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NWL Technical Report TR-2962
May 1973

76MM AMMUNITION PROGRAM
QUARTERLY PROGRESS REPORT
1 SEPTEMBER TO 31 DECEMBER 1972

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Weapons Laboratory, Dahlgren, Virginia 22448.

FOREWORD

The Naval Weapons Laboratory, Dahlgren, Virginia has been designated by NAVORD as the Technical Direction Agent to provide U. S. manufactured 76mm ammunition for the Italian designed MARK 75 (OTO MELARA) gun system. Information contained herein reports progress accomplished for the second quarter of FY 73 ending 31 December 1972.

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ABSTRACT

Major accomplishments during the period of 1 September through 31 December 1972 are reported. The program objectives, approach, schedule and the organization of technical responsibilities are given. Technical specifications provided by the Italian Government have been found to be comparable to U. S. specifications. The percussion primer design was found to be unique. The plan for providing a centrally coordinated Product Assurance Program is provided as an Appendix.

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PROGRAM OBJECTIVES

1. Provide technical documentation for procurement of the following ammunition types:
 - a. Cartridge, 76mm/62 Caliber, High Explosive
 - b. Cartridge, 76mm/62 Caliber, Blind Loaded and Plugged
 - c. Clearing Charge
2. Provide 1000 rounds of U. S. manufactured ammunition to support fleet Initial Operational Tests and Evaluation (IOT&E) of the MARK 75 gun mount and MARK 92 gunfire control system scheduled for 1 July 1974.
3. Develop the required logistics resources and provide ammunition to support the Initial Operational Capability (IOC) of PHM ships scheduled for 1 December 1974.

HIGHLIGHTS

A. On 6 September 1972, NWL was directed by NAVORD to proceed with the 76mm Ammunition Program in accordance with a previously submitted NWL program plan.

B. On 29 September 1972, NWL received 951 assembled rounds and components (primer, cases, projectiles, and propellant) sufficient to assemble an additional 100 rounds of Italian ammunition, all blind loaded and plugged (BL&P). The 76mm Ammunition Program received 150 rounds of ammunition and 50 piece parts; the balance are to be used for the MARK 75 mount TECHEVAL program under the technical direction of NWL, Code GC.

C. During November 1972, NWL received technical documentation defining the Italian ammunition. The documentation included drawings and specifications for the OPA fuzed cartridge, MK 72 fuzed cartridge, BL&P cartridge, and a base fuzed cartridge. Not included in the documentation was the clearing charge used in mount/ammunition misfires.

D. On 13 December 1972, NWL received three spare barrel liners and a spare muzzle brake and a bore evacuator. One liner with muzzle brake has been provided to the ammunition program for assembly in a mount specially designed for ammunition testing. The mount design is described in the test section of this report.

E. An Integrated Logistics Support (ILS) Management Plan has been forwarded to NAVORD. The purpose of the plan is to outline the depth and detail of logistics support required to achieve a fleet Initial Operational Capability (IOC), and to assign responsibility for major ILS elements. The ILS major milestones are shown in Table 1.

ADMINISTRATIVE

A. Partial program funding of \$1202K has been received at NWL.

B. The work breakdown structure shown in Figure 1 has been prepared to assign technical responsibilities for major program elements. The technical approach, schedule, and cost have been prepared for each program element and funds provided to all participants. Table 2 summarizes the responsibilities of the technical activities assisting NWL in meeting the program's commitments.

C. The program schedule shown in Figure 2 has been prepared with the assistance of the participating technical activities. It shows the planned procurements of U. S. manufactured ammunition parts. Each technical activity is responsible for procuring ammunition parts under their

respective cognizance. In addition to procurement of Engineering and TECHEVAL ammunition, procurement of fleet ICT&E and IOC quantities is planned.

D. The Product Assurance Plan, which provides for Quality Assurance, Cost and Producibility, Reliability, Configuration and Data Management, and Integrated Logistics Support planning is provided in Appendix A. Each participating technical activity has been requested to implement the Product Assurance Plan in their respective elements and assist NWL with overall program coordination.

E. Representatives of NAVORD and NWL met on 8 December 1972 to discuss facility requirements for loading and assembly of 76mm ammunition. It was suggested that existing multipurpose equipments at naval industrial-type plants are capable of being adapted to the 76mm design. ORD-0462D4 will coordinate with the loading activity to meet TECHEVAL, IOT&E, and IOC ammunition deliveries. NAD Crane was tentatively identified as the leading activity.

F. Representatives of NAVORD, NAVSEC, PMS, NWHL Earle, and NWL met on 19 December 1972 to discuss packaging requirements of 76mm ammunition. In particular, NWHL Earle presented the advantages of bulk containerization (Figure 3) as a method of providing transportation and storage protection to the ammunition. Major advantages of bulk containers are lower cost and the minimization of time and debris associated with ammunition strike-down aboard ship. Disadvantages include handling difficulties associated with large containers aboard ship in the event of inoperative equipment or severe environments, and poor stowage efficiency of large boxes in ships' magazines. NWHL Earle is preparing a program plan defining the level of effort required in FY 73 and FY 74. The PHM and PF ships program offices have been requested to fund this effort.

DESIGN

NAVORD has tasked NWL to pursue a low risk program to provide 76mm ammunition of U. S. manufacture for the MARK 75 gun mount. To accomplish this task, a three-phase program is planned as follows:

Phase I - Design Definition: Define the physical and functional characteristics of Italian ammunition. Prepare a functional specification allocating these requirements to sub-assembly and component parts.

Phase II - Engineering: Demonstrate the performance of U. S. manufactured ammunition parts purchased to U. S. documentation as being within the physical and functional limits established during Phase I.

Phase III - TECHEVAL: Demonstrate the complete round performance and safety of U. S. manufactured ammunition. Establish a product baseline and recommend a NAVORD release to limited production.

Phases I and II are being pursued concurrently. Concurrency is necessitated by the short time schedule; procurement lead times are the limiting factors to meeting fleet IOT&E and IOC deliveries. Test plans (see test section) have been prepared and Phase I will be completed early in the Phase II effort. Status of the design is discussed in the following sections.

COMPLETE ROUND

The Italian ammunition includes a solid base steel projectile, Comp A-3 loaded with a copper rotating band. Two projectile body designs (Figure 4) are required: one to accept the Italian manufactured OPA point detonating fuze and the other to accept the U. S. manufactured MARK 72 proximity fuze. The propelling charge is fixed to the projectile by crimping to the rotating band. The crimp pressure is adjusted to require an average axial force of 2400 kg (2000 kg minimum) to separate the projectile from the cartridge case after assembly. The propelling charge includes a brass cartridge case, a percussion primer, and M-6 propellant with 2 percent potassium sulfate added for flash suppression.

The U. S. manufactured cartridge will use the Italian projectile body design with a slight ogive modification to match the EX 400 (modified) passive IR fuze shape. A projectile body steel will be selected to provide the best fragmentation against the cruise missile threat (primary target spectrum). The propelling charge will use M-6 propellant (or another suitable U. S. formulation which will maintain the interior ballistics of the gun). A U. S. manufactured percussion primer will be used for compatibility with the MARK 75 mount. Concurrent programs to provide a brass or steel case are being pursued because of the strategic nature of copper during wartime. The primer and propellant will be hermetically sealed within the case. Figure 5 shows the all-up cartridge assembly.

PROJECTILE BODY

Two Italian projectile bodies have undergone complete metallurgical analyses. The results are summarized in Table 3. In particular, the variation of yield strength indicates that each of the two projectiles analyzed will exhibit different fragmentation characteristics. This is significant considering the BL&P projectile bodies are manufactured to the same drawing as the OPA fuze explosive projectile. Physical properties of the materials which normally influence fragmentation are specified as minimum values on the drawing; it is therefore concluded that fragmentation is not a closely controlled design feature of the ammunition.

The rotating band material was identified as copper alloy B 130, a copper gilding metal which conforms to Military Specification MIL-B-18907 (NORD).

The Italians are currently using two projectile body designs (Figure 4) for the OPA fuze and MARK 72 fuze cartridge. The OPA fuze projectile body has a 2.245-in. fuze thread and a 2.123-in.-diameter forward cavity wall to accept the 2.20-in. fuze intrusion. The projectile is 10.236-in. long. A collar, felt pad, and cardboard washer assembly resting on the Comp A-3 explosive is used in lieu of a fuze cavity liner. The MARK 72 fuze projectile body is a modified version of the OPA fuze body. The projectile body nose has been cut back 0.157 in. and a thread adapter has been designed to accept the 2.00-in. fuze thread. The 2.123-in.-diameter forward cavity wall is extended aft to accept the long intrusion MARK 72 fuze. A collar, aluminum cup, and cardboard washer rest on the explosive in lieu of a fuze cavity liner. Both designs use a set screw to hold the fuze in place.

The projectile body design proposed by NWL is shown in Figure 6. As shown, the only modifications to Italian design include:

1. a slight change in the ogive radius to improve aerodynamic compatibility with the EX 400 (modified) fuze;
2. a 2.00-in. nose thread;
3. a seating surface designed to provide a positive seat for a fuze cavity liner.

The overall projectile length and external dimensions aft of the forward bourrelet are maintained to insure compatibility with the mount handling system. It should be noted that this design will be compatible with the EX 402 adaptive microwave fuze presently in development at NOL White Oak and other fuzes designed in accordance with MIL-STD-333 (NATO standard).

A detailed view of the Italian designed rotating band seat is shown in Figure 7. The design shown in Figure 8 was prepared by NWL and is typical of U. S. manufactured ammunition. The design change was considered because of possible cost savings and ease of adapting available U. S. tooling during manufacture. The change was abandoned, however, due to the following: (1) additional testing would be required to prove out the new band seat design and (2) previous experiences with the 3"/70, which crimps to the rotating band, indicates the crimping process influences the band efficiency. Such a design change could not be considered low risk within the current program schedule.

FUZE CAVITY LINER

NWL has designed the fuze cavity liner shown in Figure 9. The purpose of the cavity liner is to insure safe removal of the fuze during normal ammunition surveillance and rework programs. The cavity liner prevents the inadvertent migration of explosive material into the fuze threads during the life cycle transportation and storage environments.

The proposed design differs from the conventional designs used in 3-in. and 5-in. ammunition which seat directly on the explosive charge. This was considered undesirable because a stress is transmitted to the explosive during gun launch. The proposed design provides a seating surface which limits the liner intrusion into the explosive cavity. The intrusion is controlled such that, at maximum deflection during setback, a clearance is maintained between the liner and the explosive. A maximum deflection of 0.030 in. has been computed for the proposed design.

FUZING

NOL White Oak has prepared a program plan to modify the EX 400 passive IR fuze (with point detonation backup feature) for service use with the MARK 75 gun. The plan includes testing of 238 fuzes for design verification during the Engineering Phase and 361 fuzes for final certification during the TECHEVAL Phase. The EX 400 is being developed as a part of the Improved 5"/54 Projectile Program. Different performance requirements (Table 4) necessitate design modifications to insure functional compatibility with the MARK 75 gun as follows:

1. Amplifier - The frequency band pass of the solid state amplifier has been optimized for the spin range of 5"/54 projectiles (250 to 288 rps). Therefore, the amplifier band pass must be modified to cover the higher frequencies associated with the 410-rps spin rate of the 76mm gun system. The modified amplifier will be optimized to cover a spin range of 300 to 410 rps permitting operation with 3"/50 as well as 76mm gun systems.

2. Reed Spin Switch - A self-destruct function is provided proximity fuzes by the use of a reed spin switch which operates on spin decay. The reed spin switch of each fuze type for a specific gun system is adjusted to give air burst at quadrant elevation firing angles greater than 20° to 25°. However, the 76mm system must operate in a dual air and surface mode at all quadrant elevations. This is accomplished by selecting an existing reed spin switch whose closure value for fuze function requires a spin rate less than that of the minimum expected terminal spin. Thus, the self-destruct action can be delayed until after impact to act as a clean-up feature.

3. Reserve Energizer - The reserve energizers (batteries) used in proximity fuzes for the Navy's high spin projectiles are of a liquid spin filled type. They are limited in operation temperature and spin ranges and in ability to withstand off-center spin without performance degradation. The large viscosity changes and electrolyte volume changes over the operational temperature range are major contributors to these basic design limitations. The 76mm system offers two known incompatibility problems with the EX 39 battery of the current EX 400 fuze: (1) an extension of the operation temperature range from the +20°F to +130°F of the 5"/54 system to a new lower limit of -20°F; and (2) the extension of the spin range from the 250 to 288 rps of the 5"/54 system to 410 rps. It is planned that the battery modifications will meet all the requirements of both the 3"/50 and 76mm gun systems.

NOL White Oak has procured 20 model line fuzes from Eastman Kodak, Rochester, New York, for survivability tests in the 76mm gun. Delivery is scheduled for mid-January. The electro optics of these fuzes are the same as the EX 400 fuze except for a change in one resistor value to increase the band-pass frequency of the amplifier to match the spin rate of the 76mm projectile. The reserve energizer is a MK 39 MOD 2 and is the same as the EX 400 reserve energizer except for an increase of 0.1 millilitre in electrolyte volume. The safety device used is a MK 42 MOD 0 which does not contain the self-destruct clean up feature to be incorporated in later units. The firing results will be used to assess the capability of the proposed fuzes to withstand the gun environments and function on target engagement.

EXPLOSIVE LOADING

NWS Yorktown has completed a preliminary study of required explosive properties. A press operation similar to that used on 5-in. projectiles is planned. Based on preliminary NWL projectile body drawings and a maximum setback acceleration of 23,000 g (proof pressure), it was determined that a minimum loading density of 1.60 gm/cc is required. The maximum thermal expansion of the explosive was computed to be 0.100 in., when subjected to a 95° temperature differential (+70°F to +165°F). This computation is based upon achieving 100 percent of the theoretical density for pressed Comp A-3.

NWS Yorktown will begin modification of pressing equipment upon receipt of final NWL drawings in January 1973. Loading studies to determine increment sizes and pressing pressures will begin in April 1973 upon receipt of projectile bodies from NWL.

CARTRIDGE CASE

Italian 76mm ammunition uses a brass cartridge case. Because of the cost and the strategic nature of copper during wartime, NAVORD has approved concurrent programs to provide brass and steel case designs. The brass design, being of minimum technical risk, is intended for the first ship deliveries. The steel design, more economical in production, will be phased in following complete test and evaluation in the MARK 75 mount.

1. Brass Case - The Italian case drawings and specifications have been reviewed by NOS Indian Head. The specified chemical composition of the Italian brass is shown in Table 5 and compared to the requirements of MIL-C-50D used in the manufacture of U. S. brass cartridge cases. The two materials are essentially identical. This finding indicates that dimensional changes to the Italian design will not be required. The proposed design for testing during the Engineering Phase is sketched in Figure 10. One fired and two unfired Italian brass cases are being examined at NOS Indian Head for metallurgical and dimensional properties.

2. Steel Case - NOS Indian Head has completed the preliminary design of a steel case shown in Figure 11. Differences in elasticity between the brass and steel (elastic moduli: 16×10^6 psi and 30×10^6 psi for brass and steel, respectively) have necessitated some dimensional changes. When compared to the brass case, the steel case will have the same overall length; however, the case diameter is slightly larger and the diametric taper is changed from 0.0402 to 0.0390 in./in. In addition, the crimp to the copper rotating band will require detailed study.

PROPELLANT

The Italians use the U. S. formulation, M-6 propellant with 2 percent potassium sulfate added for flash suppression. Table 6 shows comparison of the Italian specification to the requirements of MIL-STD-652A(MU). Only minor differences occur. NOS Indian Head has completed analyses of Italian propellant sampled from five rounds of BL&P ammunition (Table 7). In general, the propellant granulation (length, diameter, perforation, and web) showed excellent manufacturing control. The total volatiles were found to vary significantly and to exceed that required by the Italian specification. However, these data are questionable because of the small sample of propellant evaluated (one or two grains per round). It is known that the variation of total volatiles from one propellant grain to another is significant whereas the variation of the average total volatiles from charge to charge is much smaller. Closed bomb tests showed uniform control of the relative quickness and the relative force from charge to charge; this indicates an insignificant change in the average total volatiles from charge to charge.

PRIMER

The Italians have provided technical documentation on two percussion primers designated TR 54 and TR 54/63. The dated drawings show the TR 54 to be the first developed. A review by NOS Indian Head indicates that changes to the TR 54 design were made to facilitate assembly. A breakdown and study of expended primers fired during the mount TECHEVAL program showed the primers to be the TR 54 design. No explanation has been found as to why the older primers were shipped in lieu of the current TR 54/63 primers.

The Italian TR 54/63 primer assembly is shown in Figure 12. NOS Indian Head has selected this design for manufacture, primarily because of assembly ease. The only expected changes to this design, aside from slight variations in metal composition, will be the composition of the primary explosive and the black powder charge. The composition of the primary explosive is currently classified Secret by the Italians. The black powder has been screened and determined to be comparable in granulation to U. S. class 4; however, closed bomb burning rates have not been measured, and the literature suggests that rather large differences exist between black powder produced in Italy and that produced in the U. S. Class I black powder produced in Italy has been measured to have 68-percent relative quickness and 97-percent relative force when compared to U. S. powder. Varying charge weights and granulations of U. S. black powder will be tested to determine an acceptable match to the Italian powder. A test fixture has been designed which will fire remotely in the percussion mode and record these data.

A unique feature of the Italian designed percussion primers is the shear pin which holds the firing plug in place during ramming. The Italians have computed the ramming velocity of the MARK 75 gun to be 37 fps. It was reported that during early primer development, primer initiation was experienced due to the high velocity impact of the case with the barrel. The shear pin, or other retarding mechanism, is considered necessary for safe initiation.

A second primer design has been recommended by NOS Indian Head. The design shown in Figure 13 is a modified U. S. MARK 41 (3"/50) percussion primer. The modification consists of a belleville spring, separating the firing plug from the percussion cap. The belleville spring, then, replaces the shear pin of the Italian design as the retarding mechanism to insure safe ramming. The proposed design follows that of a Navy MARK 22 used in 40mm ammunition. NOS Indian Head has sufficient components in-house (with the exception of the belleville springs) to assemble 1000 primers. Bristol Spring Manufacturing Company has been contracted by NOS Indian Head for delivery of springs by 18 April 1973.

CLEARING CHARGE

Italian ammunition allotments include a clearing charge assembly. The clearing charge is used only in a misfire in which the rammed projectile remains in the barrel following the extraction of a non-functional propelling charge. Details of the clearing charge design will be reported when documentation is received from the Italian government.

MOUNT INTERFACES

The MARK 75 gun has two rocker arms in the feed system. The rocker arms transfer the cartridge from the upper station of the screw feeder to the feed drum. The cartridge is held by a foot grip at the base of the case and a nose grip at the projectile ogive. The nose grip is contoured to the ogive radius. The ogive radius of the NWL designed projectile body has been slightly modified to provide a better ballistic match with the EX 400 (modified) fuze. Thus, a detailed study of the rocker arm nose grip is planned to insure compatibility.

Discussions with Italian technical representatives assisting NWL with the mount TECHEVAL program indicates that the projectile and case separate during ramming. The amount of separation and frequency of occurrence is not known. NWL will study this to determine if the separation of the projectile from the cartridge case poses any operational problems when using this ammunition.

TESTS

TEST MOUNT

NWL has completed the design of a mount for experimental ammunition tests. Ammunition testing in the MARK 75 mount is not desirable because: (1) Special instrumentation requires the drilling of holes and the placement of pressure transducers on the bore surface; (2) the MARK 75 mount, as installed, is not portable and cannot be easily moved to the various test ranges required for special ammunition tests; (3) there are scheduling problems associated with two programs using the same facility; and (4) a catastrophic failure attributed to the experimental ammunition would endanger the concurrent mount TECHEVAL program.

The test mount is a modified 5"/38, MARK 1 MOD 4 housing with a percussion firing element and MARK 24 MOD 18 slide. The striking energy of the firing pin has been adjusted to match that of the MARK 75. A 5"/38 barrel and a 3"/70 barrel have been modified for assembly with the Italian manufactured 76mm barrel liner. Watervliet Arsenal, Watervliet, New York will modify and assemble the barrels into the configuration shown in Figure 14. Tests are scheduled to begin in early April 1973.

DESIGN DEFINITION TESTS

Test plans have been prepared to complete Phase I. These tests are summarized in Table 8 and are limited to the evaluation of Italian BL&P ammunition. Test results will be used to define functional limits.

Table 1. Integrated Logistics Support
Major Milestones

- Procure Ammunition Parts for Engineering Test and Evaluation	Jan 1973
- Release ILS Plan	1 Apr 1973
- Complete PHST System Design	1 Jul 1973
- Provide Naval Production Acceptance Gages for TECHEVAL, IOT&E and IOC Procurements	1 Aug 1973
- Procure Ammunition Parts for TECHEVAL	Aug 1973
- Provide Prototype PHST Containers	15 Sep 1973
- Provide Ammunition Loading Facilities for TECHEVAL, IOT&E and IOC Ammunition	1 Dec 1973
- Procure Ammunition for Fleet IOT&E	Feb 1974
- N&L Design Review	15 Apr 1974
- Initiate a Pilot Production of Ammunition to Meet IOC Commitments	Aug 1974
- IOC	1 Dec 1974

Table 2. Program Participants Providing Technical Support to NWL

<u>Activity</u>	<u>Program Element</u>	
NOS Indian Head	Propelling Charge	Provide two propelling charge assembly designs, a service charge, and a clearing charge which are compatible with the MARK 75 gun mount.
NWS Yorktown	Explosive Load	Evaluate procedures for loading 76mm ammunition with Comp A-3 explosive and prepare loading - assembly documentation.
NOL White Oak	Fuze	Modify the EX 400 Passive IR fuze for service use with 76mm ammunition. Conduct a fuze certification program.

Table 3. Chemistry and Mechanical Properties of Italian Projectile Bodies

Chemical Analysis¹

<u>Projectile Number</u>	<u>C</u>	<u>P</u>	<u>S</u>	<u>Si</u>	<u>Mn</u>	<u>Mo</u>	<u>Ni</u>	<u>Cr</u>	<u>Cu</u>
84	.424	.024	.047	.28	.58	<.05	.09	.11	.24
138	.459	.026	.025	.37	.83	<.05	.09	.22	.28

Mechanical Properties²

<u>Projectile Number</u>	<u>σ_y(psi)</u>	<u>σ_u(psi)</u>	<u>% Elong</u>	<u>% Red. Area</u>
84	80,300	112,000	23.1	55.1
138	107,600	131,000	18.1	54.1
Required	$\geq 71,100$	$\geq 106,700$	≥ 3	≥ 30.0

- Notes:
1. Projectile body material is equivalent to AISI 1043 with residuals of chromium and copper.
 2. Properties represent the average of three specimens per projectile.
 3. No requirement

Table 4. Performance of the 76mm/62 Compared to the 5"/54 Ammunition at Nominal Service Charge Conditions

	<u>76mm/62</u>	<u>5"/54¹</u>
Muzzle Velocit, (fps)	3070	3000
Service Pressure (psi)	49,500	52,400
Spin Rate	410	288
Axial Acceleration (g x 1000) ²	20.9	12.9
<u>Maximum Range (yd)</u>	17,908/67.8 ³	Classified
<u>Time of Flight (sec)</u>		
Operating Temperature	-20°F to +130°F	+20°F to +130°F

- Notes:
1. These data correspond to the Improved 5"/54 Projectile design requirements for which the EX 400 fuze is being developed.
 2. Accelerations are computed values based on nominal service conditions.
 3. 76mm/62 Compact OTO Automatic Gun Brochure No. 722-R; OTO MELARA, SpA; LaSpezia, Italy

Table 5. Chemistry of Brass Used for Manufacture of Italian
76mm Cartridge Cases Compared to U. S. Equipment

	Cu	Zn	Pb	Fe	Bi	Total Elements Other Than Zn-Cu
Italian	71 - 74	26 - 29	.08 max.	.1 max.	None	.8
U. S.*	68.5 - 71.5	28.5 - 31.5	.07	.05	.006	.15

*MIL-C-50

Table 6. Comparison of Chemical Composition of U. S. M-6 Propellant and Italian M-6+2 Propellant

	<u>U. S.</u> ¹	<u>ITALIAN</u> ²
Nitrocellulose (%)	87.0 ± 2.0	87.0 ± 3.0
Dinitrotoluene (%)	10.0 ± 2.0	10.0 ± 3.0
Dibutylphalate (%)	3.0 ± 1.0	3.0 ± ^{.5} 1.5
Diphenylamine (%)	1.0 ± ^{0.20} 0.10	1.0 ± .10
Potassium Sulfate (%)	1.0 ± 0.10	2.0 ± .30
Total Volatiles (%)	1.4	1.4
Moisture (%)	0.60 ± 0.20	0.60 ± 0.20
Compressibility (%)	30 min	--- ³

1. MIL-STD-652A (MU)

2. Direzione Del Munizionamento Aulla (MS);
Ctg. G-13

3. No requirement

Table 7. Italian M-6 Propellant with
2 Percent Potassium Sulfate Added

	Round 27	Round 37	Round 69	Round 84	Round 138
Moisture (%)	0.80	0.75	0.80	0.75	0.80
Nitrocellulose (%)	84.92	84.89	84.84	84.84	84.83
Dibutyl Phthalate (DBP) (%)	2.51	2.49	2.48	2.45	2.46
Dinitrotoluene (DNT) (%)	9.50	9.44	9.53	9.52	9.55
Diphenylamine (%)	0.89	0.89	0.85	0.91	0.97
Potassium Sulfate (%)	2.18	2.29	2.30	2.28	2.19
Total Volatiles (%) ¹	1.94	1.06	1.61	1.63	1.25
Granulation ²					
Length (L) (in)	0.571	0.573	0.571	0.573	0.568
Diameter (D) (in)	0.256	0.255	0.255	0.255	0.252
Perf (d) (in)	0.023	0.023	0.023	0.023	0.024
Inner Web (in)	0.043	0.043	0.044	0.043	0.043
Outer Web (in)	0.050	0.050	0.050	0.050	0.050
Average Web (in)	0.047	0.047	0.047	0.047	0.047
Web Mean Deviation	14.89	14.89	12.77	14.89	14.89
L/D	2.23	2.25	2.24	2.25	2.25
D/d	11.13	11.09	11.09	11.09	10.50
Length Uniformity	1.75	1.40	1.58	1.92	1.23

Table 7. Continued

	Round 27	Round 37	Round 69	Round 84	Round 138
Diameter Uniformity	1.56	1.18	1.18	1.18	1.79
Explosion (hr)	<5	<5	<5	<5	<5
Relative Quickness ³	117.2	117.1	119.1	118.0	117.7
Relative Force ³	102.9	103.6	103.6	103.6	103.6

- Notes:
1. These data are in question. The extreme variation in total volatiles would imply a large variation in propellant ballistics. However, the closed bomb data (relative force and relative quickness) does not support this.
 2. Granulation data are an average based on 10 grains sampled from each round.
 3. These values determined relative to 5"/38 M-6 closed bomb data. Values are meaningful on a comparative basis only.

Table 8. Design Definition Tests

<u>Test</u>	<u>Objective</u>	<u>No. of Rounds</u>
DD-1 Charge Weight Determination	Proof the modified test mount. Determine service charge weight for Italian M6 + 2 propellant.	12
DD-2 Propelling Charge Evaluation	Examine the interior ballistics of 76mm ammunition at service and 115% service (proof) charge (90°F).	10
DD-3 Propelling Charge Evaluation	Examine the interior ballistics of the service charge at temperature extremes of +120°F and -20°F.	10
DD-4 Propelling Charge Evaluation	Examine the interior ballistics of 76mm ammunition at 50%, 60%, and 75% of service charge (90°F).	5

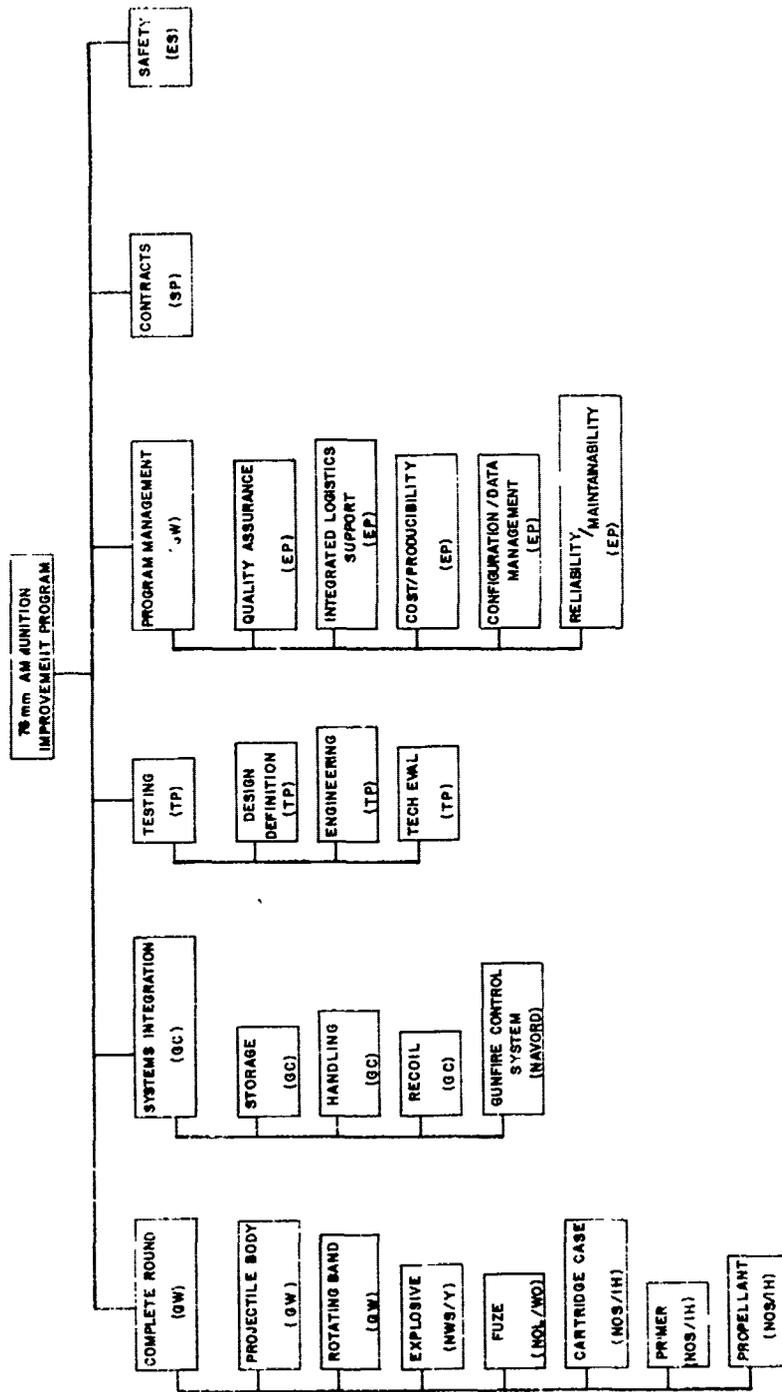


Figure 1. 76mm/62 MARK 75 MOE 0 Gun Ammunition Program Work Breakdown Structure.

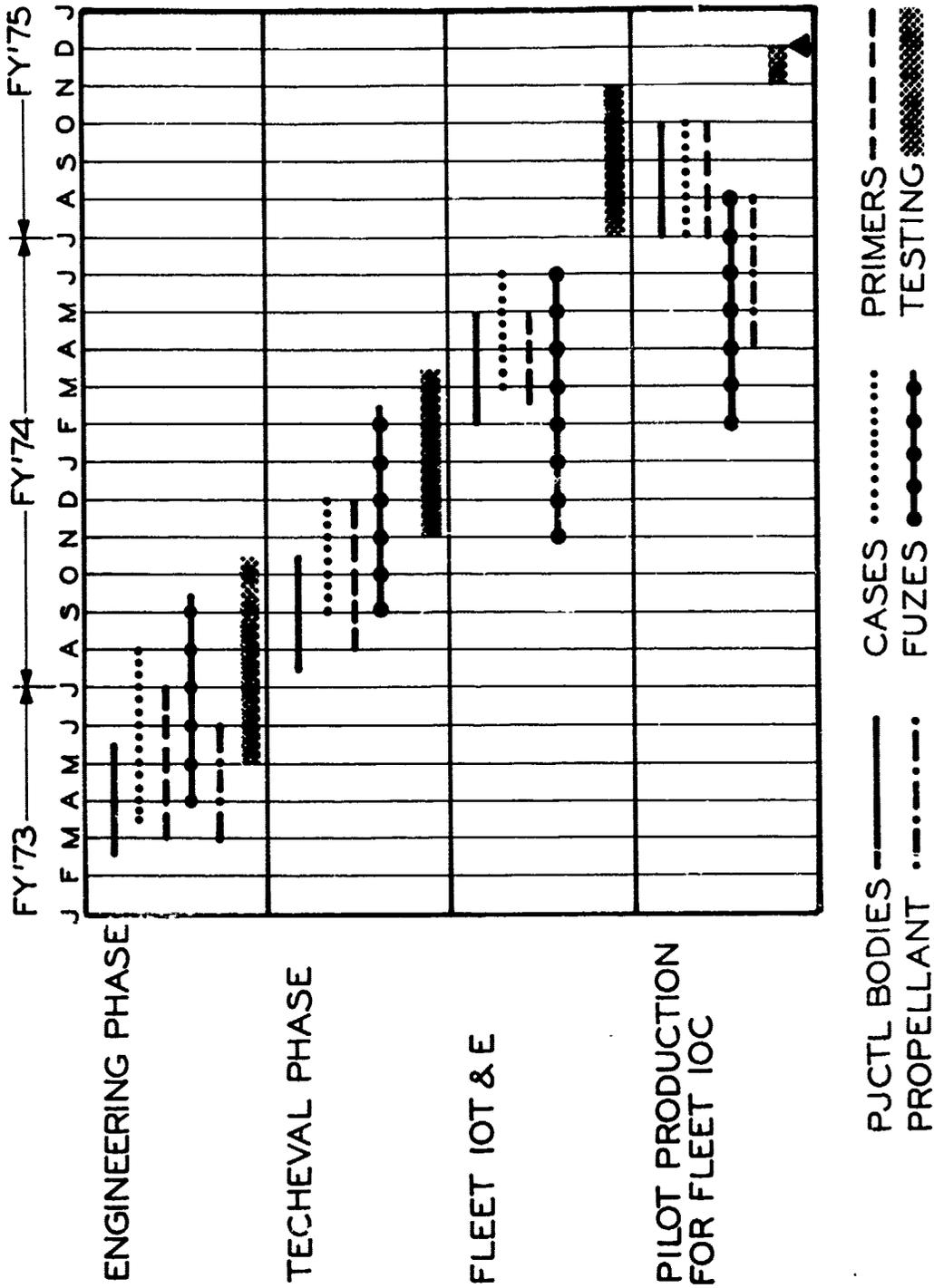


Figure 2. 76mm/62 Cal. Ammunition Procurement Schedule.

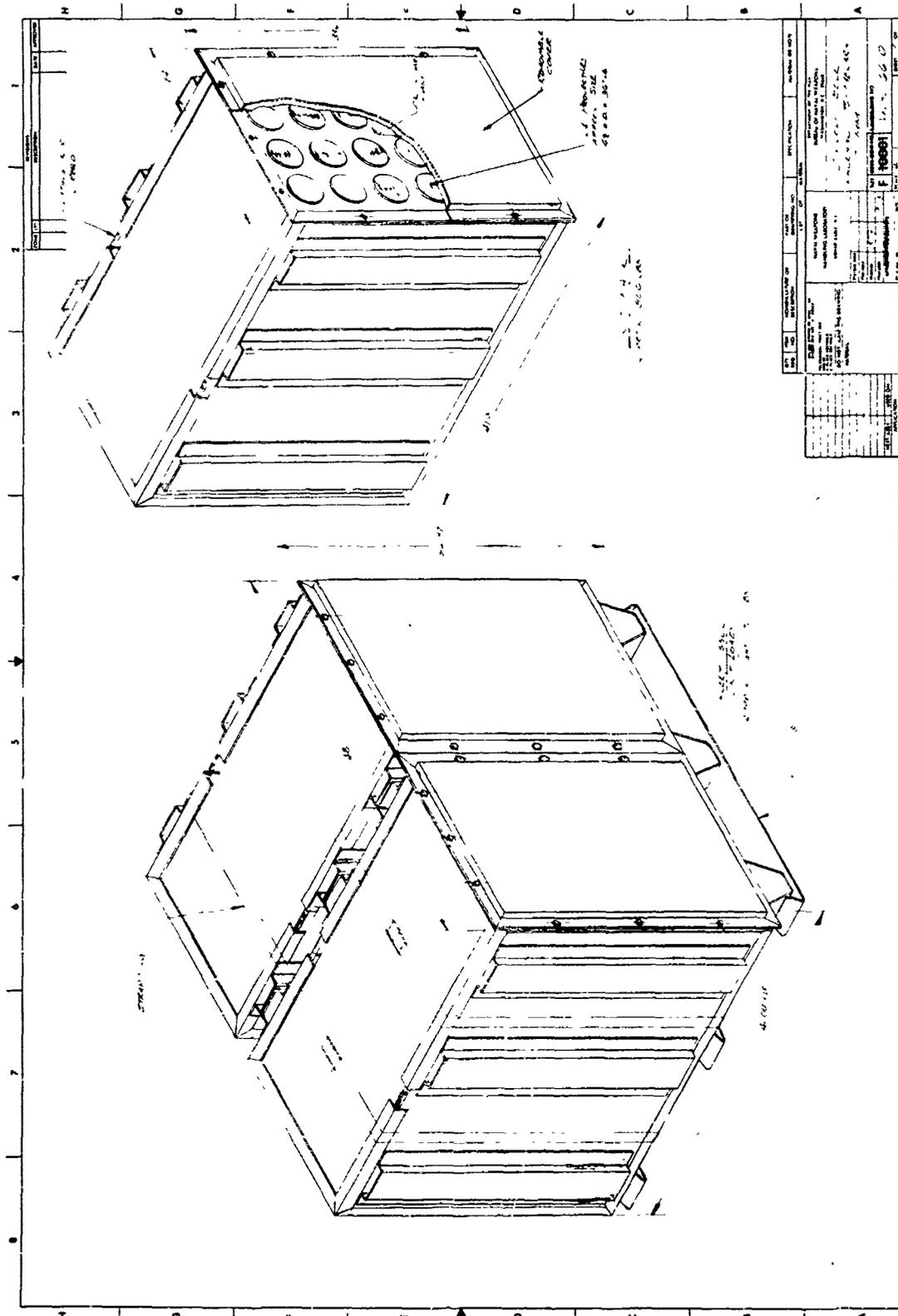


Figure 3. Bulk Packaging Concept Proposed for 76mm Ammunition.

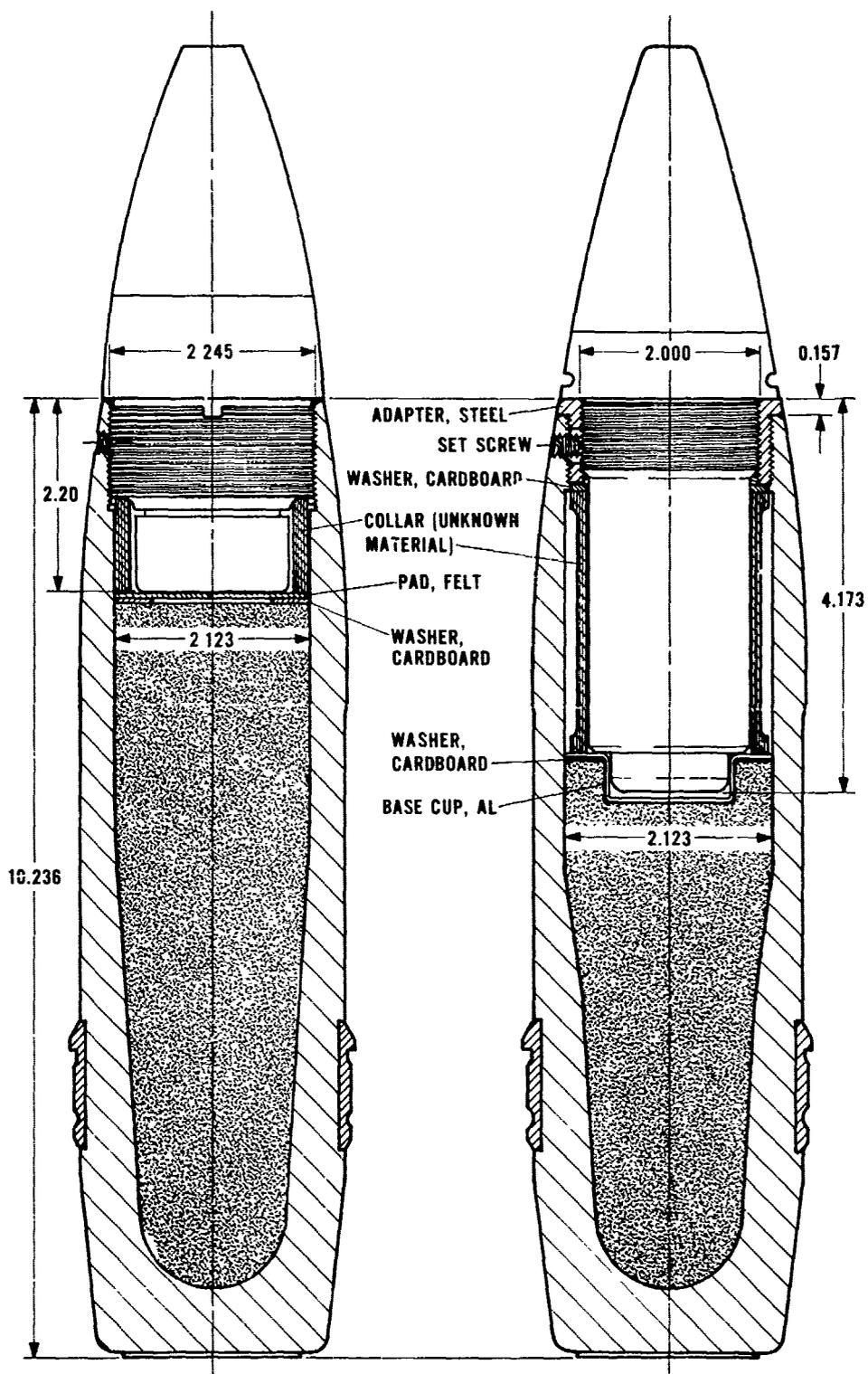
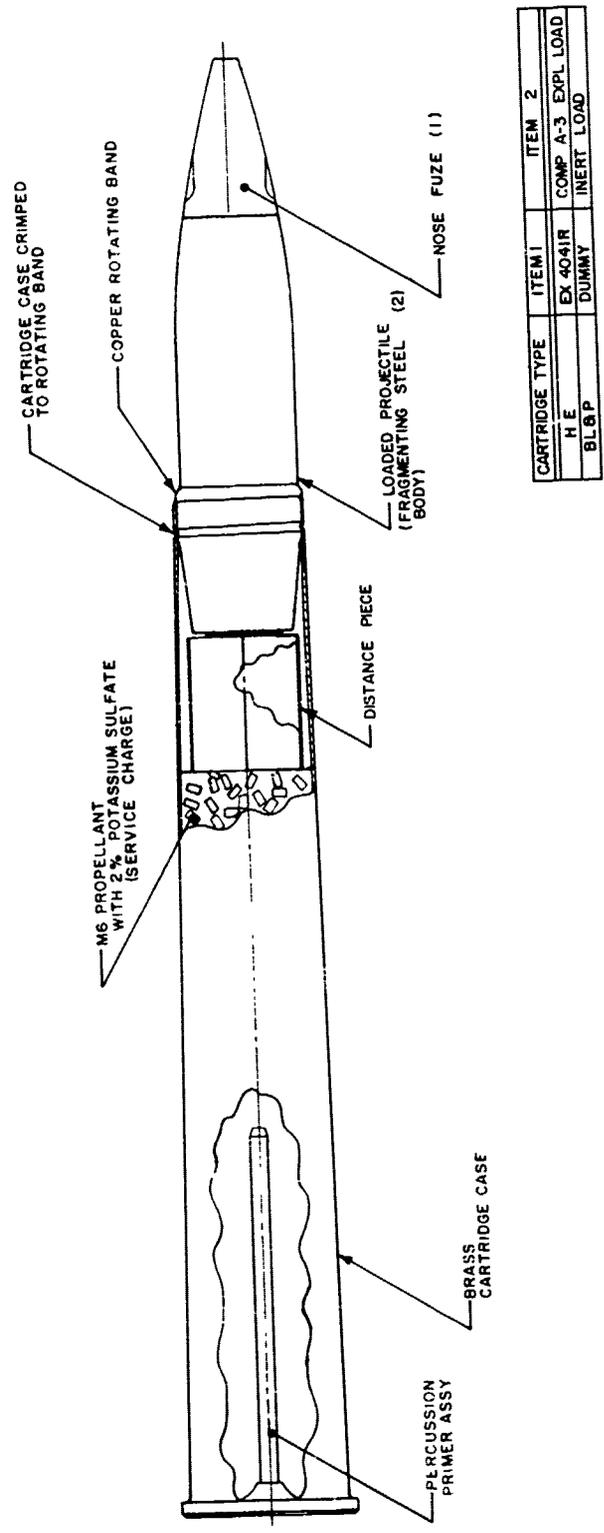


Figure 4. Italian Projectile with OPA Point Detonating Fuze (left) and Italian Projectile with MARK 72 Proximity Fuze (right).



CARTRIDGE TYPE	ITEM 1	ITEM 2
H E	EX 4041R	COMP A-3 EXPL LOAD
BL&P	DUMMY	INERT LOAD

Figure 5. 76mm/62 Cal. Cartridges.

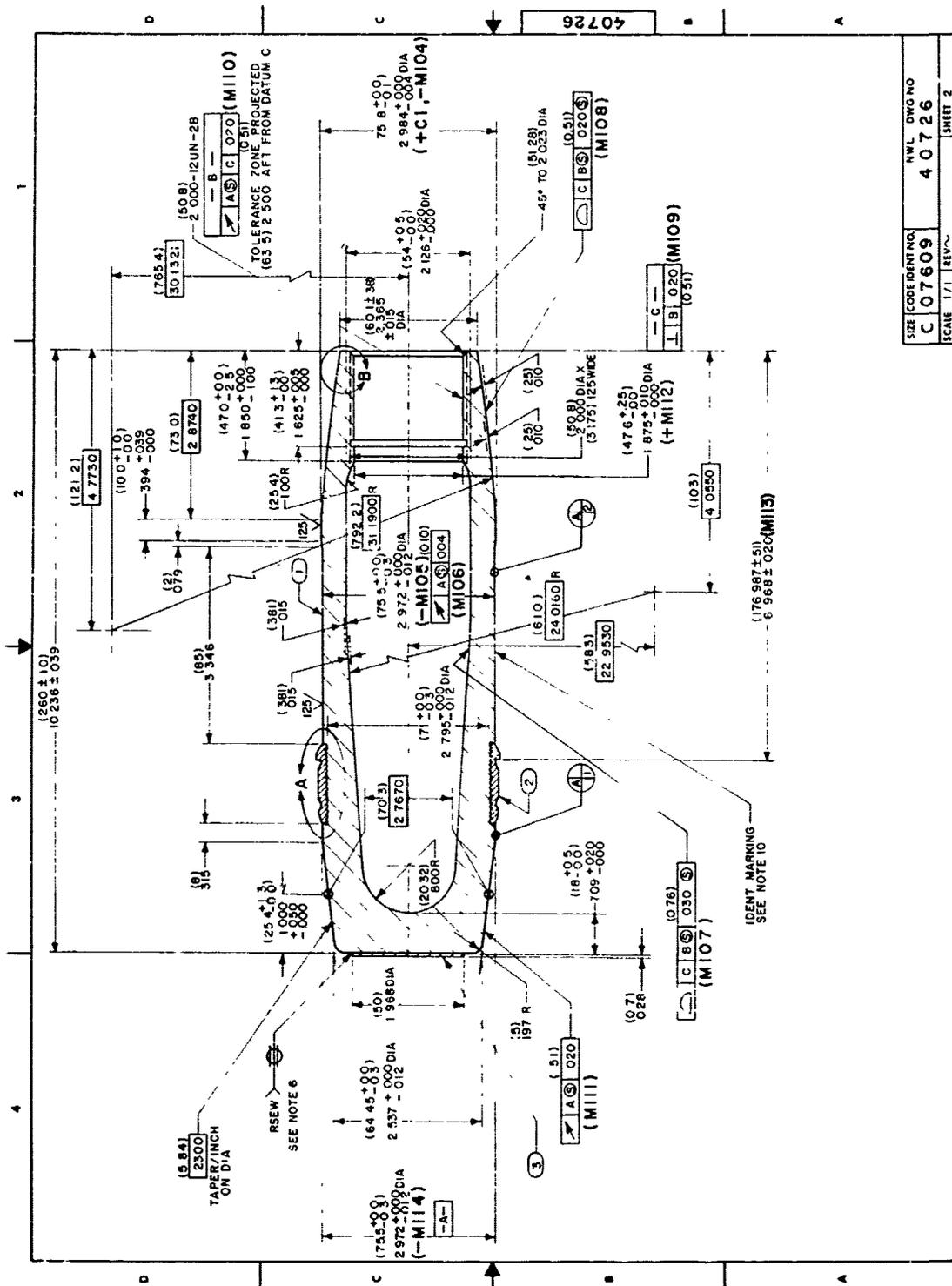


Figure 6. 76mm Projectile Body.

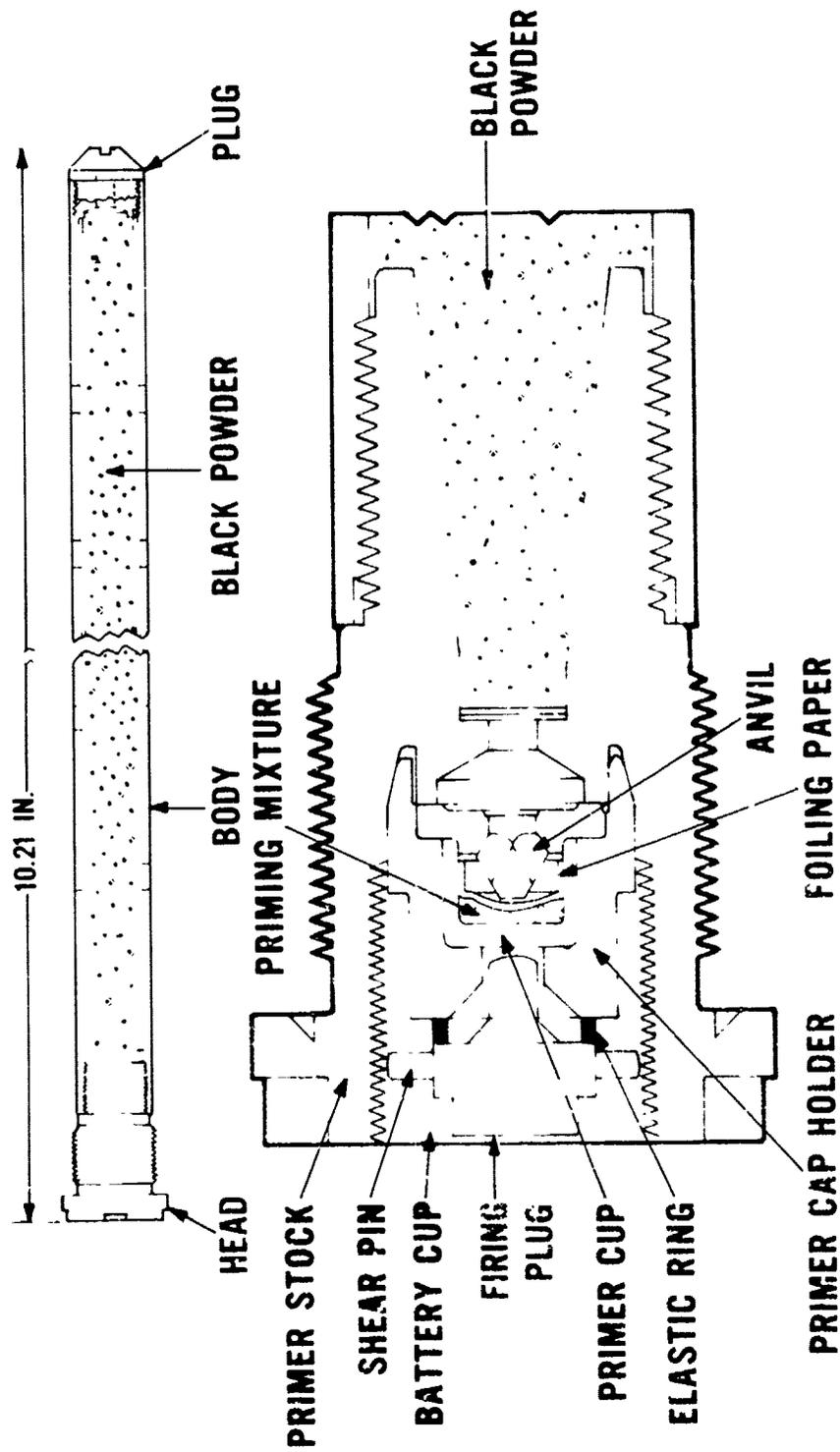


Figure 12. Percussion Primer Assembly, OTO MELARA TR 54/63.

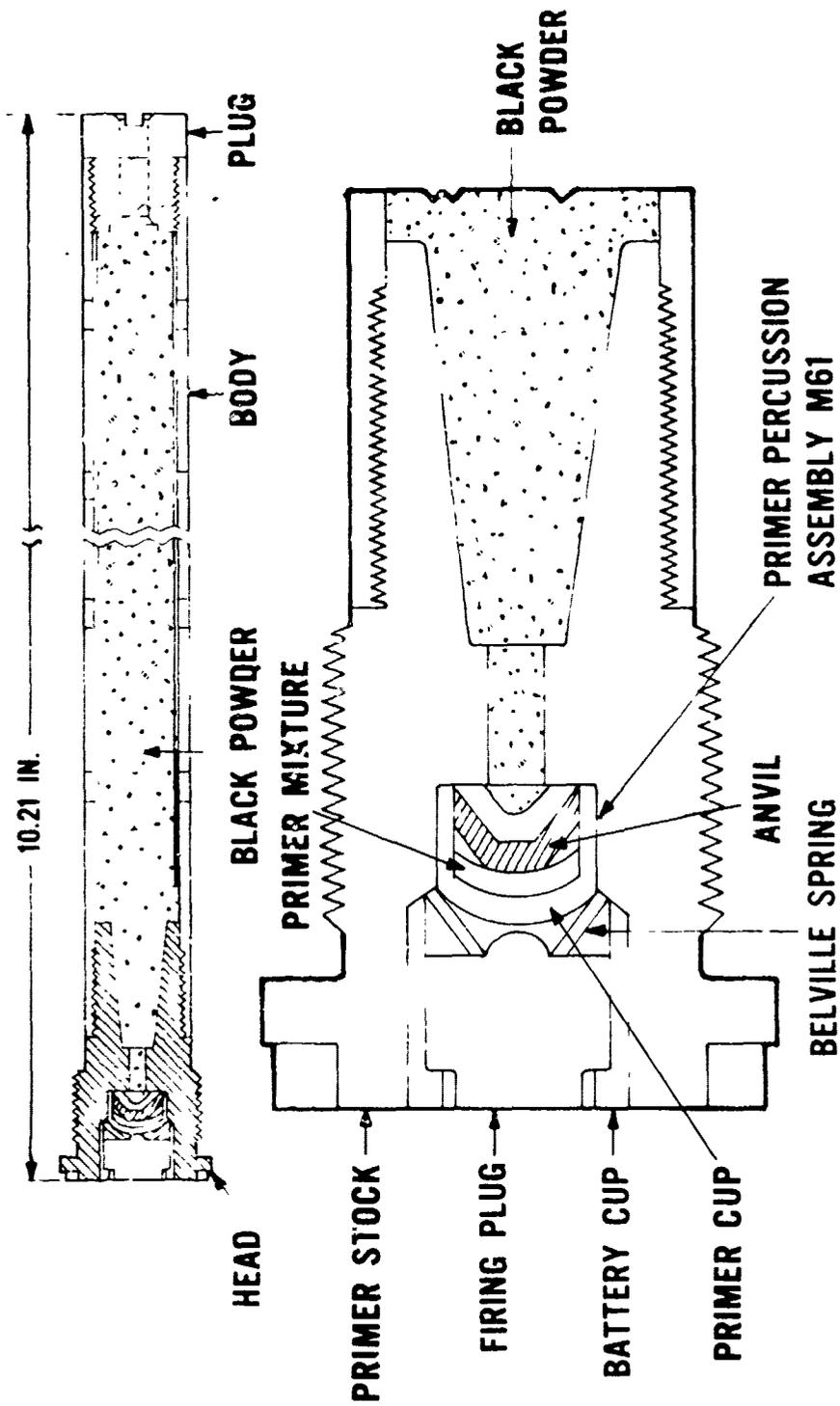


Figure 13. Percussion Primer Assembly (Proposed).

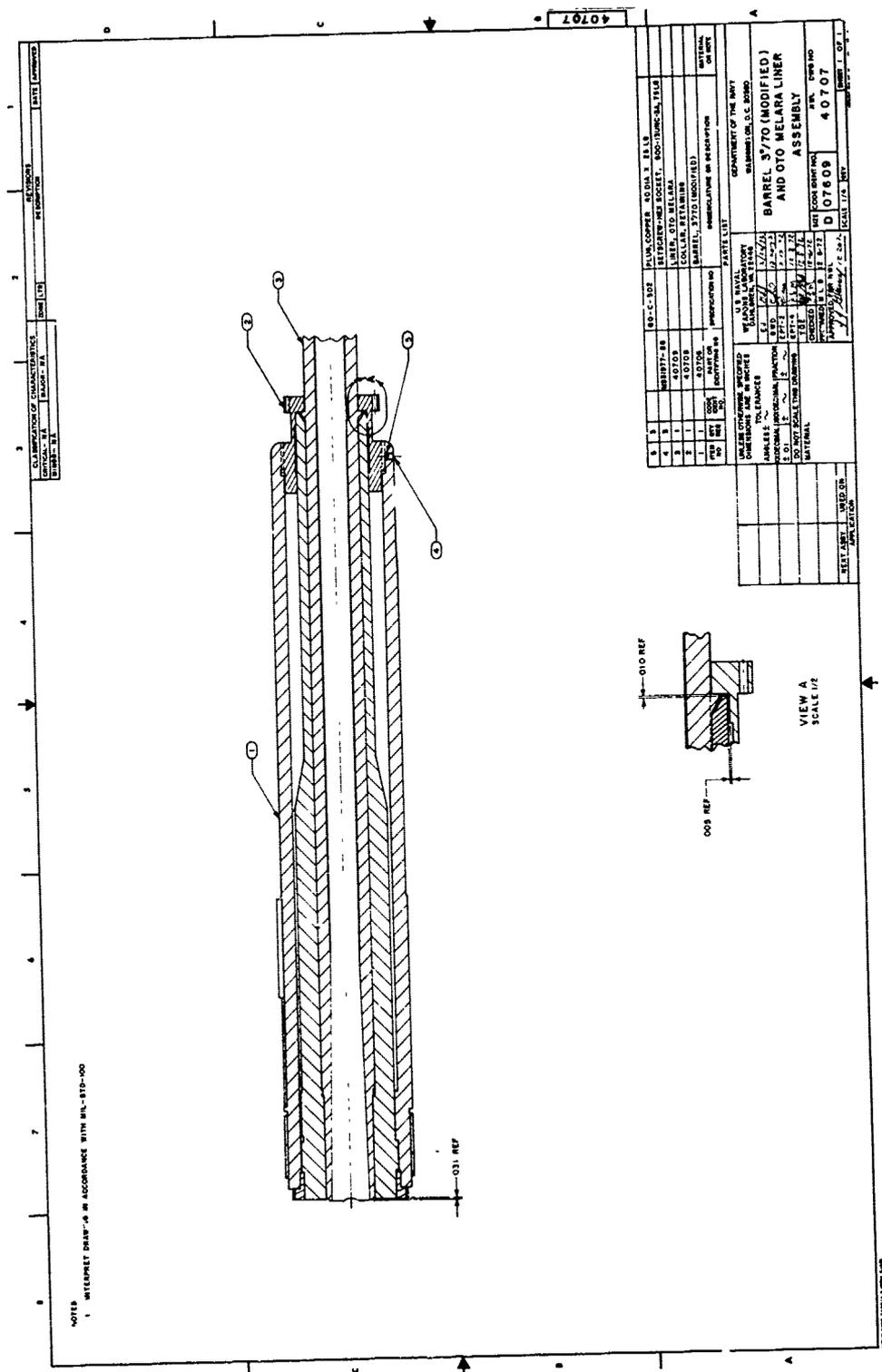


Figure 14. Barrel Assembly Ready for Installation in 5"/38 Housing.

APPENDIX A
PRODUCT ASSURANCE PLAN
FOR 76MM/62 CALIBER AMMUNITION

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INTRODUCTION

The 76mm/62 ammunition program will develop three (3) items: a proximity (IR type) fuze cartridge, a clearing charge, and a blind loaded and plugged cartridge. These ammunition items are for use with the MARK 75 MOD 0 (OTO MELARA) gun and the MARK 92 Gun Fire Control System which will be installed on class PHM and PF ships. See System Work Breakdown Structure, Figure A-1. The gun mount is currently being evaluated by NWL (Code GC) and its scheduled operational capability necessitates an IOC (Initial Operational Capability) for the ammunition of 1 December 1974.

A. SCOPE

Product assurance for the 76mm/62 ammunition should be accomplished in accordance with this plan. This plan will guide all product assurance efforts within NWL and will establish guidelines, minimum product assurance effort, and reporting procedure for other design activities involved in the program. Design responsibilities of NWL and other activities are outlined on the Design Responsibility Breakdown, Figure A-2.

B. ORGANIZATION

Upon approval, this plan will be implemented by a PA (Product Assurance) team from NWL, initially composed of five (5) members, representing the disciplines of:

- (1) configuration/data management - CM/DM member
- (2) quality assurance - QA member
- (3) integrated logistics support - ILS member
- (4) reliability/maintainability - R/M member
- (5) cost/produceability - C/P member

The Product Assurance Organization is shown as Figure A-3. One of the product assurance team members will be designated PA (product assurance) coordinator. He will coordinate the efforts of the PA team and will be their main communications link with the program management office and other design activities. Individual team members will work directly with the NWL program manager's office, as required, but shall keep the PA coordinator informed of their current work effort, progress, problem areas, etc. The PA team will call meetings of the Material Review Board, Change Control Board, and Data Requirements Review Board as required through the program. Membership of these boards will be determined by the PA team and the program management office.

C. PURPOSE

The purpose of this plan is to insure:

- (1) definition of the functional requirements of the ammunition;
- (2) allocation of the requirements to the components;
- (3) measurement (at critical points) of the achievement of the functions;
- (4) verification of the accomplishment of product assurance for the ammunition;
- (5) acquisition of documentation suitable for procurement and support of the 76mm/62 ammunition.

OBJECTIVES

The specific objectives of product assurance are:

- (1) insure definition, documentation, and updating of the functional goals (system and allocated);
- (2) insure definition, listing, scheduling, acquisition and reporting of data requirements for the program;
- (3) insure definition and control of the physical interfaces;
- (4) monitor and report the acquisition of design disclosure documents, document changes, and baseline identification;
- (5) plan and monitor the hardware identification, inspection, and audit;
- (6) acquire, evaluate and maintain inspection, audit, and test data;
- (7) provide product assurance review and assessment of procurement actions;
- (8) provide product assurance review and assessment of engineering designs and proposed changes;
- (9) specify review, coordinate, and report product assurance efforts of other activities for the program;
- (10) provide a continuing systematic produceability and cost analysis for each proposed design and design changes to ensure producible ammunition within the cost goal;
- (11) establish the reliability goal for the ammunition, allocate the goals to the subassemblies/components, analyze the effect of component failure on the ammunition, and determine the achieved reliability of the ammunition;
- (12) assist and coordinate efforts of offices responsible for planning and implementing logistic support for the program;
- (13) provide a final report outlining the product assurance effort for the program and an assessment of achievement of product assurance;
- (14) provide the necessary coordination for orderly transfer of the product assurance functions to the appropriate activity for production.

RESPONSIBILITY

A. PROGRAM MANAGER

The NWL program manager is responsible for the ammunition development. The program manager will communicate to the PA team via the PA coordinator any program decision or action which would effect product assurance and report any difficulty arising from use of the plan.

B. PRODUCT ASSURANCE TEAM

The PA team will be responsible for implementing this plan. Each team member will be responsible for that portion of the plan which involves his discipline. The team will report directly to the program manager via the PA coordinator.

C. OTHER ACTIVITIES

Other activities shall implement a product assurance plan consistent with the milestones, objectives and procedures of this plan. Their reporting methods should be similar to those outlined in this plan. They should communicate with the PA team via the PA coordinator on matters involving product assurance. Copies of documents and records maintained by other activities in performance of product assurance will be made available to the NWL PA team on request. Upon request of the NWL program manager, other activities will allow and assist NWL personnel to perform audits of their procedures and processes used in maintaining product assurance or manufacture/assembly of ammunition or ammunition components.

PROCEDURES

A. FUNCTIONAL GOALS

Identify and Document. Functional goals for the 76mm/62 ammunition shall be established by:

(1) a coordinated effort between program management and the PA team to list the functions of the ammunition. The list of functions will be used to establish the framework for a functional specification.

(2) The listed functions will be measured by testing the Italian designed ammunition. The PA team will review the test plan to ensure all listed functions are being measured. The measurements will be recorded, compiled and evaluated to establish functional goals for the specification.

(3) The functional goals will be allocated by a coordinated effort between program management and the PA team to the subassemblies/components of the design. The allocations will become part of the functional specification.

(4) The CM/DM team member will coordinate the review, approval, and authentication of the functional specification and provide for management of the document.

Intended Use. The functional specification will be used for:

- (1) engineering design considerations for the subassemblies/components;
- (2) reliability prediction for the ammunition and allocation of reliability levels for subassemblies/components;
- (3) definition of values to be measured at functional audit;
- (4) the development of a surveillance specification for the ammunition;
- (5) control and document changes to the functional and reliability goals;
- (6) establishing QA provisions for subassemblies/components;
- (7) evaluation of product assurance for the program.

B. DATA REQUIREMENTS

Identify and Document. The DRRB (Data Requirements Review Board) shall convene to establish a list of all engineering data required through the program. They will identify:

- (1) each data item;
- (2) the type and form of each data item;
- (3) the purpose of each data item;
- (4) the source of each data item;
- (5) the control document for content and preparation of each data item;
- (6) the scheduled date for acquisition of each data item.

The CM/DM team member will compile the information on the ADL (Authorized Data List), Figure A-4 and the Data Acquisition Check List, Figure A-5.

Intended Use. The lists will be used by the CM/DM team member as working and reporting documents. Engineering data will be acquired in accordance with the ADL. Changes to the ADL will be made only with concurrence of the members of the DRRB. The Data Acquisition Check List will alert the CM/DM team member when scheduled data is not delivered on the prescribed date.

C. INTERFACE CONTROL

Identify and Document. Interface definition will begin when the ammunition and component designs are proposed. The interface requirements will be supplied by the ammunition design engineer designated by the NWL program manager. The CM/DM team member will document the requirements in the form of interface control documents which define the overall configuration, the interface design parameters and the subassembly/component interface dimensions and limits. The drawings will be approved by the cognizant all-up ammunition design engineer, the program manager, the CM/DM team member and the NWL chief engineer. The CM/DM team member will manage the drawings.

Intended Use. The drawings will be used for control of interface areas of subassembly/component design. The interface areas of design proposals or design changes must be within the defined interface limits. Changes to interface control drawings shall be approved by the initial approving offices and subassembly/component design engineers effected by the change.

D. RELIABILITY GOALS

Identify and Document. Reliability goals for the ammunition are closely related to, and therefore will be established concurrent with the functional goals. The reliability goals will be determined by input from NAVORD results of GC gun firing tests (related task - MK 75 gun), and from tests to evaluate the Italian ammunition. The reliability goals, like the functional goals, will be allocated to each subassembly/component in the design. The reliability goals will be documented as an attachment to the functional specification.

Intended Use. See Intended Use under FUNCTIONAL GOALS.

E. PA DESIGN REVIEW

The PA team will review engineering designs and design changes for the 76mm/62 ammunition. The reviews will be concentrated for the milestone events, Figure A-6. The PA input will come either from direct involvement in the design process or as a review of the proposed design/design change and will include:

- (1) cost prediction for the design/design change and its effect on the cost goal;
- (2) suggestions for "state-of-the-art" materials and processes which could enhance production, performance or cost;
- (3) make a reliability prediction and assess the effect on the reliability goal;
- (4) review the dimension and tolerance structure;
- (5) review for conformance to interface limits;
- (6) review material and commercial component selection for possible problems in procurement;
- (7) predict inspection processes and costs and identify any problem areas;
- (8) predict any problems in manufacturing processes or production quantities and recommend solutions;
- (9) assess the ability of the design to accomplish the functional goal;
- (10) determine logistic support requirements necessary to support the design/design change.

F. DESIGN DISCLOSURE DATA

Identify and Document. Design disclosure data will be identified on the ADL and scheduled on the Data Acquisition Check List. Design disclosure documents may be prepared at NWL, prepared at other activities, or purchased as part of a procurement contract in accordance with stipulations listed below:

(1) Documents prepared at NWL shall be produced from data supplied by the cognizant design engineer. The drawing preparation, review, approval, authentication, and distribution shall be coordinated by the CM/DM team member.

(2) Documents prepared at other activities shall remain under the control of the preparing activity. The form and level of the documents shall be comparable to the NWL documents for each phase of the program. The design must conform to the interface control drawing limits.

(3) Documents procured by NWL contracts will be specified by the CM/DM team member and he will coordinate the review and acceptance of the documents.

Changes. NWL proposed changes to documents under NWL cognizance shall be submitted on a marked up copy to the CM/DM team member. He will determine who needs to review and approve the change. He will prepare the required change control documents (Engineering Change Proposal or Notice of Revision), route the change for review and comment and coordinate the document change and change approval.

NWL proposed changes to documents under another activity cognizance will be submitted on marked copy to the CM/DM team member. He will determine who, if anyone, at NWL needs to review the proposed change. He will prepare any required change control documents, route the change for review and comment, and forward it for review and concurrence to the cognizant activity.

Other activities may change their documents without NWL approval except those changes which effect function or interface will require approval of the NWL program manager. Changes which would violate the interface limits will not be approved until the interface control drawings are changed and approved.

Document Status and Baselines. The CM/DM team member will report all document acquisition and/or document changes and identify the procurement baseline. This information will be reported on the Status Accounting and Baseline Identification, Figure A-7. Other activities will keep the CM/DM team member informed of their document acquisition and change and their procurement baseline so this information can be included in the report.

G. RELIABILITY MODEL

The R/M team member shall investigate the possibility of a computer reliability model for the 76mm/62 ammunition. Such a model would be used to:

- (1) determine whether the reliability allocations achieve the reliability goal;
- (2) determine the effect of changes to component reliability on the system reliability;
- (3) input actual reliability measurements and shift allocations to measure achievement of the reliability goal.

H. FAILURE MODES AND EFFECT ANALYSIS

The R/M team member shall review the engineering design and prepare an analysis of the effect the failure of each component/subassembly has on the system. Each failure will be categorized according to whether the gun system would be effected, the ammunition would be effected, or both would be effected. This analysis will be used to:

- (1) help assign the classification of characteristics;
- (2) assist in the reliability prediction and allocation;
- (3) predict failures and determine cause of failures in testing;
- (4) aid the PA team in review of the engineering design.

I. PROCUREMENT

The PA team shall assist in the preparation of or review each proposed procurement action initiated at NWL for the 76mm/62 ammunition program. The PA team will assist the initiator of the procurement action to:

- (1) establish the lot size, sampling plan, special inspection equipment and processes, acceptance and rejection criteria, and hardware identification requirements;
- (2) review to ensure that current cost and producibility analyses were used in procurement planning;
- (3) review to ensure the failure causes and component reliability allocations are considered in the component design and inspection plans;
- (4) review for ILS planning requirements;
- (5) review for data acquisition requirements and prepare the CDRL (Contract Data Requirements List, DD Form 1423);
- (6) report any discrepancies and recommendations to the initiator of the procurement action.

J. HARDWARE IDENTIFICATION

Components. Hardware component identification requirements will be based on the level of inspection required for the component and the intended use of the component. The PA team shall determine the identification requirements and shall provide for accomplishment of the identification either by a contractor or at NWL. The identification is used to relate the hardware to the design documentation, inspection data, assembly data, and test data and will generally be:

- (1) by individual serial number when inspection data is required for each component;
- (2) by lot number when inspector data is required on a sample for lot acceptance (the sampled components could be serialized if needed for particular tests);
- (3) by part number when components are off the shelf commercial items and no inspection is required.

Assemblies. Assemblies will be identified by individual serial number either applied as a new number or recorded from a major components individual serial number. Identification of components making up each assembly shall be recorded under the assembly serial number and test data will be recorded by the assembly serial number.

K. INSPECTION

Establishing the inspection requirements and the acquisition, maintenance and use of the data shall be the responsibility of the QA team member. He will:

- (1) establish inspection levels, inspection processes and equipment, and acceptance and rejection criteria based on the engineering design and its producibility, functional goals, reliability goals and the FMEA analysis;
- (2) determine who will perform the inspection and the form of the inspection data, and identify any required cost data;
- (3) monitor the inspection process as required to ensure correct procedures are being used and the data is accurate;
- (4) outline the requirements for hardware shipments for inspection and provide for collection of the inspection data. See Hardware Inspection and Data Collection, Figure A-8;
- (5) convene the Material Review Board to review the inspection data and report the assessment of the hardware suitability to the Program Manager;
- (6) maintain the inspection data so it can be traced to the hardware and the tests involving that hardware.

L. TESTS

Plans. Test plans prepared at NWL should be done by a coordinated effort between the Program Manager, the PA team, and the test activity. All other test plans shall be reviewed by the PA team. A test plan should identify each functional or reliability goal being measured by the test and the form of the data generated by the test. The functional or reliability goal to be measured should be documented in the functional specification (See PROCEDURES, A. FUNCTIONAL GOALS). The PA team will report to the Program Manager any inadequacies in the test plan and any PA team recommendations.

Results. Test results shall be reviewed by the PA team. Data which measures the functional and reliability goals shall be reported in the form recorded from the test. The PA team shall report their evaluation of the test to the program manager with recommendations (as applicable) for design changes, inspection changes, retest, etc. The QA team member shall maintain the test data and correlate it with the inspection data.

M. LOGISTIC SUPPORT

The ILS team member shall plan for the logistic support required by the program during ammunition development and shall prepare the ILS plan for logistic support of the ammunition through its life cycle.

The Integrated Logistics Support Management Plan is a forerunner of the ILS plan which: establishes the level of ILS effort required for support of the program, identifies the ILS management team and each member's area of responsibility, and provides guidelines for planning by the ILS management team. The ILSMP shall be prepared by the ILS team member.

ILSP. The Integrated Logistics Support Plan specifies in detail: all areas where support is required; who is responsible for support in each area, the relationship between each area of support; and when the support will be required. The ILSP shall be prepared by the ILS team member.

The ILS team member must work closely with the program manager and NAVORD to prepare the ILSMP and ILSP. The plans are management plans and will be used for program planning by the program manager and NAVORD. The plans shall be maintained and revised during the program by the ILS team member.

N. OTHER ACTIVITIES

The PA team members shall identify with persons at other design activities who are responsible for their type of support function. Each member will be responsible to assess other activities accomplishment of their product assurance function, and to correlate product assurance data from other activities with their own data in reports to the program manager.

O. FINAL REPORT AND PA TRANSFER

The PA team shall provide for a smooth transfer of the PA functions at the end of the development program.

Toward the end of the development program the PA team shall prepare a final report to the program manager outlining the PA effort during the program and specifying data that verifies achievement of product assurance for the 76mm/62 ammunition. The report will be submitted to the NWL Design Review Committee to support the program managers request for release to limited production.

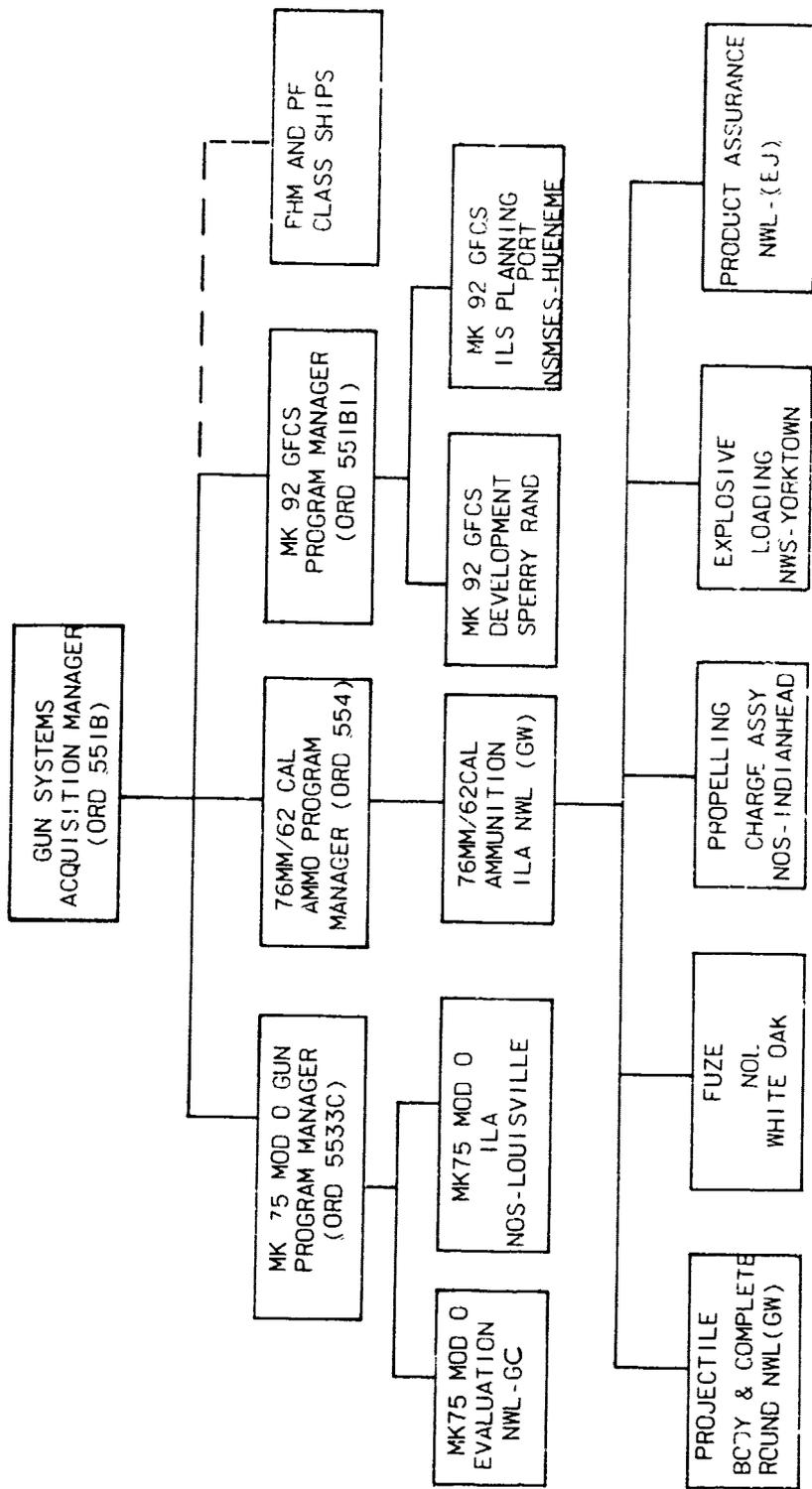


Figure A-1. System Work Breakdown Structure.

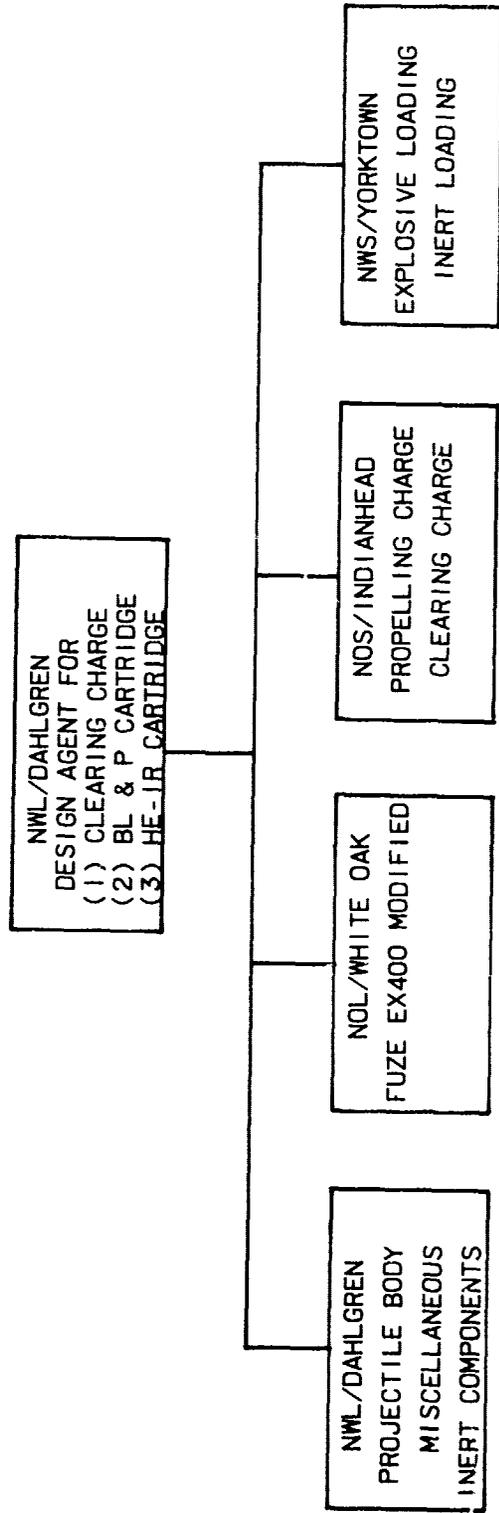


Figure A-2. Design Responsibility Breakdown.

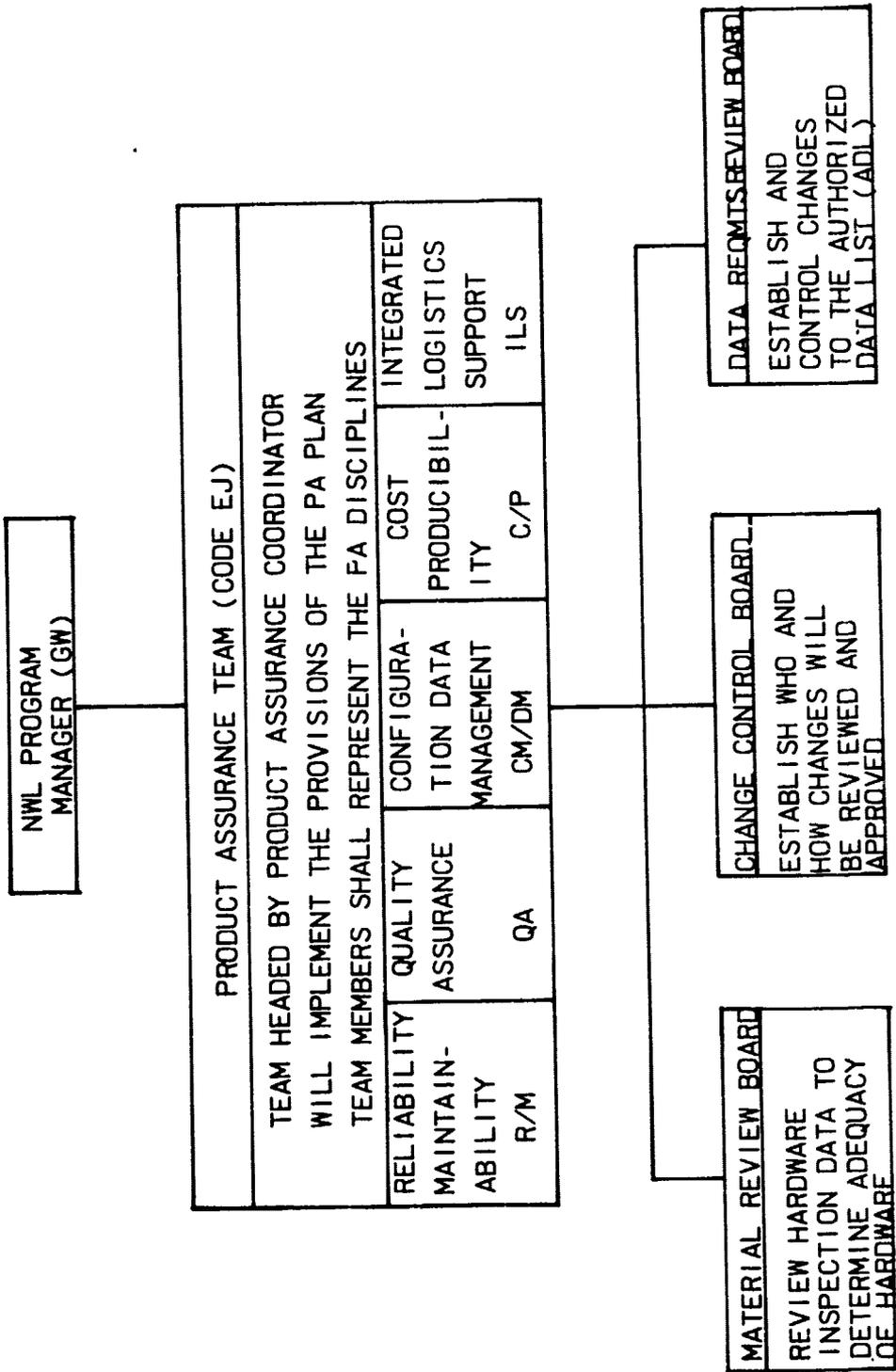
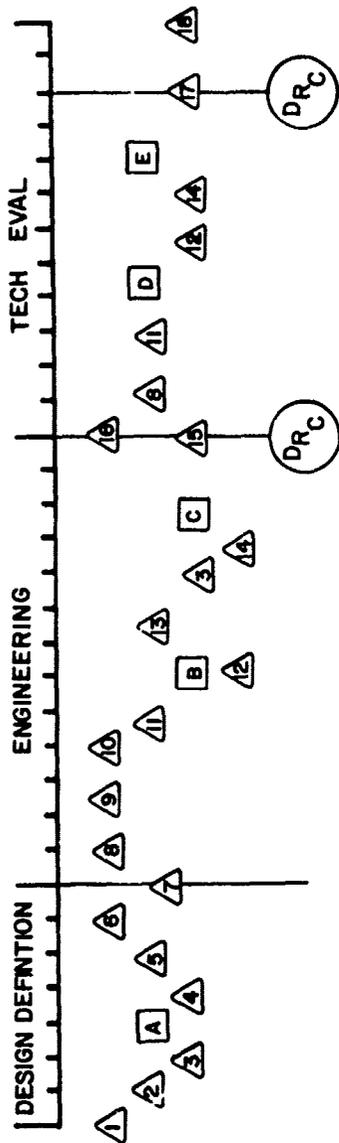


Figure A-3. Product Assurance Organization.



NOTE:

- | | | | |
|---|------------------------------|---|-------------------------------------|
| ▲ | RELEASE - LOMF | ▲ | PREPARE DESIGN DISCLOSURE DOCUMENTS |
| ▲ | FRAMEWORK OF FUNCTIONAL SPEC | ▲ | REVIEW CONTRACT |
| ▲ | REVIEW TEST PLAN | ■ | PROGRAM-CONTRACT ENGR HARDWARE |
| ▲ | PROGRAM-TEST ITALIAN DESIGN | ▲ | ESTABLISH BASELINE IDENT |
| ▲ | REVIEW TEST RESULTS | ▲ | FMEA ANALYSIS |
| ▲ | ESTIMATE RELIABILITY GOALS | ▲ | MATERIAL REVIEW BOARD REPORT |
| ▲ | AUTHENTICATE FUNCTIONAL SPEC | ■ | PROGRAM-ENGINEERING TESTS |
| ▲ | ESTABLISH PLAN | ▲ | PRODUCT ASSURANCE EVALUATION |
| ▲ | REVIEW ENGR DESIGN | ▲ | RELEASE ILS PLAN |
| ▲ | PREPARE ICD'S | ■ | PROGRAM-CONTRACT FOR TECHEVAL |
| | | ■ | PROGRAM-TECHEVAL TESTS |
| | | ▲ | FINAL PA REPORT |
| | | ▲ | TRANSFER PA FUNCTIONS |

Figure A-6. Milestone Events.

76 mm /G2 AMMUNITION STATUS ACCOUNTING & BASELINE IDENTIFICATION			
FOR BASELINE IDENTIFICATION: 1- ENGINEERING PHASE; 2 - TECHEVAL PHASE			
ASSY DWG OR DL NO.			
TITLE	COMMENTS	SHT NO.	
CARTRIDGE, LOADED & FUZED	NWL/D COGNIZANT ACTIVITY	1	
CARTRIDGE, BLIND LOADED & PLUGGED	NWL/D COGNIZANT ACTIVITY	2	
CLEARING CHARGE	NOS/IH COGNIZANT ACT	3	
PROPELLING CHARGE	NOS/IH COGNIZANT ACT	4	
PROJECTILE, BLIND LOADED & PLUGGED	NWL/D COGNIZANT ACT	5	
PROJECTILE, LOADED & FUZED	NWL/D COGNIZANT ACT	6	
FUZE	NOL/WO COGNIZANT ACT	7	
CURRENT STATUS AS OF THIS DATE			

Figure A-7. Status Accounting and Baseline Identification (Sample Form - Sheet 1 of 2)

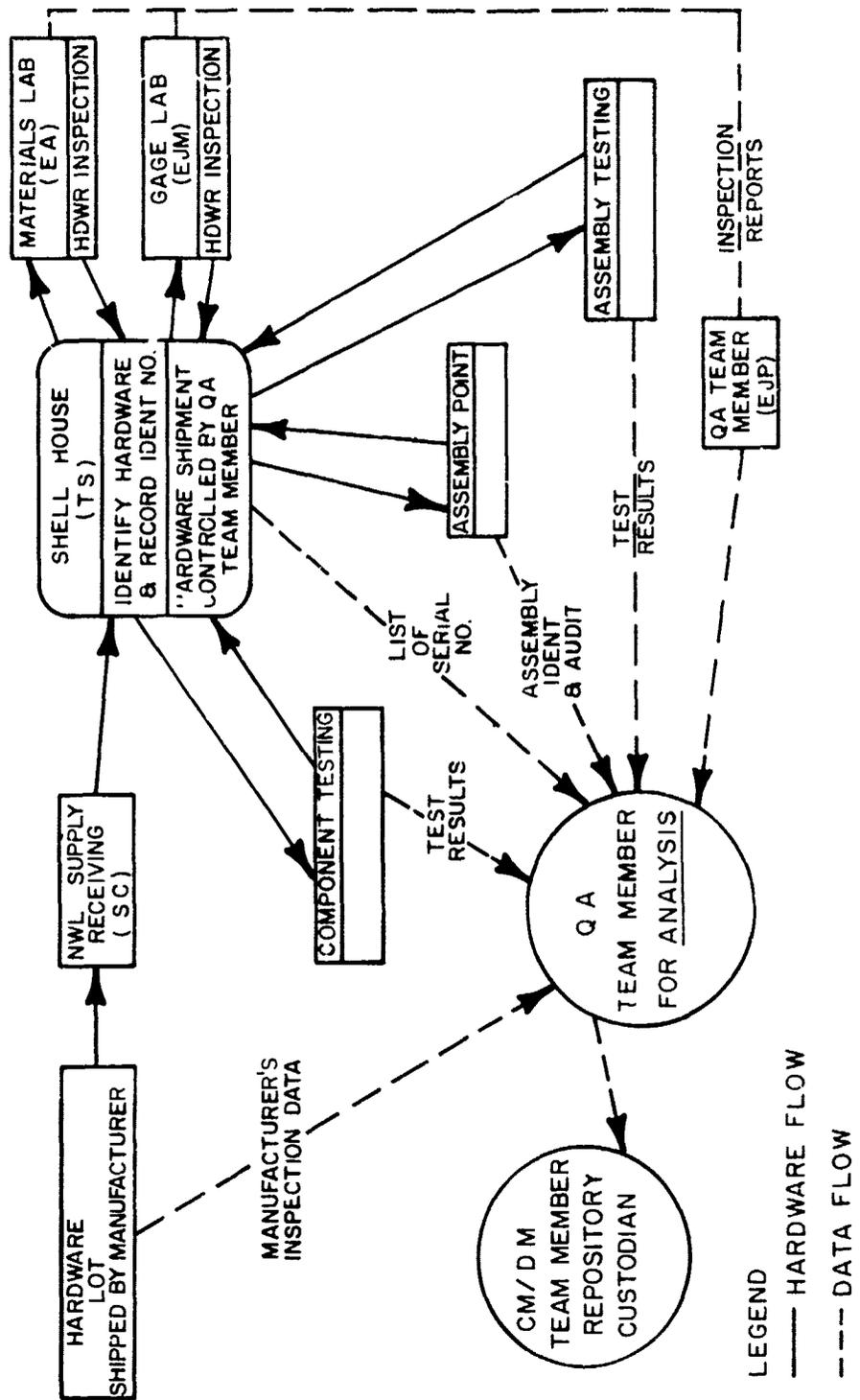


Figure A-8. NWL Hardware Inspection and Data Collection.

APPENDIX B
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13 ABSTRACT			

Major accomplishments during the period of 1 September through 31 December 1972 are reported. The program objectives approach, schedule and the organization of technical responsibilities are given. Technical specifications provided by the Italian Government have been found to be comparable to U.S. specifications. The percussion primer design was found to be unique. The plan for providing a centrally coordinated Product Assurance Program is provided as an Appendix.