Type B Accident Investigation of the Mineral Oil Leak Resulting in Property Damage at the Atlas Facility Los Alamos National Laboratory New Mexico

March 2001

Office of Defense Programs
National Nuclear Security Administration
U.S. Department of Energy
Washington, DC 20585

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On January 17, 2001, I appointed a Type B Accident Investigation Board to investigate the mineral oil leak and resulting damage at TA-35, Building 125, Atlas Project, at Los Alamos National Laboratory, in Los Alamos, New Mexico that was detected on January 8, 2001. The Board's responsibilities have been completed with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1A, *Accident Investigations*.

I accept the report of the Board and authorize release of this report for general distribution.

Ralph E. Erickson 3/16/01

Ralph E. Erickson
Acting Chief Operating Officer
for Defense Programs

Date

This report is an independent product of the Type B Accident Investigation Board appointed by Acting Chief Operating Officer for Defense Programs, Ralph E. Erickson.

The Board was appointed to perform a Type B Investigation of this accident and to prepare an investigation report in accordance with DOE Order 225.1A, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U. S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

Accident Investigation Terminology

Causal Factor - an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct cause, which is the immediate event(s) or condition(s) that caused the accident; root cause(s) which is (are) event(s) or condition(s) that, if corrected, would prevent recurrence of the accident; and contributing cause(s), which are causal factors that collectively with other causes increase the likelihood of an accident, but individually did not cause the accident.

Events and Causal Factors Analysis - include charting, which depicts the logical sequence of events and conditions (causal factors) that allowed the event to occur, and the use of deductive reasoning to determine events or conditions that contributed to the accident.

Barrier Analysis - a review of the hazards, the targets (objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or management controls.

Change Analysis - the systematic approach that examines planned or unplanned changes in a system that caused undesirable results related to the accident.

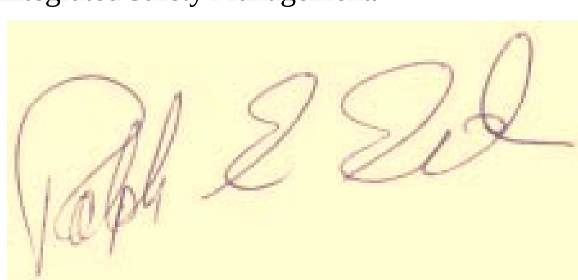
PROLOGUE
Interpretation of Significance

On January 8, 2001, a leak of 6700 gallons of mineral oil was detected at the Atlas Facility, Los Alamos National Laboratory (LANL). The leak, caused by a failed gasket on a tank, seeped into the basement of the building and resulted in $1,800,000 of damage to experimental equipment in two collocated laboratories. The Accident Investigation Board concluded that LANL had not effectively implemented the Quality Assurance Program developed for the construction of the facility, nor had they adequately conducted a hazard analysis process that could have identified controls for the mitigation of such an occurrence. The loss of property in this accident is quantifiable, but the loss of the associated research, and the impacts on the involved programs and personnel is not. The fact that these losses were preventable through straightforward, reasonable measures only adds to the cost of the accident.

There has been a significant amount of programmatic and external pressure on LANL during the design and construction of Atlas. DOE and the Laboratory have been under considerable criticism for weaknesses in project management, facility design, and construction programs. Defense Programs initiated the construction of Atlas without ensuring that funding would be available for facility operations. Furthermore, the possible relocation of Atlas to DOE facilities in Nevada has been under consideration for a period of time. While these pressures were apparent during this investigation, they do not excuse the failure to adequately address requirements placed upon the facility. The Department must recognize that despite budgetary concerns, all of its activities need to be conducted within the framework of the established requirements and expectations placed upon them. There must always be a balance of resources between programmatic work and the potential risks associated with the activity. Even in situations such as this accident, where the safety, health and environmental hazards are limited, the lack of due consideration for collocated activities resulted in substantial impacts that could have been readily avoided.

This accident also demonstrates the importance of a defense-in-depth strategy, even for a low hazard activity. The concept of defense-in-depth is three-pronged: (1) actions are taken to avoid the occurrence of an undesirable event, but at the same time (2) actions are also taken to mitigate the consequences of the event, should it occur anyway. Finally, (3) actions are taken to ensure the integrity of the protective envelope. This accident could have been avoided if the Quality Assurance Program had been effectively implemented; it could also have been avoided had controls been identified and implemented to protect the vulnerable property and programs. In this case, neither action was properly conducted.

All DOE and Contractor facilities should ensure that property protection and programmatic impacts are given appropriate attention in all endeavors. The risks associated with a mission should be understood, controls should be developed and implemented, and resources balanced such that government property is protected as well as the environment and the safety and health of the workers and the public. These are the basic tenets of both property management and Integrated Safety Management.



Executive Summary

Overview

The Department of Energy (DOE) Office of Defense Programs, within the National Nuclear Security Administration (NNSA), conducted a Type B Accident Investigation of a 6,700-gallon mineral oil leak from the First Article Assembly, a test tank associated with the Atlas facility at Technical Area (TA) 35. TA-35 is located at the Los Alamos National Laboratory (LANL), Los Alamos, New Mexico. The oil leak resulted in approximately $1,800,000 in damages to property in the basement of the building and cleanup costs for the leak of $95,000. A five member Accident Investigation Board composed of subject matter experts from DOE Headquarters and Field Offices conducted the investigation January 17 to February 16, 2001.

Atlas is a pulsed power facility designed to perform high energy-density experiments in support of weapon-physics and basic-research programs. Atlas can provide 27-32 Mega-amperes (MA) of electrical current to a target in a cylindrically symmetric geometry. Electrical current in this range allows fielding of large-scale experiments that employ design, engineering and experimental skills analogous to full scale nuclear weapons testing. Specifically, Atlas is a short-pulse, high-current generator designed to drive hydrodynamic experiments to conditions relevant to stockpile stewardship. These experiments will enable the study of the response of materials to (1) strong shock waves and ultra-high pressures in large volumes, and (2) converging geometry with enhanced diagnostic access. Among other uses, this will allow the study of strength at high strain rate, friction, spall, hydrodynamics in complex geometry, and shocks in strongly coupled plasmas.

Consistent with the direction provided by DOE O 225.1A, *Accident Investigations*, the purposes of the investigation were to (1) determine what happened, (2) why it happened, and (3) what could be done to prevent recurrence – not to determine fault or fix blame. The scope of the Board's investigation was to review and analyze the circumstances of the accident to determine its causes. The protection of property is a contractual requirement of DOE implemented through the Department of Energy Acquisition Regulation (DEAR), although it is not part of the Integrated Safety Management DEAR Clause. Therefore, this investigation focused on the accident from a project management perspective. However, the investigation did include an evaluation of the adequacy of the safety management systems of LANL and DOE as they related to the oil leak. The Barrier Analysis results from the investigation were linked to the five core functions of Integrated Safety Management.

Accident

On January 8, 2001, upon arriving at work at 6:00 a.m., a Mechanical Technician discovered oil on the floor in the Atlas machine High Bay area located in Building 125 at TA–35. Initial inspection of the building revealed that mineral oil leaked from the First Article Assembly, which holds 11,515 gallons. Approximately 6,700 gallons leaked onto the High Bay floor, of which approximately 500 gallons seeped into the basement area. The dripping oil damaged several laser systems, associated ultra-fast optics, and electronics located in the basement. The damage to equipment in the basement is estimated to be $1,800,000.

The cleanup costs are $95,000 for the High Bay and basement areas. LANL determined that there were no injuries or environmental impact as a result of this accident or the associated cleanup.

On January 17, 2001, Ralph E. Erickson, Acting Chief Operating Officer for Defense Programs, U. S. Department of Energy, established a Type B Accident Investigation of this accident in accordance with DOE Order 225.1A, *Accident Investigations*.

Results and Analysis

During the initial response to the event, Atlas facility personnel determined that the leak was due to a failed Rear Tri-Plate Gasket that was used to join two tank sections together in the First Article Assembly. The gasket, which is 83 inches long, spans a three-inch gap between the two tanks. A tear in a lower corner of the gasket, about six inches long, provided a leak path of about 2.7 in^2. Neither LANL nor the Board were able to determine the exact time of the onset of the leak, but based on the fact that some minor leaking was still occurring at the time of discovery, it most likely began overnight between Sunday and Monday, January 7 and 8, 2001.

Subsequent evaluations by the Board, in cooperation with LANL subject matter experts in materials science, determined that the failed gasket did not meet the physical properties specified in the design and procurement packages when the First Article Assembly was fabricated. More specifically, the gasket material did not have a nylon fabric insert as required, and therefore did not meet the tensile strength specification. Both the nylon fabric and the tensile strength had been explicitly called out in the procurement package. It was also determined that the gaskets had not been delivered to the facility in the manner specified by the procurement package, they had not been inspected upon receipt at the Laboratory, nor had they been inspected since installation.

The Board reviewed the design and specifications of the Rear Tri-Plate Gaskets in comparison with the intended application. The Board determined that the design was based on engineering assumptions that were not consistent with the application, and the gasket specifications used for the procurement did not contain sufficient detail to ensure the gasket received was appropriate for the application. Furthermore, the assumptions used in the design were not translated into specifications to be used during the assembly of the tanks.

The design and construction of the Atlas machine were governed by a quality assurance (QA) procedure written specifically for this application. However, the Board determined that the QA procedure had not been adequately implemented with respect to the gaskets. It was apparent to the Board that a high level of attention had been paid to the major components of the machine, such as the Marx Units, electrical capacitors, and related electrical components, but much less attention was paid to the gaskets, even though they were assigned the same Quality Grade Level. The Board determined that implementation of the QA program was not adequate to ensure that all components were properly evaluated.

The Board determined that the authorization basis established for the facility, including the Facility Safety Analysis, its associated Facility Safety Plan, and related documents did not comply with requirements promulgated by LANL for the consideration of property damage and programmatic impact during the identification of facility hazards. Consequently, the implementing documents, such as the Spill Preparedness Plan developed for the facility, did not establish measures that would mitigate consequences to facility or collocated property and programs. Furthermore, line management did not effectively or fully implement the programs established by these documents.

The Board also reviewed the initial response to the leak by both facility personnel and LANL's Emergency Management and Response personnel. The Board concluded that all actions taken were appropriate and timely, and identified no issues requiring corrective actions.

The Board reviewed recent, related events that it considered as precursors to this accident. Of particular note was an event that occurred at the same facility one month before this leak occurred. While no leak resulted from the accident, it directly focused the attention of the Atlas personnel and collocated personnel on the potential for property and programmatic impacts, should a leak occur. However, identified corrective actions have been intentionally delayed until after construction is completed and normal operations established.

Conclusion

The Board concluded this accident was preventable. All components did not receive the level of attention specified by their assigned Quality Grade Levels due to significant weaknesses and inconsistencies in the implementation of the Quality Assurance program. The basis of the design for the Rear Tri-Plate Gaskets was not consistent with the application, nor were design assumptions carried forward into the fabrication and installation specifications. Furthermore, processes for the recognition, evaluation, and mitigation of hazards did not comply with LANL and DOE requirements, and consequently were not capable of protecting the collocated laboratories.

There were significant and closely related precursor events that were identified by both LANL and the Board. However, LANL failed to proactively respond to those events, and has delayed implementing the lessons learned into the facility's design and operation. The Board concluded that the potential for property damage and programmatic impacts on collocated activities was known and understood by facility personnel. However, LANL failed to acknowledge that risk within the analyses and preparations supporting the facility.

A fully implemented QA program, coupled with comprehensive and fully implemented hazard analyses and spill preparedness programs would have either prevented or mitigated the leak without the resulting property damages. The Board understands the need of Defense Programs and its Contractors such as LANL to undertake some risk in attaining its mission in the stewardship of the nation's nuclear weapons program. However, the risks associated with the mission should be understood, controls should be developed and implemented, and resources balanced such that government property is protected as well as the environment and the safety and health of the workers and the public. These are the basic tenets of both property management and Integrated Safety Management.

Causal Factors and Judgments of Need

The accident investigation process is designed to lead the Board to the determination of the causes of the accident, from which the judgments of need are then derived. The **direct cause** is the immediate event or condition that caused the oil leak. **Root causes** are events or conditions that, if corrected, would prevent recurrence of this and similar accidents. **Contributing causes** are events or conditions that collectively with other causes increase the likelihood of the oil leak but that individually did not cause the accident (contributing causes are tabulated in section 3.10, and are cross-referenced to the root causes and judgments of need). **Judgments of Need** (JON) are managerial controls and safety measures believed necessary to prevent or minimize the probability of a recurrence.

DIRECT CAUSE: A gasket on a tank containing insulating mineral oil failed, allowing the oil to leak onto and damage equipment in two basement laser laboratories.

ROOT CAUSES: The Physics Division failed to implement established processes for Quality Assurance in the design, fabrication and assembly of the First Article Assembly. The Physics Division failed to conduct a comprehensive process for hazard recognition and mitigation, including consideration of property protection, in accordance with established laboratory requirements

No.	JUDGMENTS OF NEED	Related Causal Factors
JON 1	LANL needs to ensure institutional requirements for the recognition and evaluation of property and co-tenant impacts, and resulting controls, are effectively implemented.	• Physics Division did not ensure that the Spill Preparedness Plan developed for Atlas was properly scoped to address potential leakage during non-operational periods and protection of property. (CC 2) • Physics Division did not ensure that requirements of the Spill Preparedness Plan were effectively implemented. (CC 3) • Physics Division did not implement LANL requirements requiring the consideration of property protection and impact on co-tenants in development of Facility authorization basis, Facility Safety Plans and hazard analysis. (CC 4) • The FMU did not effectively implement their responsibility to ensure that tenant operations do not adversely affect other building tenants. (CC 5) • Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events. (CC 7)
JON 2	LANL needs to develop and ensure implementation of an institutional Quality Assurance process applicable to all capital projects per DOE 0 414.1A or 10 CFR 830.120, as appropriate.	• Physics Division did not ensure effective implementation of the Atlas project Quality Assurance requirements. (CC 1) • Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events. (CC 7)
JON 3	LANL needs to ensure that facility spill preparedness, prevention, and mitigation plans provide for property protection as well as personnel and environmental protection, and that they are effectively implemented. Specific to Atlas, the plan needs to address the following: • Total inventory of oil in the Atlas facility; • Static as well as operating conditions; • Provisions for leak monitoring and inspection; • Spill response training; • Secondary containment; and • Impacts on collocated tenants.	• Physics Division did not ensure that the Spill Preparedness Plan developed for Atlas was properly scoped to address potential leakage during non-operational periods and protection of property. (CC 2) • Physics Division did not ensure that requirements of the Spill Preparedness Plan were effectively implemented. (CC 3) • Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events. (CC 7)
JON 4	LANL needs to develop a Preventive Maintenance program for the Atlas facility, including periodic inspection of gaskets using specific performance criteria.	• Physics Division did not develop and implement a Preventative Maintenance Program for the First Article Assembly and Atlas Machine. (CC 6)
JON 5	LANL needs to evaluate the implication of design, fabrication, and Quality Assurance shortcomings of the First Article Assembly and apply lessons learned to the Atlas machine.	• Design specifications in drawings for the procurement of the Rear Tri-Plate Gasket were less than adequate. (CC 8) • Design assumptions for the Rear Tri-Plate Gasket were less than adequate. (CC 9) • Physics Division did not ensure effective implementation of the Atlas project Quality Assurance requirements. (CC 1)

1.0 Introduction

The Department of Energy (DOE) Office of Defense Programs, within the National Nuclear Security Administration (NNSA), conducted a Type B Accident Investigation of a 6,700 gallon mineral oil leak in the Atlas facility at Technical Area (TA) 35. TA-35 is located at the Los Alamos National Laboratory (LANL), Los Alamos, New Mexico. The oil leak resulted in approximately $1,800,000 in damages to property in the basement of the building and cleanup costs for the leak of $95,000. A five-member Accident Investigation Board composed of subject matter experts from DOE Headquarters and Field Offices conducted the accident investigation January 17 to February 16, 2001. The Board Chair was Dr. Douglas Minnema of the Office of Technical Support, Defense Programs, DOE/NNSA. The investigation was performed consistent with the direction provided by DOE O 225.1A, *Accident Investigations*. The Barrier Analysis results from the investigation were linked to the five core functions of Integrated Safety Management.

On January 8, 2001, upon arriving at work at 6:00 a.m., a Mechanical Technician discovered oil on the floor in the Atlas machine High Bay area located in Building 125 at TA–35. Initial inspection of the building revealed that mineral oil leaked from the First Article Assembly, which holds 11,515 gallons of oil. Approximately 6,700 gallons leaked onto the High Bay floor, of which approximately 500 gallons seeped into the basement area. The dripping oil damaged several laser systems, associated ultra-fast optics, and electronics located in the basement. LANL determined that there were no injuries or environmental impact as a result of this accident or the associated cleanup.

On January 17, 2001, Ralph E. Erickson, Acting Chief Operating Officer for Defense Programs, DOE/NNSA, established a Type B Accident Investigation Board for this accident in accordance with DOE O 225.1A, *Accident Investigations* (see Appendix A for the Appointment Memorandum).

1.1 Facility Description

LANL occupies approximately 43 square miles of DOE land situated on the Pajarito Plateau in the Jemez Mountains of Northern New Mexico. The closest population centers are the communities of Los Alamos, White Rock, and San Ildefonso Pueblo. The closest metropolitan center is Santa Fe, population approximately 70,000, located 35 miles away.

As technologies, U. S. priorities, and the world community have changed, LANL's original mission has evolved from primarily designing nuclear weapons to the following five areas: (1) stockpile stewardship, (2) stockpile management, (3) nuclear materials management, (4) non-proliferation and counter-proliferation, and (5) and environmental stewardship. LANL's mission today is to apply science and engineering capabilities to problems of national security.

LANL currently consists of 49 active Technical Areas (TAs). Technical Area 35 includes multiple facilities that house physics experiments operated by the Physics (P) Division and several other technical divisions. Building 125 houses the Atlas Project operated by P-22, an Optics Laser Laboratory operated by the Condensed Matter and Thermal Physics Group of the Material Science and Technology Division (MST-10), and a smaller laser laboratory operated by the Machine Science Technology Group of the Dynamic Experimentation

Division (DX-6). In addition, this building contains a machine shop, a glass laboratory, other small support shops, and office space to support the research efforts.

1.1.1 Atlas Project

Atlas is a P-Division experimental facility within Building 125. Building 125 was built for another project in the 1970's and has been used for several experimental systems since then. The conceptual design of Atlas was approved in 1994. Construction is essentially complete at this time and in January 2001, LANL submitted a Project Critical Decision 4 (CD-4) request to Defense Programs to commence operations.

Atlas is a pulsed-power machine designed to perform high energy-density experiments in support of weapon-physics and basic research programs. Atlas can provide 27-32 Mega-ampere (MA) of electrical current to a target in a cylindrically symmetric geometry. Electrical current in this range allows fielding of large-scale experiments that employ design, engineering and experimental skills analogous to full scale nuclear weapons testing. Specifically, Atlas is a short-pulse, high-current generator designed to drive hydrodynamic experiments to conditions relevant to stockpile stewardship. It will enable the study of the response of materials to strong shock waves and ultra-high pressures in large volumes in converging geometry with excellent diagnostic access. Among other uses, this will allow the study of strength at high-strain rate, friction, spall, hydrodynamics in complex geometry, and shocks in strongly coupled plasmas.

All safety evaluations have concluded that Atlas will be a low hazard, non-nuclear, non-accelerator facility. All construction and operational decisions have been guided by this determination. Outside Architect/Engineer firms with guidance and oversight by the LANL Project Management Organization in collaboration with the Atlas design team designed the building and modifications to accommodate Atlas.

Atlas contains 24 sets of maintenance units (each maintenance unit contains four Marx Units) located in 12 tanks, which are filled with approximately 160,000 gallons of dielectric mineral oil for electrical insulation. The maintenance units are oriented in a circle around a central target chamber. Each of the 12 tanks is attached to two Vertical Transmission Line (VTL) Tanks. These tanks house the Tri-Plate Assembly Transmission Lines. The Marx Units are used to store a large amount of electrical energy (see Figures 1 and 2). When discharged, this capacitor bank delivers a high current pulse through Tri-Plate Assembly transmission lines to a cylindrical load in the central target chamber. The load receives a strong inwardly directed force due to the magnetic field generated by the current pulse. This causes it to deform plastically and move inward while most of its material remains in the solid state. In a few microseconds, it can be accelerated to a velocity of 10 millimeters per microsecond, which is approximately the escape velocity from earth. This highly uniform imploding cylinder can be studied directly or can impact a target designed to explore the physical phenomena of interest.

In addition to the Atlas machine, there is another tank in the same room that is referred to as the First Article Assembly (see Figure 3). This assembly is similar to the 12 tanks in Atlas and includes the First Article Maintenance Unit (MU) Tank holding the Marx Unit and the associated VTL Tank that houses the Tri-Plate Assembly. The oil capacity of the standard configuration of First Article Assembly is 11,515 gallons, with one Marx Unit installed. The First Article Assembly is used for the testing of individual Marx Units. This testing is part of the quality acceptance testing of the electrical components of the Marx Units and the full function of the units prior to use in the Atlas machine. Similar testing, using the First Article Assembly, is also part of the Atlas maintenance activities.

The MU Tanks containing the Marx Units in the Atlas machine and in the First Article Assembly are connected to their VTL Tanks by gasketed connections. The Rear Tri-Plate Gaskets are U-shaped, 0.38-inch thick, 83-inch high, 23-inch wide

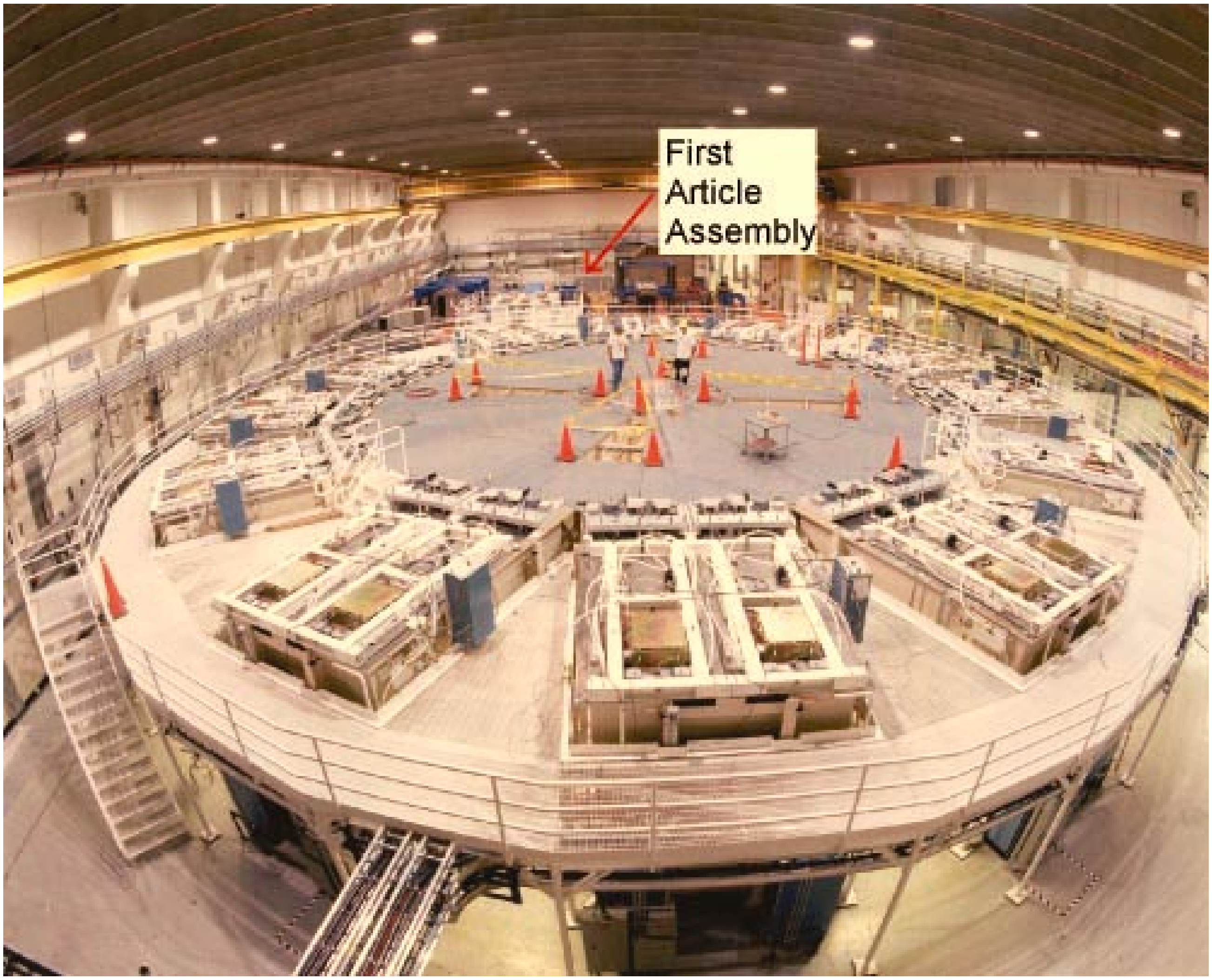


Figure 1. The Atlas machine at LANL. In the background is the First Article Assemble where the leak occured.

at the bottom, with a 7-inch wide vertical opening (see Figure 4). The gasket serves as the pressure boundary for the 3-inch gap between the First Article MU Tank and VTL Tank, subject only to the static pressure of oil contained within the connected tanks. The failure of this Rear Tri-Plate Gasket in the First Article Assembly resulted in the subject oil leak.

Prior to the procurement of the First Article Assembly, a Prototype Assembly was designed and constructed that included a tank for the switch/cable header assembly and a half-length VTL Tank. This Prototype Assembly was used for electrical testing of components in late 1997 and in 1998. The Prototype Assembly used a similarly designed gasket with the same material properties specified for the gaskets in the Atlas machine and First Article Assembly. The only differences were minor changes in the gasket dimensions to allow for more ease in fabrication. The Prototype Assembly has been decommissioned, however the Rear Tri-Plate Gasket from the assembly was recovered for the Board to evaluate.

A 40,000-gallon storage tank, located on the south side of Building 125, can store oil from the First Article Assembly or the Atlas machine. The oil distribution system includes a transfer capability to the Atlas machine and First Article Assembly and includes provision for heating and filtering the oil.

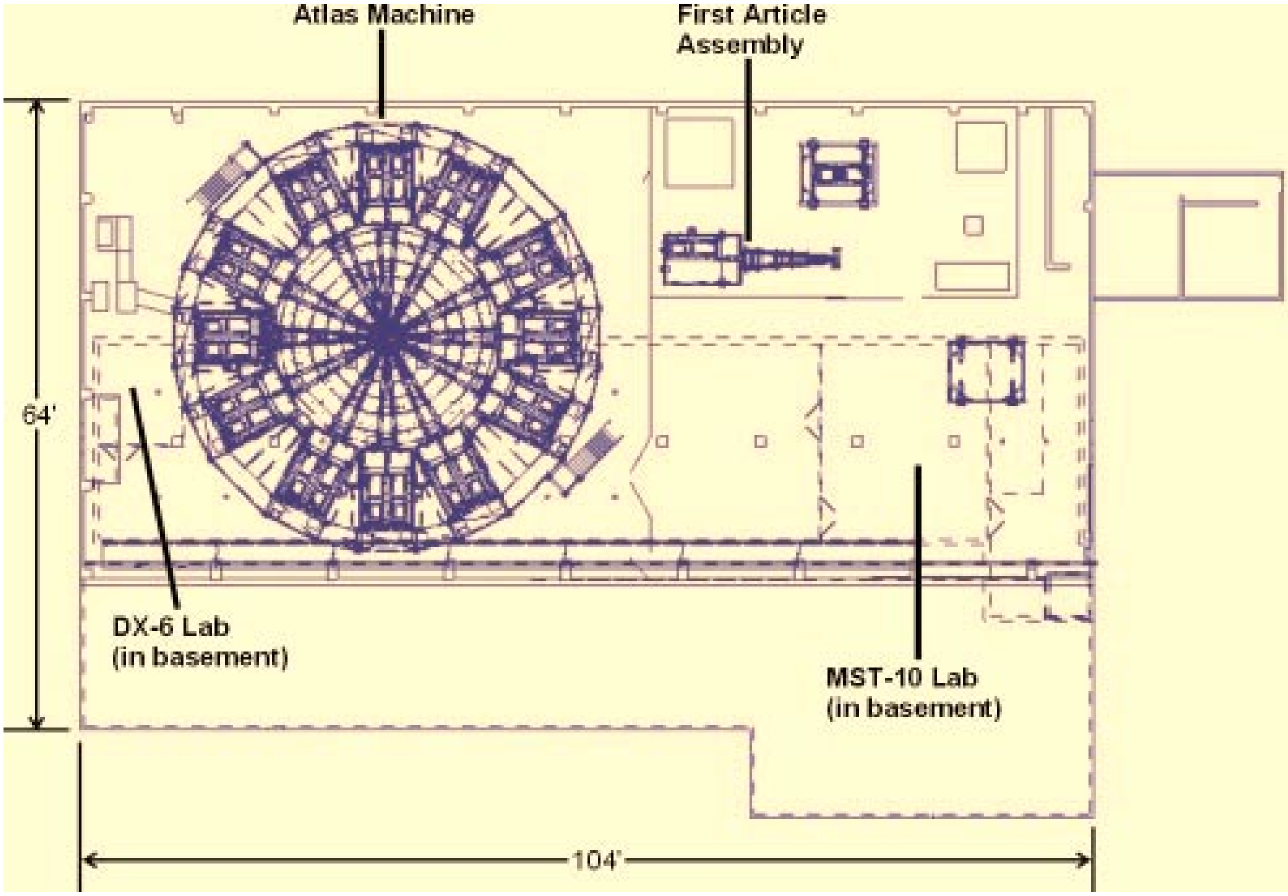


Figure 2. Schematic of the Atlas High Bay area, showing the relative locations of Atlas.

LANL has completed preparations for operation of the Atlas facility. A Laboratory-directed Readiness Assessment has been performed and determined that the facility is ready to operate. LANL has submitted a request to Defense Programs for approval of Project CD-4, authorization to begin operations. At the time of the oil leak, the twelve Atlas tanks and the First Article Assembly were filled with mineral oil. The Atlas system had been operated for acceptance testing as part of the CD-4 approval process.

1.1.2 MST-10 and DX-6 Laboratories

There are other activities collocated in Building 125, but in particular two laboratories were directly impacted by the accident. The MST-10 Optics Laser Laboratory occupies about 1,300 ft^2 and houses on-going experiments in the east basement area of the building. These experiments are laser based to develop optical reflectivity and surface second harmonic capabilities and examine the physics of these processes. The projects in progress at the time of the oil leak and impacted by the accident were: Melting Dynamics in Metals, Ultra-Fast Dynamics in Correlated Electron Material, Ultra-Fast Scanning Tunneling Microscopy, Terahertz Spectroscopy of Condensed Matter, Plasma Dynamics in Gases, Solid Target Plasma Physics, and High Energy Density Hydrodynamics (HEDH) Diagnostics. The Optics Laser Laboratory has been in this basement location since 1987 (see Figures 2, 5, and 6).

The DX–6 laser laboratory is located in a corner of the west end of the Building 125 basement area, and occupies about 400 ft^2. This lab is used for research and development of electron sources and is operated in support of the LANL science-based, stockpile stewardship program. Equipment in this lab includes lasers, optics, vacuum systems, and supporting electronic components. This experimental set-up has not been used for over two years due to funding constraints (see Figure 2).

The basement area of Building 125 was originally built and configured to supply laser pulses to laser amplifiers in the basement. In the mid-1980's the amplifiers were removed, otherwise the basement laboratory remained the same. The basement is ideal for laser operations due to its stable foundation, minimal temperature variation, and remote location.

1.1.3 Organizational Structure

The Regents of the University of California (UC) manage LANL under a management and operating contract with DOE/NNSA. UC has managed the Laboratory since its inception in 1943. The DOE/ NNSA Los Alamos Area Office (LAAO), a part of the Albuquerque Operations Office (AL), administers the contract with UC and oversees contractor operations at the site. The Deputy Administrator for Defense Programs, NNSA, is the responsible Program Secretarial Officer for LANL. The responsible program office within Defense Programs is the Office of Facilities Management and ES&H Support.

Both Building 125 and the Atlas machine are owned by P-Division. The construction of Atlas was the responsibility of P-26, Atlas Construction Group.

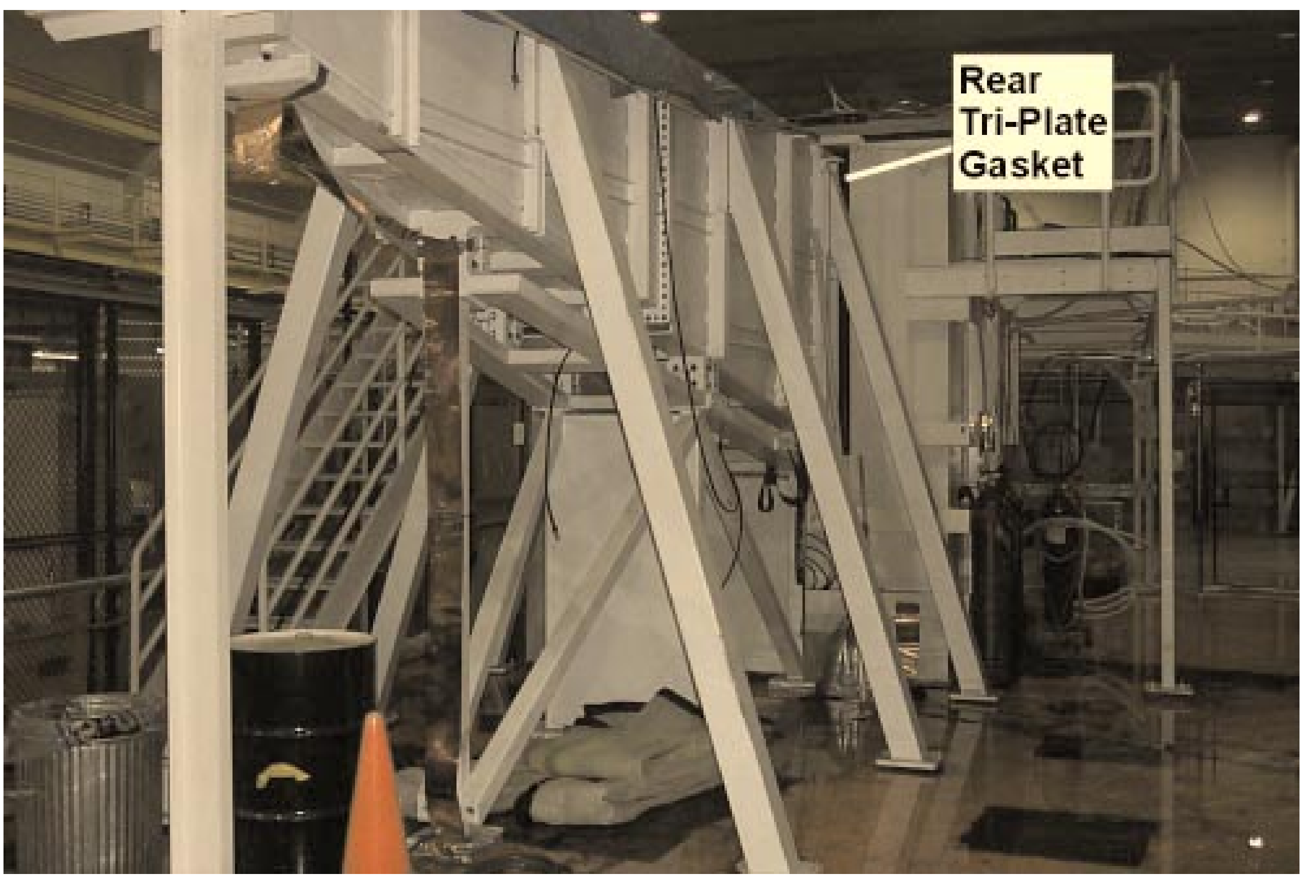


Figure 3. The First Article Assembly, where the leak occured, is composed of the Maintenance Unit Tank and the Vertical Transmission Line Tank (note oil on floor).

Figure 4. The interior of the Maintenance Unit Tank, showing the location of the Rear Tri-Plate Gaskets as installed.

As of January 2, 2001, P-26 was dissolved and P-22, Hydrodynamics and X-Ray Physics Group, assumed operational responsibility of the Atlas machine. Many of the P-26 personnel were incorporated into P-22, maintaining continuity of facility knowledge. Building modifications were managed by PM-3, Construction Project Management. The Associate Laboratory Directorate for Nuclear Weapons provides funding for both the construction and operation of Atlas.

Management of Building 125 is the responsibility of Facility Management Unit (FMU) 77, a direct report to the P-Division Director and a peer of the P-22 Group Leader. FMU-77 is responsible for overall area and building management, including utility lines, electrical panels, and mechanical rooms. FMU-77 is responsible for permitting work that exceeds the limits specified in the Facility Safety Plan, including operations that could adversely affect other tenants. FMU-77 also provides services such as ES&H support, hazard analysis coordination, and

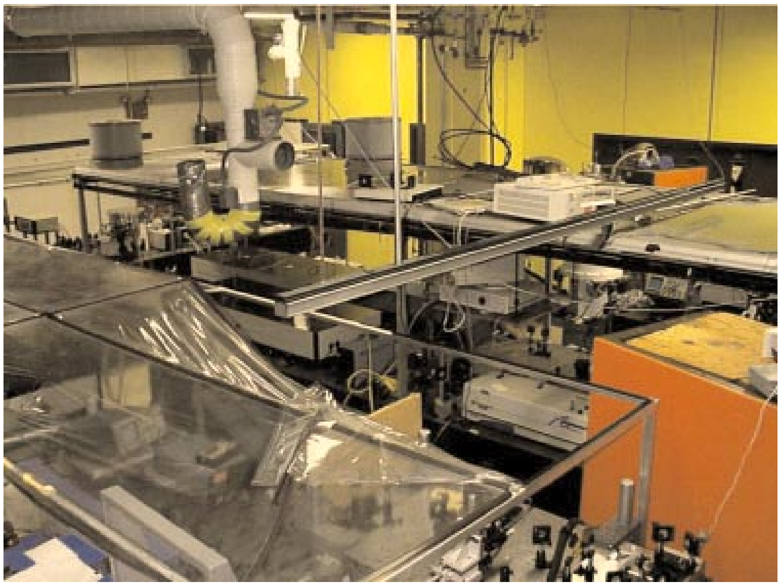


Figure 5. Overview of the MST-10 Optics Laser Laboratory in the basement of Building 125, where much of the damage occured.

addressing co-tenant concerns. The line organizations of the building tenants, such as P-22/ Atlas Group and MST-10/Optics Laser Group, are responsible for their experimental processes, safety responsibilities, operational equipment in the building, and the physical space occupied by the equipment. They are responsible for their own technical work activities and procedures, job specific employee training, and physical security and maintenance of their equipment. Roles and responsibilities of each organization are delineated in Facility-Tenant Agreements and the Integrated Safety Management System Description. On October 2, 2000, the P-26/Atlas Project Group and the MST-10/Optics Laser Group signed Facility-Tenant Agreements with FMU-77. The Group Leader of MST-10 reports to the MST Division Director, a peer of the Physics Division Director.

During the period when Atlas construction and testing were underway, Defense Programs was considering whether the Atlas machine would be operated at LANL, moved to Nevada, or not operated at all. Consideration has been given to moving the Atlas machine to the Nevada Test Site (NTS) after construction completion and initial test operations at LANL. In mid-August 2000, Defense Programs requested a detailed plan for the relocation of Atlas to NTS. As late as mid-September, 2000, it was uncertain as to whether funds would be allocated to operate the facility in Los Alamos or maintain the facility in a cold standby/non-operating mode. The present plan is to operate at LANL for the next year for physics experiments with a decision on the location for future operations dependent on the outcome of the National Environmental Policy Act review at NTS and other processes.

1.2 Scope, Purpose, and Methodology

The Type B Accident Investigation Board began its investigation on January 17, 2001, and completed the onsite investigation on February 16, 2001. The Board reviewed and analyzed the circumstances of the accident to determine its causes. The investigation was performed in accordance with

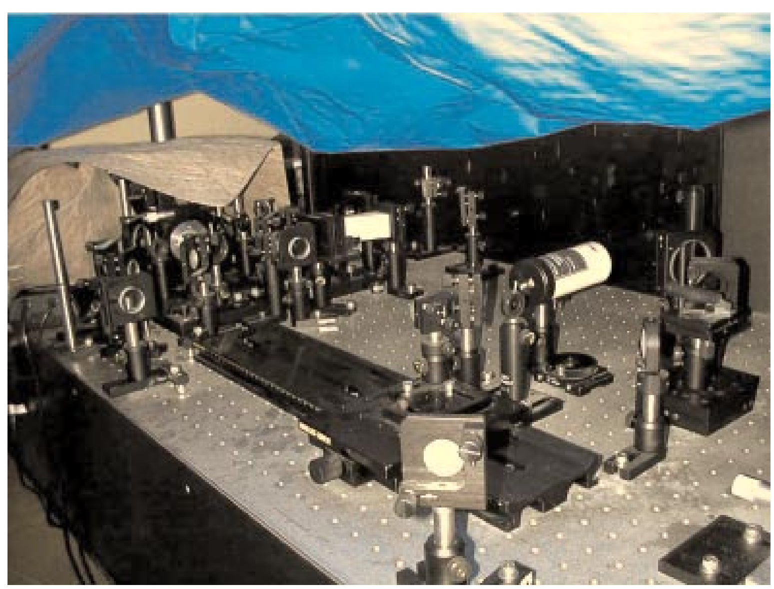


Figure 6. Laser optics table in the MST-10 Optics Laser Laboratory with mineral oil damage.

DOE O 225.1A, *Accident Investigations*. The protection of property is a contractual requirement of DOE implemented through the Department of Energy Acquisition Regulations (DEAR), although it is not part of the Integrated Safety Management DEAR Clause. Therefore, this investigation focused on the accident from a project management perspective. However, the investigation did an evaluation of the adequacy of the safety management systems of LANL and DOE as they related to the oil leak. The Barrier Analysis results from the investigation were linked to the five core functions of Integrated Safety Management.

The purposes of this investigation were to (1) determine what happened, (2) why it happened, and (3) what could be done to prevent recurrence of similar accidents occurring at TA-35 and across the DOE complex.

The Board conducted its investigation using the following methodology:

- Inspecting and photographing the accident scene and individual items of evidence related to the oil leak;

- Gathering facts through interviews, document and evidence reviews, and inspection of the accident scene;

- Reviewing emergency response;

- Overseeing physical testing of gasket material;

- Analyzing facts and identifying causal factors using events and causal factors charting analysis, barrier analysis, and change analysis; and

- Developing judgments of need for corrective actions to prevent recurrence based on analysis of the information gathered.

2.0 Accident

On January 8, 2001, a leak of approximately 6,700 gallons of mineral oil was discovered in Room A-100 (High Bay) of Building 125 in TA-35. The leak covered the floor of Room A-100, and an estimated 500 gallons of the oil leaked to the basement of the building where two laboratories are located. The oil dripped onto laser systems and associated optical instruments, laser tables, microscopes and electronic equipment located in the basement laboratories, causing permanent, irreparable damage to the equipment. Total damage to the affected equipment has been estimated at $1,800,000. The cleanup costs for the oil leak are $95,000.

The source of the mineral oil leak was found to be the First Article Assembly containing 11,515 gallons of mineral oil. A gasket between the First Article MU Tank and its connecting VTL Tank failed, permitting approximately 6,700 gallons of oil to escape. The First Article Assembly is located in the northeast section of Building 125, Room A-100 that also houses the Atlas machine. The MST-10 Optics Laser Laboratory, Room A-16, where most of the property damage occurred, is located under the southeast corner of this room (see Figures 2, 5, and 6).

2.1 Background

The First Article Assembly (see Figure 7), used for testing of individual banks of electrical components and Marx Units, is collocated with Atlas in Building 125. The First Article Assembly was completed and filled with dielectric mineral oil in October 1999, and has been utilized for 367 tests of facility electrical components since then. The first half of the tests were conducted with a plate attached to the First Article MU Tank and without the VTL Tank. The other half of these tests were conducted with the subject gasket and VTL in place. The last tests using the First Article Assembly were performed on August 11, 2000. At the time of the accident, the First Article Assembly was filled with oil and ready for any maintenance or other testing needed to support the Atlas machine.

During the construction phase of the Atlas machine, the floor area of the High Bay under the machine was stripped of the lead-based paint and resealed with epoxy paint. The stripping and repainting under the machine was performed to allow the installation of grout pads under the Marx Tanks. Also, the epoxy seal of the floor and the sealing of the pipe penetrations were performed for oil spill mitigation. The floor area on the east side of the High Bay was not sealed during the construction phase due to storage of equipment in this area and schedule impacts. The stripping and repainting process would have limited the access to the High Bay area and delayed scheduled Atlas machine construction activities. The First Article Assembly is located on the unsealed floor area of the High Bay.

2.2 Discovery and Initial Response

On Monday, January 8, 2001, at 6:00 a.m. a Mechanical Technician arrived at work and discovered oil on the floor in Room A-100 (High Bay) of Building 125 at TA-35. The leak occurred sometime during the weekend. The employee who discovered the leak made a series of calls to the Emergency Management and Response Duty Officer, the P-22 staff and management, the FMU-77 Facility Manager, and the P-22 Group Leader to notify them of the leak. Responding P-Division

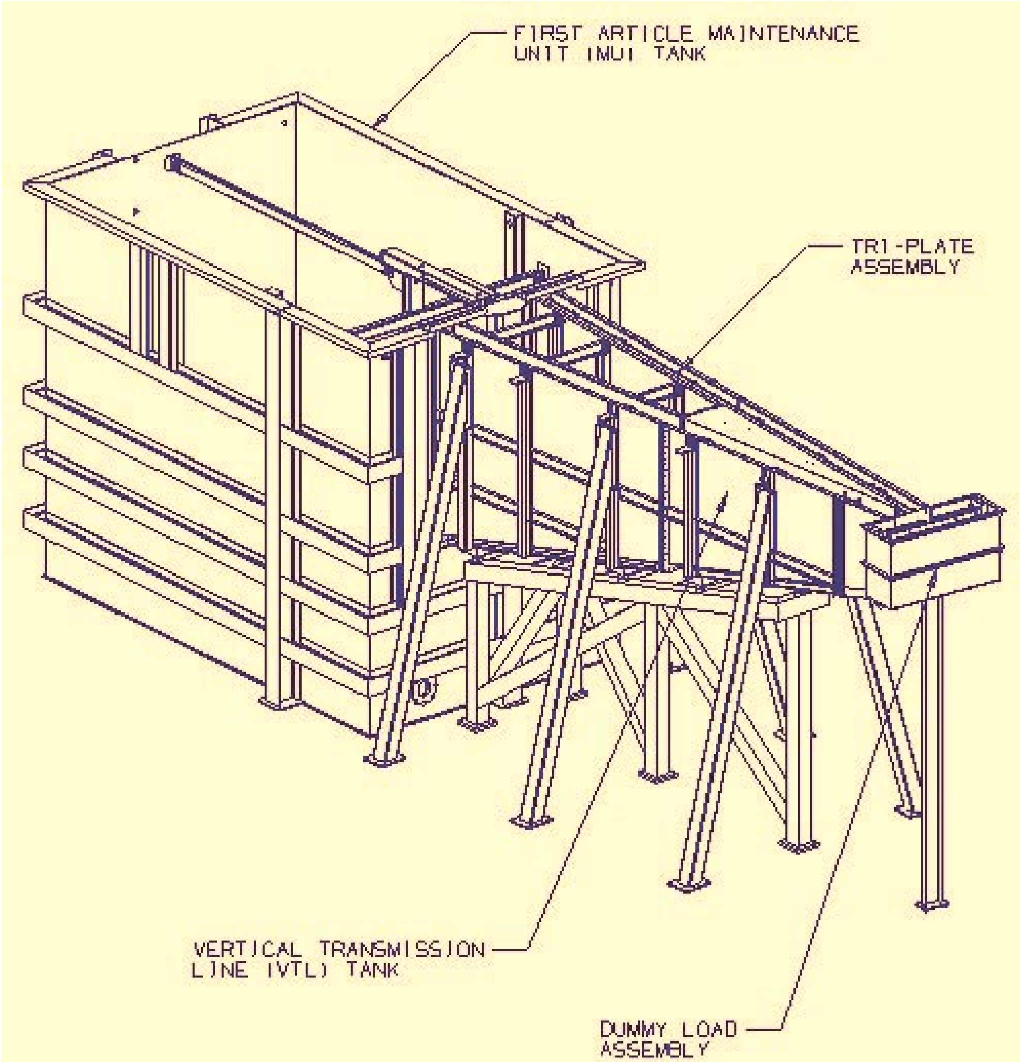


Figure 7. Schematic of the First Article Assembly, identifying the major components.

employees, who are extremely knowledgeable of the Atlas machine operations and associated hazards, entered the building and determined the source of the leak to be the First Article Assembly. They concluded that the gasket between the First Article MU Tank and its associated VTL Tank had failed (see Figure 8). The initial responders attempted to initiate a transfer of the remaining oil in the test tank to the storage tank, but were unable to locate a key for the system controls. They initiated an inspection to determine the extent of the oil leak. A small amount of oil was found to have leaked past the High Bay (east) door that was protected by a flexible boom. This oil was contained within the building. Also, a small amount of oil (several gallons) was found outside of the west door of the High Bay. The responders positioned a portable barrier around the oil to prevent further leakage. This oil was cleaned up, and LANL determined that there was no environmental impact.

The responders then proceeded to the basement to inspect for possible leakage. They discovered that oil was seeping down through the concrete floor and around floor penetrations onto the laboratory areas in the basement. Oil was observed dripping onto lasers, optical instruments, laser tables, microscopes, and electronic equipment. Attempts were made to position plastic covers to protect the equipment, however, the equipment in the spill area had already been exposed to the oil. Personnel from the Optic Laser Laboratory arrived and made an inspection of the laboratory equipment. They determined that the equipment in the laboratory had sustained significant damage. An inventory of the equipment and an initial damage estimate of $3,250,000, based on 100% loss were prepared by the MST-10 staff. This estimate was later refined to the current estimate of $1,800,000.

The initial responders from P-Division focused on moving the oil in the High Bay from the unsealed areas over the Optics Laser Laboratory (in the basement) to the sealed area under the Atlas machine and the trench on the north side of the High Bay.

Within the first hour after the leak discovery, the key was located and the remaining oil in the First Article MU Tank was transferred to the storage tank. The First Article MU Tank was then used as a storage unit for oil pumped from the floor. The tear in the gasket occurred mid-way in the tank and the remaining tank provided approximately a 5000 gallon capacity for oil.

The Emergency Management and Response Incident Commander mobilized response teams for cleanup and offsite transport of the leaked oil. Electrical power for the facility, except for lighting, was locked-out to mitigate electrical shock hazard during cleanup operations. The P-22 staff continued cleanup efforts until relieved by the cleanup response team. The cleanup activities were performed during normal work hours through the afternoon of January 10, 2001. Final cleanup of the building was completed on the morning of January 11, 2001 and control of Building 125 was returned to the FMU-77 Facility Manager.

The Emergency Management and Response Incident Commander indicated that there were no unexpected problems with the emergency response and cleanup efforts. The Board concluded that the initial response activities were appropriate and properly completed.

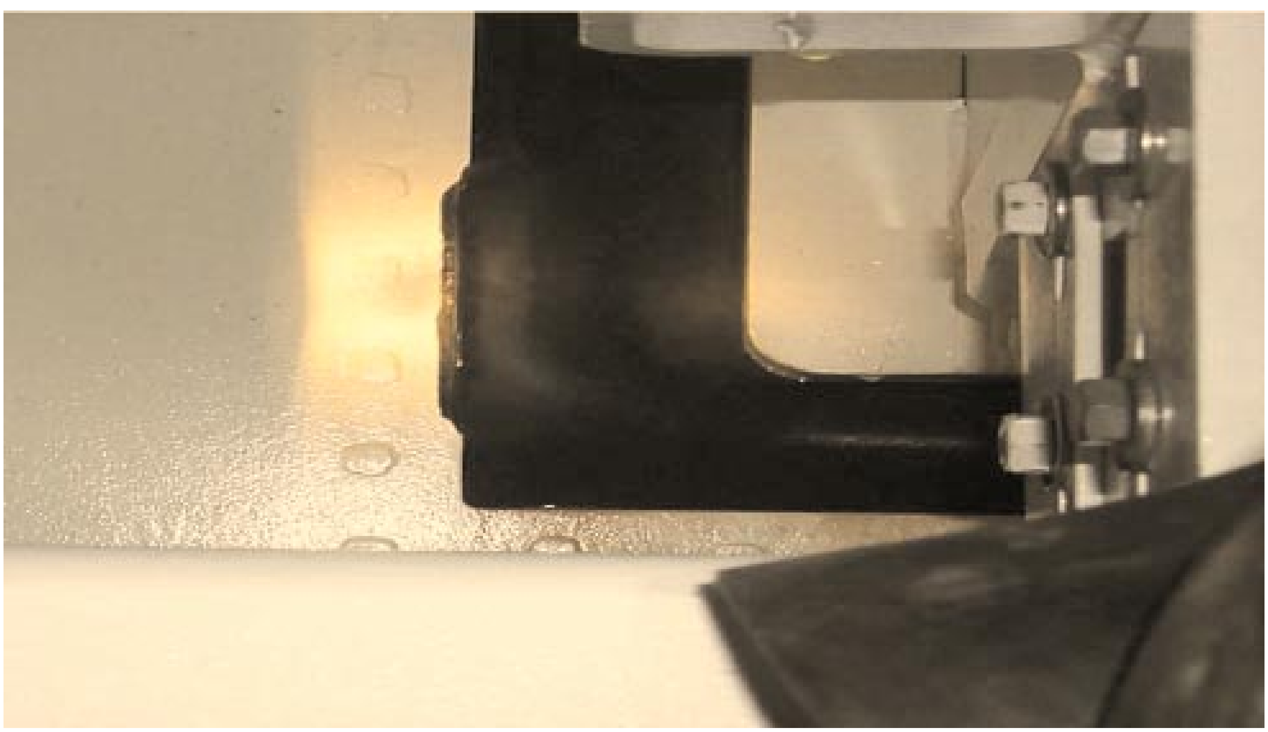


Figure 8. This tear in the right Rear Tri-Plate Gasket of the First Article Assembly created a 2.7 in^2 providing the leak path for the mineraloil.

Figure 9. The right Rear Tri-Plate Gasket and one of the backing bars after removal. The gasket displayed significant deterioration along borders where the backing bars were attached

2.3 Accident Reconstruction

In order to reconstruct the accident, the Board gathered relevant information associated with the failed gasket and its configuration in the First Article Assembly. The First Article Assembly consists of the First Article MU Tank, Marx Unit, VTL Tank, and the enclosure for the Dummy Load (see Figure 7). Two Rear Tri-Plate Gaskets connected the First Article MU Tank and the VTL Tank (see Figure 4).

The Board closely examined the condition of these Rear Tri-Plate Gaskets. A six-inch tear in the right gasket along the First Article tank edge was observed. The tear created an opening of approximately 2.7 in.[2] and was identified as the source of the mineral oil leak (see Figure 8). Numerous cracks, 6- to 12-inches long and approximately 0.25 inches deep, were identified along the metal/gasket interfaces (see Figure 9). The outside surface of the left Rear Tri-Plate Gasket had a large number of surface cracks and one major tear. The Board also noted that the Rear Tri-Plate

Gaskets bulged outward because of the hydrostatic pressure of the mineral oil.

The exact time and date of the leak could not be confirmed; however, based on the 2.7 in.^{2} opening in the gasket, Atlas personnel estimated that it could take as little as two to three hours for the tank to drain to the bottom of the tear. An Atlas Project Mechanical Technician discovered the leak on Monday at 6:00 a.m. on January 8, 2001. P-22 Atlas personnel observed the oil still flowing shortly after the discovery, so the rupture may have occurred earlier on Monday morning.

The Board also noted that the First Article MU Tank and VTL Tank interfaces were not coplanar, the interface surfaces of the tanks were not rounded, and the First Article MU Tank was slightly bulged. The Board took various measurements of the assembly to compare them with the design basis and specifications. More detailed facts concerning the failure of this Rear Tri-Plate Gasket were gathered through material testing. The results of these evaluations are discussed in Section 3.1 of this report.

The Board inspected the floor of the High Bay to determine the sources that led to the oil entering the basement area. Cracks, pipe chases, and expansion joints were noted in the east portion of the flooring. To provide spill containment, some booms and berms were installed around the doors and equipment. Flexible booms had been installed at the west and south doors and at the east roll-up door. It was noted the east door boom was not fully attached to the floor. At the west end area, metal berms had been installed around the mineral oil supply piping and the fire protection loop that penetrated into the basement. Foam sealant had been applied around the penetrations and between the berms and floor interface. From discussions with P-22 personnel, it was determined that this sealant failed and some oil flowed down the fire protection loop penetrating into the DX laboratory area.

2.4 Related Events

The following related events have been identified:

- On November 28, 2000, a full “12 tank” Atlas pulsed-power performance test was conducted. The system was configured to deliver ~28 MA to the target area. Nine microseconds after peak current, an electrical breakdown occurred at a nylon insulator, causing damage to the transmission line and tank. No oil loss resulted, although a similar failure at a different location might have made a penetration in the oil tank. Corrective actions included routine cleaning and evaluation of the insulating oil and evaluation of potential oil spills. The impact on the Optics Laser Laboratory in the basement in case of a future oil spill was a major concern to MST-10 after this incident. Corrective actions were initiated, including a commitment by P-22 to seal the High Bay floor over the Optics Laser Laboratory. A report titled “Informal Analysis of Atlas Transmission Line Breakdown” documented this event.

- On August 3, 2000 (estimated by P-22 personnel), while filling the First Article Assembly from the oil storage tank, the pump was left on and overfilled the tank. The excess oil (estimated at 500 gallons) spilled onto the High Bay floor. The oil was cleaned up and no critique or incident report was filed due to the small quantity of the oil spilled and the absence of consequences. Oil level detectors were subsequently installed on the First Article Assembly and the Atlas machine that turn off the oil pumping system and prevent overfilling.

- On November 17, 1997, LANL discovered a flooded sub-basement in TA-35, Building TSL-27, that resulted from the freeze induced rupture of a chiller line. This caused $3,200,000 in damage to the facility and to equipment used for Nonproliferation and International Security operations. The resulting DOE Type B Investigation found that line management did not perform adequate assessments to determine the consequences to mission should equipment fail and did not learn from previous accidents.

- LANL issued a Price-Anderson Amendment Act (PAAA) non-compliance report to DOE on October 19, 2000 describing non-compliance with quality assurance requirements for the Laboratory. Two quality issues were reported:

    1. Failure to establish the institutional requirement for the procurement process, and

    2. Weakness in implementation of the LANL Quality Assurance Program at the working level, including procurement, inspection and acceptance testing, and document and record management.

LANL has prepared a corrective action plan that is being implemented for the non-compliance. Additionally, in December 2000, the Associate Laboratory Director for Nuclear Weapons issued a Directive detailing the quality assurance for nuclear weapons activities. This Directive requires an assessment of QA practices by March 9, 2001 and expects implementation to begin by June 1, 2001. The research performed by the Atlas Program falls under this Directive.

3.0 Facts and Analysis

3.1 Gasket Design, Fabrication and Installation

The Board performed various measurements to compare the as-found condition of the First Article Assembly with the design, fabrication and installation specifications. These included specifications for dimensions, tolerances, surface finish, and material composition for the metal and gasket components. According to the design drawing, the Rear Tri-Plate Gaskets were to be constructed of the following:

1. Material: Nitrile (Buna N) Polymer, Nylon fabric insertion 15 oz
2. Hardness: 60 plus or minus 5 Duro–Shore A
3. Tensile Strength: 1000 psi
4. Finish: Smooth
5. The gaskets were to be shipped flat.

For the First Article Assembly, the following specifications were noted:

1. First Article MU Tank and Rear Tri-Plate Gasket interfaces required an 0.125-inch x 45° chamfer all around inside corner.
2. VTL Tank interfaces were required to have a 0.06-inch radius at its edges.
3. Drawings and supporting design calculations are based on the First Article MU Tank and VTL Tank interfaces being coplanar. [Although the Rear Tri-Plate Gaskets were intended to permit some offset, no specification for the offset distance was given.]

No torque specifications were documented for the bolts that secured the Rear Tri-Plate Gaskets in place. Determination of the required torque to assure the gaskets would seal properly was part of the installation plan for the Prototype and First Article Assemblies. [However, during installation, 30 ft-lb was verbally specified.]

The Board, with the assistance of P-22 personnel, inspected the as-found condition of the First Article Assembly, took a variety of measurements, and removed the Rear Tri-Plate Gaskets. In addition, the Board, with the assistance of LANL materials science subject matter experts, evaluated two Rear Tri-Plate Gaskets. One gasket was from the Prototype Assembly that was used for tests in 1997 and 1998; the other was the failed gasket removed from the First Article Assembly. These laboratory analyses were performed by the Polymer Materials and Coatings Group of MST and were observed by members of the Board. (Refer to memoranda in accident investigations records, "Infrared Analysis of Gasket Material," J. Schoonover, et al., Feb 6, 2001; "Results of Mechanical Property Measurements of Atlas Gasket Materials," E. Orler, Feb 7, 2001; and "Results of Density Measurements of Atlas Gasket Materials," K. Wilson, Feb. 7, 2001). The Board made the following observations with respect to the gaskets:

1. <u>There was no nylon fabric reinforcement in the First Article Assembly Rear Tri-Plate Gaskets.</u> The Board noted that there was a difference in characteristics between the gaskets taken from the Prototype Assembly and the First Article Assembly. There was evidence of fiber in the Prototype Gasket, but there was no evidence of fibers in the First Article Assembly Gasket. The P-22 personnel made similar observations on the day of the leak discovery.

2. The Prototype Assembly Gasket and the First Article Assembly Gaskets were of similar, but not identical, chemical composition. Fourier Transform Infrared Spectroscopy was performed on samples from the First Article Assembly and Prototype Assembly. The results showed a presence of Nitrile, the component identified in the drawing. Differences were observed in hydroxide (OH) content, but no conclusions could be made. There was no spectral evidence indicating that the gaskets were made of Neoprene or Viton. Interviewees acknowledged that the material specifications for the Rear Tri-Plate Gaskets were taken directly from a manufacturer's material list for "Nitrile-Nylon Inserted Diaphragm." The Board concluded that some of these specifications, such as Nylon Fabric Insertion 15-ounce and Tensile strength 1000 psi, were unclear as procurement requirements and may have been interpreted differently by various manufacturers of the gaskets. The Nitrile (Buna N) Polymer specifications did not provide a requirement for Nitrile content. Nitrile is a copolymer of butadiene and acrylonitrile, and its content varies in commercial products from 18% to 48%. The exact percentage of Nitrile was not quantified, but appeared to be of similar magnitude in both samples. As the Nitrile content increases, resistance to petroleum based oils and hydrocarbon fuels increases. The Board determined that the two gaskets' materials were different, but both contained the Nitrile component specified in the requirements.

3. The Rear Tri-Plate Gaskets did not meet Tensile Strength requirements. Tensile measurements were performed on the Prototype Assembly and First Article Assembly Gaskets, including samples taken from the lowest portion of the gasket exposed to the oil and from the top portion of the gasket that was not exposed to the mineral oil. The Prototype Gasket material had a pronounced yield point. In contrast, the tensile strength of the First Article Assembly Gasket material was much lower than the Prototype Gasket. The First Article Assembly Gasket strength characteristics were similar to those of un-reinforced rubber. The Young's modulus for the Prototype Assembly Gasket ranged from 4000-9300 psi, depending on the direction of the applied stress during testing. This range is apparently related to the orientation of the nylon reinforcement. The Young's modulus for the First Article Assembly Gasket was not significantly dependent on orientation. However, the modulus varied significantly when exposed in mineral oil. The modulus of material exposed to the oil was 370-440 psi compared to 1100-1270 psi for the sample not exposed to the oil.

4. The First Article Assembly Gaskets showed significant degradation due to exposure to the mineral oil. Density measurements were performed on the Prototype Assembly and First Article Assembly Gaskets. Tests were conducted on samples taken from the lowest portion of the gasket exposed to the oil and from the top portion of the gasket that was not exposed to the mineral oil. The densities of the two types of gaskets are not the same. The Prototype Gasket had an average density of 1.21 to 1.23 g/cm^3 for all portions, whereas the density of the First Article Assembly was 1.42 g/cm^3 when exposed to oil and 1.54 g/cm^3 when not exposed to oil. When combined with the tensile strength test results, the Board concluded that exposure to oil had resulted in significant degradation of the physical properties of the gasket material.

With respect to the installation of the Rear Tri-Plate Gaskets in the First Article Assembly, the Board made the following observations:

1. The Rear Tri-Plate Gaskets were shipped rolled and secured to a pallet. This is noteworthy as the rolling of the gaskets could introduce additional stress outside of their design parameters.

2. The First Article MU Tank interface edges were not ground to a chamfered edge. This design feature was intended to reduce stress concentration on the gasket.

3. The VTL Tank interface was not machined to a rounded edge. As with the chamfered edge of the MU Tank, this feature was intended to reduce stress concentration on the gasket.

4. Tank interfaces were not coplanar. The offset measurements ranged from 0.35 to 0.85 inches.

The last three observations above need further discussion to explain their significance. The Board was provided with Atlas design calculations developed to determine the maximum stresses on the Rear Tri-Plate Gasket as a result of the hydrostatic pressure from the mineral oil. Atlas engineers used an established formula from *Roark's Formulas for Stress and Strain, 5th Edition*. According to Roark, the formula can be used provided that:

- The maximum deflection of the plate (gasket) is not more than one-half the thickness.

- The edge conditions are those of a rectangular plate with two long fixed edges; two short edges simply supported.

- Forces on the flat plate are oriented in a direction normal to the plane of the plate.

Contrary to these assumptions, the Board determined that:

- The deflection in the gasket (caused by the pressure of the oil) exceeded one-half of the thickness of the gasket. The gasket retained this deflection even after removal from the First Article Assembly.

- The edge conditions selected for the gasket design calculation do not accurately represent the installed conditions of the gasket. The edge conditions of the installed gaskets are more complex than are those of a rectangular plate with two long fixed edges; two short edges simply supported.

- The pressure from the mineral oil was not in a direction normal to the plane of the gasket, since the First Article MU Tank and VTL Tank interfaces with the gasket were not coplanar. The offset measurements between the First Article MU Tank and the VTL Tank ranged from .35 to .85 inches. (This condition would also violate the assumption regarding deflection of the gasket.)

Based on the differences between the design assumptions and the installed configuration of the gasket, the Board concluded that the design basis for the gasket did not accurately reflect the actual stresses in the gasket. Of special concern are the corner areas where the horizontal and vertical backing bars meet, which is the region where the First Article Assembly Rear Tri-Plate Gasket failed. The stress concentration factor in these corner areas could be much greater than the value used in the Atlas project calculations.

The Board found that the gasket calculations and the associated specifications were used for both the two gaskets in the First Article Assembly and the 24 gaskets in the Atlas machine. Furthermore, the Board determined that the assumptions used for the design of the gaskets were not incorporated into specifications for their installation. For example, neither the allowable gasket deflection nor the allowable deviation from coplanar alignment of the MU and VTL Tanks were specified in assembly drawings or procedures.

The Board also measured torque readings for the backing bar mounting bolts. The values ranged from 4 ft-lb to 21 ft-lb at the time of removal, but the Board could not make a conclusion concerning the torque at installation based on the torque readings at removal.

Conclusion

Although the same specifications were provided for the Prototype Assembly and First Article Assembly Gaskets, the tests described above and physical inspection show that the two materials are not comparable, especially with respect to tensile strength. In addition, the strength of the First Article Assembly Gasket was further reduced when exposed to the mineral oil and also reduced by not having the specified nylon insert. As a result, the tensile strength of the First Article Assembly Gasket was lower than required by the specifications and this factor contributed to the material failure and subsequent oil leak.

From this analysis the Board concluded the following:

The Rear Tri-Plate Gaskets installed on the First Article Assembly did not meet design and procurement specifications for material composition and tensile strength.

- The Rear Tri-Plate Gaskets installed on the First Article Assembly did not meet shipping and installation specifications.
- Design assumptions for the Rear Tri-Plate Gaskets did not accurately represent the First Article MU Tank and VTL Tank interface design and as-built conditions.
- Design specifications in drawings did not contain adequate detail and clarity to ensure the procurement of the appropriate gasket.
- Of significant importance, the Board concluded that the Rear Tri-Plate Gaskets used on the Atlas machine should be re-evaluated by LANL to determine if a similar failure could occur. LANL should confirm the Atlas Rear Tri-Plate Gaskets are adequate for their intended application.

3.2 Atlas Quality Assurance

An Atlas Quality Assurance Project Plan (QAPP) was prepared in January 1996 and incorporated into the Project Execution Plan. The Project Execution Plan designated Atlas as a Management Level 3 (ML-3) project and defined the quality assurance requirements to be applied considering the graded approach. The QAPP established four methods for acceptance of items and services that can be used either singly or in combination:

1. Evaluation of supplier's Certification of Conformance;
2. Source inspection/surveillance, post-installation inspection;
3. Receiving inspection; and
4. Post-installation testing.

A supplemental Quality Assurance plan entitled *Atlas Special Facilities Equipment Quality Assurance Program Plan* was prepared in October 1997 as a subset of the Atlas QAPP. The purpose of this plan was to define quality assurance requirements for Atlas special facility equipment, not including the exterior facility. This plan defined Quality Grade Levels (1-4) based on risk to the project if a failure should occur in the part. Quality Grade Level 1 is the most rigorous, and Quality Grade Level 4 is the least rigorous. The failed gasket in this accident was defined as a Quality Grade Level 2 item. A Quality Grade Level 2 designation was assigned to structures, components, and systems whose failure or malfunction of the specific item alone would result in a major condition adversely impacting the Atlas project such as a major impact to cost and/or schedule, potential noncompliance with statutory requirements, temporary, or minor damage to the environment, or safety significant items for the protection of workers.

The quality requirements for Quality Grade Level 1 and 2 Purchased Products specified in the Special Facilities Equipment QAPP included:

- A Certificate of Conformance,
- Test data, and
- 100% Independent Verification of drawing attributes or sampling inspection based on an acceptable quality history.

The quality requirements for Quality Grade Level 1 and 2 Assembled on Site Products specified in the Special Facilities Equipment QAPP included:

- Written work and verification instructions, and
- Independent verification of critical attributes.

A contractor for LANL developed the Special Facilities Equipment QAPP. The contractor also provided specialists knowledgeable in the area of quality assurance to the Atlas project. These personnel were tasked with implementing the quality assurance requirements in the plan. These QA specialists left the project in mid-1999. At this point in the project, no one was specifically assigned responsibility for defining and enforcing quality requirements. This was shortly before receipt of the failed gaskets on the First Article Assembly.

A Certificate of Conformance, dated August 1999, was received from the manufacturer of the First Article Assembly Rear Tri-Plate Gasket. No receipt inspection or independent verification of drawing attributes was performed for this gasket. No record of work instruction or independent verification for the assembly of the test tank and associated gaskets were produced.

Conclusion

The Board concluded that LANL did not adequately implement the applicable quality assurance plans. Specifically, the project did not have an assigned QA manager and staff; receipt inspections of key components were not performed; self-assessments of the QA implementation were not performed; and no assembly instructions were prepared and utilized for the First Article Assembly. As a result of not fully implementing the quality assurance plans, a non-conforming gasket was improperly installed in the First Article Assembly that was the direct cause of the accident.

3.3 Procurement

The Special Facilities Equipment QAPP defines the following procurement requirements for Quality Grade Level 2 items:

- Supplier must be on approved supplier list,
- Certificate of Conformance required,
- Test data shall be requested,
- 100% Independent Verification of drawing attributes or sampling inspection based on an acceptable quality history,
- Items shall be inspected, and/or tested and accepted, in accordance with the quality requirements,
- Quality Manager shall conduct random assessments of the Atlas project, and
- A minimum of one management assessment shall be conducted annually to verify the adequacy of the QAPP.

The First Article Assembly equipment was procured under two subcontracts. Subcontractor A supplied the First Article MU Tank Assembly for the Marx Units and Subcontractor B provided the VTL Tank, stand-off insulators, center Tri-Plate Tank Gaskets, and the Rear Tri-Plate Gasket (the gasket that leaked). Both of these subcontracts were solicited and awarded by the LANL Business Operations Division Procurement Group. During the fabrication process, the Atlas Project Engineer visited the production facilities to evaluate the quality of the products, perform inspections, and make any needed adjustments. During these site visits, the

Rear Tri-Plate Gasket was not available for inspection, since it was procured from a subcontractor to Subcontractor B.

The First Article MU Tank was received at LANL in May 1999 and the VTL Tank and associated parts were received in August 1999. Certificates of Conformance, dated August 1999, were received for each of the items procured from Subcontractor B. A Subcontractor B engineer signed the Certificates of Conformance for the gasket, even though it was manufactured by a subcontractor to Subcontractor B. No inspection or testing was performed upon receipt at LANL on the Rear Tri-Plate Gasket or other procured articles for the First Article Assembly.

The electrical components of the Marx Units that are housed in the First Article MU Tank are important elements for the proper functioning of the Atlas machine. These components were assigned a Quality Grade Level 2 in accordance with the Special Facilities Equipment QAPP, the same designation assigned to the First Article Assembly components. However, the inspection and acceptance testing were much different. The electrical components for the Marx Units were purchased under a separate procurement. LANL implemented an onsite, rigorous testing protocol and acceptance criteria to ensure that the capacitors met the prescribed reliability budget for a design life of 3,000 shots. The capacitors are a special-manufacture item that have a potential for failure and were designated as a special emphasis area by the LANL Design Engineer. The QAPP required independent verification, inspection, and testing. These were implemented.

Conclusion

Besides the issues already identified related to the implementation of the QA program in general (section 3.2), the Board concluded that the Rear Tri-Plate Gaskets for the First Article Assembly were treated less rigorously than other components of the same Quality Grade Level during LANL's procurement, receipt, and installation efforts. Because the gaskets were not inspected or tested like the electronic components, the non-conforming Rear Tri-Plate Gaskets were not identified prior to installation in the First Article Assembly.

3.4 Spill Preparedness

LIR 404-50-01.1, *Water Pollution Control*, requires that a Spill Prevention Control and Countermeasures (SPCC) Plan be developed and implemented prior to an aboveground storage tank (AST) being placed into operation. If the AST supports experimental equipment such as a Marx Tank, the LIR advises that the experimental equipment be included in the SPCC. The Facility Manager, safety and environment responsible line manager, and supervisors are to ensure that any requirements identified be included in a Hazard Control Plan. According to the LIR Implementation Status Report of 02/01/01, ESH-18 determined that this LIR was implemented.

Prior to issuance of the LIR, TA-35 personnel identified a need to develop an SPCC Plan to address the hazard of the planned outdoor oil storage tank to fulfill a requirement of 40 CFR Part 112, *Oil Pollution Prevention*. At the time, the outside storage tank was not complete, and information was not available to complete the SPCC document. Therefore, its development was delayed, but meanwhile the P-Division personnel saw the need to prepare a document to address the storage of large quantities of oil in Building 125, and the potential for its release to the environment. They contracted for the development of the *Spill Preparedness Plan* dated May 1999. This document identified the potential for a major spill that could flood the building floor and flow into the basement, and suggested methods for directing oil into the basement to prevent its escape to the environment. Of important note is that this document addressed the static, non-operational as well as the operational aspects of potential spills, and provided mitigating and preventive measures. It also identified the First Article Tank as a potential spill source.

The plan contained numerous requirements, including:

- A written inventory of available spill control equipment shall be maintained and checked monthly by operations personnel.

- Employee training will be conducted at least annually to provide instruction on the operation and maintenance of equipment and proper spill response measures.

- Training must include the protocol used to report spills so that immediate countermeasures can be initiated. Personnel involved in spill response will be instructed on safety precautions and trained in how to use available spill control materials. Such training will include periodic spill response equipment tests and spill equipment deployment drills. (A sample log to document equipment testing and drills was included in the plan.)

- Project personnel will be properly trained to perform basic maintenance inspections for leakage from equipment, piping, and oil drum storage. (A sample inspection form was included in the plan.)

- At the end of each day, temporary containment booms will be placed around HV Maintenance Unit [First Article Assembly] in a manner to provide secondary containment in case of an unattended leak.

- Regular maintenance inspections will be performed on the Atlas machine, the HV Maintenance Unit, supply lines (including across basement ceiling), R & D operations, and oil drums.

- General operator observations should include a check for leaks, secondary containment condition and general safety condition at the site.... . Walk around inspections will be performed quarterly by the FM using a form similar to inspection forms in Appendix A.

- The HV Maintenance Unit will have some type of overflow protection for initial filling.

- It is likely that an oil spill on the first floor could migrate to the basement through cracks and improperly sealed utility sleeves; all these areas will be sealed properly.

The Physics Division did not implement this comprehensive set of spill preparedness requirements.

Subsequently, efforts were initiated in July 2000 to calculate the maximum foreseeable oil spill and ensure it could be contained within Building 125. This volume was estimated at 29,000 gallons, based on a leak from one Marx Unit Tank, and including the volume of oil shared by all tanks. P-26 personnel concluded this volume could be contained within the building using 2-inch barriers if all potential leak paths were sealed. Plans were initiated to seal the remainder of the floor of the High Bay as project schedule permitted. Sealing the remainder of the floor has not been completed to date.

In July 2000, P-Division issued an SPCC to address the requirements of 40 CFR Part 112. This document only addressed the 40,000 gallons of oil contained in the outside AST. No mention or consideration of the 160,000 gallons of oil in the Atlas machine and the 11,515 gallons of oil in the First Article Assembly is provided in the SPCC Plan. In addition, a revised, one page, *Spill Preparedness Plan (TA-35-125)* was published by P-26 in November 2000, and includes the following provisions:

- All potential exit paths have been sealed against uncontrolled oil flow from the defined area into the environment.

- A floor coating has been applied to seal any hidden cracks in the concrete floor structure and as an added benefit this encapsulates the existing lead base floor covering as well.

This plan assumed that any release of oil from Atlas into Building 125 could be totally contained within the building. The plan states that the floor area in the Atlas High Bay can contain the 29,534 gallons of oil from a spill. It recognizes that the building basement is available and would contain the entire machine capacity should additional volume be necessary. No consideration or recognition of property damage or disruption of co-tenants is provided. Requirements such as training, temporary spill containment measures, and equipment inspection contained in the May 1999 plan were not incorporated in the November 2000 version. As noted by the Board during inspection of the facility, the entire floor has not been sealed. Furthermore, the sealing of penetrations was found to be ineffective in preventing oil from leaking into the basement.

As discussed earlier, an operational event that damaged one of the Atlas transmission line tanks in November 2000 led to discussions between the FMU-77 Group, the Atlas Group, and the researchers in the basement Optics Laser Laboratory (MST-10) regarding the potential for an oil spill into the basement. It became clear that the entire High Bay floor had not been sealed and that additional acceptance testing operations would occur before any sealing activities could take place. The potential for damage to the basement laser laboratory equipment as a result of both oil and dust/debris from full power shots was recognized and discussed. The Atlas Group believed that they could control a spill during the remaining tests and committed to sealing the remainder of the floor after completion of testing. Additional requirements for the placement of booms along the sealed portion of the floor during test shots were implemented to prevent oil flow over the unsealed portion of the floor should a spill from the Atlas machine occur. However, no consideration of a static, non-operational oil leak was addressed in these discussions, and the First Article Assembly was not identified as a possible spill source.

In this present accident, the floor was challenged with approximately 6,700 gallons, significantly less oil than the calculated maximum 29,534 gallons of available containment. Even with this reduced volume, oil leaked past the building barriers and also reached the basement. The volume for the maximum foreseeable oil spill was recalculated while the Board was onsite and the revised number is 32,938 gallons. The spill prevention process does not address this additional volume.

Conclusion

Based on these considerations, the Board concluded the following:

- Booms and berms installed in the building were not designed for the protection of property located in the building basement.
- Booms and berms installed in the building were designed to contain oil in the building to prevent environmental releases.
- Spill Preparedness Plans prepared for the facility took credit for the basement as secondary containment for a spill to prevent environmental release.
- Assumptions utilized in the Spill Preparedness Plans were not adequate, and were not implemented.
- P-Division delayed taking corrective actions for recognized spill preparedness weaknesses to avoid impacting acceptance testing schedules for Atlas.
- No routine program for inspecting gasket condition has been implemented for either the First Article Assembly or the Atlas machine.
- Because the controls (sealed floors, booms, leak detection devices, and inspection of equipment) identified in the various spill preparedness plans were not implemented or failed as designed, the oil was not contained and leaked into the basement area causing property damage.

3.5 Hazard Recognition and Authorization Basis

The Atlas Project has been categorized as a non-nuclear low hazard activity in accordance with LANL LIR 300-00-05.1, *Facility Hazard Categorization*. LANL LIR 300-00-07.1, *Non-nuclear Facility Safety Authorization*, describes facility safety authorization as the affirmation by line managers that facility and activity level controls adequately protect workers, the public and the environment. A secondary purpose of authorization is to protect property. It specifies that the Authorization Basis for non-nuclear low-hazard facilities will be the Facility Safety Plan (FSP). The FSP is prepared at the FMU level and shall describe as a minimum the facility and its activities, identify and analyze their hazards, and establish facility-level controls. Readiness to commence low-hazard activities within the FMU is verified by the performance of a Readiness Assessment conducted by the Laboratory. Laboratory implementation guidance for the Facility Safety Plans states that "The operations of each tenant are reviewed for their impact on the operations of the other tenants…."

The FSP for FMU-77, which includes Building 125, was approved on September 25, 1999. The FSP includes descriptions of facilities within FMU-77, the hazards presented by these activities and operating limits to control the hazards. The FSP contains a discussion of the electrical hazards of the Atlas Marx banks and High Voltage Capacitors, but does not address the potential for oil spill or its potential impact on other building tenants. The Board noted that the previous revision of the FSP contained an operating limit requiring additional analyses by the FMU for "the use or storage of oil and other low toxicity liquid chemicals in containers greater than 60 gallons or of a total volume exceeding 1000 gallons." This limit, which would have required more analysis of the >160,000 gallons at Atlas, and other LANL requirements were not carried forward to the latest revision of the FSP. The reason provided to the Board for the removal of these requirements was feedback from facility tenants, internal assessments, and institutional changes in the FSP requirements.

The FMU-77 FSP requires analyzing changes in work process, room usage, or proposed new operations. LANL requirements documents define hazard as "Any source or situation with potential to cause injury or harm to workers or the public, harm to the environment or incurred liability, or damage to or loss of property." Hazards and situations or circumstances in which they could cause harm must be identified and evaluated to determine whether controls are needed to reduce the risk to an acceptable level. Controls identified by the FSP process are implemented using the Hazard Control Plan (HCP). The HCP developed for the Atlas activities only addresses safety hazards that include high voltages, elevated work platforms, and slippery surfaces. Oil spill mitigation and control is referenced to the Atlas Spill Preparedness Plan (previously discussed in Section 3.4). No consideration of property damage or loss is provided.

The Atlas facility organization was transitioning from the construction and startup phase to operational status at the time of the accident. The First Article Assembly has been effectively operating for 18 months, but does not have supporting operational programs such as a Preventive Maintenance Program in place. Physics Division has delayed development of programs necessary to support operations, such as Preventive Maintenance and procedures until after the approval to begin operation is received.

A LANL-directed Readiness Assessment (RA) to confirm readiness to commence Atlas operation was completed by LANL on January 4, 2001. The RA concluded that Atlas was prepared to safely commence operation. Several issues were listed as Observations in the RA that addressed the lack of operating procedures, maintenance requirements, and health protection monitoring. None of these issues were identified as pre-start findings. The RA did not address the identification and mitigation of potential oil spills or the hazard evaluation of the oil stored in the Atlas facility. The Board noted that the RA had not established prerequisites for performance of the facility.

Hazards associated with operations of the Atlas facility are identified and addressed in the *Facility Safety Analysis (FSA) for the Atlas Pulsed-Power Facility*, November 1, 2000. This document identifies potential hazards and evaluates their potential effect on the public, worker and the environment. The potential for a leak of mineral oil from the Atlas machine is addressed. The most severe potential consequences identified were to the environment and were categorized as "substantial contamination of the originating facility/activity, minor onsite contamination, no offsite contamination." The analysis recognized that a piping break could result in a leak into the basement, and that a large leak would create an operational problem but would not present a significant offsite hazard. Potential consequences for collocated tenants and property were not considered.

Facility-Tenant Agreements are required for all facilities. A Facility-Tenant Agreement has been established for FMU-77 management and Building 125 tenants that include P-26 and MST-10. The agreement outlines the roles and responsibilities as defined in the LIR. The FMU-77 Facility-Tenant Agreement also includes the duties of the Facility Manager, the responsibilities of the individual employees, and the approved FMU-77 policies and procedures. Based on the agreement, the Facility Manager (FM) shall concur with all changes in tenant operations or configuration that could adversely affect other tenants or the physical facility. The FMU shall also monitor the tenant operations to determine if they meet the FSP and Facility-Tenant Agreement requirements. For known life-threatening hazards and potential major environmental contamination incidents, the FM and tenant are required to agree that resources will be negotiated to ensure mitigation.

Although recommendations were developed in the 1999 Spill Preparedness Plan, FMU-77 did not ensure implementation of these recommendations. The FSA identified monitoring as a control to mitigate the spill hazard, but the FMU-77 did not ensure this control was in place.

Conclusion

Based on these considerations, the Board concluded the following:

- Hazard analyses and mitigation measures assumed that any leak would occur during machine operation, not when the machine was shutdown or the building unoccupied.

- The potential for property damage was not addressed in the development of the Facility Safety Plan, the Facility Safety Analysis, and the scope of the RA.

- Hazard analyses performed for the facility identified that the potential for a spill would overflow to the basement, but mitigation measures to protect property located in the basement were not identified and implemented.

- The facility hazard analysis did not consider the potential impact of facility hazards on collocated tenants in the building.

- Since property damage was not identified as a hazard in the analysis documents, appropriate controls were not identified to prevent damage to the collocated tenants. However, if the controls identified in the spill control plan were in place, the property damage may have been avoided.

The Board also concluded that if a Preventative Maintenance Program was in place for the First Article Tank operations and were further developed for the Atlas Machine, the deterioration of the gasket might have been discovered prior to failure.

3.6 Feedback and Improvement

The Board determined that throughout the timeframe of the Atlas project LANL had several opportunities to identify and respond to lessons learned from related events. Section 2.4 discussed four events that were directly related to this accident. Some of those events focused direct attention on the potential hazards to collocated programs and property. Another represented a self-identified programmatic breakdown in the lab-wide QA program that contains the same issues identified for this accident. In addition, the RA made several observations about the lack of operating procedures, maintenance requirements, and health protection monitoring. However, these observations were not elevated to a level that would prompt appropriate and timely corrective actions.

The Board noted from both interviews and documents that the facility personnel were aware of the potential for property damage and programmatic impacts to collocated activities. However, the response to these concerns was not timely, and was never incorporated into the formal process for the identification, evaluation, and mitigation of these hazards.

Conclusion

The Board concluded that there had been multiple opportunities for LANL to recognize and correct the situations that resulted in this accident before its occurrence. However, lessons learned from previous events were not incorporated in a proactive and timely manner. Even when corrective actions were identified, they were intentionally delayed so as to not impact project schedule.

3.7 DOE Oversight

DOE provides oversight of Physics Division construction and project activities through the LAAO Project Management Group, which provides oversight of facility construction and project completion. The LAAO Facility Representatives (FR) provide oversight of operational activities.

The Project Management Group personnel have been closely involved with execution of the Atlas project. Their oversight focused on budget and schedule execution of the First Article Assembly and the Atlas machine, and a review of the project CD-4 package for approval. No assessments of facility performance were conducted by DOE to support CD-4.

LAAO operational oversight of Atlas has been limited to review of facility startup plans and response to occurrences. The LAAO Project Manager consulted the FR Team Leader on the plan for facility startup and the contractor RA. The FR Team Leader provided input to the RA scope and Team makeup, and concurred with the level of RA and startup authority. No operational assessments of the Atlas facility operations or of the LANL-directed RA of Atlas have been performed by DOE.

Shortcomings in the utilization and effectiveness of the LAAO FR Program were identified in a previous accident investigation (*Type A Investigation of the March 16, 2000 Plutonium-238 Multiple Intake Event at the Plutonium Facility, Los Alamos National Laboratory, New Mexico*) and in a LAAO FR Program Self-Assessment performed August 2000. An Action Plan was developed in response to a Judgment of Need from the Type A Investigation, and implementation is in progress. Corrective actions for the LAAO FR Program Self-Assessment are under development and are expected to closely parallel those from the Type A Accident Investigation.

In December 1999, the LAAO FR Program developed a staffing plan to ensure that resources are appropriately applied to facilities with the highest risk. The Atlas facility, characterized as a non-nuclear, low hazard facility in P-Division, is currently not a high priority facility for FR coverage. Available resources are applied to higher risk facilities and are available to the Atlas facility on an as-needed basis. Additional oversight of lower risk facilities, such as Atlas, is planned, as additional resources become available.

Conclusion

The DOE oversight of the Atlas project did not identify the programmatic breakdown of the Atlas project QA processes or the weaknesses of the facility hazard analysis processes. However, the Board concluded that the level of oversight provided was consistent for the level of hazard identified for the facility. Furthermore, the Board evaluated the corrective actions underway to respond to the judgments of need identified in the recent Type A accident investigation at the LANL Plutonium Facility, and concluded that if implemented fully, these corrective actions should improve the oversight at other facilities such as Atlas. Therefore, no judgments of need were identified in this area.

3.8 Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any management or physical means used to control, prevent, or impede the hazard from reaching the target (i.e., persons or objects that a hazard may damage, injure, or harm). The results are integrated into the Change Analysis Worksheet, Attachment 3. Attachment 2, Barrier Analysis Worksheet, contains the complete barrier analysis performed by the Board.

The Board reviewed engineered containment (gaskets, berms, sealed floor, and leak detection devices) and management controls (Inspection, Hazard Control, Spill Prevention Plan, Facility Hazard Analysis, and Quality Assurance) in identifying barriers and assessing their performance.

Physical barriers that either failed or were missing include:

- Containment: Gaskets were used as part of the primary containment boundary, rather than bolting the First Article MU Tank to the VTL Tank, introducing a potential gasket failure into the design.

- Gaskets: The Rear Tri-Plate Gasket did not meet design specifications and failed under the static pressure of the oil.

- Berms: Installed berms were intended to contain any leakage. The sealing around some berms did not contain the leak and some berms were not installed.

- Sealed Floor: A sealed floor with effective sealing around floor penetrations would have lessened the leak into the basement. The east side of the High Bay area had not been sealed.

- Leak Detection Devices: No leak detection device with alarm capability was installed to provide notification of the leakage.

Management System barriers that either failed or were missing include:

- Inspection: A periodic inspection could have identified potential bulges or cracks in the gasket. No inspection frequency of the gaskets had been developed.

- Hazard Control Plan, Spill Prevention Plan, and Facility Hazard Analysis: The potential for a leak and overflow to the basement had been recognized, but no actions to protect property in the basement had been identified and implemented.

- Quality Assurance: An effective QA program may have detected the deteriorating gasket, the flawed design and/or the inadequate specification.

- Avoidance: Keeping high-value equipment out of vulnerable areas in the basement would have lessened the property damage.

- Feedback and Improvement: P-Division did not take prompt action on lessons learned from precursor events.

Table 3-1 Consolidated Barrier Analysis and ISMS Link presents the Board's summary of the physical and management barriers consolidated from Attachment 2. The physical and management barriers are also linked to the five core functions of Integrated Safety Management.

3.9 Change Analysis

The change analysis process examines planned or unplanned changes that caused undesirable results related to the accident. This process analyzes the difference between what is normal, or expected, and what actually occurred prior to the accident. The results of the change analysis are integrated into the Change Analysis Worksheet to support the

Table 3-1. Consolidated Barrier Analysis and ISMS Link

TARGET	Property
Physical Barriers	1. Oil Containment Systems 2. Rear Tri-Plate Gasket 3. Berms and Booms 4. Sealed Floor 5. Leak Detection Devices
Management Barriers	6. Inspection 7. Hazard Control Plan, Spill Prevention Plan and Facility Hazard Analysis 8. Quality Assurance 9. Avoidance 10. Feedback and Improvement
Hazard	Mineral Oil

The identified physical and administrative/managerial barriers link to the five core Integrated Safety Management System (ISMS) functions as follows:

- Define the Scope: Hazard recognition, evaluation, and mitigation processes did not include property and collocated programs within their scope. (7)
- Analyze Hazards: Potential failure of passive design features (i.e., gaskets) were not evaluated. Failure during non-operational periods was not considered. (7, 9)
- Implement Hazard Controls: Identified controls were not effectively or fully implemented. (3, 4, 5, 6)
- Perform Work within Controls: The QA program was not effectively implemented during performance of work. (1, 2, 8)
- Provide Feedback and Improvement: There were multiple precursor events that were not responded to in an effective or timely manner. (6, 8, 10)

development of casual factors. The Events and Causal Factors Chart, Attachment 4, contains the complete documentation of the Change Analysis.

Conditions differing from the ideal situation that contributed to the oil leak were: an improper gasket installed on the First Article Assembly; Quality Assurance Program requirements were not fully implemented for the First Article Assembly; flanges of the First Article MU Tank and connecting VTL Tank were not coplanar; and the gasket was not shipped in the specified "flat" configuration. Unsealed cracks and penetrations existed in the floor near the First Article Assembly. The First Article Assembly has been effectively operating for some eighteen months, but does not have supporting operational programs such as a Preventive Maintenance Program in place.

The Facility Hazard Analysis assumed that any leakage would occur as a result of machine operation when the building was occupied. Yet, the leak occurred on a static tank over a weekend when no workers were in the building, and was undetected until the following Monday morning because there was no level monitoring or leak detection system installed to provide an alarm. High-value equipment was located in a vulnerable area, in a building occupied by multiple tenants from different organizations. The potential for oil to leak into the basement had been recognized, and basement space was credited to help contain a potential leak; however, no mitigation plans to protect the laser laboratory equipment had been developed.

3.10 Causal Factors Analysis

A causal factors analysis was performed in accordance with the DOE Workbook, *Conducting Accident Investigations*, Rev. 2. Causal factors are the events or conditions that produced or contributed to the occurrence of the accident and consists of direct, root and contributing causes.

The **direct cause** is the immediate event or condition that caused the oil leak.

Root causes are events or conditions that, if corrected, would prevent recurrence of this and similar accidents.

Contributing causes are events or conditions that collectively with other causes increase the likelihood of the oil leak but that individually did not cause the accident.

A summary of the Board's causal factor analysis is presented in Attachment 4, Events and Causal Factors Chart. The Board's summary of Causal Factors follows.

DIRECT CAUSE

A gasket on a tank containing insulating mineral oil failed, allowing the oil to leak onto and damage equipment in two basement laser laboratories.

ROOT CAUSES

RC 1 Physics Division management failed to implement established processes for Quality Assurance in the design, fabrication and assembly of the First Article Assembly. (CC1, CC8, CC9)

RC 2 Physics Division management failed to conduct a comprehensive process for hazard recognition and mitigation, including consideration of property protection, in accordance with established laboratory requirements. (CC2, CC3, CC4, CC5, CC7)

No.	Contributing Cause	Discussion
CC1	Physics Division did not ensure effective implementation of the Atlas project Quality Assurance requirements.	• The Rear Tri-Plate Gaskets installed on the First Article Assembly did not meet design and procurement specifications for material composition and tensile strength. • The Rear Tri-Plate Gaskets installed on the First Article Assembly did not meet shipping and installation specifications. • Design assumptions used in specifying the Rear Tri-Plate Gaskets for the First Article Assembly and Atlas machine do not accurately represent the First Article MU Tank and VTL Tank interface design and as-built conditions. • A Quality Assurance plan had been developed that was applicable to the Atlas and First Article Assembly design and construction, however, key elements of the plan were not adequately implemented, including: a. The project lacked a QA Manager and staff, b. Receipt inspections of key components were not performed, c. No self-assessments of QA implementation were performed, d. No assembly instructions were prepared and utilized for the First Article Assembly. • The Rear Tri-Plate Gaskets for the Atlas First Article Assembly were treated less rigorously than other Quality Grade Level 2 components.
CC 2	Physics Division did not ensure that the Spill Preparedness Plan developed for Atlas was properly scoped to address potential leakage during non-operational periods and protection of property.	• Booms and berms installed in Building 125 were not designed for protection of property located in the building basement. • Booms and berms installed in Building 125 were designed to contain oil in the building to prevent environmental release. • Spill Preparedness Plans prepared for the facility took credit for the basement as secondary containment for a leak to prevent leakage to the environment. • Hazard analyses and mitigation measures for the facility assumed that any leak would occur during machine operation, not when the machine was shutdown and the building was unoccupied. • The potential for property damage was not addressed in development of the Facility Safety Plan and Facility Safety Analysis. • Assumptions utilized in development of the facility Spill Preparedness Plan were less than adequate.
CC 3	Physics Division did not ensure that requirements of the Spill Preparedness Plan were effectively implemented.	• Booms and berms installed in Building 125 for spill containment did not function as intended. • The first floor of Building 125 was not completely sealed.

No.	Contributing Cause	Discussion
CC 4	Physics Division did not implement LANL requirements for the consideration of property protection and impact on co-tenants in development of the authorization basis, Facility Safety Plans and hazard analysis.	• There was no leak detection and alarm instrumentation installed on the Atlas facility or Building 125. • Hazard Analyses performed for the facility identified the potential for a leak that would overflow to the basement, but mitigation measures to protect property located in the basement were not identified and implemented. • Hazard analyses and mitigation measures for the facility assumed that any leak would occur during machine operation, not when the machine was shutdown and the building unoccupied. • The potential for property damage was not addressed in development of the Facility Safety Plan and Facility Safety Analysis. • The facility hazard analysis did not consider the potential impact of facility hazards on collocated tenants in Building 125.
CC 5	The FMU did not effectively implement their responsibility to ensure that tenant operations do not adversely affect other building tenants.	• The facility hazard analysis did not consider the potential impact of facility hazards on collocated tenants in Building 125.
CC 6	Physics Division did not develop and implement a Preventative Maintenance Program for the First Article Assembly and Atlas Machine.	• No routine program for inspection of gasket condition has been implemented for either the First Article Assembly or the Atlas machine. • The Atlas facility organization was transitioning from the construction and startup phase to operational status at the time of the accident. • Physics Division has delayed development of programs necessary to support operations, such as Preventive Maintenance and procedures until after the approval to begin operation is received.
CC 7	Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events.	• The facility Feedback and Improvement Program did not effectively apply lessons learned from precursor events. • A month prior to this accident, an event occurred at the Atlas facility that directly focused attention on potential property damage and co-tenant concerns, but response was delayed and less than adequate. • The facility did not effectively implement lessons learned from a previous property damage accident investigation at TA-35, in considering vulnerability of property located in basements. • Pre-requisites for performance of the facility Readiness Assessment were not established.
CC 8	Design specifications in drawings for the procurement of the Rear Tri-Plate Gasket were less than adequate.	• Design specifications in drawings did not contain adequate detail and clarity to ensure the procurement of the appropriate gasket. • Design specifications for the Rear Tri-Plate Gaskets are the same for the First Article Assembly and the Atlas machine.
CC 9	Design assumptions for the Rear Tri-Plate Gasket were less that adequate.	• Design assumptions used in specifying the Rear Tri-Plate Gaskets for the First Article Assembly and Atlas machine do not accurately represent the First Article MU Tank and VTL Tank interface design and as-built conditions. • Design assumptions for the Rear Tri-Plate Gaskets are the same for the First Article Assembly and the Atlas machine.

4.0 Judgements of Need

Judgments of need (JON) are managerial controls and safety measures believed necessary to prevent or minimize the probability of a recurrence. They flow from the Causal Factors and are directed at guiding managers in the development of corrective actions. Attachment 4, Events and Causal Factors Chart, summarizes the Board's causal factors and associated judgments of need.

No.	JUDGMENTS OF NEED	Related Causal Factors
JON 1	LANL needs to ensure institutional requirements for the recognition and evaluation of property and co-tenant impacts, and the resulting controls, are effectively implemented.	• Physics Division did not ensure that the Spill Preparedness Plan developed for Atlas was properly scoped to address potential leakage during non-operational periods and protection of property. (CC 2) • Physics Division did not ensure that requirements of the Spill Preparedness Plan were effectively implemented. (CC 3) • Physics Division did not implement LANL requirements requiring the consideration of property protection and impact on co-tenants in development of Facility authorization basis, Facility Safety Plans and hazard analysis. (CC 4) • The FMU did not effectively implement their responsibility to ensure that tenant operations do not adversely affect other building tenants. (CC 5) • Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events. (CC 7)
JON 2	LANL needs to develop and ensure implementation of an institutional Quality Assurance process applicable to all capital projects per DOE 0 414.1A or 10 CFR 830.120, as appropriate.	• Physics Division did not ensure effective implementation of the Atlas project Quality Assurance requirements. (CC 1) • Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events. (CC 7)
JON 3	LANL needs to ensure that facility spill preparedness, prevention, and mitigation plans provide for property protection as well as personnel and environmental protection, and that they are effectively implemented. Specific to Atlas, the plan needs to address the following: • Total inventory of oil in the Atlas facility; • Static as well as operating conditions; • Provisions for leak monitoring and inspection; • Spill response training; • Secondary containment; and • Impacts on collocated tenants.	• Physics Division did not ensure that the Spill Preparedness Plan developed for Atlas was properly scoped to address potential leakage during non-operational periods and protection of property. (CC 2) • Physics Division did not ensure that requirements of the Spill Preparedness Plan were effectively implemented. (CC 3) • Physics Division did not implement an effective Feedback and Improvement Program incorporating lessons learned from precursor events. (CC 7)

No.	JUDGMENTS OF NEED	Related Causal Factors
JON 4	LANL needs to develop a Preventive Maintenance program for the Atlas facility, including periodic inspection of gaskets using specific performance criteria.	• Physics Division did not develop and implement a Preventative Maintenance Program for the First Article Assembly and Atlas Machine. (CC 6)
JON 5	LANL needs to evaluate the implication of design, fabrication, and Quality Assurance shortcomings of the First Article Assembly and apply lessons learned to the Atlas machine.	• Design specifications in drawings for the procurement of the Rear Tri-Plate Gasket were less than adequate. (CC 8) • Design assumptions for the Rear Tri-Plate Gasket were less than adequate. (CC 9) • Physics Division did not ensure effective implementation of the Atlas project Quality Assurance requirements. (CC 1)

5.0 Board Signatures

Date: 3/15/01

Douglas M. Minnema, Ph.D., CHP, Chairperson
U. S. Department of Energy
National Nuclear Security Administration
Office of Defense Programs

Date: 3/7/01

Gene E. Runkle, Member, Trained Accident Investigator
U.S. Department of Energy
National Nuclear Security Administration
Albuquerque Operations Office

Date: 3-15-01

James Slawski, CIH, CSP, Member
U. S. Department of Energy
National Nuclear Security Administration
Office of Defense Programs

Date: 3/13/01

Larry Hinson, PE, Member
U.S. Department of Energy
Savannah River Operations Office

Date: 03/07/01

William Ortiz, Member
U.S. Department of Energy
National Nuclear Security Administration
Kirtland Area Office

6.0 Board Member, Advisors, and Staff

Chairperson	Douglas M. Minnema, DOE/NNSA/DP-45
Member	Gene E. Runkle, DOE/NNSA/AL/OSS
Member	James Slawski, DOE/NNSA/DP-45
Member	William Ortiz, DOE/NNSA/AL/KAO
Member	Larry Hinson, DOE/SRS/HLW-OD
Advisor	Ralph Fevig, PE, CSP, DOE/NNSA/AL/ISRD
Advisor	Steve Fattor, DOE/NNSA/AL/SPD
Legal Advisor	Michele Reynolds, DOE/NNSA/AL/OCC
Technical Writer	Robin Phillips, SAIC
Administrative Support	Arminda Roberts, DOE/NNSA/AL/ISRD Cynthia Doughty, SAIC Sandra Robinson, SAIC
Laboratory Observer	Phillip Thullen, Deputy Director, ES&H Division, LANL

ATTACHMENT 1

BOARD APPOINTMENT MEMORANDUM

United States Government

Department of Energy
National Nuclear Security Agency

memorandum

DATE: January 17, 2001

REPLY TO
ATTN OF: DP-3/J .Roberson/6-6895

SUBJECT: Establishment A Type B Accident Invetigation Board

TO: David Gurule, Area Manager, LAAO

Thru: Rick Glass, Manager, AL

I hereby establish a Type B Investigation Board to investigate the property damage as result of an oil leak at TA-35, Building 125, Los Alamos National Laboratory (LANL) on January 8,2001.

The following individuals are appointed to the Board in the listed capacity:

Chairperson:	Doug Minnema, DOE/HQ/DP-45
Trained Accident Investigator:	Gene Runkle, DOE/AL/OSS
Board Members:	James Slawski, DOE/HQ/DP-45 Will Oritz, DOE/AL/KAO Gene Runkle, DOE/AL/OSS Larry Hinson, DOE/SRO
Advisor:	Ralph Fevig, DOE/AL/ISRD Steve Fattor, DOE/AL/SPSD
Administrative Support:	Arminda Roberts, DOE/AL/ISRD
Tech Writer:	Robin Phillips, SAIC

The Board will be assisted by advisors and consultants and other personnel as determined by the Chairperson.

The scope of the Board's investigation will include, but not limited to, identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the oil leak and resultant property damage; developing conclusions; and determining the judgements of need that, when implemented, reduce the probability of a similar recurrence.

The investigation will be conducted in accordance With DOE Order225.1A. The scope will include the adequacy of the safety management systems including maintenance practices.

The Board will provide my office with periodic reports on the status of the investigation, but will not include any conclusions until an analysis of all the facts has been completed. The report should be completed by February 16, 2001. Any delay to this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report.

By copy of this memorandum, I am advising the supervisors of each of the board members that this assignment is full-time until the investigation and report are completed. The advisors to the Board shall assist the Board in the requested. Board Members and advisors are requested to attend an opening briefing to be held at LAAO on January 17, 200 1, at 1:00 p.m.

Ralph E. Ericksou
Acting Chief Operating Officer
for Defense Programs

cc;
M. Creedon, DP-l, HQ
T. Gioconda. DP-2, HQ
D. Crandall, DP-I0, HQ
J. Van Fleet, DPp13, HQ
D. Crowe, DP-45, HQ
D. Michaels, EH-l, HQ
S. Stadler, EH-2, HQ
D. Vernon, *W-21,* HQ
L. Kirkman, OSS, AL
D. Pellegrino, ISRD, AL
K. Zamora, LAAO
L. Hinson. SRO
J. Brown, LANL

ATTACHMENT 2

BARRIER ANALYSIS WORKSHEET

Hazard: Oil Leak		**Target: Equipment**	
What were the barriers?	How would the barrier perform?	Why did the barrier fail?	How did the barrier affect the accident?
Containment	Gaskets were used rather than bolting the transmission line to ease the alignment of the First Article MU Tank and the VTL Tank.	The gasket is more prone to failure than bolting the transmission line to the tank.	With the introduction of the gasket, a potential failure in the gasket was introduced into the design.
Gasket	The gaskets were designed to contain the oil in the First Article Assembly.	The material in the gasket did not meet design specification. The gaskets were not transported and installed as specified. The gasket design may not have been adequate.	Since the gasket did not meet the specifications, the gasket failed under the static pressure of the oil and the oil leaked causing the property damage.
Berms and booms	The berms were installed to contain a leak.	They were designed to contain oil within the building and prevent environmental impact. The berms intended to prevent oil from leaking to the basement did not work. They were not adequately designed to protect property in the basement.	Because of the failures of these berms, the oil was not contained and leaked into the basement area.
Sealed Floor	A sealed floor with effective sealing around floor penetrations would have lessened the leak into the basement.	The entire area of the first floor had not been sealed.	Since the floor was not sealed, the oil leaked through cracks, expansion joints, and floor penetrations.
Leak detection devices	A leak or excess flow device would alarm a central station warning of a possible leak and summon emergency response.	There was no leak detection device with alarm capability installed. No surveillance in lieu of a leak detection device was performed.	The leak or excess flow device could have provided earlier response to the leak.

Hazard: Oil Leak		**Target: Equipment**	
Inspection	A Preventive Maintenance program of routine inspection or replacement could have identified potential bulges or cracks that existed in the gasket.	The Atlas project was in transition from a construction and acceptance-testing phase to an operational phase. No maintenance program for the gaskets had been developed. The gasket was designed to last the entire 10-year anticipated life of Atlas.	Visual inspection of the gaskets may have identified the incipient cracks so that the oil could have been drained and the gasket replaced.
Hazard Control Plan, Spill Prevention Plan, and Facility Hazard Analysis	These plans and analysis would identify the potential hazard and associated control to prevent the leak.	Identified potential for spill to basement and took credit for basement as secondary containment. Developed Spill Preparedness Plan to limit consequences of spills and did not implement. Considered only operational conditions, not leak from idle machine. Did not evaluate property damage as a consequence from a leak to basement.	The controls identified in the May 1999 Spill Preparedness Plan could have mitigated the accident.
Quality Assurance	An effective QA program may have detected the incorrect gasket and installation.	There was no acceptance testing of the gasket. No installation instructions for the gasket, therefore it was not discovered that the gasket and its installation did not meet design specifications. No acceptance inspection of First Article Assembly Tanks (chamfered & rounded edges).	Because the gasket and its installation did not meet design specifications, the gasket failed and the leak resulted.

Hazard: Oil Leak		**Target: Equipment**	
Avoidance	Keeping high-value equipment out of the basement would have lessened the property damage. Draining tanks when not in use would have minimized potential hazard.	Co-tenants & property protection were not considered in development of safety plans, safety analysis, or associated controls.	Safe work practices LIR guidance to develop controls for property protection was not implemented.
Oversight	Oversight organization would ensure that LANL and Atlas met DOE and institutional expectations.	Oversight was focused on Budget & Schedule.	With emphasis on Budget and Schedule, weakness in QA program was not recognized.
Feedback and Improvement	Facility would incorporate lessons learned from previous events and operating experience to improve Facility activities.	Lessons learned from November 2000 event and other precursors were not incorporated into Facility processes.	November 2000 event focused attention to potential property damage in the basement area and co-tenant concerns and actions were delayed.

ATTACHMENT 3

CHANGE ANALYSIS WORKSHEET

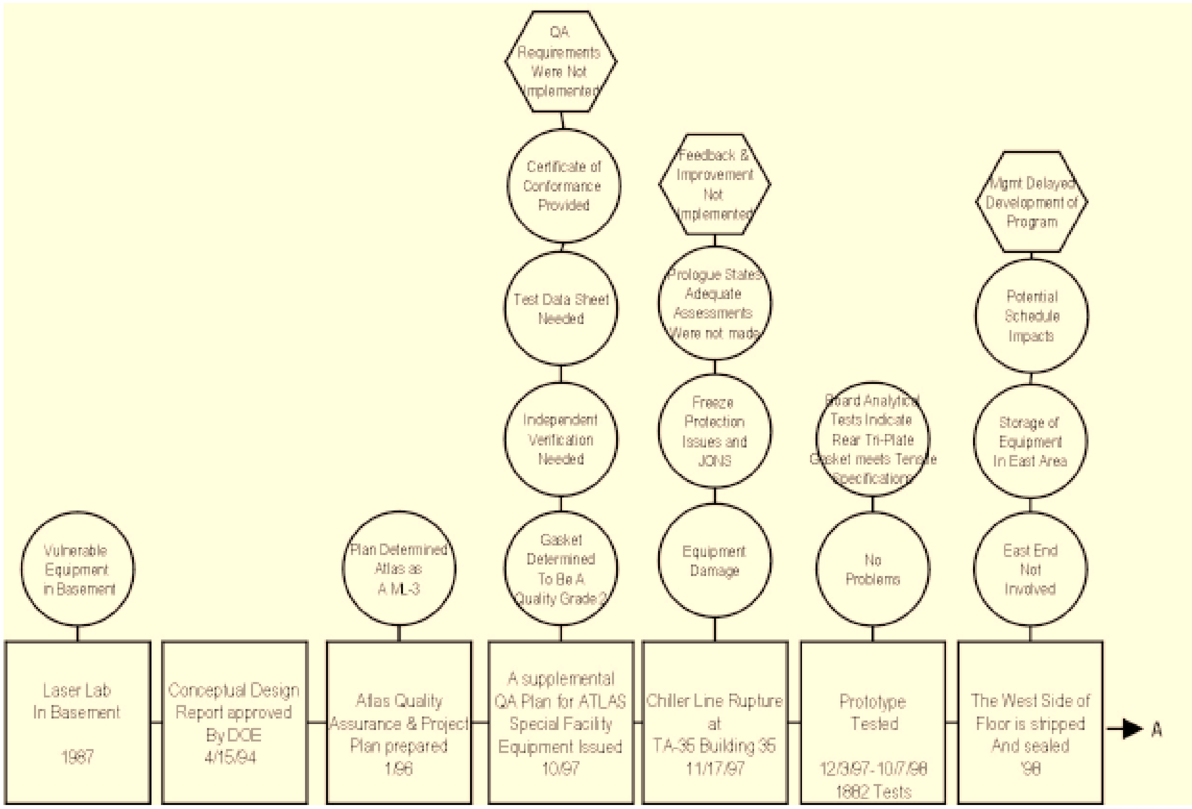
Accident Situation	Prior, Ideal, or Accident-Free Situation	Difference	Evaluation of Effect
Non-conforming gasket installed on First Article Assembly.	Ideal - Proper gasket installed.	Improper gasket had insufficient resistance to stress.	Improper gasket failed, resulting in oil leak that caused accident.
Hazard of oil leaking from Atlas machine to basement was recognized but not adequately mitigated. Hazard Analysis did not address property damage.	Ideal - Hazards Analysis & Mitigation Process identifies and develops mitigation for identified hazards, including potential for property damage.	Actions were not developed and implemented to protect laser equipment in basement. Contin-gencies for an unattended machine were developed in May 1999 Spill Preparedness Plan that could have limited damage had they been implemented.	When leak occurred, there were no effective barriers to prevent oil from reaching laser equipment in basement.
Spill Preparedness Plan took credit for space in basement as secondary containment to assure that an oil leak would be contained within the building and have no environmental impact.	Ideal - Spill Preparedness Plan would address protection of laser equipment in basement.	November 2000 Revision of Spill Preparedness Plan did not address protection of equipment in basement, nor did it propose methods to limit leakage to basement.	When oil leak occurred, there was no identified method to prevent oil from impacting laser equipment in basement.
No Preventive Maintenance program including inspection of the gaskets had been implemented.	Ideal – Implemented Preventive Maintenance program that required periodic inspection of gaskets.	No Preventive Maintenance or inspection process existed.	Inspection of the gaskets would have likely identified the deteriora-tion that had occurred in the gaskets prior to failure.

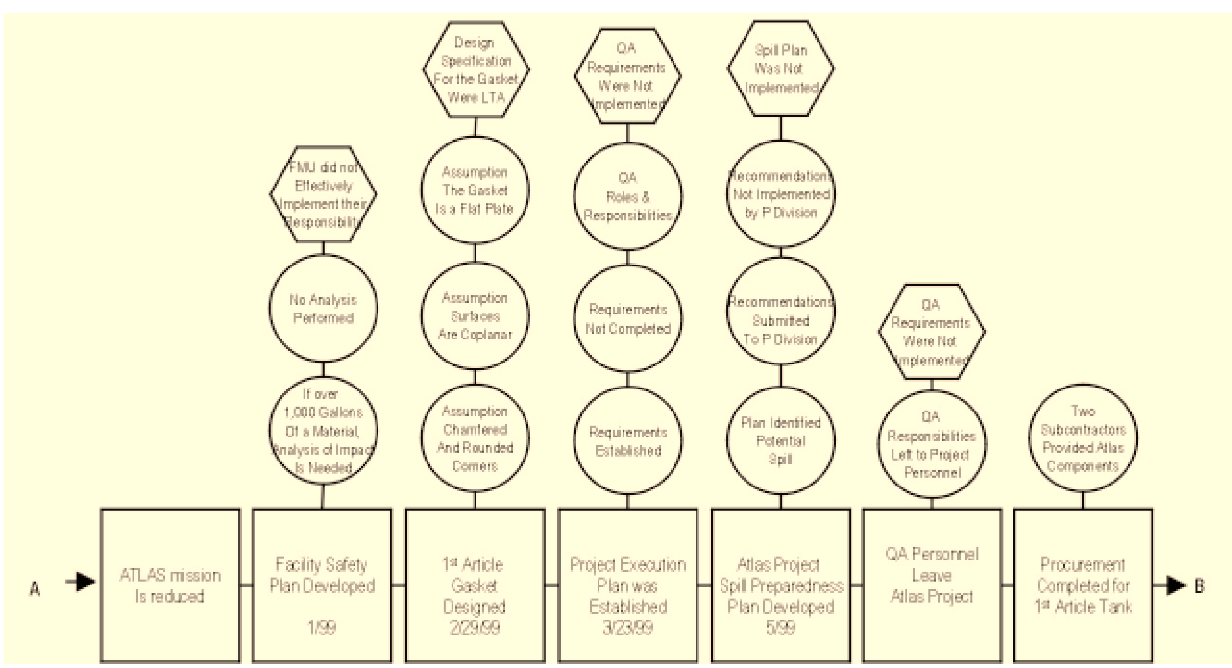
Accident Situation	Prior, Ideal, or Accident-Free Situation	Difference	Evaluation of Effect
Quality Assurance Program not fully implemented for First Article Assembly.	Ideal – Quality Assurance Program fully implemented.	Receipt inspection of gaskets and quality verification of installation not performed Degree of rigor applied to First Article Assembly was not commensurate with Quality Level 2 significance assigned by Designer.	Consistent Quality Assurance Program implementation (such as rigor applied to high-tech electrical components) would have identified the non-conforming gasket material.
Laboratory containing valuable laser equipment was located in a vulnerable location, under the Atlas machine, where the potential for an oil leak existed.	Ideal – High value equipment would not be located in a vulnerable area. Lessons learned from previous Type B property damage Accident Investigation implemented.	Laboratory containing laser equipment remained in a vulnerable location in the basement under Atlas, despite the concern that an oil leak could impact the laboratory.	When oil leak occurred, the laser equipment was in the leak path and was impacted by the leaking oil.
The flanges of the First Article MU Tank and VTL Tank were out of alignment by .35 to .85 inches.	Ideal – Flanges of First Article MU Tank and VTL Tank that were connected by the gasket would have been aligned, as assumed in design calculations.	Design of gasket did not account for any additional stress caused by misalignment of gasket.	Stress on gasket was not accurately accounted for by design.
Facility assumed that any oil leak would occur during machine operation when facility was occupied and personnel available to respond.	Ideal – Potential for oil leak would be evaluated both for periods of operation and non-operations.	Leak occurred over weekend when no operations were in progress and building was unoccupied.	No one was available to detect leak and initiate response to stop leak and protect vulnerable equipment.
Poor coordination between multiple tenants in same building from different organizations.	Ideal – Fully coordinated consideration of all building tenants and aggregate hazards.	Control of aggregate hazards from all tenant's activities was not effective.	Concerns over potential leak that could damage laser laboratory in basement were not fully considered and adequately addressed by primary tenant group.
Unsealed cracks and penetrations existed in the building floor in the area of the First Article Assembly.	Ideal – The entire building floor would have been sealed.	LANL sealed floor directly under Atlas machine but delayed sealing remainder of floor due to schedule considerations.	Building floor directly over laser laboratory was not sealed, allowing oil leakage from the operating floor to the basement.

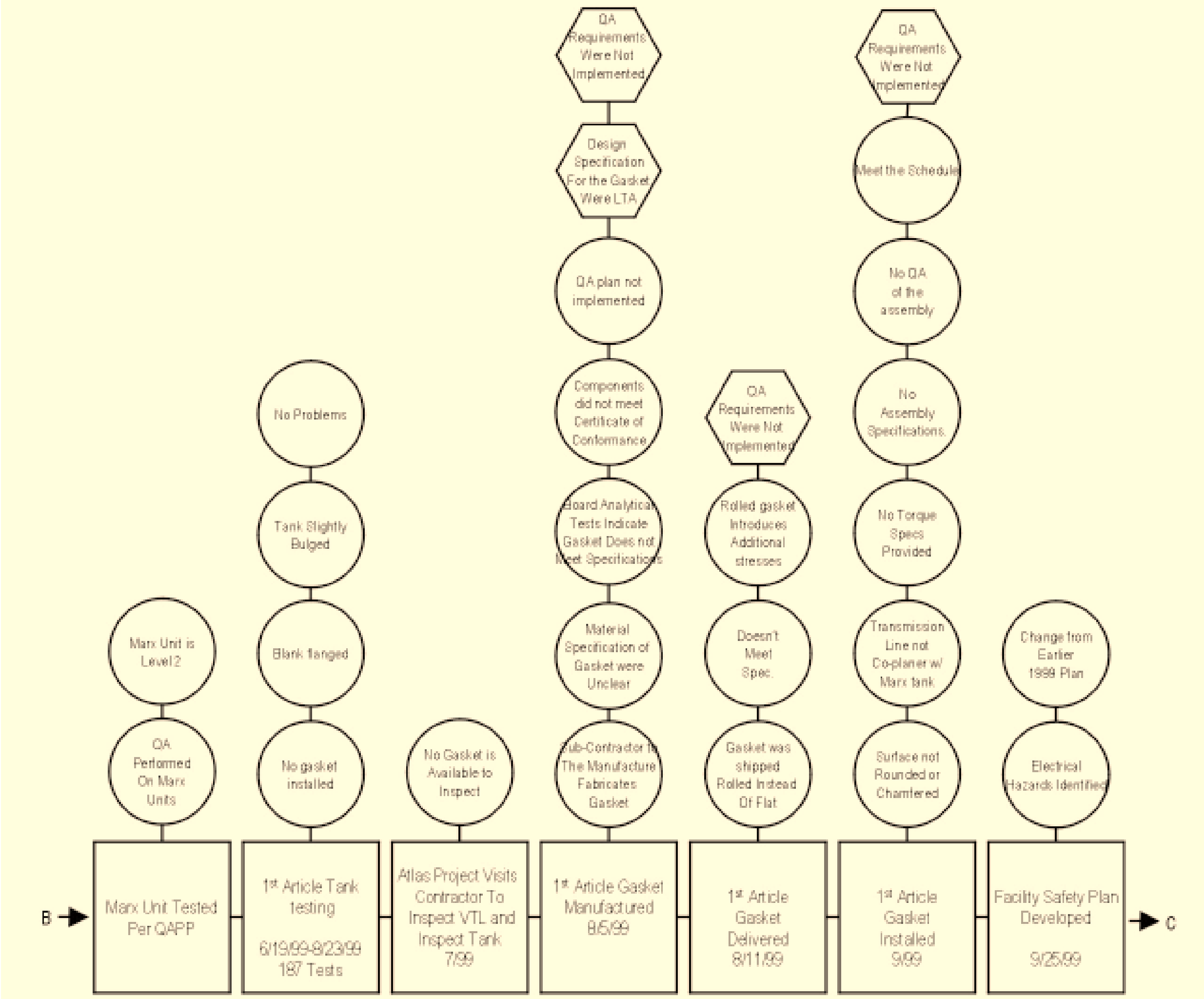
Accident Situation	Prior, Ideal, or Accident-Free Situation	Difference	Evaluation of Effect
The building, containing ~ 170,000 gallons of oil, contained in the Atlas machine and First Article Assembly had no leakage detection and alarm capability.	Ideal – A leak detection system to monitor for leakage and provide alarm capability to a monitoring station at all times would have been incorporated into system design.	No provision for detection of changes in level or leakage from the oil containment vessels. No alarm capability for leaking tanks.	The leak from the First Article Assembly occurred at some unidentified time over a weekend and was not discovered until people arrived at work on Monday morning. There was no early warning system that could have permitted personnel to respond and mitigate the leak.
Atlas facility was in transition from construction and testing to operations.	Ideal – Project Execution Plan prerequisites for CD-4 complete, including: O & M Manual SA and Hazard Control Plan	O & M Manual not complete HCP & SA does not consider unmonitored operations.	No inspection program in place. Unrecognized “static” hazard.

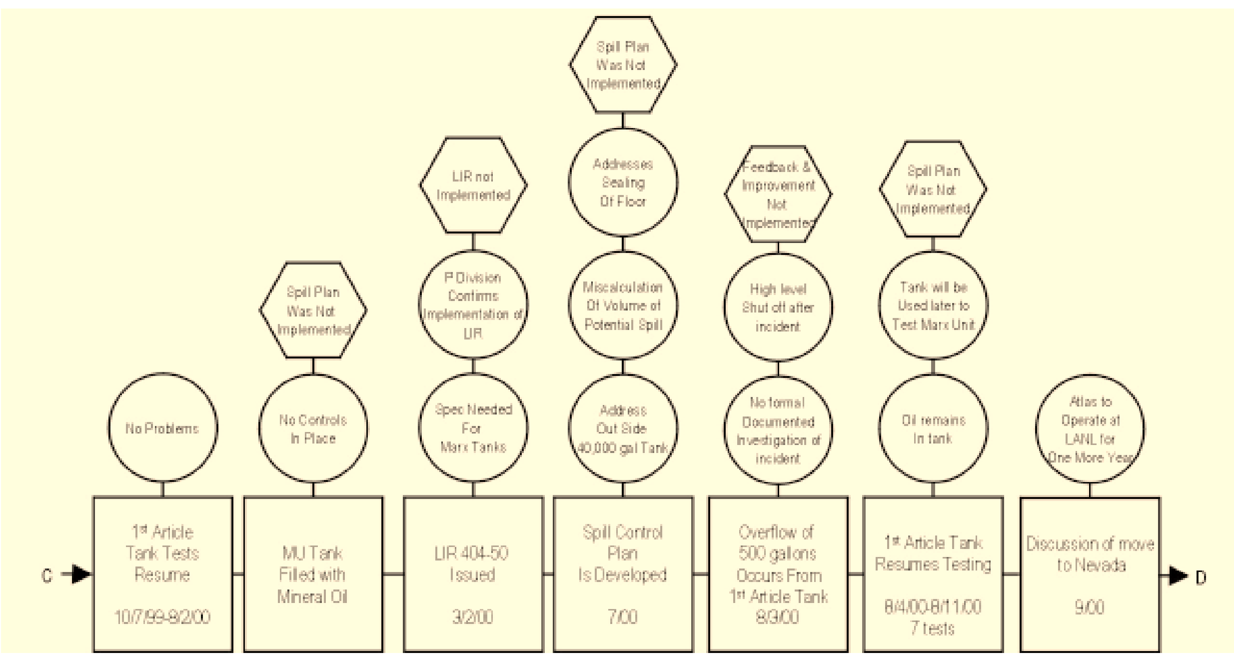
ATTACHMENT 4

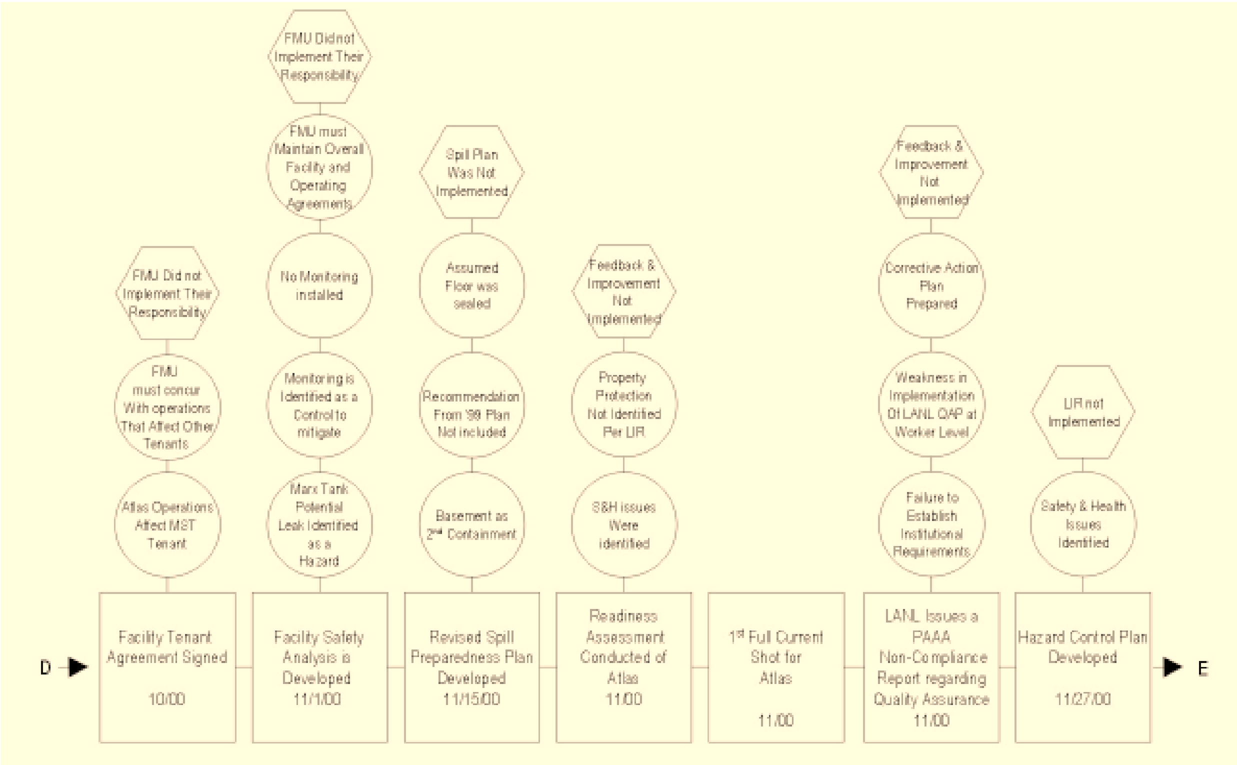
EVENTS AND CAUSAL FACTORS CHART

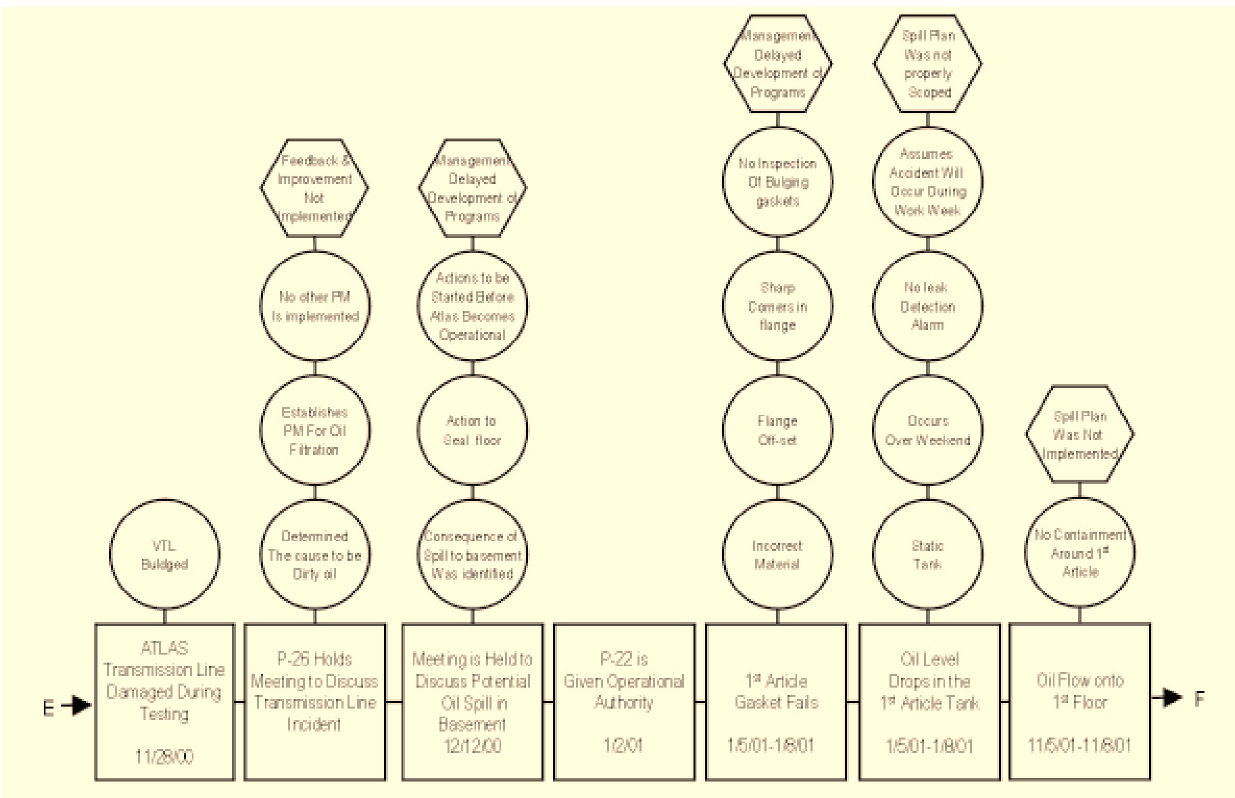


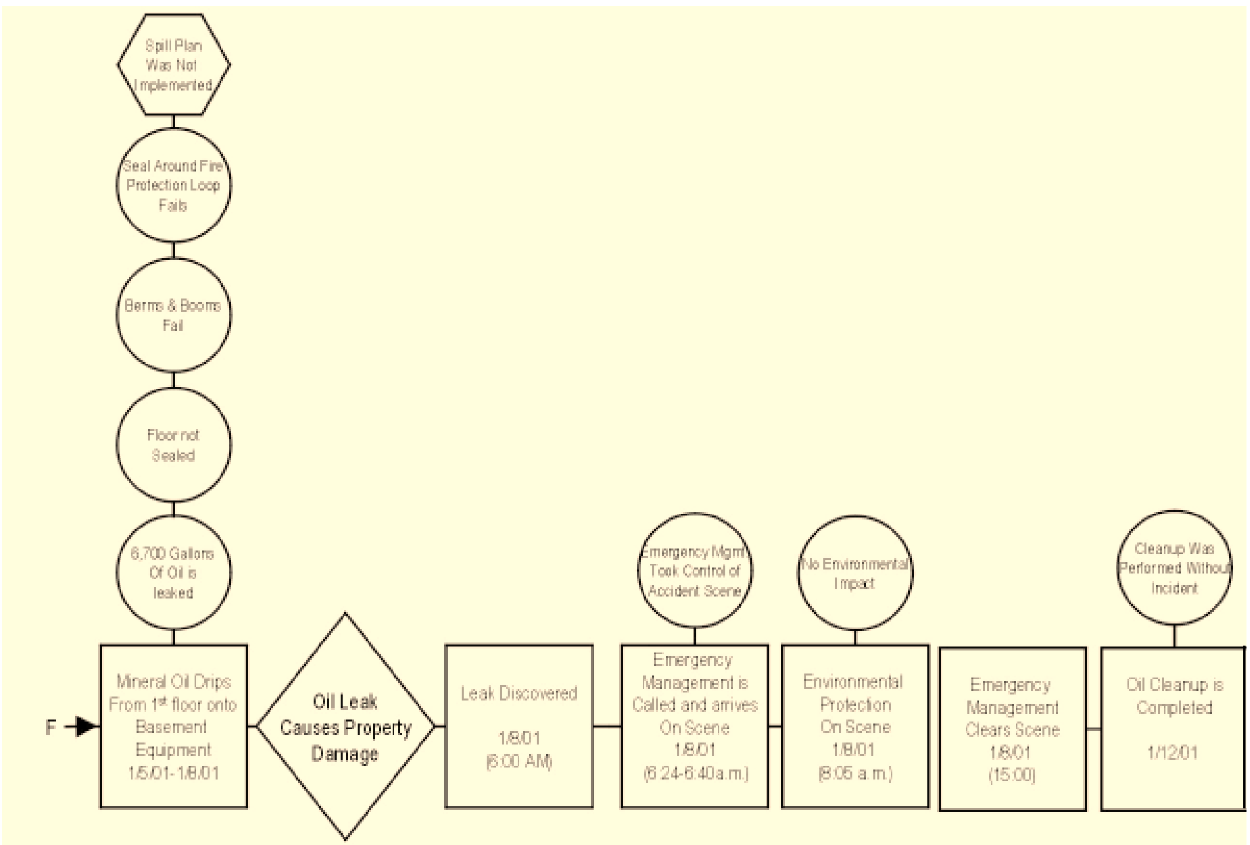



B
Marx Unit Tested Per QAPP
QA Performed On Marx Units
Marx Unit is Level 2
1st Article Tank testing 6/19/99-8/23/99 187 Tests
No gasket installed
Blank flanged
Tank Slightly Bulged
No Problems
Atlas Project Visits Contractor To Inspect VTL and Inspect Tank 7/99
No Gasket is Available to Inspect
1st Article Gasket Manufactured 8/5/99
Sub-Contractor to The Manufacturer Fabricates Gasket
Material Specification of Gasket were Unclear
Board Analytical Tests Indicate Gasket Does not Meet Specifications
Components did not meet Certificate of Conformance
QA plan not implemented
Design Specification For the Gasket Were LTA
QA Requirements Were Not Implemented
1st Article Gasket Delivered 8/11/99
Gasket was shipped Rolled Instead Of Flat
Doesn't Meet Spec.
Rolled gasket Introduces Additional stresses
QA Requirements Were Not Implemented
1st Article Gasket Installed 9/99
Surface not Rounded or Chamfered
Transmission Line not Co-planer w/ Marx tank
No Torque Specs Provided
No Assembly Specifications.
No QA of the assembly
Meet the Schedule
QA Requirements Were Not Implemented
Facility Safety Plan Developed 9/25/99
Electrical Hazards Identified
Change from Earlier 1999 Plan
C


C
1st Article Tank Tests Resume 10/7/99-8/2/00
No Problems
MU Tank Filled with Mineral Oil
No Controls In Place
Spill Plan Was Not Implemented
LIR 404-50 Issued 3/2/00
Spec Needed For Marx Tanks
P Division Confirms Implementation of LIR
LIR not Implemented
Spill Control Plan Is Developed 7/00
Address Out Side 40,000 gal Tank
Miscalculation Of Volume of Potential Spill
Addresses Sealing Of Floor
Spill Plan Was Not Implemented
Overflow of 500 gallons Occurs From 1st Article Tank 8/3/00
No formal Documented Investigation of incident
High level Shut off after incident
Feedback & Improvement Not Implemented
1st Article Tank Resumes Testing 8/4/00-8/11/00 7 tests
Oil remains In tank
Tank will be Used later to Test Marx Unit
Spill Plan Was Not Implemented
Discussion of move to Nevada 9/00
Atlas to Operate at LANL for One More Year
D


FMU Did not Implement Their Responsibility
FMU must Maintain Overall Facility and Operating Agreements
Spill Plan Was Not Implemented
Feedback & Improvement Not Implemented
FMU Did not Implement Their Responsibility
No Monitoring installed
Assumed Floor was sealed
Feedback & Improvement Not Implemented
Corrective Action Plan Prepared
FMU must concur With operations That Affect Other Tenants
Monitoring is Identified as a Control to mitigate
Recommendation From '99 Plan Not included
Property Protection Not Identified Per UR
Weakness in Implementation Of LANL QAP at Worker Level
UR not Implemented
Atlas Operations Affect MST Tenant
Marx Tank Potential Leak Identified as a Hazard
Basement as 2nd Containment
S&H issues Were identified
Failure to Establish Institutional Requirements
Safety & Health Issues Identified
D
Facility Tenant Agreement Signed 10/00
Facility Safety Analysis is Developed 11/1/00
Revised Spill Preparedness Plan Developed 11/15/00
Readiness Assessment Conducted of Atlas 11/00
1st Full Current Shot for Atlas 11/00
LANL Issues a PAAA Non-Compliance Report regarding Quality Assurance 11/00
Hazard Control Plan Developed 11/27/00
E


Management Delayed Development of Programs
Spill Plan Was not properly Scoped
Feedback & Improvement Not Implemented
Management Delayed Development of Programs
No Inspection Of Bulging gaskets
Assumes Accident Will Occur During Work Week
No other PM Is implemented
Actions to be Started Before Atlas Becomes Operational
Sharp Corners in flange
No leak Detection Alarm
Establishes PM For Oil Filtration
Action to Seal floor
Flange Off-set
Occurs Over Weekend
Spill Plan Was Not Implemented
VTL Bulged
Determined The cause to be Dirty oil
Consequence of Spill to basement Was identified
Incorrect Material
Static Tank
No Containment Around 1st Article
E
ATLAS Transmission Line Damaged During Testing 11/28/00
P-26 Holds Meeting to Discuss Transmission Line Incident
Meeting is Held to Discuss Potential Oil Spill in Basement 12/12/00
P-22 is Given Operational Authority 1/2/01
1st Article Gasket Fails 1/5/01-1/8/01
Oil Level Drops in the 1st Article Tank 1/5/01-1/8/01
Oil Flow onto 1st Floor 11/5/01-11/8/01
F


Spill Plan Was Not Implemented
Seal Around Fire Protection Loop Fails
Berms & Booms Fail
Floor not Sealed
6,700 Gallons Of Oil is leaked
F
Mineral Oil Drips From 1st floor onto Basement Equipment 1/5/01- 1/8/01
Oil Leak Causes Property Damage
Leak Discovered 1/8/01 (6:00 AM)
Emergency Mgmt Took Control of Accident Scene
Emergency Management is Called and arrives On Scene 1/8/01 (6:24-6:40 a.m.)
No Environmental Impact
Environmental Protection On Scene 1/8/01 (8:05 a.m.)
Emergency Management Clears Scene 1/8/01 (15:00)
Cleanup Was Performed Without Incident
Oil Cleanup is Completed 1/12/01

ACRONYMNS AND TERMINOLOGY

AL	Albuquerque Operations Office
AST	Above-ground Storage Tank
CFR	Code of Federal Regulations
COC	Certificates of Compliance
CD-4	Critical Decision 4
DEAR	Department of Energy Acquisition Regulation
DOE	Department of Energy
DX	Dynamic Experimentation Division
DX-6	Machine Science Technology Group
EH	Office of Environment, Safety and Health
ES&H	Environment, Safety and Health
FM	Facility Manager
FMU	Facility Management Unit
FR	Facility Representative
FSP	Facility Safety Plan
HEDH	High Energy Density Hydrodynamics
HV	high voltage
JON	Judgment of Need
LAAO	Los Alamos Area Office
LANL	Los Alamos National Laboratory
LIR	Laboratory Implementing Requirements
MA	Mega-ampere (one million amperes)
M&O	Management and Operating
MST-10	Condensed Matter and Thermal Physics Group
MST	Materials Science and Technology Division
MU	Maintenance Unit
OH	hydroxide
OSHA	Occupational Safety and Health Administration
P	Physics Division
P-22	Hydrodynamics and X-Ray Physics Group
P-26	Atlas Construction Group
PAAA	Price-Anderson Amendments Act of 1988
PM	Preventive Maintenance
QAPP	Quality Assurance Program Plan
RA	Readiness Assessment
SPCC	Spill Prevention Control and Countermeasures
TA	Technical Area
UC	University of California
VTL	Vertical Transmission Line