

"SPECIAL STUDY OF SAFETY IN PYROTECHNICS MANUFACTURING"

(OVERVIEW)

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I. INTRODUCTION. In June 1989, a fire and deflagration occurred at one of the Army ammunition plants (AAPs). The plant was mixing an Infrared (IR) Decoy Flare composition in a mixing bowl when the incident occurred. The bowl contained 200 pounds of mixture which included magnesium, teflon, acetone, hycarb binder, and hexane.

A Board of Investigation (BOI) was formed immediately to identify a potential cause(s). As a result of the investigation, the BOI concluded that the most probable cause of the fire and deflagration was electrostatic discharge into the mixture.

As shown in figure 1, the plant was using a Cowles Dissolver System. The mixing bowl had been teflon coated to facilitate removing the mixture from the bowl as well as the clean-up process. However, the coating acted as an insulator and created some lack of grounding between the mixer bowl and the mixer shaft. A reading was taken of potential differences between the hexane dispenser tube and the mixer shaft and a net potential difference of 1,800 volts was found. A video tape taken of the operation at the time of the fire did, in fact, indicate a one-point initiation at precisely that location in the mixer bowl. A subsequent interview with one of the operators revealed that the flow of hexane into the mixer bowl had decreased that day by 50% as compared to the flow the day before.

The BOI deduced that the decreased hexane flow increased the vapors in the mixer bowl and an electrostatic discharge ignited the hexane vapors which then ignited the flare composition.

Within a week after the completion of the BOI, word was received at U.S. Army Technical Center for Explosives Safety (USATCES) that another Army activity was preparing to start a similar operation using basically the same materials and equipment. The USATCES representative, who had been a member of the BOI, was sent to observe the start-up of this operation and pass along lessons learned.

A review of the planned IR mixing operations revealed that the batch size would be considerably smaller (in the 5 pound range) and their Cowles mixer bowl was not teflon coated. A test was conducted to determine if electrostatic discharge was occurring here as it was at the other activity. The same problem of a high potential difference could not be duplicated.

From the results of the BOI and the subsequent visit to another activity, the following conclusions were made:

A. Non-standard Production Processes. Although the two activities were using similar technology, there were significant differences in procedures and equipment that were unique to each activity.

B. Fear of Losing "Proprietary Information." In some cases, the contractors managing the ammunition plants are in direct competition with other manufacturers and thus are protective of their procedures and equipment design and do not want to lose their advantages by revealing "Proprietary Information."

C. No exchange of "Lessons Learned." The exchange of "Lessons Learned" is almost non-existent. Problems uncovered during the BOI were discussed with other plants and they were totally unaware of the problems. In fact, some of the plants were not aware that a fire had occurred at another plant.

D. Production Schedules Not Known at Other Activities. Again, because of contractual concerns and a desire to keep some information confidential within an organization, the production schedules of specific plants are normally not known at other plants. There did not seem to be an effort to hide the information, but more likely a lack of interest or concern for what other plants were doing.

E. Safety Information Stops at Safety Office. During some comparisons, it was found that the Safety Offices at some plants were receiving accident/incident information and lessons learned and were promptly filing them away in their safety files without passing the information along.

F. Need to Get Information Down to The "Worker." In discussions with the workers, it was found they were not aware of previous accidents and the resulting fatalities and injuries. When asked about previous accidents and fatalities at their own plants, the workers were very vague as to when they occurred, why they occurred, and what the results were. Since these are the people who are most likely to suffer during an incident, they should be fully informed of the hazards involved and how they may prevent mistakes of the past.

II. PURPOSE OF USATCES STUDY. In August 1989, the Development and Production Explosives Safety Division of USATCES began a study of all pyrotechnic manufacturers to:

- A. Identify similarities and differences among Pyrotechnic processors.
- B. Identify the "best" ways of doing the same job.
- C. Look at the latest technologies being developed for pyrotechnic processes.
- D. Identify problems or potential problem areas.

III. ACTIVITIES VISITED. The USATCES planned to visit Government-owned, Government-operated (GOGO), Government-owned, contractor-operated (GOCO), and contractor plants in order to gain a broad perspective of policies and procedures in pyrotechnics manufacturing. Due to various causes, the contractor plants were not visited. However, the designers for both Navy and Army pyrotechnics were visited. One company was performing testing for the Army's Mixing, Granulating, and Drying (MIGRAD) systems and was visited to discuss their results of testing IR compositions. The Pyrotechnics Sub Group of the Joint Ordnance Commanders Group was visited to present preliminary findings of the USATCES study. The following were visited:

- A. Pine Bluff Arsenal (PBA)
- B. Longhorn Army Ammunition Plant (LHAAP)
- C. Lone Star Army Ammunition Plant (LSAAP)
- D. Lake City Army Ammunition Plant (LCAAP)
- E. Crane Army Ammunition Activity (CAAA)
- F. Naval Weapons Support Center (NWSC)
- G. U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal
- H. Joint Ordnance Commanders Group (JOCG) Pyrotechnic Sub Group
- I. Sværdrup Corporation (Stennis Space Center)

IV. FINDINGS. There were several significant findings during the study. Because of curtailment of funding, some of the findings were not sufficiently studied to be included in this report. The following findings were observed or studied enough to be reported before completion of the overall USATCES study and final report.

A. Non-Standard Visitor Protection. The USATCES visits to the various plants revealed that the personal protective equipment (PPE) required of visitors was quite varied and not consistent with the types of areas visited.

(1) At one plant the visitors were required to wear basically the same clothing as the workers and were suited-up in cotton coveralls, conductive safety shoes, and safety eyewear.

(2) At another plant the visitors were required to wear only grounding straps over their street shoes.

(3) At another plant they were required to wear "NOMEX" shop coats and safety eyewear.

(4) The safety philosophies at the various plants varied significantly as to what visitors wore when visiting pyrotechnics facilities and how these visits were conducted.

B. Non-Standard Worker PPE. During the USATCES visits to the various plants, there was an obvious non-standard use of PPE.

(1) At one pyrotechnic manufacturer, the operators and supervisors were wearing cotton coveralls, conductive shoes, and safety eyewear.

(2) At another manufacturer, the operators were wearing "NOMEX" coveralls, conductive shoes, and safety eyewear while the supervisors wore "NOMEX" shop coats.

(3) At each location there were different safety philosophies on which PPE should be worn and how it was worn.

C. Non-Standard Use of Fire Suits. There were different safety philosophies on the use of fire suits.

(1) At one manufacturer the operators were wearing aluminized suits, hoods, and gloves over their cotton coveralls when handling magnesium powder.

(2) At another activity doing a similar type mix as above, the operator wore only a face shield in addition to cotton coveralls and conductive shoes when handling magnesium powder.

(3) When questioning the operators, they expressed a feeling of being safe. The operators wearing the aluminized suits felt they were protected from any fire as long as they were wearing the suit. However, from previous accidents and reports, we were able to determine that the IR composition fires occurred so fast that the operators were not properly protected.

(4) The USATCES representative looked at several existing self-cooled, heavy duty fire suits that had been purchased over the past fifteen years and observed that these suits were too heavy and bulky to be of real use in day-to-day operations. At all activities having these suits, the suits were stored out of the way.

(5) In questioning operators and supervisors, it was commonly believed that the cotton coveralls were static free. However, tests conducted by the Army and Navy have both proven that even cotton coveralls will have static buildup in low humidity conditions. Again, the operators had false beliefs that they were completely safe merely by wearing cotton coveralls.

D. MIGRAD.

(1) The MIGRAD is an abbreviation for the mixing, granulating and drying of pyrotechnic compositions. The line set up at PBA was a pilot plant model set up to test the concept of mixing, granulating, and drying of pyrotechnic composition in one operation. Plant systems will be 60 liters or 120 liters in capacity. The inert ingredients will be remotely charged into the mixing bowl and the bowl sealed with the exhaust vent to form one unit. Once the pyrotechnic composition has dried, the material will be pushed out of the system and slide down a chute into a velostat bag. An operator will personally remove the bag from the system.

(2) Sverdrup Technology Incorporated conducted testing at Stennis Space Center to determine which pyrotechnic compositions the MIGRAD would be able to handle. From their testing, they were able to determine that the MIGRAD could not handle certain "hot" items such as IR compositions.

E. Hazard Classification of IR Compositions.

(1) The USATCES found that there is not total agreement as to the hazard classification of IR compositions. The Army and Navy agree that the IR compositions should be hazard classified 1.3 when in the pressed state or in the final assembled state as an IR Decoy Flare. They also agree that the IR compositions in the wet state are 1.3. However, the Navy considers IR compositions to be 1.1 in the dry state while in process and the Army considers it to be 1.3. Classifying IR compositions as 1.1 vs 1.3 would have a significant effect on location of processing buildings because of the required separation distances. If a current operation/building is classified as 1.3 and the classification is changed to 1.1, then quantity distance (QD) would change and could cause some changes in location of the operation or shut down adjacent operations.

(2) During the USATCES study, it was found that the Army's tests to establish hazard classification did indicate that the IR compositions should be hazard classified as 1.3. However, later tests by the Navy and Sverdrup have shown that IR compositions react more violently than a mass fire and have indicated that additional test and studies do need to be conducted. As shown in figure 2, the accidents involving IR compositions since 1968 prove that processing of IR compositions has been deadly and costly. In that relatively short time, there have been 13 fatalities and over 30 serious injuries along with untold millions in property damages. In some cases, the entire plant operations were destroyed and were never restarted.

IV. CONCLUSIONS. The USATCES "Study of Safety in Pyrotechnics Manufacturing" is still in process and will be completed during fiscal year 1991. This paper has provided an overview of some of the findings of the study. The following conclusions are only a sampling of the total conclusions that will be included in the final report.

A. There is a definite need for the exchange of lessons learned among the AAPs and Activities. The workers on the line should be the recipients of these lesson learned so they will be aware of the hazards of their job and be better prepared to perform their daily tasks.

B. The PPE for visitors and workers at the various ammunition and explosives manufacturers and processors should be standardized.

C. The use of fire protection apparel should be standardized and the use of such equipment well defined in order to provide maximum protection to the worker.

D. IR compositions such as Magnesium-Teflon-Viton and Magnesium-Teflon-Binder (MTV/MTB) should be studied and tests conducted to determine the correct hazard classification of the compositions during processing in both the wet and dry states.

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(OVERVIEW)***

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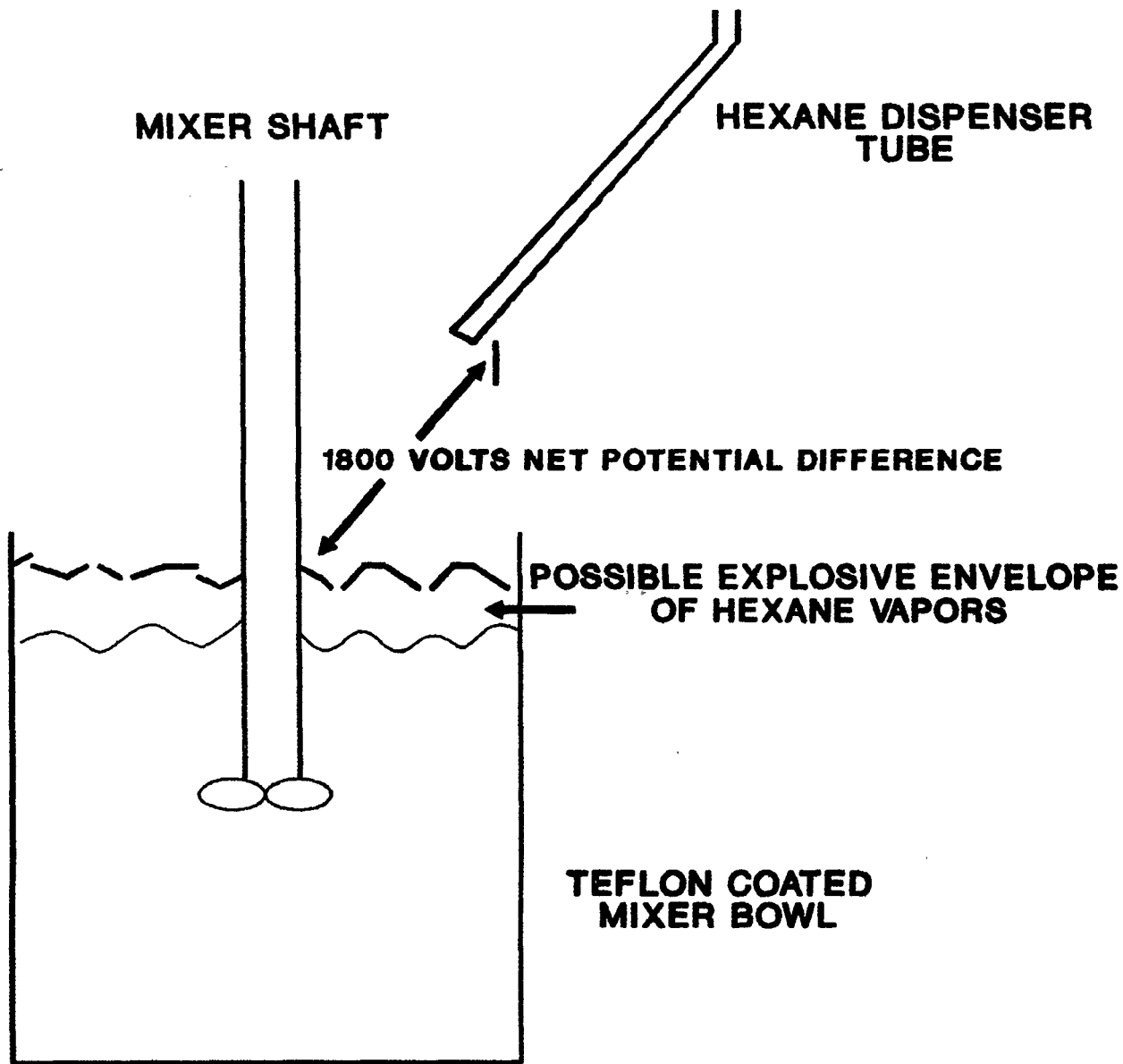


BACKGROUND

- **JUNE 1989 IR COMPOSITION MIXING FIRE**
- **JULY 1989 SIMILAR OPERATION BEGINS AT ANOTHER ACTIVITY**

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MEASUREMENT OF POTENTIAL DIFFERENCE



FRONTAL VIEW OF
COWLES DISSOLVER SYSTEM

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CONCLUSION

- **NON-STANDARD PRODUCTION PROCESSES**
- **FEAR OF LOSING "PROPRIETARY INFORMATION"**
- **NO EXCHANGE OF "LESSONS LEARNED"**
- **PRODUCTION SCHEDULES NOT KNOWN AT OTHER ACTIVITIES**
- **"SAFETY INFORMATION" STOPS AT SAFETY OFFICE**
- **NEED TO GET INFORMATION DOWN TO THE "WORKER"**

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PURPOSE OF USATCES STUDY

- IDENTIFY SIMILARITIES AND DIFFERENCES
- IDENTIFY "BEST" WAY TO DO THE JOB
- STUDY LATEST TECHNOLOGIES
- IDENTIFY PROBLEMS OR POTENTIAL PROBLEM AREAS

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ACTIVITIES VISITED

- ✓ PINE BLUFF ARSENAL
- ✓ LONGHORN ARMY AMMUNITION PLANT
- ✓ LONE STAR ARMY AMMUNITION PLANT
- ✓ LAKE CITY ARMY AMMUNITION PLANT
- ✓ CRANE ARMY AMMUNITION ACTIVITY
- ✓ NAVAL WEAPONS SUPPORT CENTER (CRANE)
- ✓ ARDEC (PICATINNY ARSENAL)
- ✓ JOCG PYROTECHNIC SUB GROUP
- ✓ SVERDRUP CORPORATION (STENNIS SPACE CENTER)

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FINDINGS

- **NON-STANDARD VISITOR PROTECTION**
 - **COTTON COVERALLS, SAFETY SHOES, SAFETY EYEWEAR**
 - **STREET SHOES W/GROUND STRAP**
 - **NOMEX SHOP COATS**

- **NON-STANDARD PERSONAL PROTECTIVE EQUIPMENT (PPE)**
 - **COTTON COVERALLS**
 - **NOMEX SHOP COATS**

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FINDINGS (CONT)

- **NON-STANDARD USE OF FIRE SUITS**

- **ALUMINIZED FIRE SUIT**

- **FACE SHIELD W/COTTON COVERALLS**

**SIMILAR OPERATIONS
DIFFERENT LOCATIONS**

- **TOO MUCH FAITH IN ALUMINIZED SUITS**

- **EXISTING SELF-COOLED SUITS TOO HEAVY AND BULKY**

- **COTTON COVERALLS ARE NOT STATIC FREE**

- **LOW HUMIDITY WILL ALLOW STATIC BUILDUP**

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FINDINGS (CONT)

- **MIGRAD (MIXING, GRANULATING, DRYING)**
 - **ARMY TESTING MATERIALS FOR**
 - **WILL NOT ACCOMMODATE IR FLARE COMPOSITIONS**
 - **OPERATOR MUST MANUALLY DISCHARGE MIX FROM SYSTEM**

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FINDINGS (CONT)

- **HAZARD CLASSIFICATION OF IR COMPOSITIONS**
 - **ARMY CLASSIFIES AS 1.3 AT ALL TIMES**
 - **NAVY CLASSIFIES AS**
 - **1.3 - FINISHED ITEM**
 - **1.3 - WET STATE DURING PROCESSING**
 - **1.1 - DRY STATE DURING PROCESSING**

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SUMMARY OF ACCIDENTS INVOLVING IR PYROTECHNIC COMPOSITIONS

<u>DATE</u>	<u>LOCATION</u>	<u>OPERATION</u>	<u>FATALITY</u>	<u>INJURY</u>
16 AUG 68	NWSC CRANE, BLDG 200	ASSEMBLY	3	1
18 DEC 68	NWSC CRANE, BLDG 198	EXTRUDER	1	1
13 NOV 75	CELESCO INDUSTRY	BLENDING	0	0
9 DEC 75	CELESCO INDUSTRY	MIXER	0	0
7 JAN 80	LONGHORN AAP	MIXER	1	1
19 DEC 83	TRACOR MBA, BLDG M-25	ASSEMBLY	2	19
18 JUL 85	BERMITE DIVISION	MIX/BLEND	0	0
8 AUG 85	TRACOR MBA	EMPTYING TUMBLER	3	5
19 MAY 86	DELA TEK	MIX/BLEND	1	2
28 AUG 86	KILGORE CORPORATION	DRYING ROOM	2	1
29 SEP 87	KILGORE CORPORATION	EXTRUDER	0	0
26 JUL 89	LONGHORN AAP	MIXER	0	0
9 NOV 89	TRACOR AEROSPACE	MIXING/DRYING	0	0
			<u>13</u>	<u>30</u>

**SOURCE: JOINT ORDNANCE COMMANDERS GROUP (JOCG), SUB-GROUP FOR ORDNANCE
SAFETY REPORT OF CONVENTIONAL AMMUNITION AND EXPLOSIVES ACCIDENTS.**

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CONCLUSIONS

- **NEED MORE AND BETTER EXCHANGE OF LESSONS LEARNED INFORMATION**
- **NEED TO STANDARDIZE WORKER AND VISITOR PPE**
- **NEED TO STANDARDIZE FIRE PROTECTION SUITS**
- **NEED TO REVIEW THE HAZARD CLASSIFICATION OF MTV/MTB IN DRY STATE DURING PROCESSING (1.1 VS 1.3?)**