Non-Nuclear Hazard Analysis at Pantex

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History

Pantex Overview: The Pantex Ordinance Plant was authorized on February 24, 1942, with construction completed on November 15, 1942. In less than ten months after Pearl Harbor, the first bomb came off the line at Pantex. In a few short months, this remarkable building project turned a wheat field into a bomb factory. During World War II, Pantex was used to load munitions such as bombs and artillery shells with TNT. At the end of WWII, Pantex was jubilant the war had ended even though they were out of a job. In 1949 the entire installation (16,031.9 acres) was sold to the Texas Technological College (now known as Texas Tech University) for one dollar. The land was sold subject to recall under the National Security Clause.

In 1951, the United States Atomic Energy Commission (USAEC) selected the Pantex site for expansion of their nuclear weapons assembly facilities. Proctor & Gamble was the first Maintenance and Operations (M&O) contractor selected by the AEC. Mason & Hanger - Silas Mason Co., Inc. took over as the M & O contractor of the Pantex Ordinance Plant on October 1, 1956. The name was officially changed to "Pantex Plant" on October 4, 1963. “Pantex” is the short version of the “Panhandle of Texas”. In 1965, Pantex performed disassembly and modification of nuclear weapons. Currently, Pantex is involved with retrofitting and repairing weapons, dismantling weapons that are surplus to the stockpile, sanitizing components from dismantled weapons, and developing, testing and fabricating high-explosive components. BWXT Pantex was awarded the contract in 2000 and officially began the business of operating the Pantex Plant on February 1, 2001.

Pantex operations involving both nuclear and non-nuclear activities have been evaluated over the years using a variety of methods. However, for the purposes of this paper only the non-nuclear aspects will be addressed. The hazards analysis techniques of the ‘40s to the ‘70s were probably not as subtle or as sophisticated by today’s standards. However, we are to assume the analysis techniques used by the hazard analyst was the best available technology for the time period. Although there has never been a nuclear explosion in our working history, Pantex has suffered four explosive events, three in the 1960s and one occurred in 1977, which unfortunately claimed three lives. The process that generated the latter explosion is no longer performed at Pantex and the lessons learned from the explosive events in the 60s were incorporated into site policy and procedures thereby preventing additional unplanned explosions.

During the decade of the 1980s into the early 1990s the Department of Energy (DOE) established the *Safety Analysis and Review System* Order, DOE 5481.1(et seq.) (Ref. 1) as the predominate order for the preparation and review of non-nuclear safety analyses. This order essentially provided the safety basis for the operation(s) by identifying the hazards, controlling or eliminating the hazards, assessing the risk of the operation and documented management authorization for the facility/operation. This order (5480.1A et. seq.) established the hazard classes (low, moderate, and high) and provided a basic format for the safety analyses. DOE Order 5481.1B along with 19 other DOE Orders was canceled in September of 1995 by DOE N 251.4 (Ref. 2), and DOE 420.1 *Facility Safety* (Ref. 3) was released in October of 1995.

The OSHA Process Safety Management (PSM) Rule was codified in 29 CFR 1910.119 (Ref. 4) early in 1990. The PSM rule contained requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals as listed in Appendix A of the PSM rule. Pantex did not and does not have any of the chemicals above the threshold quantities (TQ) found in Appendix A. However, since Pantex "manufactured" (by OSHA definition) explosives we were subject to the PSM rule as codified in 29 CFR 1910.109(k)(2) (Ref. 5). The Department of Energy incorporated the 29 CFR 1910.119 PHA requirements in the DOE Explosive Safety Manual (ESM) (Ref. 6), in the mid 1990s.

Pantex published a Facility Hazard Categorization list that identified requirements for 708 facilities/operations at about the same time frame. This list categorized the facilities/operations as nuclear, (requiring a DOE O 5480.23 Safety Analysis Report) (Ref. 7), or non-nuclear that either required a PHA according to the ESM, a PHA as a best business practice, or the facility was classified as a standard industrial hazard (that required job specific hazards analysis). The list contained 39 facilities/operations as requiring PHAs and three facilities/operations requiring PHAs as a best business practice. This list was later expanded to a total of 94 facilities/operations that either were scheduled for a PHA or had completed a PHA.

The first PHA teams were established using individuals trained and qualified by organizations outside the plant with the experience and expertise to qualify them as a PHA team leader. The PHA teams were staffed with Plant personnel from the technical and management areas with experience and expertise in explosive operations, explosive safety, industrial safety/industrial hygiene, fire protection, and on occasion DOE site office personnel. The PHA teams utilized two "what-if" checklist approaches to develop the PHA. One checklist was developed from the ESM and the second was similar to a "what-if" checklist derived from a hazard procedures publication, referred to locally as the "red book".

The 1990 version of the ESM consisted of nine chapters with each chapter having numerous sections. The PHA Team developed the ESM checklist by dividing the chapters and sections into "bite size" statements and selecting only the applicable sections that applied to the process being analyzed. These statements were placed sequentially into a five column table that gave the statement an identifying number, a specific reference that points to the section in the ESM where the statement was derived, a commentary regarding the topic, a pointer to the specific Pantex "Safeguard" and type of control (engineered or administrative) and any action items regarding the statement. The action items from the table were carried forward to the PHA narrative section as “Action Items/ Recommendations”. The PHA directed facility management to resolve all action items and recommendations identified by the PHA Team.

To demonstrate the ESM was covered adequately a lengthy checklist was derived (e.g. 80-90 pages). Figure 1 is an example of a typical ESM checklist with responses.

No: 21	**Method:** ESM Checklist	**Type:** Chapter VII /Operating Procedures	**Name:** Operating Procedures	
Item	**Topic**	**Responses**	**Safeguards**	**Action Items**
21.14	Are operations prohibited from being performed with a superseded, inactive, or unapproved procedure? Reference section 2.5.a	Yes, operations are not performed without up to date procedures	STD-XXXX-AC	
21.15	Are files of active procedures maintained? Reference Section 2.5.b	Yes, procedures are in the plant document control system.	STD-XXXX-AC	
21.16	Has an audit system been established that will evaluate routinely the adequacy, availability, and currency of procedures: Reference Section 2.6.a	Yes	STD-XXXX-AC	
21.17	Do audits include an evaluation of operation knowledge and compliance with procedures? Reference Section 2.6.a	Yes	Internal Audit Procedures - AC	

Figure 1 Typical ESM Checklist

The complement to the ESM checklist is similar to a “What-if” type checklist. This checklist was derived from a series of questions that was based on a Hazard Evaluation Procedures publication known locally as the “Red Book”. The supplemental questions covered eight categories such as process, equipment, operations and management issues. Examples of the “Red Book” questions are illustrated in Figure 2. The “Red Book” item numbers were sequential to the ESM checklist.

No: 22	**Method:** Checklist	**Name: Materials and Flow Sheet**		
Item	**Topic**	**Responses**	**Safeguards**	**Action Items**
22.83	What is the potential for external fire?	High, this is the intended process in the trays and chambers. High, to areas within burning ground (i.e. grass fires)	Firebreaks – EC Procedures –AC Training – AC Process Design -EC	
22.84	How much experience do the facility and company have with the process? If limited, is there substantial industry experience?	Diesel, from 1952, some 47 years Gas since 1997	Procedures – AC Training - AC	
22.85	Is the company a member of industry groups that share experience with particular chemicals or processes?	Share with laboratories as a board member of the safety committee	DOE-Manual M440.1 - AC	
22.86	Is the unit critical to overall facility operations on a throughput or value-added basis? Does shutdown of this unit require other units to be shut down as well?	Yes, this process is dependant operation. Limitation on storage	Limitation on storage –EC RCRA Permit – AC DOE Explosive Safety Manual - AC	

Figure 1 Typical Red Book Checklist

The “Red Book” checklist was a lengthy document typically over 100 pages in length. The PHA Team members answering the applicable questions in both checks assured that all possible events were covered. The checklist approach for preparing PHAs continued until 2002.

Current Non-Nuclear Hazard Analysis

Pantex, in a continuing improvement effort, decided in 2002 to review our experience in developing and maintaining PHAs. For the previous seven years the use of checklists and ad hoc PHA teams were very successful in the application of the intent of the ESM PHA requirements. However, it was believed we could improve upon our original and proven PHA process by establishing a team of hazard analysts who would continue to develop the process and be responsible for the final product. The hazard analysts were established as a separate section in the Authorization Basis (AB) Department. The AB Department employed hazard analysts who were preparing nuclear AB type documents and the decision to use the analysts to continue developing non-nuclear PHAs was a distinct advantage.

The newly established Non-Nuclear Hazard Analysis (NNHA) Section continued to build upon a proven PHA system by first developing a Handbook (Ref. 8) that provided PHA Team Leads consistent direction. The Handbook paralleled the quantitative nuclear documented hazard analysis (DSA) approach using qualitative methods. This product of this approach is a PHA that contains four chapters and at least three appendices. Chapter 1 is an executive summary of the PHA, Chapter 2 describes the facility process and process flow, Chapter 3 is the hazards analysis and control effectiveness evaluation, and Chapter 4 describes the Operational Safety Controls (OSC) and their credited requirements.

This qualitative approach built upon the proven checklist approach in several different ways. First, although the PHA Team makeup was similar, i.e., a qualified PHA Team Leader, process expert(s), and various outside subject matter experts (SME) such as explosive safety, industrial safety, fire protection, etc., the team leader belonged to a section whose sole responsibility was to prepare non-nuclear hazard analyses (PHAs). Secondly, the PHA team applying a modified Hazard and Operability Study (HAZOP) and Failure Modes and Effects Analysis (FMEA) develops process flow and subsequent tasks. This methodology allows all hazards associated with each process task to be qualitatively analyzed with the engineered or administrative controls identified. These controls are identified as either preventive or mitigative, and in some cases a specific control may provide both preventive and a mitigative functions.

The controls are evaluated as to their effectiveness and then flowed into a separate section in the PHA that specifically develops each control for their preventive/mitigative function(s) and why the control should function as designed. The controls are identified and developed in two separate sections, Engineered or Administrative Controls. Additionally, each control is identified in a separate table and tied to the specific hazard analysis event(s) in which it is credited as a preventive to mitigative control.

Walking through our qualitative process, the PHA Team establishes the boundaries of the PHA with an Inputs and Assumptions document that identifies the parameters of the assessment. The PHA Team performs a walkdown of the processing area where operations personnel provide an overview of the function of the processes. Each team member participates in identifying the potential hazards in the process area and these are added to the PHA as an appendix and used during the process and task discussions.

The PHA Team establishes a process flow in future meetings. This process flow may be a simple line diagram or may involve several processes in which each process has its own process flow. Figure 3 is an example of a typical process flow.

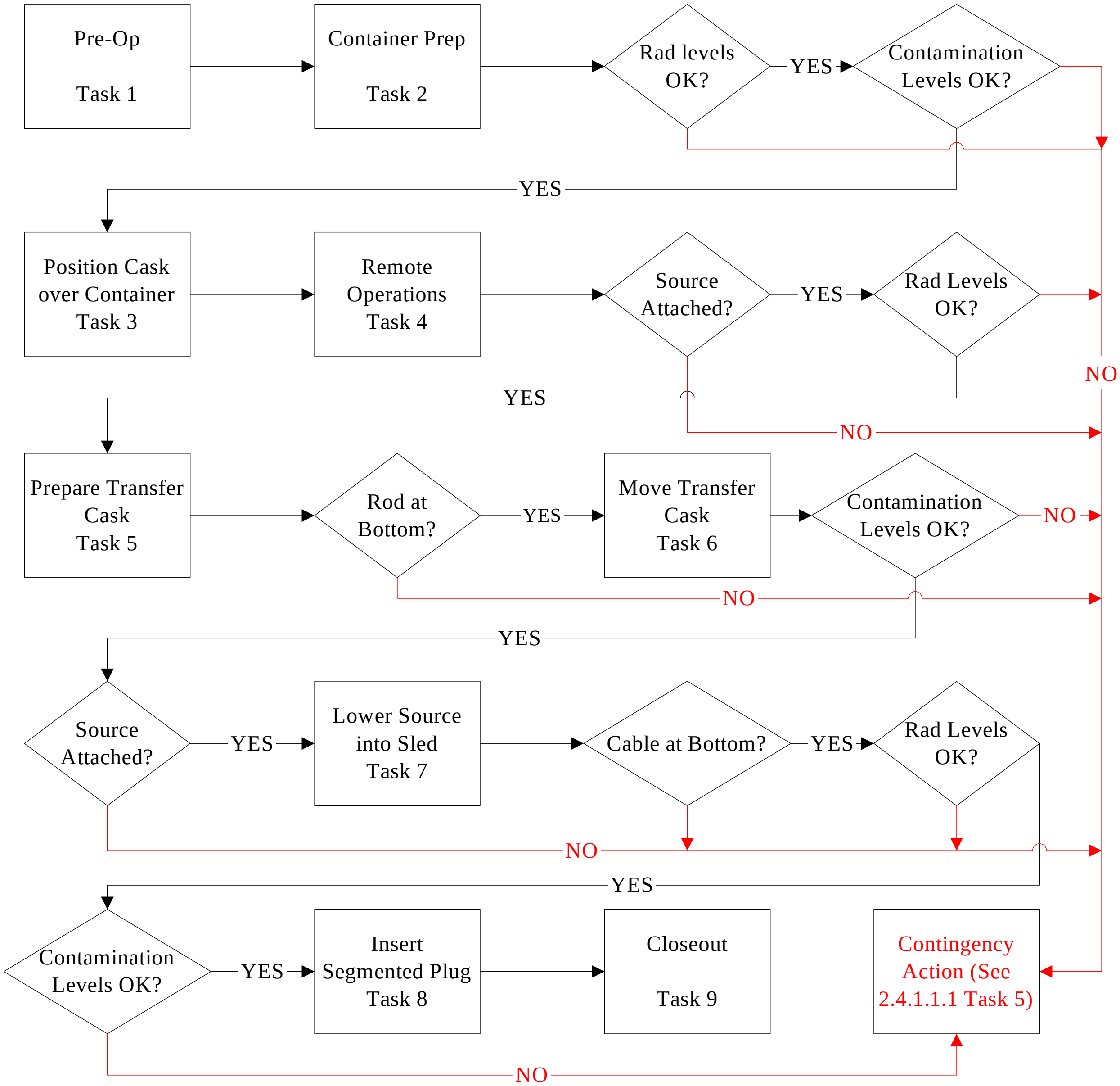

Figure 3 Example Process Flow

Each task in the process flow is described in the PHA. The hazards identified with each task description are evaluated and tabulated in a subsequent PHA section. During the discussion of the hazards involved with the tasks, any potential contributory hazards associated with the facility are discussed and dispensation techniques applied.

The hazards are documented in a hazards evaluation table by category. That is, events that can be common to each task are listed in a *General* category, events that are classified as *Natural Phenomena* (snow/hail/rain, high winds, etc.) or classified as *External* events (offsite accidents, range fires, etc) have separate categories from the hazards associated with each task. Figure 4 is an example of identified hazards in tabular form as would be seen in the PHA.

Item	Event	Potential Consequences	Operational Safety Controls	Discussion
GENERAL				
G-1	An electrical insult caused by radiography equipment electrical part contacting an explosive component during the radiography process results in an explosive response.	Personnel Serious Injury/Fatality Significant Equipment/Facility Damage	**Prevention** Procedures Qualification **Mitigation** Facility Structure	Procedures: Procedures (Ref. 10) prevents the event by use of the move right system that assures the facility is can receive the amount of explosives being shipped, and the receiver knows and approves the explosive shipment. Reference 11 prevents the event by specifying the quantities of HE. Qualification: NDE Personnel prevent the event through training and qualification/certification to perform neutron radiography on explosive components and qualified to handle explosive components. Facility Structure: The Facility was originally constructed as a radiography facility for explosive components.
3.3.3.2.2 Task 6 Move Cask				
3.0	The facility suffers a complete a loss of power while the transfer cask is suspended resulting in the cask dropping with subsequent personnel exposure to gravely high radiation levels.	Personnel Serious Injury / Fatality Significant Equipment / Facility Damage	**Prevention** Hoist Construction Procedures **Mitigation** Radiation Protection Program	Hoist Construction: Hoist construction prevents the event by using hoist-holding brakes. Holding brakes are required on all hoists and designed to hold a minimum of 100% of the rated load in the event of a power failure. The holding brakes are automatically applied upon the loss of power (Ref. 50). Procedures: Procedures (Ref. 46, Ref. 51, and Ref. 52) prevent the event by verifying the PM crane/hoist is current and the crane/host is inspected prior to use. Radiation Protection Program: The Radiation Protection Program mitigates the event consequences by assuring continuous coverage during tasks that have the potential to create very high radiation (Ref. 39).
Natural Phenomena				
N-1	Flooding leads to excessive water in Building XX	NA	NA	The Site Safety Analysis Report (Ref. 60) states flooding attributed to river or stream flooding, tsunamis, tidal surges, dam failures, ice jams, etc., are not possible or extremely unlikely for the Plant.
External Events				
E-1	Airplane/helicopter crash causing total structural failure and subsequent explosive response.	Personnel Serious Injury / Fatality Significant Equipment / Facility Damage Environmental Contamination	**Mitigation** Emergency Plan	Emergency Plan: The Emergency Plan (Ref. 25) and associated procedures (EPP) mitigate the consequences of the event through the mobilization of personnel with emergency response duties such as maintenance workers, utility workers, fire and rescue, and security forces to stabilize and recover from the event. Site Safety Analysis Report (Ref. 60) evaluates the consequences of an aircraft crash at Plant and Appendix B of the facility SAR (Ref. 14) specifically addressed the aircraft impact.

Figure 4 Examples of Tabular Form for used for PHA Hazard Analysis

The OSCs identified for the process hazards are then evaluated in a control effectiveness table. This table lists the control and provides a summary of the ways the control could fail, a possible cause for the failure, a safeguards/discussion as supporting documentation to prevent the failure. In essence this table documents why each control can be relied upon to effectively provide their preventive/mitigative functions. The control effectiveness tables are developed for both

Engineered and Administrative controls. Figure 5 is an example of a control effectiveness table found in the Chapter 3 Hazard Analysis section of the PHA.

Table 3-2 Control Effectiveness Table				
Engineered Control				
Control	**Failure**	**Cause**	**Safeguard**	**Discussion**
Facility Structure	Fires in the facility Facility overpressure Fragment penetration Spalling Missiles	General deterioration of building Lack of preventive maintenance or maintenance Lack of skilled inspectors during construction of building Lack of routine scheduled preventive maintenance Inadequate / improper materials used in construction or repair Inadequate design Unauthorized repair Range Fires, Electrical fires Internal blast, external blast, tornado, straight line winds Lightning Strike Vehicle impact	Routine scheduled preventative maintenance Scheduled Condition Assessment Surveys (CAS) Facility construction and materials used in construction Changes to facility under change control Facility design / construction requirements Training Hazards and Controls Evaluation (HCE) Process Procedures	CAS performed on a scheduled interval to assure the structural integrity of the building (Ref. 65 & 66). Craft personnel provide the facility condition assessments described in both the site maintenance plan (Ref. 66) and the Ten Year Comprehensive Site Plan (Ref. 67). Ongoing training for both craft personnel and facility occupants is important to the long-term success of the maintenance program (Ref 65). Reference 68 requires the use of an HCE evaluation whenever changes (except exact replacement in kind) occurs to facilities, processes, or activities that are required to have a PHA
Administrative Control				
Procedures	Procedures lacking in sufficient detail Outdated/Wrong Procedure Procedure not followed	Personnel error Procedures not reviewed Procedures not approved Inadequate Procedures No Procedures Inadequate Training	Procedure program Conduct of Operations Training Qualification Change control/HCE Process	Procedures are developed and provided for the facility processes and identifies operations that are performed. (e.g., Ref. 11, 22, 23, & 32). Procedures are subject to the change control process (Ref. 8, & 68). The supervisor periodically checks the operator qualifications to assure the operators maintain the necessary training and qualification (Ref. 5). The Conduct of Operations Manual (Reference 2) and manufacturing Conduct of Operations procedure (Ref. 75) addresses the development and type of procedures used at Pantex.

Figure 5 Example of Control Effectiveness Table

The Operation Safety Controls (OSCs) evaluated in the hazard analysis is flowed into the subsequent section that details the Engineered and Administrative Controls. The table is separated into two sections (Engineered Controls and Administrative Controls), the section ID of control (i.e., the specific paragraph number), the OSC title, and the event ID(s) from the hazards analysis section associated with the control. Figure 6 illustrates how the tables are presented.

Notice how the controls point back to the hazard analysis events in Chapter 3 and to the process tasks found in Chapter 2.

Section	Operational Safety Controls	Process Task (Chapter 3,Table 3-1)
4.2.1.1	Facility Structure	General G-1, G-2, G-3, G-4, G-5, G-6, G-10 Radiography Task 1- 1.1, Task 2 – 2.0, 2.1 Task 3 – 3.0, 3.1 Task 5 –5.0 Task 6 – 6.0 Natural Phenomena N-1, N-2, N-4, N-5 External Events E-2, E-3, E-5
4.2.1.2	Lightning Protection System	General Events G-6 Natural Phenomena N-2

Figure 6 Example of OSC Table

The OSCs found in each table are definitively described in the PHA Chapter 4 text as to its purpose (to prevent / mitigate or both) and function (how it works). Effective contingencies for the failure of each OSC as evaluated by the control effectiveness analysis are summarized as a subset of the function.

Conclusion

As previously described, Pantex Plant as a government installation has an interesting history. It started as a Department of Defense installation during WW II, was decommissioned, was reactivated as an AEC installation and was finally allocated as a DOE nuclear weapons installation. The nuclear side of the Plant has its' safety analyses in the form of Documented Safety Analysis for which the subsequent management of change process (Unreviewed Safety Question) can depend upon to maintain the nuclear safety envelope.

Likewise, the enhanced PHA process helps maintain the safety envelope for the non-nuclear processes at the plant. The process clearly defines the safety envelope for the facility manager (scope of analyzed operations and required OSCs) and assists in effectively applying the management of change process for their facilities/operations. In the Plants continuing improvement in our "living document" PHA process we updated the ESM (Ref. 9) Checklist based on the latest version. This revised checklist assures the Plants' explosive operations are documented in a format that demonstrates full compliance with the ESM.

References

1. DOE Order 5481.1 (et.seq) *Safety Analysis and Review System* (Archived)
2. DOE N 251.4 *Cancellation of Directions,* 9/29/1995
3. DOE O 420.1(et seq) *Facility Safety*
4. Title 29 Code of Federal Regulations Part 1910. 119, *Process Safety Management of Highly Hazardous chemicals*
5. Title 29 Code of Federal Regulations Part 1910.109, *Explosives and Blasting Agents*
6. DOE M 440.1-1A, *Doe Explosive Safety Manual*
7. DOE O 5480.23, *Nuclear Safety Analysis Reports* (Archived)
8. Handbook 0001, *Guidance Document for Non-Nuclear Hazards Analysis Section*
9. Pantex MNL 270176, DOE M 440.1-1A, *DOE Explosives Safety Manual Pantex/LLNL Version*, Revision 9A