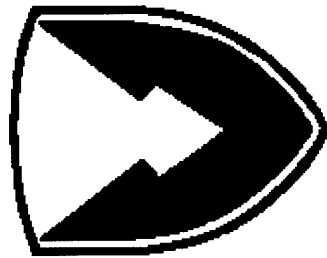


U.S. ARMY TANK-AUTOMOTIVE AND ARMAMENTS COMMAND

**U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT
AND ENGINEERING CENTER**



**Improved Manufacture of Illuminating
Candles for Mortar Ammunition**

Presented By

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**Warheads, Energetics and Combat-support Armaments Center
Armament Systems Process Division**

Presented At

44th Annual Fuze Conference & Munitions Manufacturing and Technology Symposium

Pleasanton, CA

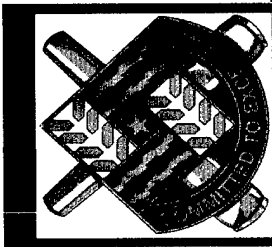
DISTRIBUTION STATEMENT A

**Approved for public release
Distribution Unlimited**

NDIA

10-12 April 2000

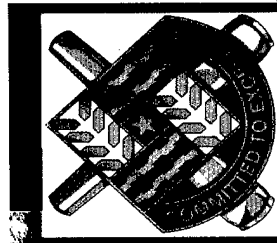
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Outline

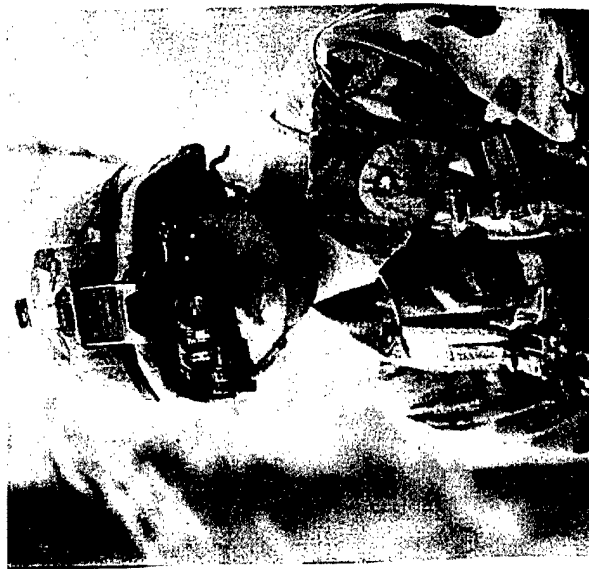
- Background / Item Description
- The Team
- Problems
- Investigation/ Results
- Solution
- Summary

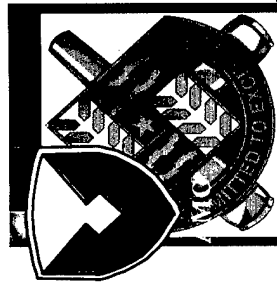




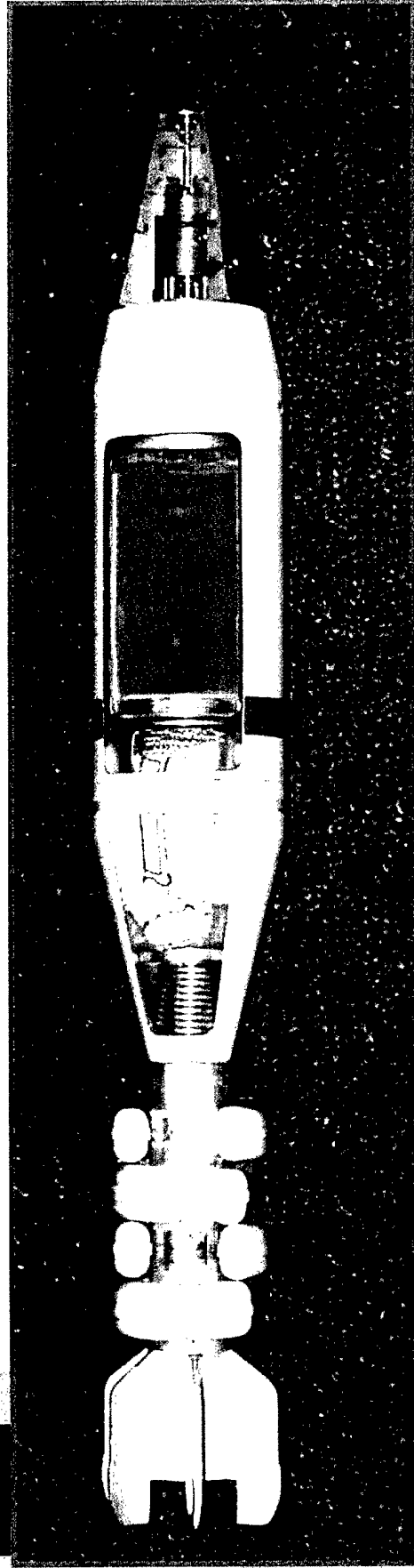
Background / Item Description

- Illuminating targets for engagement, observation, reconnaissance
 - Visible light (VL) does this overtly
 - Infrared (IR) light does this covertly
- Physical Security.
- Reduce the effectiveness of enemy Night Vision Devices (NVD) / IR Fire Control with visible light.
- Enhance the effectiveness of friendly NVDs with IR light without compromising friendly IR Fire Control Devices
- Disrupting enemy movements.
- Navigation
- Deceiving the enemy as to the intent of friendly forces
- Signaling the beginning or end of a tactical event





Cartridge, 60mm: VL Illuminating/IR Illum, M721/M767



- The M721 is the 60mm Visible Light Illuminating Cartridge (300,000 CP for 32 seconds min)
- The M767 is the 60mm Infrared (IR) Illuminating Cartridge (40 watts/steradian for 40 seconds min)
- The M721/M767 have a range of 3,200 meters to air burst at 315/400 meters HOB respectively
- The M721/M767 use the M776 MTSQ Fuze
- The weight of the M721/M767 is 3.75 pounds
- The M721 has a standard Magnesium candle
- The M767 has a IR (Navy Mix) candle
- Primary users are the US Army, USMC and US Navy



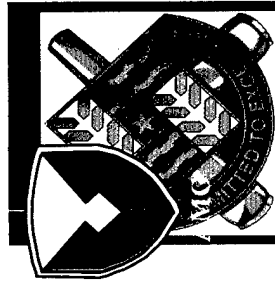
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Fire Support

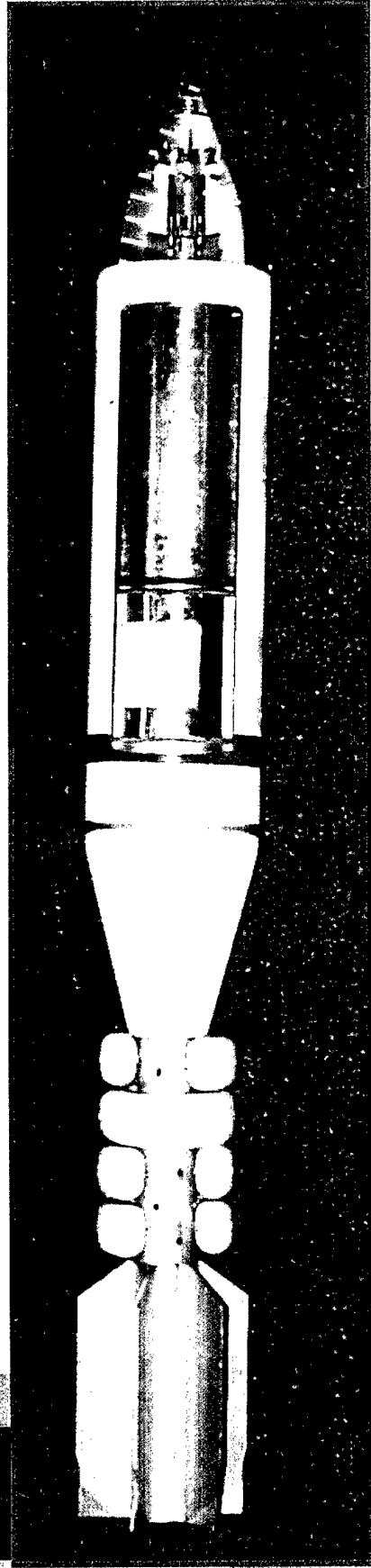


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Cartridge, 81mm: VL Illuminating/IR Illum, M853A1/XM816



- The M853A1 is the 81mm Visible Light Illuminating Cartridge (525,000 CP for 50 seconds min)
- The XM816 is the 81mm Infrared (IR) Illuminating Cartridge (75 watts/steradian for 60 seconds min)
- The M853A1/XM816 have a range of 5,100/5,050 meters to air burst at 475/550 meters HOB respectively
- The M853A1/XM816 use the M772 MTSQ Fuze
- The weight of the M853A1/XM816 is 8.9 pounds
- The M853A1 has a standard Magnesium candle
- The XM816 has an IR candle (IR mix TBD)
- Primary users are the US Army, USMC and US Navy (M853A1). US Army for XM816



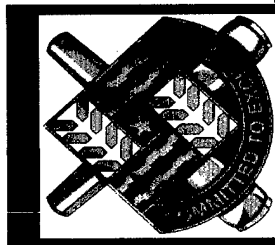
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Fire Support

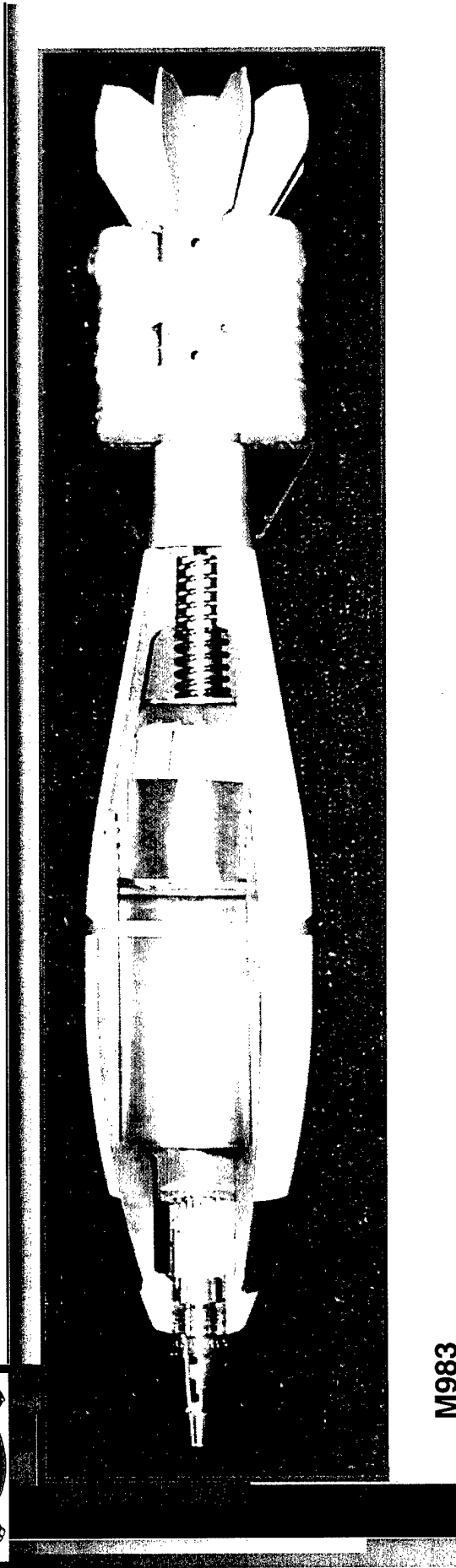


Armaments Center





Cartridge, 120mm: Illuminating/IR Illum, XM930/M983



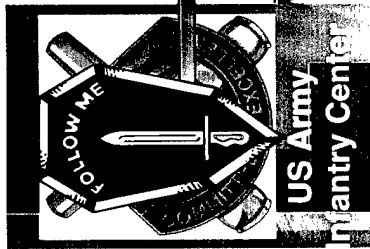
M983

- The XM930 is the 120mm Visible Light Illuminating Cartridge (1.0 M candela for 50 seconds min)
- The M983 is the 120mm Infrared (IR) Illuminating Cartridge (100 watts/steradian for 50 seconds min)
- The XM930/M983 have a range of 6,675 meters to air burst at 500/600 meters HOB respectively
- The XM930/M983 use the M776 MTSQ Fuze
- The weight of the XM930/M983 is 30 pounds
- The XM930 has a standard Magnesium candle
- The M983 has an IR candle (Navy Mix)
- Primary user is the US Army

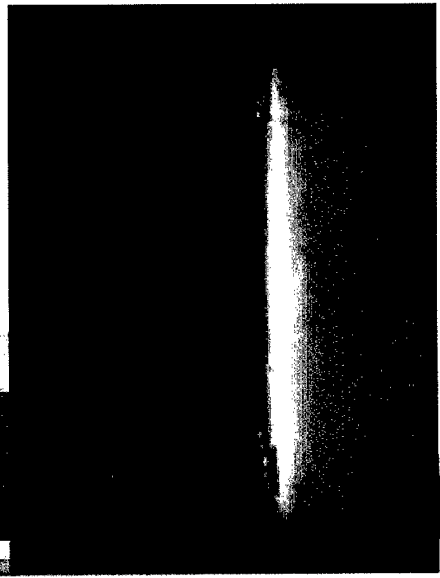


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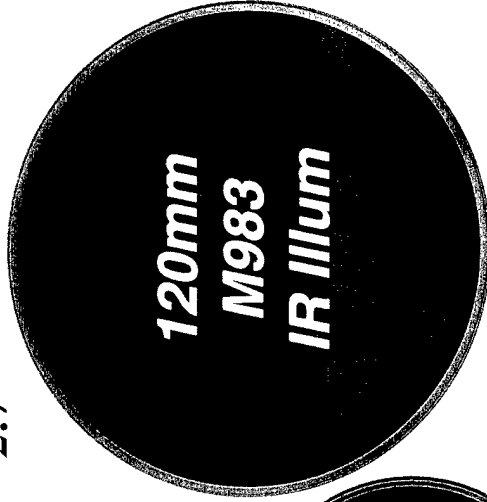
Illumination Area Effectiveness



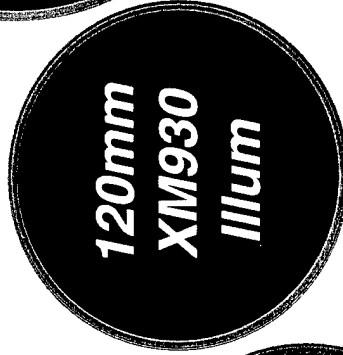
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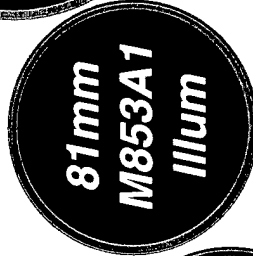
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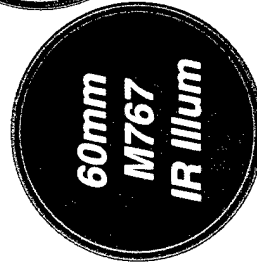
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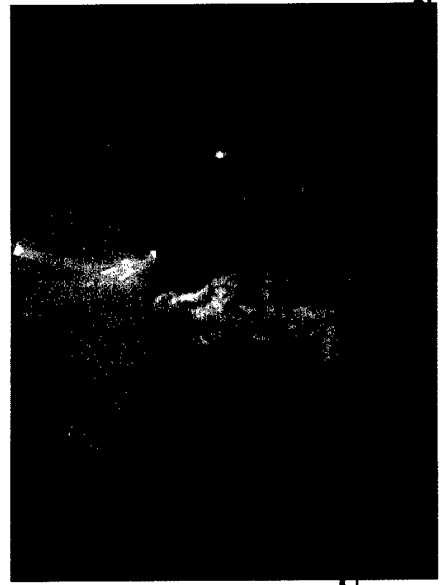
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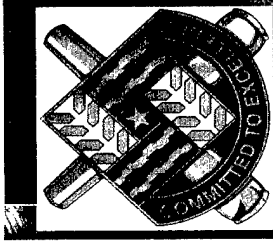
1.4



1.0



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The Team

- Successful partnering between PM-Mortars, TACOM-ARDEC, Pine Bluff Arsenal, Crane Army Ammunition Activity and the Test and Evaluation Command has led to successful execution of all programs
 - Root Cause Analysis
 - Decision trees
 - Weekly IPT meetings
 - Quarterly production reviews/PM Program Reviews
 - Ballistic tests
 - Application of lessons learned





Problems

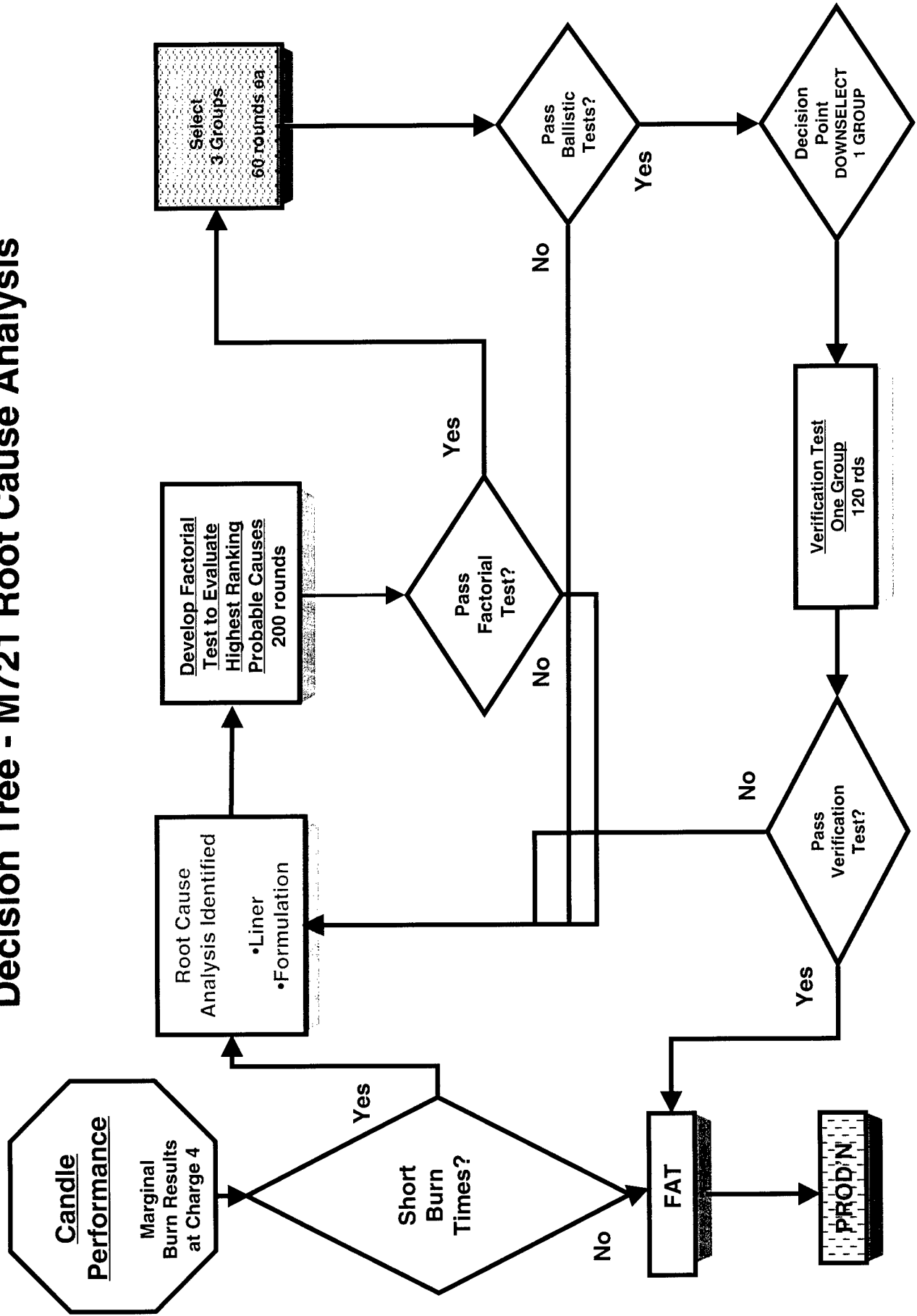
- **Candle Flickering**
 - Inconsistency of light during burning
 - The net result is a pulsating/strobe effect for the soldiers using the NVDs. This makes perception and visibility difficult.

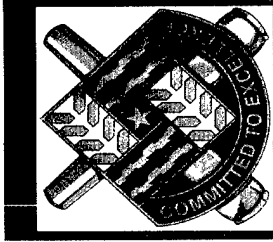
- **Non-Ignition of Candle**

- **Candle Illuminant Mix Dropout**
 - Complete (CDO)
 - Partial (IDO)



Decision Tree - M721 Root Cause Analysis



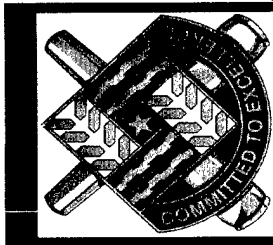


Investigation / Results

Flickering (observed solely in 60mm IR round)

- Inconsistency of light during burning
 - light will turn on and off (Strobe Effect)
- Root cause analysis identified that the flickering problem is associated with:
 - low temperature composition (inefficient burning) - diameter related
 - slag forming on flare case, blocking the opening
 - utilize pressure to blow out slag and reopen
 - » after the opening is clear, there is no excess pressure and slag reformed, thus creating the flickering effect





Investigation / Results

(continued)

- The following high ranking probable causes were identified and ballistic test results indicated that flickering still occurred
 - Mixing / blending
 - Modified liner
 - Modified formulation - no nitrocellulose (NC)
- Continued root cause analysis identified that the flickering problem is associated with inefficient burning of FW 2182 composition
 - Following changes will significantly improve combustion efficiency
 - Composition FW 2182 - reducing the oxidizer particle size
 - Black Nite - switching from cesium nitrate to potassium nitrate (limited data indicates no flickering)



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Solution

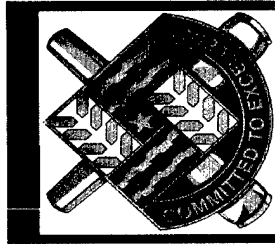
- Black Nite Composition Selected
 - Prior use in other round
 - Less expensive than FW 2182 composition

Flickering eliminated following implementation of Black Nite composition



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Investigation / Results

(continued)

- Candle Non-ignition : Candle does not ignite after fuze function and candle expulsion
 - First fire composition is blown off of the cartridge candle and does not ignite
 - Fracture in first fire composition from
 - mortar set-back
 - fuze function
 - expulsion of flare
 - pressing of flare composition

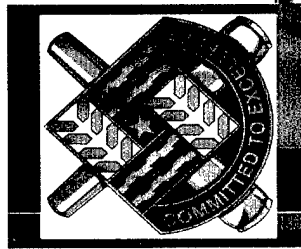
OR

- any combination of the above

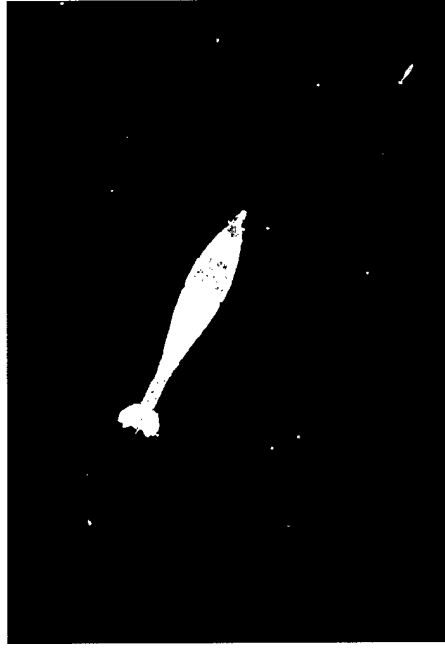


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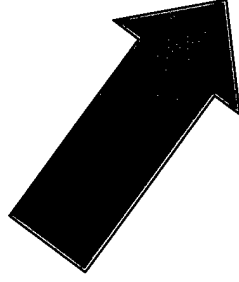




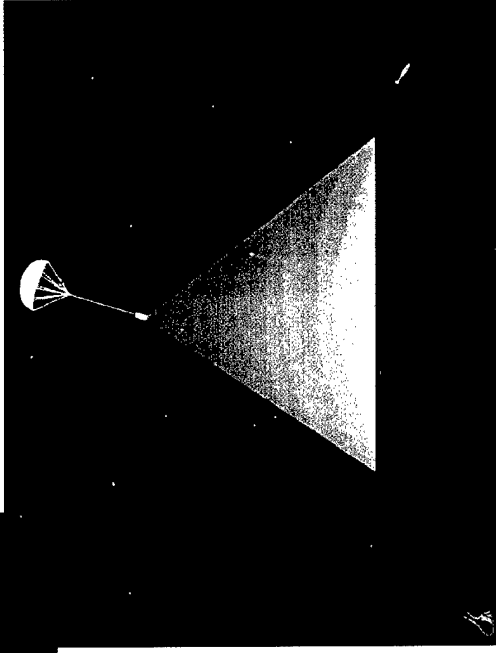
Forces Acting on 120mm Candle Assembly



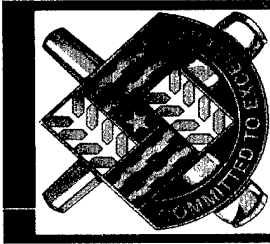
Fuze Functioning:



Setback force at launch
11K Gs



Force at Parachute Opening
400 Gs



Investigation / Results

(continued)

- Root cause analysis performed to identify probable causes:
 - problem with binder in first fire composition
 - replace solvent
 - Need to develop better ignition train
 - concave punch (Embedded for 81mm)
 - 50/50 transitional mixture of first fire and flare composition
 - Handling of the FF mix.

**Following incorporation of the above
the non-ignition problem
has been eliminated**

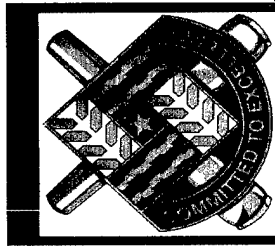


Investigation / Results

(continued)

- **Illuminant Mix Dropout**
 - Complete Illuminant drop to the ground (no recordable burn time)
 - Mechanical problem
 - Must be capable of withstanding forces of the round
 - » Expulsion
 - » Mortar Set Back
 - » Fuze Function
 - Side wall coating (liner)
 - Binder in candle
 - Additional method to fasten flare candle to canister
 - Pressing of candle causing the problem





Investigation / Results

(continued)

- Root cause analysis identified
 - Thinner coating of glue on 60mm cartridge case liner produces better mechanical properties
 - Use of fiberglass liner on 81mm and 120mm results in the candle grain having better adhesion to the canister case

Following incorporation of the canister liner changes and the current binder system, the complete dropout problem has been eliminated



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Investigation / Results

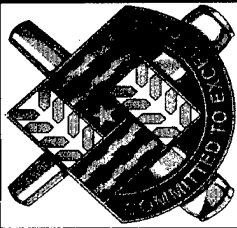
(continued)

- **Partial Dropout**
 - Candle illuminant composition falls out during candle burning
 - Thermal problem (heat from burning candle causes the illuminant composition to drop out during burning)
 - Flare does not meet the required burn time
 - » Binder in the composition
 - » Epoxy's ability to maintain adhesion integrity
 - » Protection Against Heat (coating, cardboard liner)
 - Alternate method to hold in composition (mechanical device)
 - Investigation continuing on 81mm and 120mm VL Candles
 - Candidate coatings
 - Size dependent



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Summary

- Illuminating cartridges will continue to play an important tactical role in the foreseeable future
- The U.S. Armed Services will continue to Team/Partner with the developer and manufacturer to resolve and avoid production issues.
- This partnership led to the elimination of major production issues with illuminating mortar cartridges
 - Flickering
 - Ignition Problems
 - Dropout
- Opportunities exist to continue to improve the manufacture of illuminating mortar cartridges to provide a safer, more reliable product



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