		50.063		49.938					SUCCESS
123/205RW	10	40									SUCCESS
125/056RW	11	40		49.875		49.813					SUCCESS
125/150RW	11	40									SUCCESS
119/016RW	9	0									SUCCESS
120/069RW	9	40	50.500	49.750	50.438	49.438					SUCCESS
125/141RW	8	100	50.375	49.688	50.438	49.563					SUCCESS
127/184RW	8	110	50.500	49.875	50.438	49.563					MALFUNCTION
125/143RW	11	100		50.000		49.813	7.569				SUCCESS
131/063RW	10	40									SUCCESS
131/187RW	10	100									SUCCESS
133/114RW	10	40		49.875		49.813					SUCCESS
133/207RW	10	100									SUCCESS

* AGE AFTER REWORK DATE

Appendix B

ASROC MOTOR PROPELLANT GRAINS CHEMICAL ANALYSES

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Lot/No.[a]	Year tested	Age at test (yr)	NC (%)	NG (%)	2NDPA (%)	Tal. slope/ time
Various Sheetstock Lots						
92/69	1978	10	–	–	1.93	0.73/137
118/006TL	1978	0	51.38	33.43	1.92	0.65/154
119/089RWK	1979	1	50.22	34.51	1.97	0.73/137
95/111	1979	10	–	–	1.92	0.73/137
118/006TL	1979	1	53.00	32.10	1.84	0.71/141
106/105	1980	9	–	–	1.92	0.65/154
124/014RWK	1980	2	–	33.52	1.84	–
121/007RWK	1981	3	–	33.44	1.88	–
105/019	1981	11	–	–	1.94	0.71/141
101/079	1983	14	–	34.50	1.90	–
120/054RWK	1983	6	–	33.70	1.82	–
123/097RWK	1984	6	–	33.20	2.00	–
118/058	1984	7	–	32.90	1.90	–
114/032	1985	8	–	34.30	2.00	–
Lot 141 N5 Sheetstock Lot = 79-H003-015						
Sheetstock RAAP certs	1979	0	51.80	33.40	–	–
TL 141/Grain No. 212	1984	1	52.50	32.20	2.20	0.67/151
TL 141/Grain No. 212	1987	3	52.20	32.30	2.00	0.57/175
141/Grain No. Q834[b]	1994	10	52.88	28.27	1.40	0.85/118
141/Grain No. Q777	1994	10	–	–	1.79	0.53/118
Specification limits:			48.5 - 52.0	34.9 nom.	1.5 min.	1.10 max./100 min.

[a]Legend: TL = Type life, RWK = Rework, RAAP = Radford Army Ammunition Plant
[b]Failed MIL-P-17689 minimum 2NDPA requirement.

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PM3A	1
2210	1
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6320C	3
840L	3
8430	1

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