Leaker Rocket and Contaminated Rocket Motor Processing At Blue Grass Chemical Weapon Destruction Facility – USA

By: Sam B. Hariri, P.E – Parsons
Robert Kistler – Washington Group International

I Background

Identification of the leaker munitions in the chemical depot arsenal and provision of a safe and effective disposition of the leaker munitions has a significant impact on safe termination of the chemical weapon destruction. This task is significant enough but its effect on the plant design will mainly depend on the percentage of the leakers and its complexity in order to dictate the course of treatment. In the case of the method of destruction of the chemicals neutralization is more difficult to adopt leaker operation than the incineration and leaker treatment plays a major role in the way processing plants take shape. Here in Bluegrass we got to the design of leaker treatment system at the later stages of the design because the number of the leakers was not believed to be too significant. Therefore it needed to be devised such that it could fit within the then existing design This method involves leakers operation to share the same draining and washout facilities and procedure as other munitions. However, they have to be separated before they enter the system and contaminate the processing equipment so that the normal operation schedule could not be affected. Therefore several steps were taken as given below to identify the leakers and to set up a strategy that would provide a safe and efficient way of destroying the leaker munitions without too much disruption in the normal agent destruction schedule.

II Identification of Leakers

The munitions in the BGCA contain both rockets and projectiles therefore each section will cover both types of arsenal:

<u>Rockets</u>

Historically, GB rockets at each site have had leaker percentage of total population between 0.1 – 2.2%. However, number of GB rocket leakers depends on with the type of GB agent in the rocket. Majjority of GB rockets (88.8%) have PreRoundout (PRO) agent. PRO GB rocket leak percentages at other plants (Umatilla, Pine Bluff, and Anniston) have been between 0.06 and 0.84%, respectively. As of today , 93 GB rocket leakers have been identified, out of which 17 are corked . Out of 76 GB rocket leakers, 73 are PRO agent type. It should be noted that the leak occurrences, since start of Period III surveillance (1991), has been 2.3 rockets per year on the average at BGCAPP (averaged over 1991 – 2005). The leaker rate occurance per year, from Assessment of the Stability of M55 Rockets in Storage is at 4.6. Using the higher leaker frequency rate the number of leakers at 2017 (when BGCAPP rocket processing is expected to terminate.) would be 128-151. This does not account for intrusive testing (internal leakers) of the rockets. If internal leakers are found, the prior estimate seems to be not enough. To account for such leakers, Anniston's percentage of PRO GB rocket leakers can be used as basis. So it can be concluded that if Anniston per cent leaker is used as basis the leakers could be between 125 to 435 rockets. To reach the maximum assumed 435 M55 GB rocket leakers, one needs to have 31 GB rocket leakers per year average from now until 2017. Comparing that number with 2.3 actual leakers discovered leads us to believe that the above number is on the conservative side and the low end of the range seems to be more reasonable to assume.

VX leaker rockets are estimated to be very few, however a 0.25% leaker has been assumed for our TAA analysis. Based on our information from the baseline sites, no VX leakers have occurred at Umatilla, Pine Bluff, and Blue Grass. ANCDF has had a total of .01 % of total VX rocket population. Each site has a considerable population of VX rockets. The main area where the study encountered difficulty was in the prediction of external and internal leakers. An external leaker rocket (ELR) is defined as one which can be detected through surveillance monitoring of an igloo, of the interior of the SFT , or the interior of an EONC on delivery to the unpack area (UPA). While time- consuming to handle, these are not an uncommon occurrence at the various demilitarization plants and storage sites. There is a large historical database on these ELRs extending back almost to the years the weapons were manufactured. The data is, however, not supportive of relatively simple correlations aimed at predicting with confidence just how many will be encountered at BGCA. Several historical attempts have been made by various agencies to make such a correlation with mixed success. Our study was only marginally successful in deciding on a range of possible ELR occurrence numbers that were to be used to estimate their impact in the operating schedule.

Internal leaking rockets (ILRs) were a far more difficult problem for the study team primarily because of the paucity of data. An ILR is defined as one that is leaking at the base of the warhead into a small void space in front of the sealed motor assembly. Several of these had been observed during an assessment done in 1985 but since then there have been no indications that this type exists despite de-mating operations that had the opportunity to find them. The conundrum is that to ignore their existence is to ignore the type that can cause the most disruption to the schedule. True ILRs will appear only once they have entered the normal rocket demilitarization process which is, of course, intended to deliver non-contaminated rocket motors (NCRM) for out-of-MDB disposal. Thus the study was only marginally successful in making a decision as to the prevalence of this item and its impact. Therefore this can be considered as a limitation of this study and the reader should bear this in mind when considering the result of this study.

<u>Projectiles</u>

VX and GB Projectiles

As of July 2005, no known leakers for VX and GB projectiles have occurred at BGCA. If we assume that the leaker population is similar to the other baseline plants, Umatilla and Anniston, leakers of VX and GB projectiles should be within 0.015% to 0.024% range. In other words, none or very few projectiles are estimated to be discovered as leakers for this category.

H Projectiles

As of July 2005, a total of 0.4% leakers have been identified for H projectiles at BGCA. No known parallels can be shown at this time for the other baseline sites (absence of H projectiles). However, at Anniston no leakers occurred for HD projectiles for a stockpile of more than 20 times compared to BGCA H projectiles. Though we should expect more leakers for H type munitions and this is proven by actual leakers witnessed in BGCA, it gave us confidence that the leakers in this category can be estimated to be at about no more than 60.

III Treatment Strategy and Process Design Initiatives

The strategy was structured such that the treatment system can be achieved within the then existing design which was established for treatment of the regular munitions. A decision flow chart was drawn and each section was assigned to a group of experts in that field. The work process is shown on Figure I. The main segments of work which needed to be defined and a strategy planned for are as follows:

a. Process or store the leakers, depending on where they are identified.
b. Separate or process rocket parts in SFT and removal procedure for SFTs.
c. Separate rocket motors or process the whole rocket.
d. Decon procedures.

e. Storage of rocket motors.
f. Shearing the warhead and treatment of the rocket fins.
g. Utilization of EBH for neutralization of CRMs.

The steps are demonstrated on the flow chart and alternatives available for each step are defined. The non-contaminated rocket motors (NCRM) will be treated under a separate process such as a static detonation chamber (SDC) unit. The contaminated rocket motors will most likely be processed at the end of each campaign with the same treatment process used for treating rocket warheads.

An estimate for the storage and processing capacity of the ECV, ECR and EBH rooms for handling and temporary storage of contaminated rocket motors (CRM) has been completed. A deflagration/blast pressure analysis of the ECV/ECR/EBH rooms was performed and the maximum allowable inventory of stored or in-process rocket motors was determined for each containment room. The objective was to determine maximum number of rocket motors that one can store/process in the hardened containment rooms safely so that should an accident occur the containment will be strong enough to contain safely the result of explosion and agent without a release to the other sections of the plant or the community. Secondly it was important to figure out the number of rocket motors that could safely be processed in the EBH units. Use this data in planning an operations strategy that can be used in TAA.

Assessment of the environmental permitting impact of propellant and PCB-contaminated SFT segments was completed and alternatives for processing the CRMs through the EBH and/or the MPT were examined. Leaker identification, handling and processing scenario selection will be discussed in detail in the next section. Please refer to the attached process flow chart Figure I. The chart was used to reduce the multiple possibilities of the Decision Flow Chart to a most probable processing pathway and strategy by point-by-point discussion of pros and cons. TAA iGraphix model simulation of operations and impacts of potential processing scenarios were studied. Modify the iGraphix TAA model to simulate the preferred leaker processing scenario. Estimate system availability for the RCM and other equipment in the treatment train used for processing the leakers. Exercise the modified TAA iGraphix model to parametrically predict the operational impact of the above in terms of schedule extension over the min-max range of leakers by agent type.

The final selection of the processing route was a result of the study made by several multi task groups that were assigned to analyze the risks, pros and cons of each alternative. The selected system is summarized below and will be discussed in detail in the following section. A newly designed machine is used to separate the warheads and the rocket motors. The CRMs, the ones accompanied by leaker rockets, will be overpacked and handled appropriately. The warhead whether contaminated or not will be transferred to the rocket shear machine where it will be sheared into four pieces and will be transferred to the EBH units for neutralization of the energetics. A solution of 30% caustic at 140^{o}F is used inside the EBH to hydrolyze the energetics. Resulting energetic hydrolysate is further treated in ENS for final polishing, treatment and testing before it is transferred to the energetic hydrolysate storage tanks and final processing in the SCWO units.

IV Handling and Processing of Leakers

As previously mentioned, BGAD performs an on-going surveillance of the chemical arsenal stored at the depot. The leakers found during this surveillance are placed in sealed individual munition containers (referred to as overpacks) and will eventually be delivered in enhance onsite containers (EONC) to the BGCAPP MDB as “known leakers.” Additional leakers can be discovered or created during the process itself which will be called “unknown leakers”.

In the case of leaking munitions or leaking overpacked munitions inside of an EONC, the leak occurred during transport to the MDB and these munitions are referred to as “unknown leakers.” There are two locations that CRMs can be found; in either ECV while performing RCM operations and in the motor packing room (MPR) discharge airlock, prior to the discharging of a box of 30 rocket motors from the MDB. The CRMs detected in the ECV will found via a quick-acting gross agent monitor mounted above the RCM. The CRMs detected in the MPR discharge airlock will be found via a miniature automatic continuous air monitoring system (MINICAMS) agent monitor. If agent is detected, the box of rocket motors is backed into the MPR and each rocket motor will be handled as a CRM until proven agent-free.

During the normal projectile process, the lifting lug of the projectile is removed by a nose closure removal (NCR) station. When the lifting lug is removed, the miscellaneous parts cavity and the burster well cavity are opened to the room. If agent is detected in the room, the process will be stopped and the newly found “unknown leaker” will be handled appropriately, as discussed in the next section.

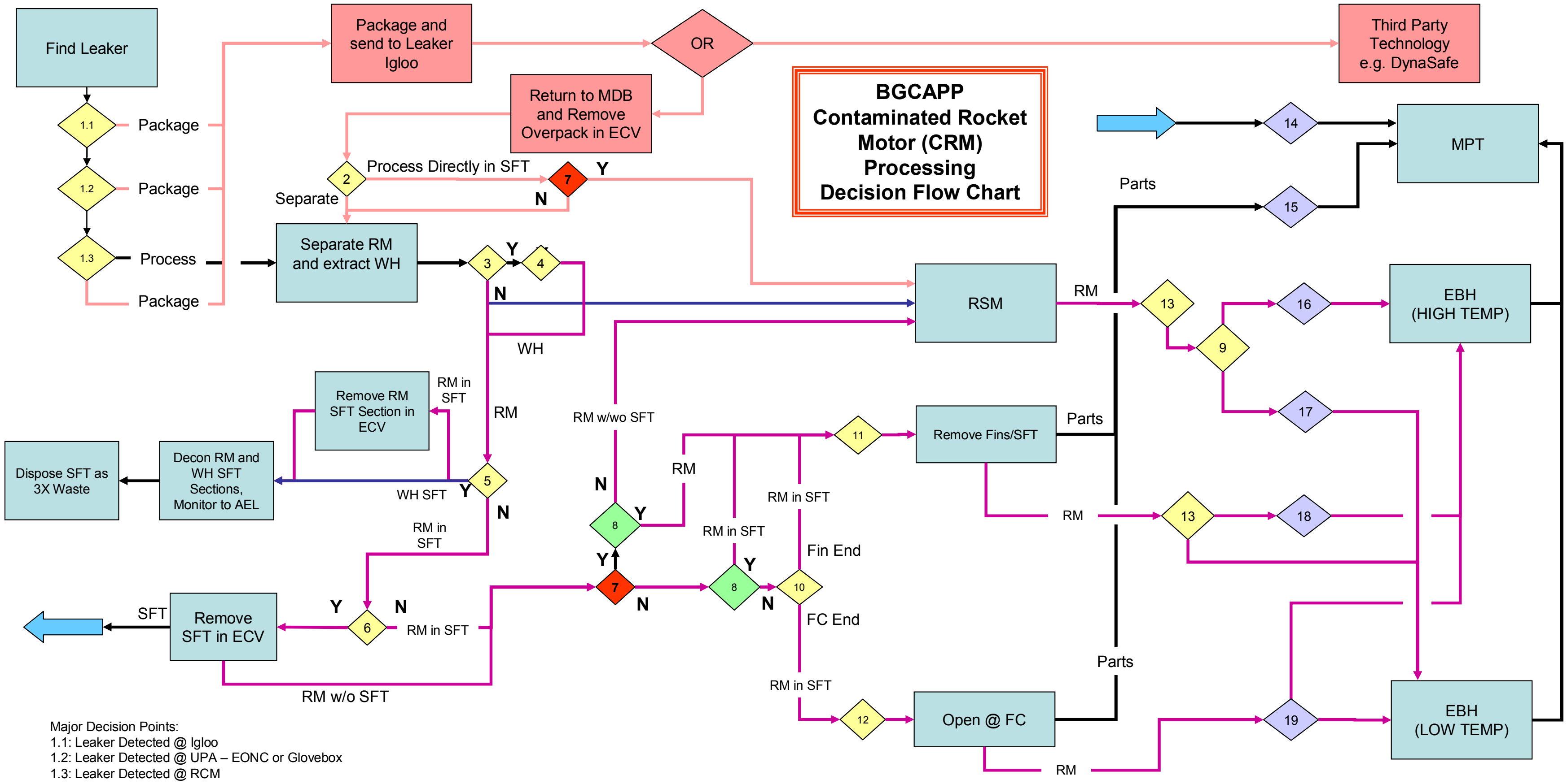
V Handling and Processing of “Known Leakers”

“Known leakers” to be processed at BGCAPP can be grouped in three categories;

GB/VX Rockets:
There are two paths for a “known” rocket leakers. Both start in ECV-1, where a demilitarization protective ensemble (DPE) team will manually open the overpacked rockets and place each rocket onto the RCM conveyor system in ECV-1. From the conveyor system the rockets can be sent through the following two scenarios:

1. The rockets will be conveyed into ECV-2 for processing by RCM-2. The rocket in its SFT will be remotely backed into RCM-2. The RCM will first separate the rocket warhead’s SFT from the rest of the motor section of the SFT and the entire complete rocket. The warhead is then separated from the motor section. The motor will remain and will be handled in its portion of the SFT. Normal RCM sends the warhead to explosion containment room #2 (ECR-2) for normal processing by rocket shear machine #2 (RSM-2) and one of the three EBHs. The rocket motor in its SFT and the warhead’s empty SFT will be conveyed back into ECV-1. The SFT from the warhead, the overpack container, and any other waste generated will be sent to the toxic maintenance area (TMA) for decontamination. The rocket motor will be conveyed to ECR-1 for processing at RSM-1. In ECR-1, the RSM will shear the rocket motor into four 8 inch pieces. By this method the first cut will be 8 inches away from the igniter and will not pose any risk for ignition. The tail fins will be separated from the rocket motor by the third cut using the shear the shear blade of the RSM. The aluminum tail fin portion will be sent to the EBH room and will be processed together with the rocket head pieces in one EBH and the rocket motors will be processed within a second EBH.

The second scenario takes into consideration historic experience from the baseline sites, which has shown some “known leaking” rockets have visual agent contamination present when removed from the overpack container in the ECV. If this is observed at BGCAPP, the entrants in ECV-1 have the option to send the



Major Decision Points:
1.1: Leaker Detected @ Igloo
1.2: Leaker Detected @ UPA – EONC or Glovebox
1.3: Leaker Detected @ RCM
2: Separate Motor or Process straight through in SFT?
3: Stop and Decon?
4: Remote Decon or DPE Entry?
5: Can SFT sections be deconned and monitored to AEL levels and treated as SW to TSDF?
6: Remove the RM SFT?
7: Is it permissible to shear the RM?
8: Must the tail fin assembly be removed?
9: Can aluminum fin sections be processed with propellant in a low temp EBH?
10: Open the RM at the fin end or the foreclosure end or both ends?
11: Where/How are the fins removed?
12: Where/How is the Foreclosure opened?
13: Use "Spare" EBH or WH EBH or new Equipment?
14 - 19: How do the parts get to the next step?

entire rocket straight into ECR-1 for processing. The RSM would process a rocket similar to a baseline site, with variations in the shears to provide for better separation of the warhead and motor. The rocket sections will be transferred to the EBH room in order to be processed as mentioned in scenario #1.

Some of the disadvantages of performing "known leaker" rocket operations includes; additional polychlorinated biphenyl (PCB) waste (from the warhead's SFT section) being sent to the EBH room, a slower throughput rate, and the mechanics and programming of the RSM may need to be reconfigured to be able to perform draining and shearing operations of a complete rocket. Testing during the design phase of the project will attempt to determine and quantify the impact from the required changes to the RSM operations.

GB/VX Projectiles

The GB and VX projectiles stored at BGAD are burster-free; therefore, there is no need to handle or process these projectiles in an explosion containment room. Normal operations have the projectiles unloaded from the EONC in UPA-1 and fork lifted to UPA-2. In UPA-2, the projectiles are loaded onto trays to be sent through the MDB for agent removal and thermal decontamination Any "known" projectile leakers will be forklift into the toxic maintenance area (TMA), where a DPE team will manually unpacked and load the projectiles onto trays.

H Projectiles

The H projectiles stored at BGAD are burster-loaded. The burster removal operation for these projectiles will be performed in ECR-1. Normal operations have the projectiles unloaded from the EONC in UPA-1. The projectiles will be loaded individually onto a conveyor system that will transport each projectile through ECV-1 to ECR-1. For those "known leakers" overpacked, the projectiles will be forklift from UPA-1 to ECV-1. A DPE team will manually open the overpacked projectiles and place the projectile on the input conveyor to ECR-1. Once the operation of removing the lifting lug, fuze well cup, and burster are complete in ECR-1, a normal operation has the ECR-1 robot placing the projectile on the output conveyor in the ECR. In the case of previously overpacked projectiles that are leaking agent, the projectile would be placed in the reject table in the ECR and a DPE team would be sent into the room. The team would place the projectile in a plastic bag prior to transporting the munition to an egg-crate type tray, on a tray conveyor, staged in the connecting room. A dolly and monorail will assist the DPE entrants in loading the tray with bagged projectile leakers. The DPE team would decontaminate the NCR station and the rest of ECR-1, as appropriate, to minimize the unnecessary spread of agent contamination in ECR-1.

V Handling and Processing of "Unknown Leakers"

"Unknown leakers" to be processed at BGCAPP can be grouped into four broad categories; EONC discovered rocket and projectile leakers, CRMs found at the RCM, CRMs found in the MPR discharge airlock, and GB/VX/H projectiles found at the NCR stations. The MDB operations have taken into consideration the handling and processing of these "unknown leaker" munition categories as follows:

Leaking Rockets and Projectiles First Found in an EONC

During normal rocket or projectile processing, the MINICAMS being used to detect agent in a sealed EONC may indicate the presence of agent. The EONC would have been previously loaded with non-leaking munitions at the bunker, and provided a vehicle to transport the chemical munitions to the MDB safely. In this scenario, the rockets or projectiles in the EONC are considered "unknown leakers" and the amount of leakers in the EONC is unknown. An EONC will transport between two pallets (30 rockets) or a range of different amounts of projectiles based on the size (8 inch or 155 mm), configuration of the pallets, and the amount on each pallets able to fit in an EONC. The "unknown leaker(s)" in the EONC may range from only one munition leaking or a group of munitions leaking or partially agent contaminated. Until the EONC is opened in the proper level of dress, the amount of "unknown leakers" is not known. The EONC will be transported into ECV-1. Personnel in DPE will remove all "unknown leakers" from the EONC. The entrants will remove the pallets from the EONC and place them on the floor of the ECV. If possible, the entrants will attempt to isolate the leaking rocket by separately covering each individual pallet and monitor using MINICAMS wands. The entrants may even manually separate the munitions from the pallet into smaller groups for additional agent monitoring. The leaking or agent contaminated munitions will be overpacked and sent back to the bunker, to be processed with known leakers. The non-contaminated munitions will be processed by their normal process.

CRMs Found at RCM

During normal rocket cutting with the RCM, the possibility exists that an ILR will be discovered by the agent monitoring above the RCM. If this occurs a DPE team will be sent into the ECV and the "unknown leaking" rocket motor will be monitored, via MINICAMS to determine if it is contaminated. If the rocket motor is determined not to be contaminated, the rocket motor will be sent to the MPR and continues in the process as a NCRM. If the rocket motor sampling determines the motor to be contaminated, the DPE entrants will overpack the CRM, which is still housed within its SFT. The overpacked CRM will be temporarily stored in the ECV until an EONC is ready to transfer the CRM back to BGAD. The warhead section is extracted from the SFT and continues on to an ECR for processing at the RSM. The warhead SFT would be prevented from continuing to the MPR and will be manually sent to the TMA for decontamination.

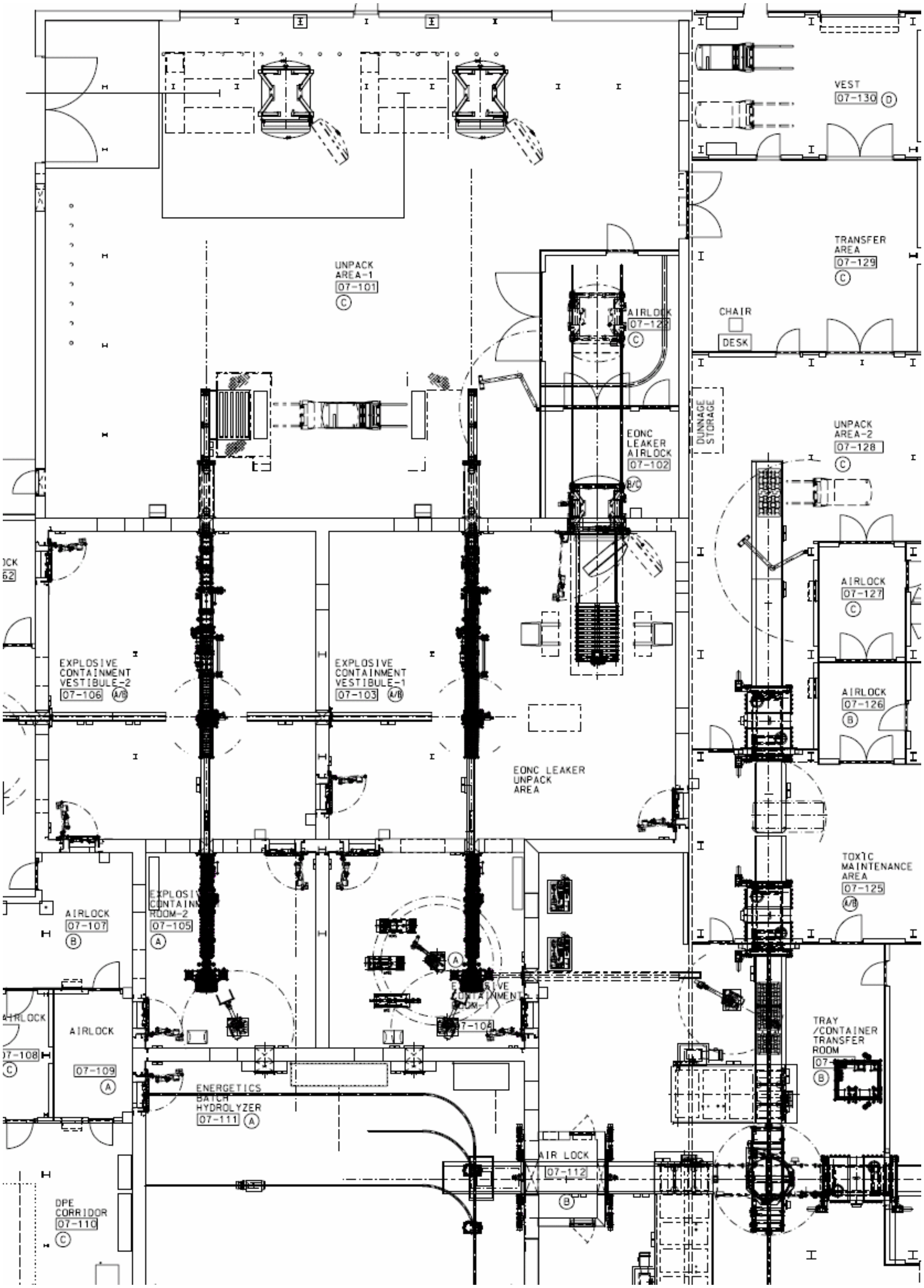
CRMs Found in the MPR Discharge Airlock

During normal rocket processing in the rocket motor packing (MPR) room, the possibility exists that a box containing a quantity of 30 rocket motors will be sampled and determined to be agent contaminated. If this occurs the box of "unknown leakers" will be conveyed back into the MPR. A DPE team will be sent into the MPR and the box of "unknown" CRMs will be manually separated into smaller groups of "unknown" CRMs and monitored, via MINICAMS, in an attempt to locate the agent contaminated motor(s). If a rocket motor(s) is determined to be agent contaminated, the CRM will be overpacked and sent to UPA-1 for pre-staging in a designated EONC. As mentioned above, the EONC may remain in the CHB for up to 90 days or returned to a BGCA bunker for storage, until processing of CRMs will be performed in the ECRs. If a rocket motor is not determined to be agent contaminated, the rocket motor will be sent through the MPR discharge airlock and continues in the process as a NCRM.

GB/VX/H Projectiles Found at a NCR Station

During normal projectile processing in the MWS room for GB and VX projectiles and in ECR-1 for H projectiles, an "unknown leaking" projectile can be found when the lifting lug is removed by the NCR station. By removing the lifting lug the miscellaneous parts and burster cavities are exposed and the internally leaking projectile will be found by the room's MINICAMS. If this scenario occurred with a GB or VX projectile in the MWS room, the process would not be stopped but would continue since the next station is designed to access the agent cavity and drain the projectile of agent. A DPE team would be sent into the MWS to decontaminate the NCR station and any pathway between the NCR station and the draining station, to minimize the spread of agent contamination in the MWS room. By performing this documentation the overall agent readings in the MDB and the exhaust of the room to theventilation filters is reduced. If this scenario occurred with an H projectile in ECR-1, the process in ECR-1 would

Figure II



VEST
07-130 D
TRANSFER AREA
07-129 C
CHAIR
DESK
UNPACK AREA-1
07-101 C
AIRLOCK
EONC LEAKER AIRLOCK
07-102 B/C
DUNNAGE STORAGE
UNPACK AREA-2
07-128 C
AIRLOCK
07-127 C
AIRLOCK
07-126 B
EXPLOSIVE CONTAINMENT VESTIBULE-2
07-106 A/B
EXPLOSIVE CONTAINMENT VESTIBULE-1
07-103 A/B
EONC LEAKER UNPACK AREA
TOXIC MAINTENANCE AREA
07-125 A/B
AIRLOCK
07-107 B
AIRLOCK
07-109 A
ENERGETICS BATCH HYDROLYZER
07-111 A
TRAY /CONTAINER TRANSFER ROOM
B
AIR LOCK
07-112 B
DPE CORRIDOR
07-110 C

continue but instead of placing the projectile on the discharge conveyor, the projectile would be placed on the reject table. The handling of the ECR processed projectile to the MWS room would occur as described for "known leaking" H projectiles.

VI Safety and Concerns

The following safety, environmental, and operational concerns exist with the processing of "known" and "unknown" leakers:

1. Personnel safety is the first most concern. When handling leaking munitions, there will be a level of dress that will require forced breathing air and some type of fully encapsulating ensemble. In an attempt to ensure entrants safety and provide the best form of comfort and reliability, the demilitarization protective ensemble (DPE) suit has been planned at BGCAPP. The stay times, maneuverability, familiarity, and air cooling method provide the best ability to handle leaking munitions, as safe as possible. Any time when placing personnel in possible contact with liquid agents, the key is to minimize handling of the munition as much as possible. In the BGCAPP design, this is attempted by the use of cranes, monorails, conveyor systems, dollies, and other forms of mechanical devices.

2. Storage of CRMs in the building poses a new threat for the safety of operation. In order to save time and effort it would be advantageous to store at least 10 pieces of rocket motors before processing. However, impact of potential explosion and flare of the rockets need to be studied. A preliminary review showed that staging of 10 rocket motors is possible. However, a final review is being made to determine maximum allowable CRM inside the ECVs for safe storage.

3. Even though DPE entries will occur on a somewhat routine basis at BGCAPP, familiarity with the operation of handling leaking munitions will not be a routine. Since this is the case, there are concerns with efficiencies and complacencies with leaker operations. Walk-through evolutions and pre-planning involving the DPE entrants, backup personnel, control room operators, key management personnel, and rescue personnel will occur prior to sending any individual to handle a leaking munition. Even simulations with programs will be run, to provide the control room operator experience on unusual operations; such as the shearing of a CRM or the processing of a full rocket in a RSM.

4. Concerning the shearing of CRMs, the CMA baseline sites have experienced random fires when cutting the rocket propellant with the RSM. To prevent these fires BGCAPP has incorporated the RCM in the design to send NCRMs outside the MDB for further processing, by means other than a shear operation. In the case of CRMs, BGCAPP felt the risk of possible fires can be minimized by incorporating the modifications (e.g., fire suppression sprays, cut locations) being implemented at the baseline sites. Reducing the number of rocket motors to be processed and the modification explained above, BGCAPP feels that potential for fire may not be completly unavoidable but will be greatly reduced.

5. Along with the processing of CRMs and full rockets, an environmental concern is raised. In both of these operations, the SFT is processed along with the motor and/or warhead. Most of the the SFTs contain >50ppb of polychlorinated byphenyls (PCBs), a Toxic Substances Control Act (TSCA) regulated waste which is contaminated with. Present plan is to send the SFT along with rocket motors through rocke t shear machine EBH and then to the MPT for final treatment. The SFTs will be treated at 2200 deg.F and 2 seconds residence time in order to have a proof for destruction of PCBs. Additional segregation processes and techniques will need to be followed at BGCAPP to stay within the TSCA requirements.