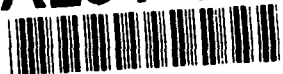


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Technical Report ARFSD-TR-92007

**M86 PURSUIT DETERRENT MUNITION BATTERY
PREAMBULATION ANALYSIS**

John Printz

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May 1992



**U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT AND
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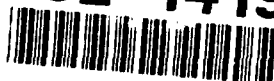
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INTRODUCTION

In late 1989, the reserve cell ammonia battery for the M86 pursuit deterrent munition (PDM) was redesigned. This redesign effort was to improve the battery's performance at cold temperatures (-25°F). During lot acceptance testing (LAT) of the improved battery, a problem was discovered at hot temperatures. The batteries tested were preactivating (i.e., becoming electrically active during the thermal cycle without the normal activation sequence) at -160°F. It soon became evident that batteries would preactivate at high temperatures; however, it was not known what the overall effects would be to the PDM system under a worst-case condition. Therefore, testing was performed to determine the system effects upon the PDM because of battery preactivation. This report will discuss both the procedure and the results of this testing.

BACKGROUND

PDM System Overview

The M86 PDM (fig. 1) is a hand-emplaced, antipersonnel land mine to be used by special operations forces (SOF) beyond the forward line of troops. The mine is essentially a modified submunition from the artillery-delivered M692/m731 area denial artillery munition (ADAM) (fig. 2).

PDM retains ADAM's basic operating and functioning sequences. The mine has seven tripline sensors that detect personnel movement when disturbed and has an antidisturbance (AD) switch that detects any tampering. It will selfdestruct (SD) because of an electronics malfunction, a low battery voltage [by means of a low voltage detection (LVD) circuit], or at a predesignated SD time.

PDM Development

The M86 PDM was developed to be used by the SOF as a hand-emplaced, antipersonnel mine for use beyond the forward line of operation. The full-scale development contract (DAAA10-84-C-0239) was awarded to Honeywell, Inc. (now known as Alliant Techsystems, Inc.) in September 1984 (ref 1).

Alliant's design scheme was to take the existing M731 ADAM submunition and modify its configuration for hand emplacement (ref 1). The primary function modes of the M731 ADAM would be retained in the PDM. These modes are the seven tripline sensors, the AD switch, and the same SD time. The PDM retained the same sensors, timing integrated circuit (IC), and system battery as ADAM. Also the PDM retained the same basic physical configuration as the ADAM submunition.

However, several changes to the ADAM submunition had to be made for the PDM configuration. The first change to be made was that the safe and arming (S&A) mechanism had to be redesigned to enable hand-emplacement and provide adequate safety. The next change was the incorporation of a transistor clamp circuit. The clamp circuit had to be placed on the firing capacitor to provide a 25-sec safe separation time for the troops; that is, the clamp circuit will deny electrical energy to the firing capacitor for at least 25 sec and therefore will provide system safety in case of a gross IC malfunction. The final change was the installation of an external arming strap assembly (fig. 3) to arm the mine by hand (activate the battery and remove the detonator's shorting bar).

PDM Production

Alliant Techsystems received the production contract for PDM molded assemblies (contract DAAA21-88-C-0088). A PDM molded assembly is the PDM mine, minus the high-explosive kill mechanism. Production was to take place at Alliant's New Brighton facility (located within the Twin Cities Army Ammunition Plant).

A design deficiency was uncovered during the first article acceptance testing (FAAT) and subsequent engineering testing at Alliant. It was discovered that the PDM battery (i.e. the ADAM submunition battery) could not provide adequate electrical energy throughout the functional lifecycle of the mine. The required functioning life of the mine is approximately 4 hr (ref 2). A series of modifications were made to the battery to compensate for the design deficiency. These changes were:

- Increasing cell 1 slot width and length
- Increasing the ampule fill
- Improving the bulkhead alignment
- Increasing the battery's vacuum duration (ref 2)

With the incorporation of these changes, a PDM unique battery was developed. These batteries were incorporated into every PDM that was subsequently released for fielding.

Preactivation Concerns

During the evaluation and production of the PDM unique batteries, another problem area was discovered. When the batteries were heated to temperatures in excess of +160°F (the PDM manufacturing process calls for heating the batteries,

along with the rest of the mine, to between +155°F and +160°F), some of the batteries would preactivate. Preactivation means that the batteries would come to voltage without any external activation forces.

PREACTIVATION EVALUATION

Ammonia Properties

To understand battery preactivation, the most important physical factor to take into consideration is the change in vapor pressure of ammonia at the high temperature extremes for PDM. These temperatures are +120°F to +125°F for high-temperature operation and +155°F to +160°F for high-temperature storage.

The vapor pressure of ammonia is plotted for various temperatures in figure 4. At ambient temperature [+70°F (+21°C)], the vapor pressure of ammonia is 8.46 atmospheres. However, the vapor pressure of ammonia is 34.23 atmospheres when the temperature is +160°F (+71.1°C). In addition, the vapor pressure of ammonia is 44.58 atmospheres when the temperature is +180°F (+82.2°C). For reference purposes, the vapor pressure of ammonia at cold temperature [-25°F (-31.7°C)] is 1.07 atmospheres (ref 3).

The ammonia inside the PDM battery is stored in a glass ampule, located at one end of the battery (fig. 5). During a normal arming (initiation) sequence, a mechanical cam action would be applied at the ampule end of the battery, causing the ampule to crush and the ammonia electrolyte to saturate the cathode salt, bringing the battery to full potential.

During preactivation, the high vapor pressure of the ammonia inside the ampule causes the glass to partially fracture, allowing the vapors to escape the ampule and wet the cathode salts. The amount of electrical energy generated by preactivation is somewhat difficult to quantify because of the number of factors involved. The following is a partial list of the factors that could determine the amount of preactivation:

- Ampule fill (fig. 5 call out 85 to 95 mL)
- Ampule glass thickness
- Thermal mass of the PDM mine
- Internal pressure of the battery (fig. 5 calls out a 5-sec vacuum pull).

As was stated earlier, the ampule full was increased 85 to 95 mL and the vacuum pull was increased from 2 sec to 5 sec. It can be concluded that the design changes to make the PDM batteries perform better at the operational temperature extremes were causing the batteries to encounter problems (i.e., preactivation) at the storage temperature extremes.

System-level Preactivation Quantification

When battery preactivation was first discovered, many questions needed to be answered. In addition to the battery level quantification, the government engineering community (ARDEC development, TECOM testing, and AMSAA evaluation communities) desired to know the system level effects of battery preactivation. These system level effects include the following:

- Does battery preactivation effect system safety?
- Does battery preactivation effect system reliability?
- Is battery preactivation an operational problem?
- Is battery preactivation a storage problem?
- Is there any way to detect battery preactivation before attempting to use PDM?
- What is the average failure rate for battery preactivation?
- Is there anything that can be done to prevent battery preactivation?

It was decided at a test integration working group (TIWG) meeting that the best way to quantify the effects of battery preactivation was to perform system level testing. This testing would be conducted in two phases. The first phase would determine the worst case effects upon the PDM system, and the second phase would determine the lowest temperature at which these worst case effects would occur.

PREACTIVATION TEST PLAN

Test Procedure

The first portion (procedure A) of the preactivation test plan (app A) called for 31 PDM mines to be thermally cycled at +150°F, +160°F, +170°F, and +180°F. Each cycle was to last 12 hr, and the mines were to be cooled to ambient temperature after each cycle. During the test, each mine's battery voltage was to be monitored by

means of two electrical leads. (These leads were installed into demonstration mines at Alliant Techsystems. PDM demonstration mines are fully functional PDM mines that contain no high-explosive kill mechanism.)

The second portion (procedure B) of the preactivation test plan called for a quantity of PDM mines to have their batteries externally enabled to the voltages discovered during procedure A. After this activation, each mine's system performance (arming, sensor deployment, detonation, etc.) would be evaluated after battery preactivation. In this test, battery preactivation is assumed to occur prior to arming (e.g., if the battery is enabled 30 sec before the arming strap is removed, battery preactivation is said to occur at time = -30 sec and arming is said to occur at time = 0).

Testing Results

The testing for the battery preactivation test plan took place in November 1990 at the ARDEC energetics test range, Picatinny Arsenal. This test report is contained in appendix B.

Procedure A Results

Thirty-one PDM mines (modified with electrical leads as discussed previously) were temperature conditioned at +150°F, +160°F, +170°, and +180°F for 12 hr each cycle. The mines were allowed to cool to the ambient temperature of the test area (approximately +70°F) after each 12-hr temperature cycle.

It was discovered that none of the mines had their batteries preactivate during the +150°F cycle. Also, none of the mines had their batteries preactivate during the +160°F cycle, which is the maximum storage temperature required for PDM. During the +170°F cycle, none of the mines had their batteries preactivate. Again, it should be noted that +170°F exceeds the high-temperature storage requirement for PDM.

During the +180°F cycle, five of the mines had their batteries preactivate. The voltage-versus-time curves for the five mines are contained in appendix B. The preactivation times ranged between 1.5 and 6 hr into the +180°F cycle and the maximum voltages ranged between 3.72 and 3.94 V. For the five mines with preactivated batteries, each mine's seven tripline sensors deployed during the +180°F cycle (the minimum voltage to enable the electronics is approximately 2.8 V, and the minimum voltage to deploy the sensors is approximately 2.0 V).

In all five cases, the batteries held a voltage above 2.8 V for approximately 3 hr. After this, the voltage dropped down and stabilized at approximately 2.0 V.

In all five cases, the batteries held a voltage above 2.8 V for approximately 3 hr. After this, the voltage dropped down and stabilized at approximately 2.0 V.

Procedure A Conclusions

Upon a review of the data gathered from procedure A, the following conclusions can be drawn concerning battery preactivation:

- Approximately 16% (5 out of 31) of the batteries preactivated during the +180°F cycle.
- Preactivation only occurred at temperature greater than +170°F.
- When the batteries preactivated, the voltages were near the full voltage of the batteries (4.0 V).
- Preactivation diminishes the electrical capacities of the batteries (i.e., the batteries are only able to hold a high voltage for approximately 3.0 hr).
- Preactivation caused the five mines in question to become duds.

The results from procedure A also indicated that the worst-case voltage for procedure B (where batteries are purposely preactivated and the system performed is monitored after reactivation) is 4.0 V.

Procedure B Results

During the procedure B testing, 11 PDM demonstration mines were placed into three groups: (1) five mines had their batteries preactivated between 15 and 25 sec prior to arming strap removal (25 sec is the safe separation time for PDM), (2) five mines had their batteries preactivated between 25 and 60 sec prior to arming strap removal (60 sec is the sensor deployment time for PDM), and (3) one mine had its battery preactivated 80 sec prior to arming strap removal (again, this is after the sensor deployment time for PDM).

The results of procedure B are contained in table 1. In every case each mine's operating sequence was translated by the preactivation time. For example, mine 44 had its battery preactivated 15 sec before arming strap removal. During the test, its sensors deployed 45 sec after arming strap removal and functioned by means of the tripline sensor. In another example, mine 22 had its battery preactivated 40 sec prior to arming strap removal. Its sensors deployed 20 sec after arming strap removal and functioned by means of the tripline sensor. In both cases, 15 sec plus 45 sec and 40 sec plus 20 sec equal 60 sec which is the time for tripline deployment (60 sec after arming strap removal).

One thing to note is the the **only** way these situations could come about would be in an environment where the mines would be used where the operational temperature is equal to the storage temperature. During subsequent system safety risk assessment meetings, it was decided, and eventually approved, that this would be a minimal risk, because there is very little--if any-- chance that the user would attempt to arm the mine between 35 and 60 sec **after** battery preactivation. Even if this situation were to occur, the user would still have some time (although less than 25 sec) to clear the area before the mine is fully armed.

Procedure B Conclusions

Procedure B confirmed the results obtained in procedure A. If a PDM mine's battery preactivated, the battery provides enough energy to enable the electronics and the sensor deployment functions. However, procedure A indicated that preactivation only occurred (during this particular test) in an extreme high-temperature **storage** condition (the maximum operational temperature for PDM is +120°F). Therefore, the **high-explosive kill mechanism is not enabled** for the following reasons:

- The S&A mechanism is not in line, because the S&A safety pin is in place.
- The detonator's shorting bar is also in place

CONCLUSIONS

The results of this pursuit deterrent munition (PDM) battery preactivation test were presented to the development, testing, evaluation, and user communities (as defined previously) during another test integration working group meeting in December 1990. During the subsequent new material release for PDM, the following procedures and policies were implemented for battery preactivation:

- The user is to inspect each mine before use. If sensors have deployed prior to use, the user is to discard the mine immediately and attempt to use another.
- The Predictive Technology Branch of the Product Assurance and Test Directorate (PA&TD) is to perform a long-storage reliability test on the PDM battery to determine the effects of battery preactivation upon the system reliability of PDM.

Upon a thorough review of the data gathered and analyzed during the PDM battery preactivation test, the following answers are provided to the questions stated earlier:

- Battery preactivation does not effect system safety (because battery preactivation occurs when the mines are in their storage configuration with **all** external safety devices in place)
- Battery preactivation does not effect system reliability (the mines become duds when batteries preactivate)
- Battery preactivation is not an operational problem
- Battery preactivation is a storage problem
- The user can inspect mines for battery preactivation before use (sensors deploy on mines with preactivated batteries)

The average failure rate for battery preactivation can be fully quantified upon completion of the PDM battery reliability test. This test is to be completed by the Predictive Technology Branch of the PA&TD.

The only real solutions to battery preactivation are either to limit the storage temperature of PDM to below +160°F or to again redesign the batteries.

RECOMMENDATIONS

Upon the completion of the pursuit deterrent munition (PDM) battery preactivation test, the following recommendations were made to the program office and the project manager.

1. Both the mded assembly contractor (Alliant Techsystems) and the load, assemble, and pack facility (Louisiana Army Ammunition Plant) should be informed of the results of the testing and implement corrective procedures to prevent battery preactivation. (Since the testing has been performed, both facilities have indeed taken preventive actions to prevent battery preactivation.)
2. The program office for area denial artillery munition (ADAM) has been informed of the results of the battery preactivation test plan. Battery preactivation in the ADAM submunition is less likely than it is for PDM (the ADAM battery does not have the design characteristics discussed previously for the PDM-unique battery). However, the possibility of battery preactivation does exist for ADAM, and preventative measures should be taken to prevent batteries from preactivating during manufacturing and storage.

Table 1. Procedure B test results

| MINE NUMBER | PRE-ACTIVATION TIME | SENSOR DEPLOYMENT | FUNCTIONING |
|-------------|-------------------------------------|--|--------------------------|
| 44 | 15 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 45 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 3 | 25 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 35 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 14 | 23 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 37 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 30 | 18 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 42 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 38 | 15 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 45 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 22 | 40 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 20 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |

| MINE NUMBER | PRE-ACTIVATION TIME | SENSOR DEPLOYMENT | FUNCTIONING |
|-------------|-------------------------------------|---|----------------------------|
| 31 | 45 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 15 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 12 | 38 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 22 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 19 | 35 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 25 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |
| 13 | 49 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 11 SECONDS AFTER ARMING STRAP REMOVAL | FUNCTIONED VIA A.D. SWITCH |
| 23 | 80 SEC. BEFORE ARMING STRAP REMOVAL | ALL AT 20 SECONDS BEFORE ARMING STRAP REMOVAL | FUNCTIONED VIA BREAKWIRE |

FIGURE I
M86 PURSUIT DETERRENT MUNITION

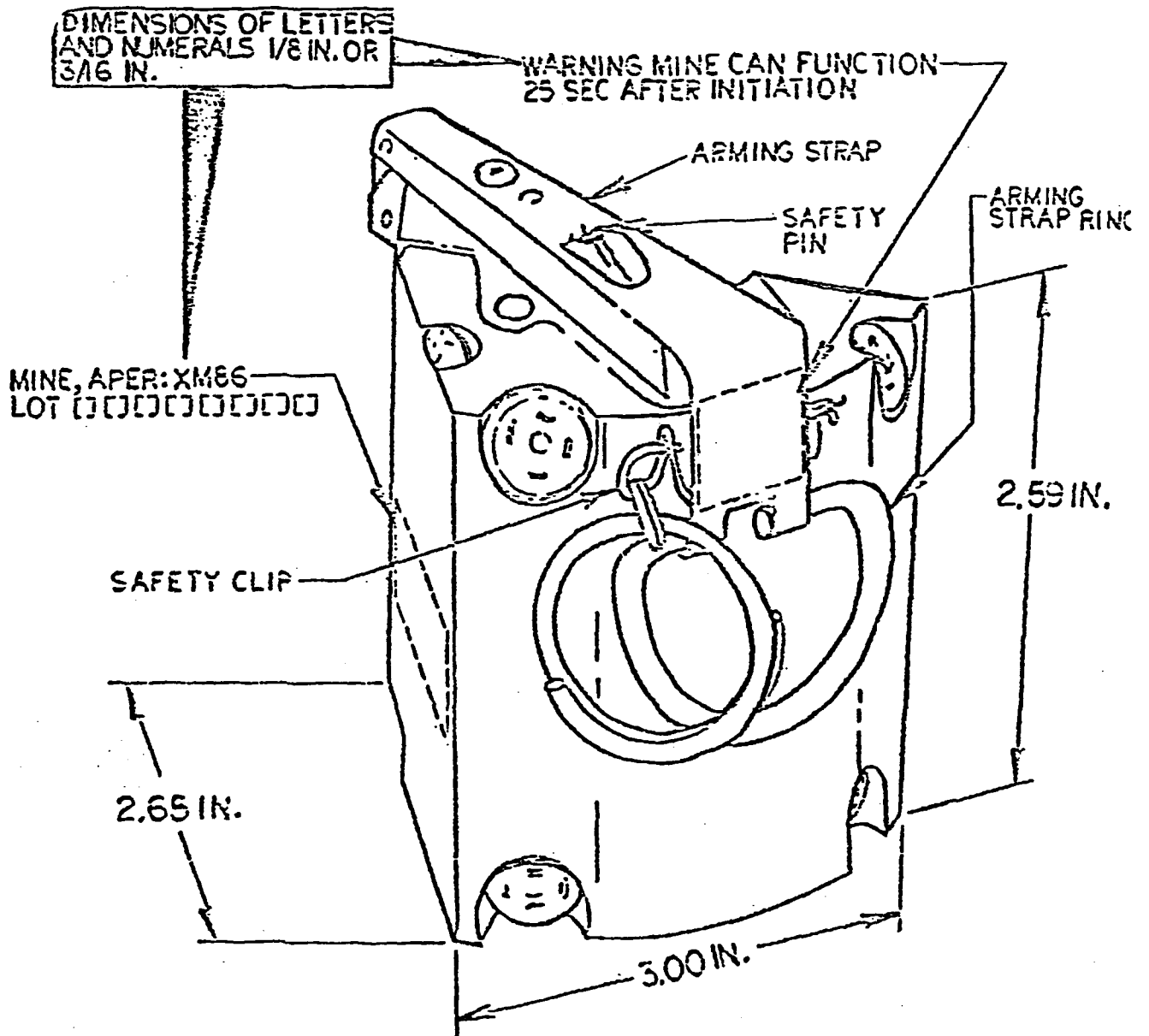


Figure 1. M86 pursuit deterrent munition

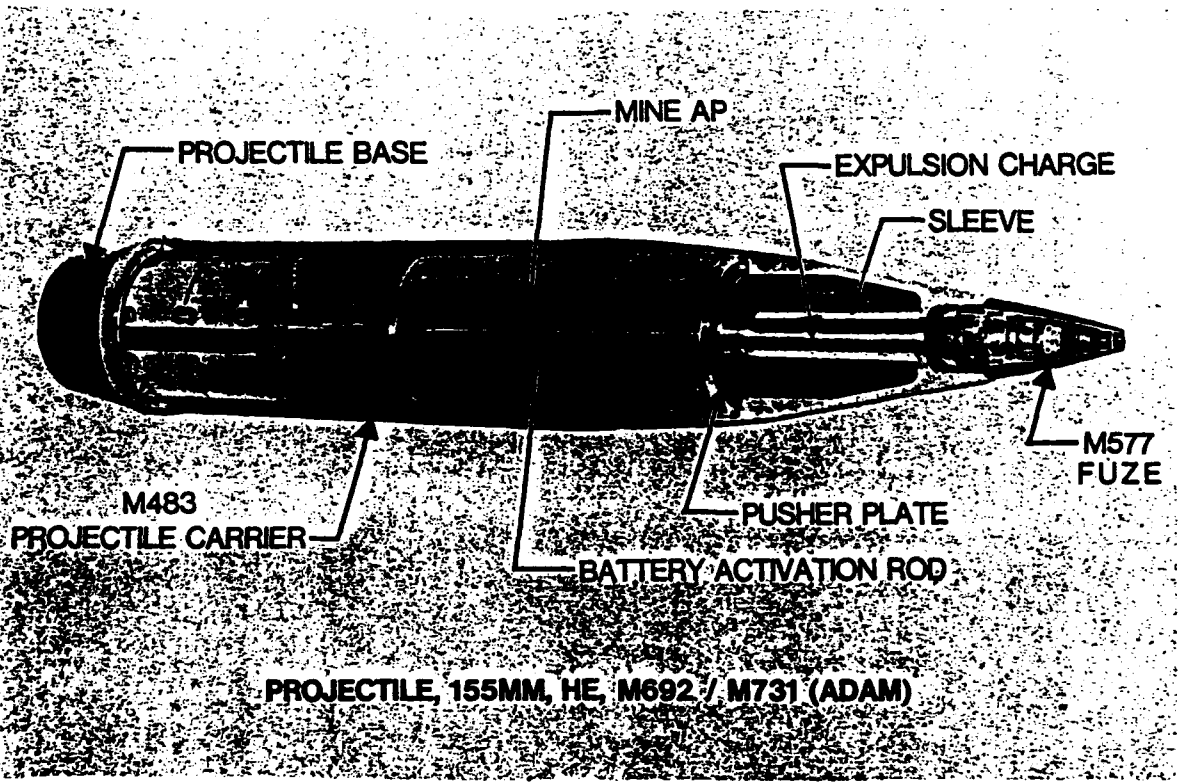
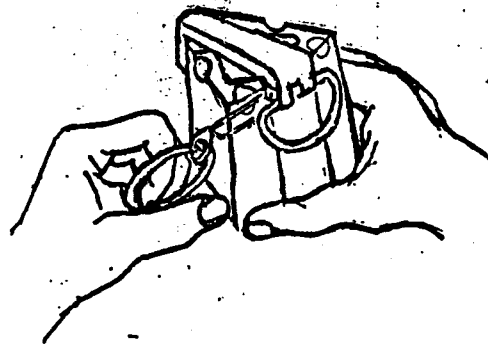
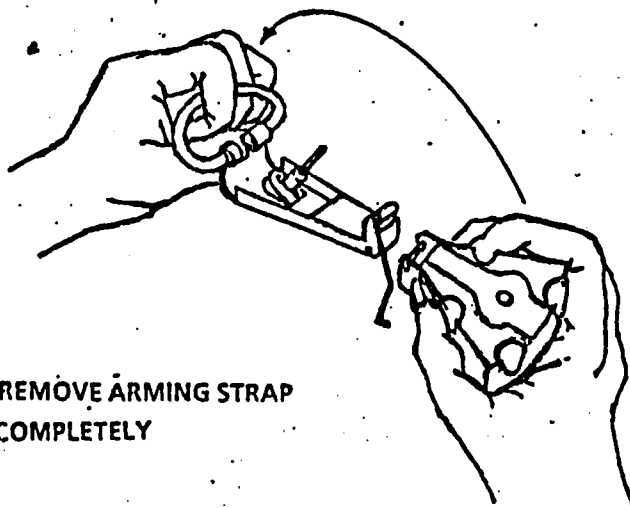


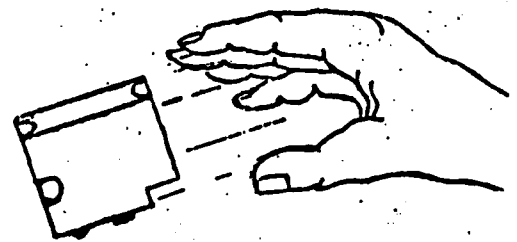
Figure 2. M692/M731 area denial artillery munition



PULL SAFETY CLIP



REMOVE ARMING STRAP
COMPLETELY



RELEASE MUNITION

Figure 3. PDM arming sequence

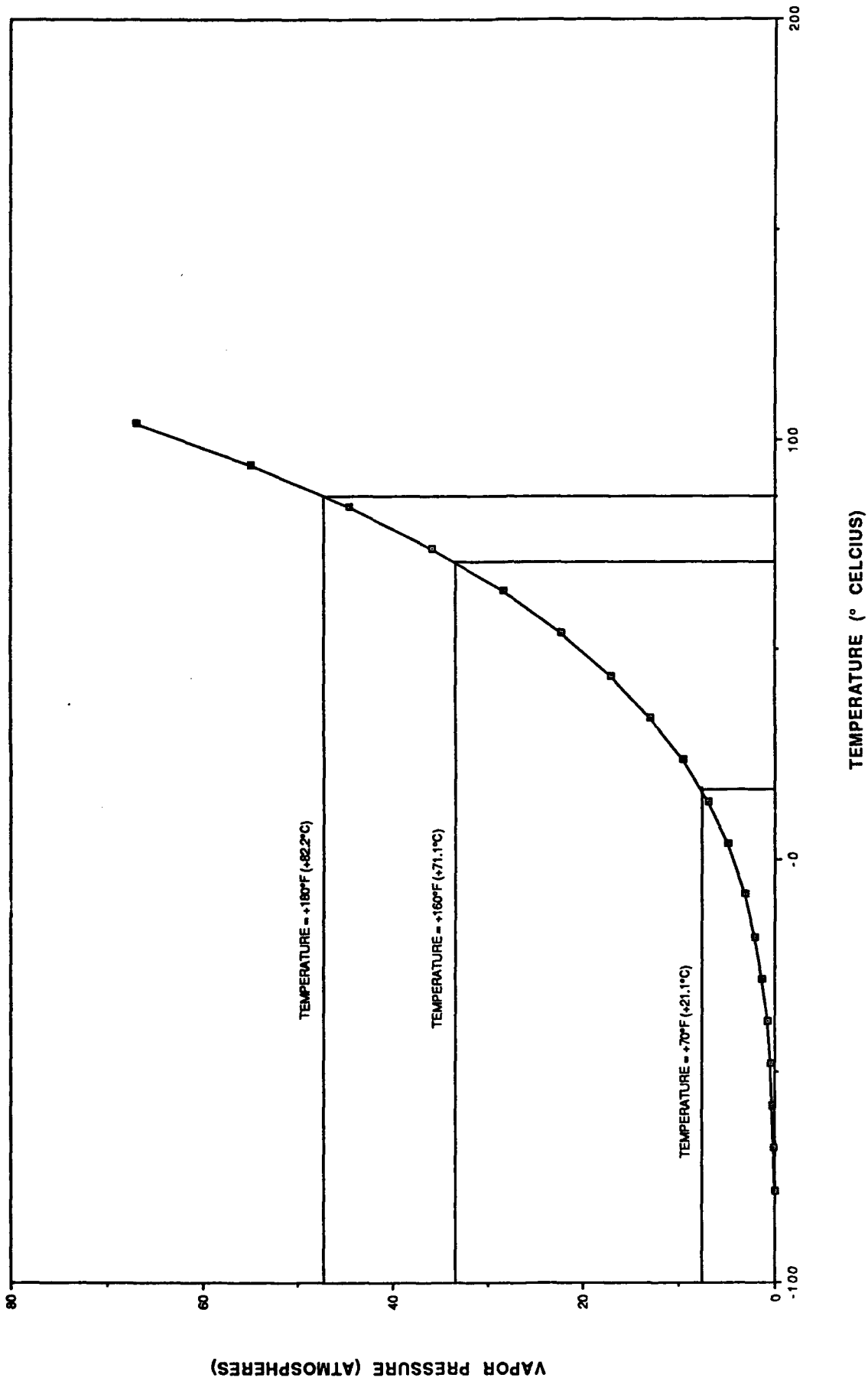


Figure 4. Vapor pressure of ammonia at various temperatures

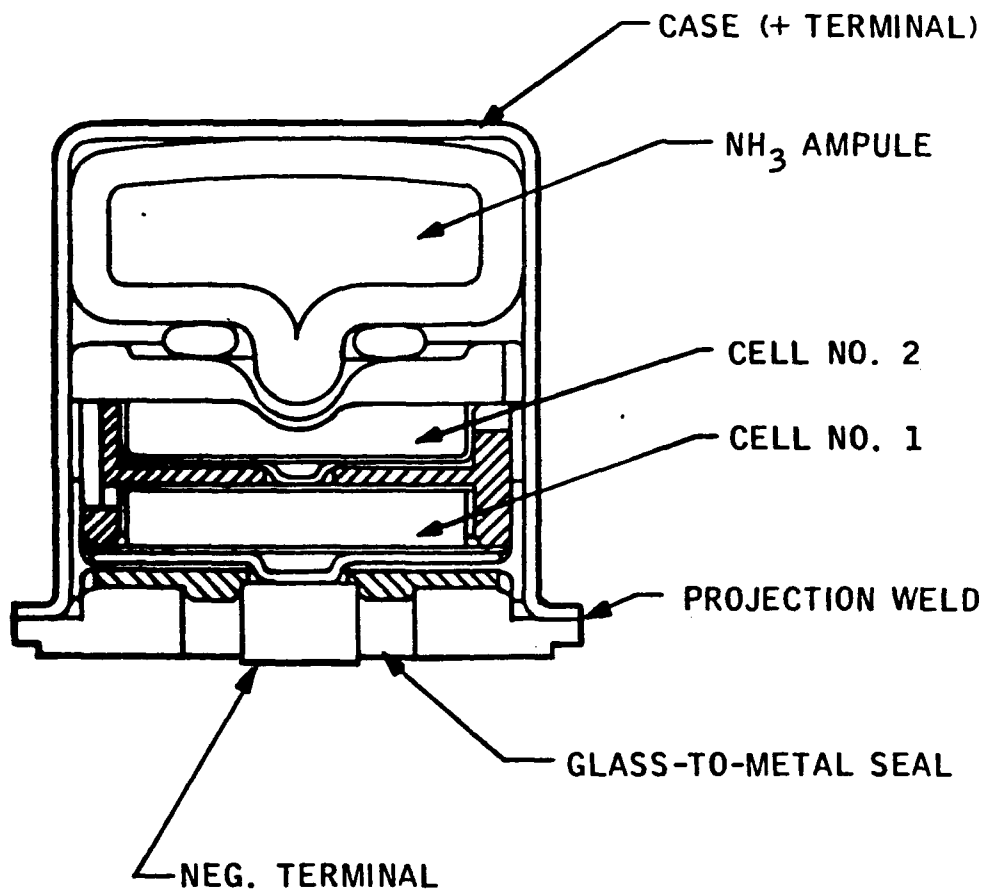


Figure 5. PDM 4 V reserve cell ammonia battery

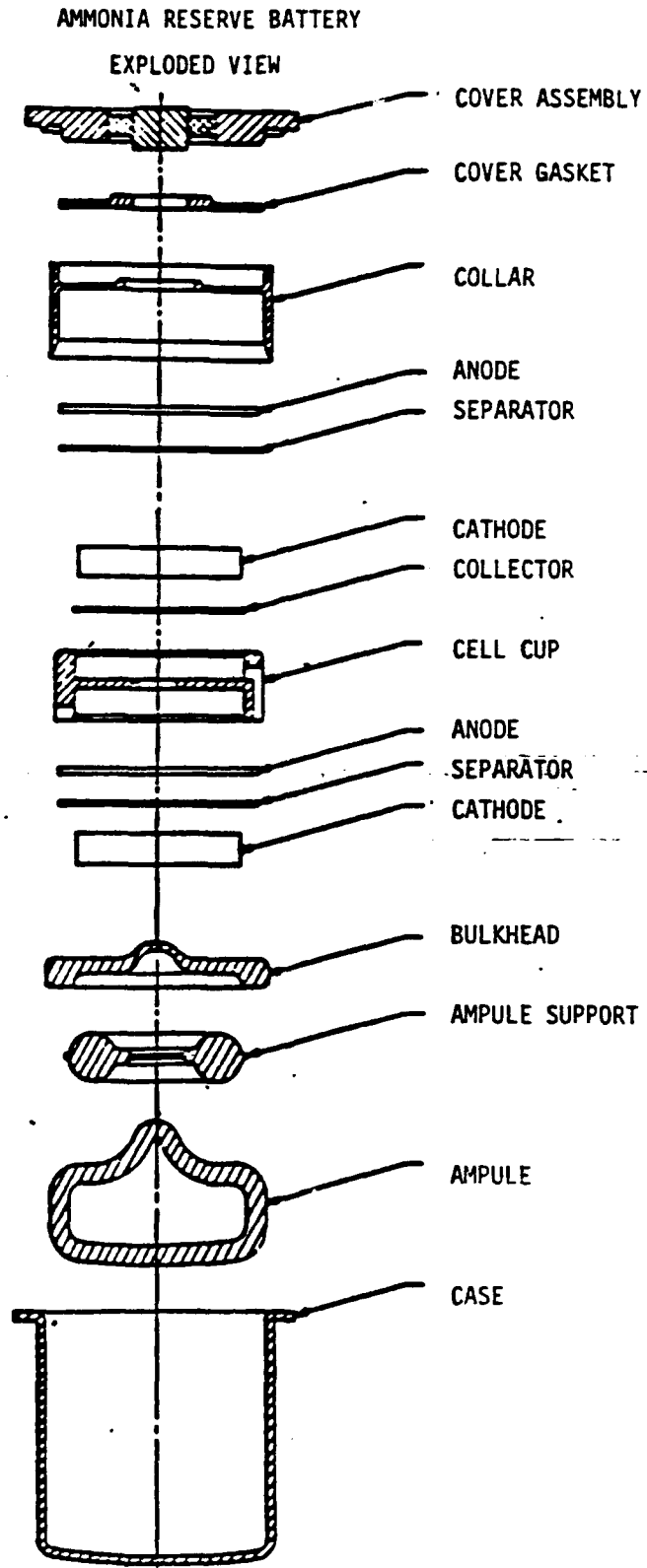


Figure 5. (cont)

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APPENDIX A
PDM BATTERY PREAMBINATION TEST PLAN (PROCEDURE A)

**TEST PLAN TO DETERMINE
THE EFFECTS OF BATTERY PRE-ACTIVATION
ON SYSTEM SAFETY AND RELIABILITY
OF THE M86
PURSUIT DETERRENT MUNITION (PDM)**

1.0: OBJECTIVES. This test will A) Subject the PDM Demonstration Mines to repeated cycles of thermal conditioning to determine the extent of battery pre-activation at varied temperatures, and B) To observe the effects of Battery pre-activation upon the system safety of the PDM.

2.0: BACKGROUND. Based upon Battery pre-activation problems encountered at Honeywell during Battery First Article Acceptance Testing (FAAT), both the extent of Battery pre-activation during thermal cycling, and the effects of Battery pre-activation upon system safety must be quantified.

3.0: TEST PREPARATION.

- 3.1. Equipment Needed: See Equipment Table.
- 3.2. Test Location: ARDEC, Bldgs. 1501 and 1530.
- 3.3. Test Data: The data collected from the testing outlined below will be acquired, tabulated and summarized in a test report.
- 3.4. Test Criteria:
 - 3.4.1. The testing outlined below in 4.0. will determine the effects of high-temperature storage upon Battery pre-activation. This testing will be in accordance with MIL-STD-810E, Method 501.3.
 - 3.4.2. The testing outlined below in 5.0. will demonstrate the effects that Battery pre-activation has upon the system safety of the PDM.
- 3.5. POC's for this action are David Lavery, X2968 and John Printz, X2669.

4.0: PROCEDURE A.

- 4.1. 36 Demonstration Mines will be prepared for testing as follows:
 - 4.1.1. The 36 mines will be marked for identification.
 - 4.1.2. Each mine will be connected to a compact computer. This device will be operating during the entire duration of the thermal cycling, and record the time that Battery activation occurs, and the Battery's voltage output for the duration of the testing.
- 4.2. The 36 Demonstration Mines will be thermal conditioned at 150° F for 24 hours. After conditioning, the mines will be cooled to ambient temperature.
- 4.3. The mines will be thermal conditioned at 160° F for 24 hours. After conditioning, the mines will be cooled to ambient temperature.
- 4.4. The mines will be thermal conditioned at 170° F for 24 hours. After conditioning, the mines will be cooled to ambient temperature.
- 4.5. The mines will be thermal conditioned at 180° F for 24 hours. After conditioning, the mines will be cooled to ambient temperature.

- 4.6. Mines that did not activate will be added to the lot of mines that will undergo the testing outlined in Procedure B.

5.0: PROCEDURE B.

- 5.1. 14 Demonstration Mines, in addition to those that did not activate during the thermal conditioning test, will be prepared for testing as follows:
 - 5.1.1. The mines will be marked for identification.
 - 5.1.2. Each mine will have the two rivets on the apex of the Arming Strap drilled out and the apex of the Arming Strap removed.
 - 5.1.3. Each mine will have the Shorting Bar removed manually.
 - 5.1.4. Each mine will be connected to a portable digital voltmeter.
 - 5.1.5. The mines will be divided into three lots; Lot A, Lot B and Lot C.
- 5.2. Strike the Battery balls on the mines in Lot A at the specified force.
 - 5.2.1. Pull arming strap within first 25 seconds of Battery activation.
 - 5.2.2. Record the following data:
 - 5.2.2.1. Whether sensors deploy and the time from Arming Strap removal that sensors deploy.
 - 5.2.2.2. If the mine detonates Anti-Disturbance upon Sensor Enable (78 seconds after Arming Strap removal).
 - 5.2.2.3. If the mine fails to detonate Anti-Disturbance, whether the mine Self Destructs by the maximum Self Destruct time.
 - 5.2.2.4. If the mine fails to Self Destruct, whether the mine detonates following a second Anti-Disturbance attempt immediately following the maximum Self Destruct time.
- 5.3. Strike the Battery balls on the mines in Lot B at the specified force.
 - 5.3.1. Pull arming strap between 26 and 60 seconds after Battery activation.
 - 5.3.2. Record the results as outlined in Section 5.2.2.
- 5.4. Strike the Battery balls on the mines in Lot C at the specified force.
 - 5.4.1. Pull arming strap after 61 seconds of Battery activation.
 - 5.4.2. Record the results as outlined in Section 5.2.2.

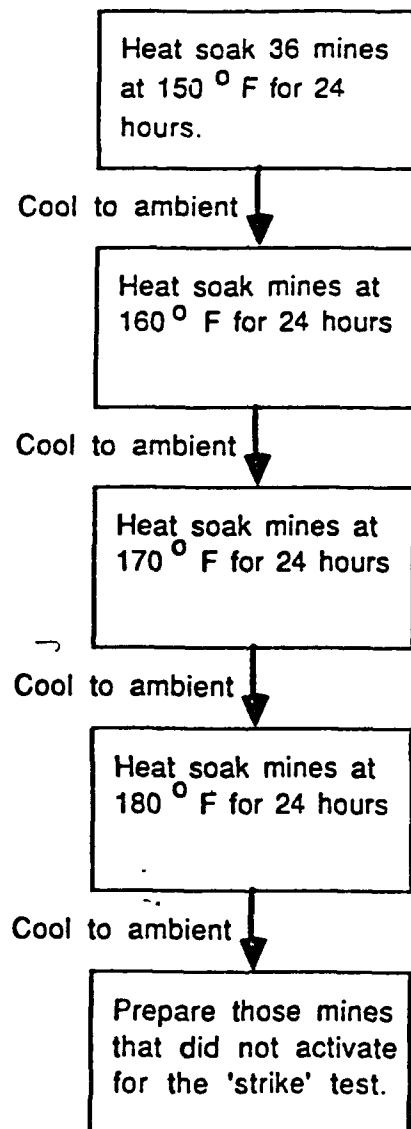
6.0: REPORTING.

A detailed test report shall be prepared by the POC's for this action.

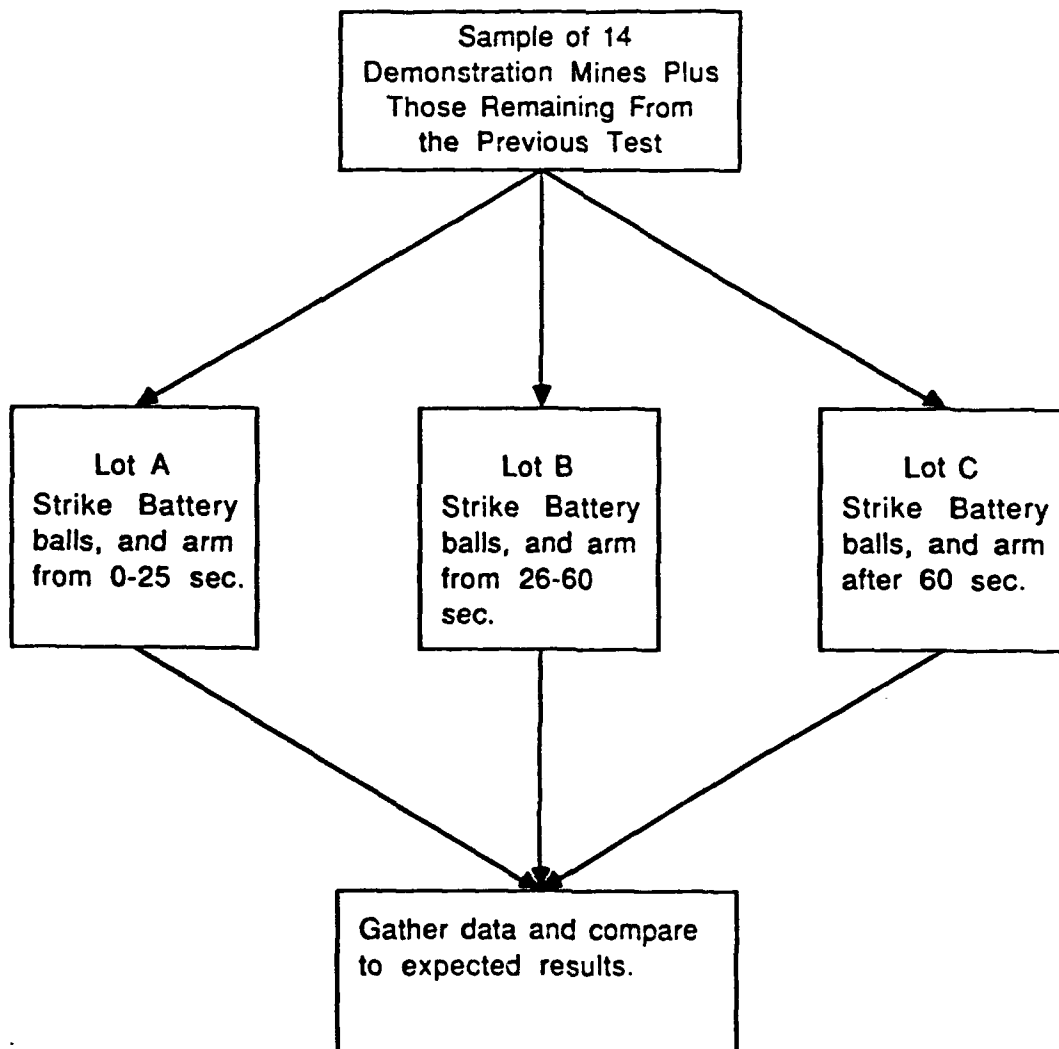
7.0: EQUIPMENT TABLE.

- 7.1. 50 Demonstration Mines (M86 PDM's with only the M100 Micro-Detonator in the Explosive Train) with Exposed Leads from V_B and Ground in the Test Pad Area.
- 7.2. Environmental Chamber(s).
- 7.3. Digital Thermocouple(s) for the Environmental Chamber(s).
- 7.4. Portable Digital Voltmeter.
- 7.5. Adjustable Force Hammer.
- 7.6. Compact Computer.

9.0: THERMAL CYCLING FLOWCHART



10.0: CONTROLLED BATTERY ACTIVATION FLOWCHART



APPENDIX B
ENERGETICS TEST RANGE FIRING REPORT

U.S. Army ARDEC
AED, Energetics Test Range
Picatinny Arsenal, NJ 07806-5000
Firing Record

Date Nov 26 1990

Sheet 1 of 5

Test No. IDLE

Subject: PDM Mines Temperature Conditioning Test

Test Requested By: John Printz SMCAR-FSP-E X2669

SYSTEM DESCRIPTION

The Pursuit Deterrent Munition (PDM) is a hand emplaced antipersonnel mine intended for use as a positive self-destructing, rapidly emplaced munition to protect Special Operations Forces, and other forces operating beyond the Forward Line of Own Troops during withdrawals from pursuing enemy ground troops.

The PDM is essentially the Area Denial Artillery Munition (ADAM) mine incorporating changes to adapt the munition from an artillery delivered mine munition to a hand emplaced mine. The PDM retains the basic ADAM angular configuration with an externally mounted arming mechanism. The arming mechanism provides the means for activating the reserve battery, removal of the shorting bar and provides for a pull ring and pin to maintain the initial safety. The PDM contains seven ADAM tripline assemblies, the ADAM antisturbance switch, the short time ADAM self-destruct capability, and the complete firing train and kill mechanism of the ADAM mine.

Submitted By: Rehan Monammed Approve

H. Pontius, Ch, Energetics Test Range

U.S. Army ARDEC
AED, Energetics Test Range
Picatinny Arsenal, NJ 07806-5000
Firing Record

Date 26 November 1990
Sheet 2 of 5
Test No. IDLE

Subject: PDM Mines Temperature Conditioning Test

Test Requested By: John Printz SMCAR-FSP-E X2669

Objective of this test were to subject the PDM demonstration mines to repeated cycles of thermal conditioning to determine the extent of battery pre-activation at varied temperatures, and to observe the effects of battery pre-activation upon the safety of the PDM. Mines were supplied with test leads attached to the battery terminals.

Test Procedures

In phase one of the program, eleven PDM demonstration mines were tested and were subjected to the following conditions to determine if the detonator can be fired :

1. Safety pin pulled; which prevents the arming strap from being removed during storage transportation and handling.
2. Arming strap pulled partially; to determine if the mine would activate. The waiting time was 15 seconds.
3. The arming strap pulled all the way after the elapsed time; the sensors were deployed approximately 62 seconds after arming strap was removed.
4. Tripline pulled after 20 seconds elapsed. The purpose of 20 seconds was to determine if the mine would activate. See Table 1 for complete test results.

In phase two of the program, 31 mines were selected randomly and placed in a conditioning box to determine the extent of battery pre-activation at varied temperatures.

1. Multi-conductor shielded cable was connected to the mines battery terminals to monitor the voltage with a digital multimeter. The conditioning box was set at 150° F for 48 hours. The temperature was measured with a digital thermometer, at the end of the cycle, the box found to 2° F low. The actual temperature of this test was therefore 148° F. All remaining conditioning was done using the digital thermometer to set temperature. During this process, the voltage was only monitored at the end of 48 hour period. At 150° F none of the mines self activate , e.g. no voltage was measured across the battery terminals. Then the mines were cooled to ambient temperature for 12 hours.
2. The PDM mines were placed in the conditioning box at 160° F for 12 hours. The voltage reading was taken manually due to failure of the automatic recording system by digital multimeter every hour. At 160° F no voltage was measured across the battery terminals. At the end of 12 hour period, the mines were cooled to ambient temperature.

Submitted By: Rehan Mohammed

Approved By: H. Pontious, Ch, Energetics Test Range

U.S. Army ARDEC
AED, Energetics Test Range
Picatinny Arsenal, NJ 07806-5000
Firing Record

Date 26 November 1990
Sheet 3 of 5
Test No IDLE

Subject: PDM Mines Temperature Conditioning Test
Test Requested By: John Printz SMCAR-FSP-E X2669

3. The PDM mines were placed in the conditioning box at 170° F for 12 hours. The voltage reading was taken manually by digital multimeter every hour. At 170° F, zero voltage was measured across the battery terminals. At the end of the 12 hour period, the mines were cooled to ambient temperature.
 4. The PDM mines were placed in the conditioning box at 180° F for 12 hours. The voltage reading was taken manually by digital multimeter every 1/2 hour. At 180° F, five PDM mines were activated and the average initial voltage measured across the battery terminals was 3.87 volts. At the end of the 12 hour period, no additional mines were activated and the mines were cooled to ambient temperature.
- In phase three of the program, eleven thermally conditioned mines were selected randomly for testing following the same procedure as in phase one of the program. See table 2 for complete test results.

Submitted By: Rehan Mohammed Approved By: H. Pontious, Ch, Energetics Test Range

U.S. Army ARDEC
AED, Energetics Test Range
 Picatinny Arsenal, NJ 07806-5000
Firing Record

Date 26 November 1990
 Sheet 4 of 5
 Test No. IDLE

Subject: PDM Mines Temperature Conditioning Test

Test Requested By: John Printz SMCAR-FSP-E X2669

| Round No | Voltage measured | Strap pulled | Sensors Deployed | Tripline Pulled | Mine Detonated | Anti-Disturbance switch Function |
|----------|------------------|--------------|------------------|-----------------|----------------|----------------------------------|
| 23 | 4.21 | Yes | Yes | Yes | Yes | - |
| 22 | 4.25 | Yes | Yes | Yes | Yes | - |
| 3 | 4.22 | Yes | Yes | Yes | Yes | - |
| 14 | 4.23 | Yes | Yes | Yes | Yes | - |
| 30 | 4.26 | Yes | Yes | Yes | Yes | - |
| 38 | 4.23 | Yes | Yes | Yes | Yes | - |
| 31 | 4.24 | Yes | Yes | Yes | Yes | - |
| 12 | 4.23 | Yes | Yes | Yes | Yes | - |
| 19 | 4.20 | Yes | Yes | Yes | Yes | - |
| 9 | 4.28 | Yes | Yes | No | Yes | Yes |

Table 2 - Phase 3 Results

Submitted By: Rehan Mohammed Approved By: H. Pontious, Ch, Energetics Test Range

26 NOV 1990

Energetics Test Range Firing Record
PDM Mines Temperature Conditioning Test

Test No 1DLE
Page 5 of 5

| Round No | Safety pin Pulled | Arming strap Pulled Partially | Waiting time1 (sec) | Arming Strap pulled fully | Sensors Deployed | Waiting time2 (sec) | Tripline Pulled | PDM mine Detonated |
|----------|-------------------|-------------------------------|---------------------|---------------------------|------------------|---------------------|-----------------|--------------------|
| 1 | Yes | Yes | 15 | Yes | Yes | 20 | Yes | Yes |
| 33 | Yes | Yes | 15 | Yes | Yes | 20 | Yes | No |
| 34 | Yes | Yes | 15 | Yes | Yes | 20 | Yes | No |
| 25 | Yes | Yes | 40 | Yes | Yes | 15 | Yes | No |
| 26 | Yes | Yes | 45 | Yes | Yes | 15 | Yes | No |
| 7 | Yes | Yes | 15 | Yes | Yes | - | Yes | No |
| 8 | Yes | Yes | 45 | Yes | Yes | 15 | Yes | Yes |
| 42 | Yes | Yes | 70 | Yes | Yes | 20 | Yes | Yes |
| 41 | Yes | Yes | 95 | Yes | Yes | 20 | Yes | Yes |
| 46 | Yes | Yes | 95 | Yes | Yes | 20 | Yes | Yes |
| 47 | Yes | Yes | 20 | Yes | Yes | 20 | Yes | Yes |

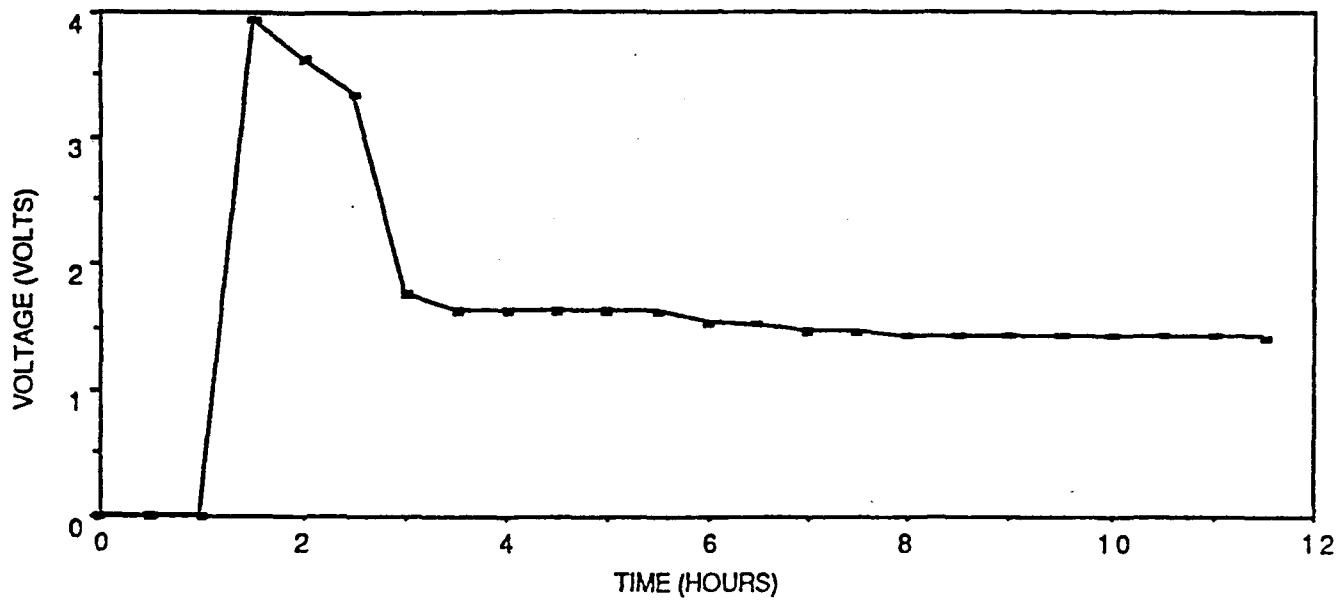
Note: The mines were not conditioned.

Waiting time1: The time between Arming Strap partially and pulled fully.

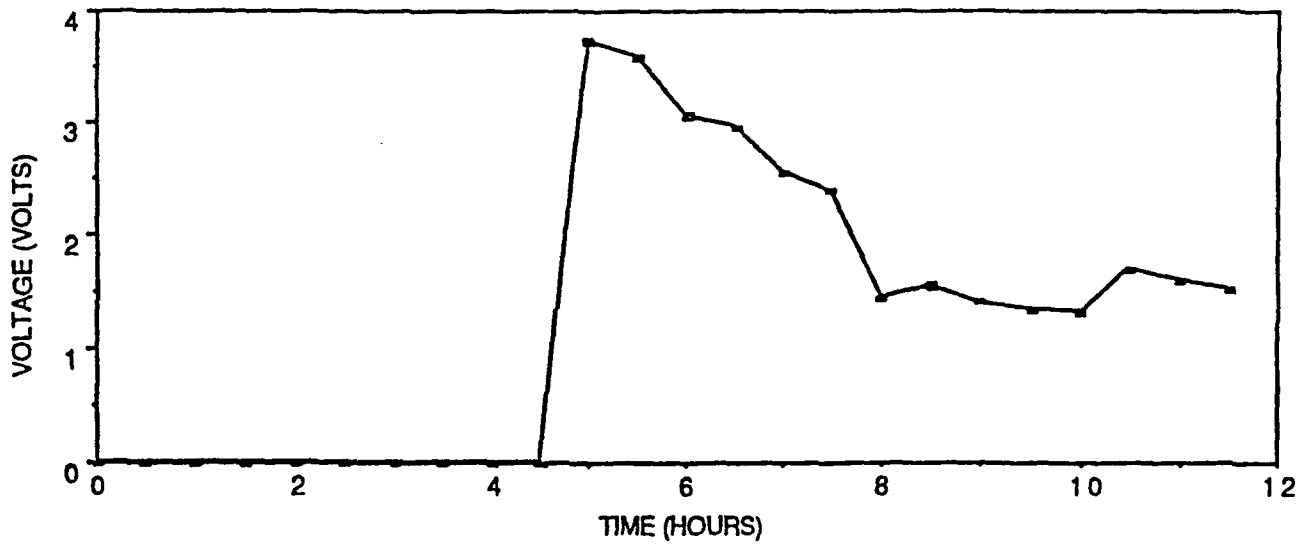
Waiting time2: The time between Sensor Deployment and the tripline pulled.

Table 1 - Phase 1 Results

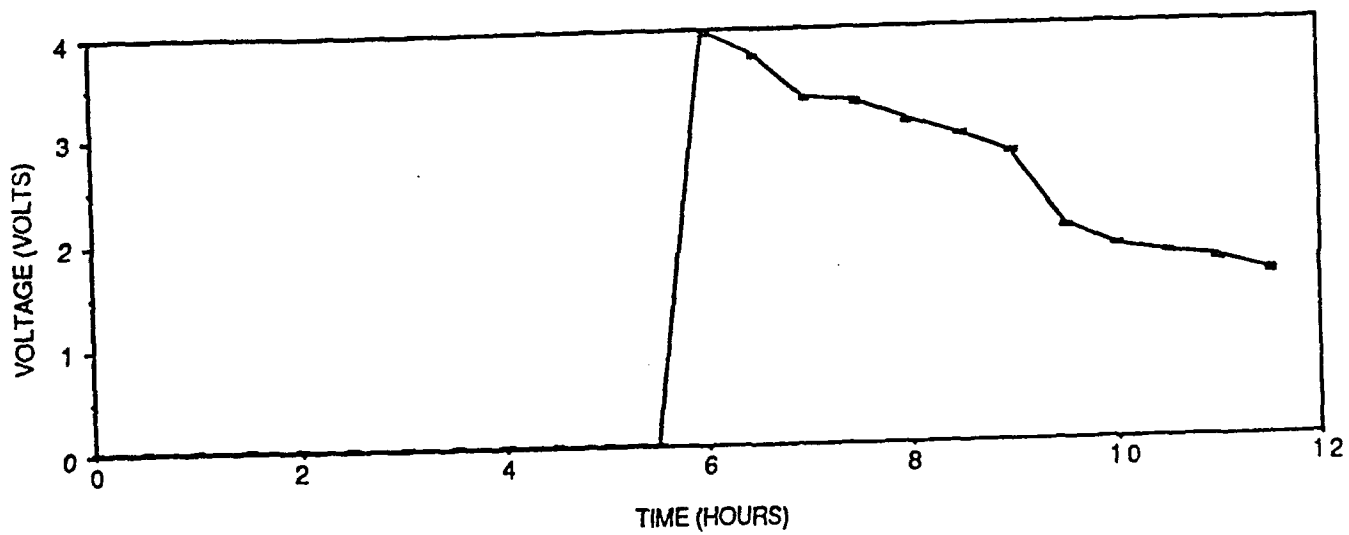
PRE-ACTIVATION VOLTAGE-VERSUS-TIME CURVES
+180° CYCLE: MINE #3



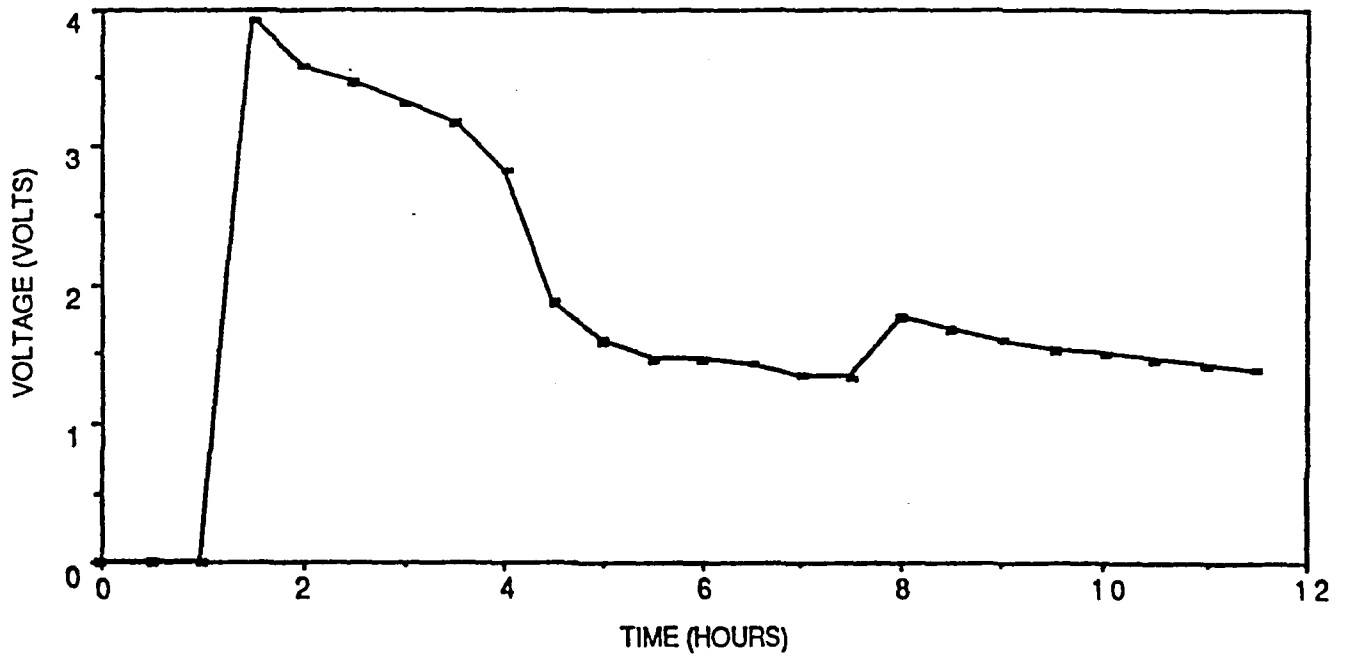
PRE-ACTIVATION VOLTAGE-VERSUS-TIME CURVES
+180° CYCLE: MINE #7



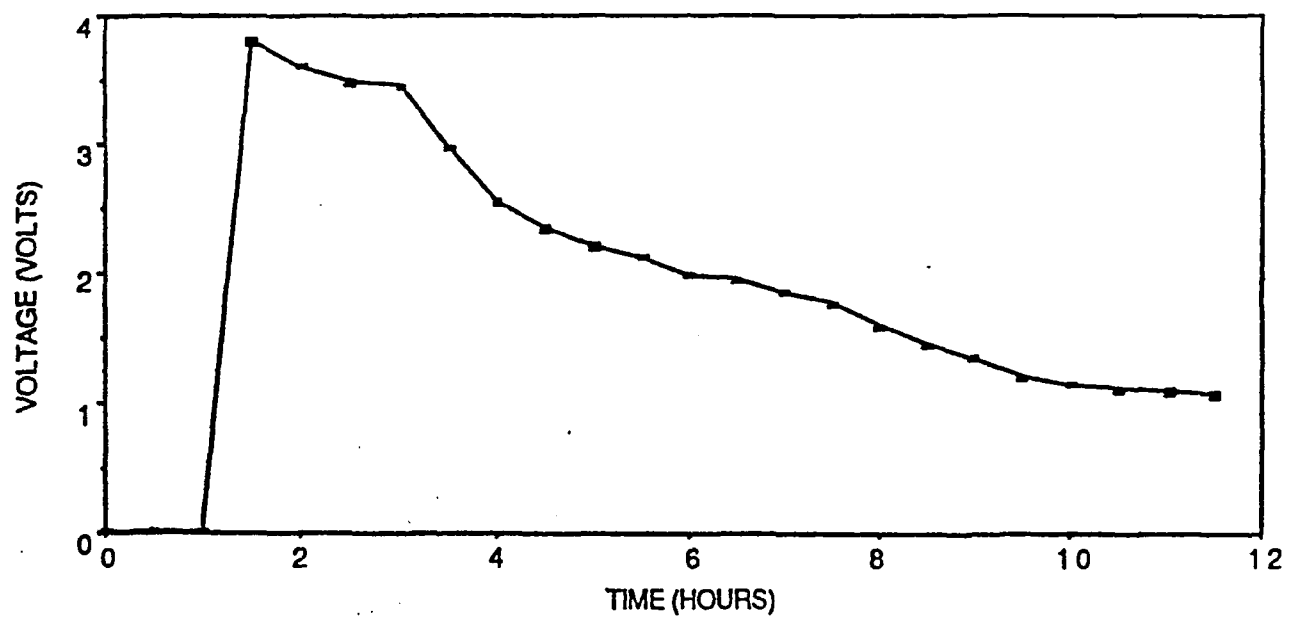
PRE-ACTIVATION VOLTAGE-VERSUS-TIME CURVES
+180° CYCLE: MINE #16



PRE-ACTIVATION VOLTAGE-VERSUS-TIME CURVES
+180° CYCLE: MINE #22



PRE-ACTIVATION VOLTAGE-VERSUS-TIME CURVES
+180° CYCLE: MINE #23



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