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DOE/OR-8

EVALUATION OF POTENTIAL FOR INCIDENTS HAVING HEALTH OR SAFETY IMPACT

Approved for Release to the Public by:

11-16-95

Timothy W. Joseph, Ph.D. Date
DOE Health Study Agreement COR

JUNE 1985

This document has been reviewed for classification and has been determined to be UNCLASSIFIED.

K-25 Site ADC Signature ORNL

Oct. 30, 1995
Date

DOE/OR 860

EVALUATION OF POTENTIAL FOR INCIDENTS HAVING HEALTH OR SAFETY IMPACT

JUNE 1985

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ACRONYMS

BLEVE	Boiling Liquid Expanding Vapor Explosion
CPAF	Cost Plus Award Fee
CUP	Cascade Uprating Program
DCS	Distributed Control System
DEM	Department of Environmental Management
DOE	Department of Energy
EPO	Environmental Protection Officer
FMPC	Feed Materials Production Center
FSAR	Final Safety Analysis Report
GAT	Goodyear Atomic Corporation
HHIRF	Holifield Heavy Ion Research Facility
HMMC	Hazardous Materials Management and Control
HRLAF	High Radiation Level Analytical Facility
IDLH	Immediately Dangerous to Life or Health
LEL	Lower Explosive Limit
LSS	Laboratory Shift Supervisor
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
OSR	Operational Safety Requirements
PEL	Permissible Exposure Limit
PGDP	Paducah Gaseous Diffusion Plant
PPEM	Paducah Plant Emergency Manual
PSS	Plant Shift Superintendent
RCW	Recirculating Water
RORC	Reactor Operations Review Committee
SAR	Safety Analysis Report
TLV	Threshold Limit Value

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Operation of the large complex Department of Energy (DOE) facilities at Fernald, Ohio; Portsmouth, Ohio; Oak Ridge, Tennessee; and Paducah, Kentucky, requires the use of materials that, if not contained, have the potential for adverse health effects to humans. Some of these materials (e.g., uranium hexafluoride, hydrogen fluoride, and ammonia) are involved directly in operating processes. Others (e.g., chlorine, natural gas, and gasoline) are used in auxiliary support processes. However, throughout the lifetime of these facilities, DOE, its predecessors, and its contractors have given high priority to the safety of employees and the general public. As a result, operators of the facilities have achieved outstanding safety performance records over many years. In more recent years, the safety of employees, the public, and the environment has been elevated to a position of first priority.

About 1977, the DOE initiated a highly structured Safety Analysis Report (SAR) program for nuclear-related work that is now mature and is being successfully used to assess risks and to evaluate the adequacy of safety and detection systems, administrative controls, emergency response planning, and other actions designed to minimize the likelihood of hazardous events and to effectively respond to adverse situations should they occur. The SAR program, however, does not include standard industrial risks as might be encountered in nonnuclear industries that can be controlled to low levels by strict adherence to industrial safety standards.

Recognizing that extensive reviews have already been performed for many operations, the survey addressed by this report was undertaken at the initiative of Martin Marietta Energy Systems, Inc., following the accident in Bhopal, India. At the request of the DOE, personnel at the facilities operated by NLO, Inc., and Goodyear Atomic Corporation (GAT) were asked to participate. The objectives were to (1) collectively identify and reexamine potential incidents that could cause large numbers of casualties, (2) evaluate the adequacy of existing prevention/response actions, and (3) identify improvements where possible.

Although this evaluation can be considered more analogous to a hazardous materials survey than to a systems analysis of the type necessary to identify accidents comparable to the one that occurred at Bhopal, its findings--along with those resulting from the SAR program--reaffirm the conclusion that the potential for an accident with consequences similar to those at Bhopal is essentially non-existent.

The survey was made by contractor personnel at each facility under the leadership of a site representative who conducted the reviews that form the basis for this report. Evaluations were generally qualitative and based on a best-judgement approach by knowledgeable personnel representing operating, technical, safety, environmental, and emergency control/response disciplines. At each facility a review panel was formed; and this group of advisory personnel, appointed by the facility manager or laboratory director, reviewed, commented on, and challenged the team's findings.

Primary concern was given to large-impact situations whereby a single event or a series of events could be reasonably postulated to cause five or more fatalities. Attention was also focused on materials, systems, or facilities outside the formal SAR program--specifically, standard industrial hazards having very serious consequences, even though the probabilities of occurrences are low. It was further recognized that a single, manageable event occurring with or following other events might progress into a much more serious situation.

The hazard level, probability, and risk matrix concept developed for the safety analysis and review system (OR 5481.1B) was used as a general guide for this survey. However, strict adherence to this order was not required, and contractor personnel exercised considerable flexibility in conducting and presenting the site reviews. An explanation of the risk concept from OR 5481.1B is presented in Appendix A. Tables prepared for the site reviews were intended to address specific site concerns as perceived by the representatives and review panels and were therefore not intended to be uniform from site to site. However, to provide reasonable consistency among the potential hazards tables presented in the site reviews, the tables were edited utilizing the consequences, probability range, and risk level definitions from OR 5481.1B.

In this survey, a deliberate effort was made to address real hazards having multiple-fatality potential as opposed to material releases or events that could cause perceived problems or have a public relations impact.

Seismic considerations addressed the same events as were used in the SARs. Based on a seismic activity study, seismic events for each facility were defined that would be expected to have a ten percent probability of exceedence during the remaining plant lifetimes, which corresponds to a 237-year return period. The resulting evaluation-base earthquakes were determined to be those producing ground level accelerations of 0.05 g for Portsmouth and Fernald, 0.08 g for Oak Ridge, and 0.18 g for Paducah. The facilities were evaluated at these levels.

For the gaseous diffusion plants, representatives used operating conditions close to those currently experienced or projected, and thus some differences in analyses exist.

1.2 FINDINGS

The conclusions from this survey were based on the facility reviews and on extensive group discussions with both the site representatives and other personnel at each facility and are listed below:

1. Despite the outstanding safety records that have been achieved, situations exist throughout the facilities surveyed that have the potential to cause serious injury or death to employees who are either working on a specific job or are within the immediate area. These situations include moving and connecting gas cylinders, electrical switching and maintenance operations, maintenance and operation of heavy or rotating equipment, operations involving toxic or corrosive chemicals, and other generally recognized industrial hazards. Because of the effective use of safeguards, however, such situations were not deemed to have a serious potential for multiple fatalities.

2. Existing safety, environmental, and risk analyses have been very effective in identifying concerns and prompting actions to reduce risk to human life. Given the size and complexity of these facilities, there are relatively few materials or situations at the sites for which credible scenarios for multiple fatalities were developed.

3. This survey indicates, almost invariably, that the lower the quantity of material on hand, the lower the risk of large, serious releases or events. Attention should be given to formally adopting and using an optimum working inventory* philosophy for all potentially hazardous materials.

4. Current surveillance and detection systems provide a high probability that large releases or major events will be quickly detected. Most instrumented detection systems for chemical releases, however, are specific to recognized materials and discharge points; hence, a lower level of confidence exists that releases of unusual materials would be detected quickly.

5. Several materials or situations present potential hazards of general concern:

   a. Anhydrous hydrogen fluoride, chlorine, and ammonia are present in sufficiently large quantities to present significant hazards in the event of catastrophic tank or cylinder failures.

   b. Uranium hexafluoride is utilized at all of the gaseous diffusion plants, and the rupture of a cylinder containing liquid UF_6 could have severe impact. [Other situations, especially if the cascades were at Cascade Uprating Program (CUP) conditions, could lead to the release of UF_6.] This concern is being addressed through the SAR program; however, employee awareness of actions to be taken in the event of a large UF_6 release should be given greater attention. Due to the somewhat isolated locations of the facilities and their large areas, on-site consequences of materials are of greatest concern. However, studies of dispersion models indicate that the combination of worst weather conditions and large releases has the potential for significant off-site impact.

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*Optimum working inventory is defined as the minimum feasible inventory considering operational requirements and resulting frequency of material transfer activities. For example, a working inventory that is too low could increase the risk of a release by requiring excessive cylinder changeout or material transfer operations.

c. Gaseous and liquid fuels, as well as other hazardous materials, are widely used and transported throughout all of the facilities. Leakage or spills of these materials present the potential for impacting relatively large numbers of employees. These situations represent common industrial hazards and are not addressed through the SAR program.

d. The stockpile of UF_6 cylinders, filled before the rigid application of administrative controls (about 1975) to ensure that cylinders are free of hydrocarbon oil, represents an unknown risk in the future when the contents of these cylinders are heated to the liquid phase for transfer or processing.

6. The impact of seismic events on the reactors at the Oak Ridge National Laboratory (ORNL) was not included in the original SARs, and there appears to be no firm schedule for updating the SARs to include seismic evaluations although such actions are planned for the reactors that are expected to remain in operation. The impact of seismic events on stored enriched uranium at the Y-12 Plant is receiving increased attention. Corrective actions are planned, and engineering design is currently in progress.

7. Much of the emergency planning at the facilities presupposes that mass evacuation would not be the correct action if large material releases were to occur. However, the degree to which employees would correctly and rapidly respond to instructions to remain indoors, secure buildings, etc. has not been determined through large-scale drills. Additionally, whether the large-scale evacuation of employees beyond the facility parking lots could be effectively accomplished is unknown, should such action be necessary.

8. Emergency access to plant public address systems is limited to intrafacility buildings that are relatively close together. No remote tie-in capability exists at some facilities.

9. Large numbers of visitors who are unfamiliar with warning signals and emergency response procedures present a unique concern, especially at ORNL.

10. Biological work (ORNL at Y-12) was assessed by the ORNL review committee as posing no risk within the context of the multiple fatality criteria used in this survey.

11. Events that develop at slow or moderate rates can likely be managed by facility personnel so as to avoid large-scale, multiple-person impacts. Rapidly developing events, simultaneous events, or a rapid series of events present the most serious situations. In this sense, seismic or catastrophic failures that could initiate significant structural failures or multiple events have the most serious consequences, although the probability of occurrence may be very low.

1.3 RECOMMENDATIONS

This survey resulted in fresh and comprehensive internal reviews of each facility. Follow-up actions by the individual facilities should be taken to reduce risks by disposing of unused materials and reducing inventories when possible.

Additionally, the following recommendations are made:

1. An optimum working inventory policy should be established and seriously implemented for all potentially hazardous materials. Such a policy has the potential for cost control benefits as well as for reducing the impact if a material release occurs. Special consideration should be given to scheduled reviews and inspections to ensure that unused and unnecessary inventories, however small, of hazardous materials are not retained. When required, contractor policies and procedures should be revised to formally include this action.

2. The present survey reflects a material and inventory evaluation at a single time. Programs at all of the facilities are dynamic and variable. In addition to routine hazardous materials management activities, each facility should maintain a current listing of materials where releases have the potential for multiple (five or more) fatalities. A report listing the materials, inventory quantities, and changes in the inventories from the last review should be provided to senior management annually.

3. Plans for protection of the facility population and the public in the event of major material releases should be reevaluated. The need for enhanced employee awareness or for conducting emergency drills involving employees should be evaluated by each facility. Specific attention should be given to plans to ensure visitors' safety in the event of a serious event. Assurance of a functional and available public address system should be given additional attention.

4. Facility emergency drills and training exercises should be structured to provide greater training and instruction for the general facility population and to include some simulated situations involving multiple and rapidly progressing events. The rate-of-development component (e.g., a very dense and rapidly expanding cloud of toxic gas) should be given greater attention in emergency response training.

5. Each facility should give deliberate attention to managing intrafacility transfers of gaseous and liquid fuels (and other hazardous materials) so as to minimize risk to the facility population.

2. SITE REVIEWS

PORTSMOUTH URANIUM ENRICHMENT FACILITY

Facility Representative

C. H. Hutchings

Review Panel

E. R. Wagner
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B. L. Williamson

2.1 PORTSMOUTH URANIUM ENRICHMENT FACILITIES

2.1.1 Introduction

The Portsmouth Uranium Enrichment Facilities are designed and operated in accord with established regulatory and industry standards to ensure the safety of plant personnel and the surrounding populace. Although a number of hazardous materials are utilized in several plant processes, these materials--both radioactive and nonradioactive--are safely contained during normal operations. However, as with any operation utilizing hazardous materials, the potential for accidents that result in the release of these materials (with the possibility of harm to humans or the environment) is a reality. In recognition of this potential, a number of studies have been performed over the past several years to identify the potential accident scenarios, the potential consequences, and the associated risks.

The Environmental Impact Statements (ERDA-1555 and ERDA-1549) examined the effects of plant operations on the environment and the public. A number of credible accidents that could cause the release of UF_6, F_2, Cl_2, SO_2, and HF are described and analyzed. These studies were performed to assess the effects of accidental releases of hazardous materials upon the plant environs. However, the accident scenarios were developed on the basis of professional judgement and experience in operating a uranium enrichment plant. In the aftermath of Three Mile Island, it became clear that a more rigorous approach was required for assessing the probability, risks, and potential consequences of accidents. As a result, the Safety Analysis Program was initiated.

The Safety Analysis Program provided, in part, for the thorough analysis of the probabilities for and potential consequences of accidents at the Portsmouth Uranium Enrichment Facilities. The consequences examined were far more inclusive than those considered in the Environmental Impact Statements and included effects upon plant employees, the public, and the physical plant. These studies are documented in the SARs for the facilities. In addition to evaluating potential accidents from operational errors and equipment malfunctions, the studies included analyses of the potential effects of natural phenomena (e.g., seismic events, floods, high winds, and tornadoes). Potential hazards having significant health or safety impact are listed in Table 2.1.

2.1.2 Potential Hazards

Although the above-mentioned studies were conducted rigorously within the prescribed project scope, the question arose as to whether other accident scenarios outside the scope of the Final SAR (FSAR) should be considered if they postulated more serious consequences (e.g., multiple fatalities). In response to this concern, a task force was appointed to evaluate and assess the potential for such accidents. As part of its activity, the task force reviewed existing site studies related to plant safety and the health effects of the hazardous materials used.

Table 2.1. Portsmouth Uranium Enrichment Facility potential hazards having significant health or safety impact

System/ material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative	Consequence level	Probability (per year)	Risk level
Uranium hexafluoride	28,000 lb	Dropping and rupturing a cylinder inside the building	Administrative controls Design features Employee training Operating procedures Inspection of cylinders Emergency response	Medium	10^{-3} to 10^{-2}	Low
	28,000 lb	Dropping and rupturing a cylinder outside the building	Administrative controls Design features Employee training Operating procedures Inspection of cylinders Emergency response	Medium	10^{-3} to 10^{-2}	Low
High-assay UF_6 sampling area	460 lb	12-in. cylinder vapor release	Administrative controls Design features Employee training Operating procedures Emergency response	Low	$<10^{-2}$	Ext. low
	55 lb	5-in. cylinder vapor release	Administrative controls Design features Employee training Operating procedures Emergency response	Low	$<10^{-3}$	Ext. low
Anhydrous hydrogen fluoride	1,260 lb	Release at X-342A HF vaporizer	Design features Equipment inspection Employee training Operating procedures Emergency response	Low	$<10^{-3}$	Ext. low
	Maximum spill from HF tank, 30,000 lb	Rupture of two main tanks	Design features Equipment inspection Employee training Emergency response	High	Unknown (could involve events outside the scope of the FSAR)	Unknown
Chlorine	2,000 lb	Failure of 1-ton cylinder valve Failure of connector Knock off cylinder valve during cylinder changeout	Employee training Operating procedures Equipment inspection Emergency response	Medium	$<10^{-3}$	Ext. low

Table 2.1. (continued)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative	Consequence level	Probability (per year)	Risk level
Chlorine trifluoride	2,000 lb	Leaking 1-ton cylinder valve Knock off cylinder valve during cylinder changeout	Employee training Operating procedures Equipment inspection Emergency response	Medium	$<10^{-3}$	Ext. low
Ammonia	300 lb	Manifold failure	Employee training Operating procedures Emergency response	Medium	$<10^{-3}$	Ext. low
Fluorine	240 lb	Rupture of outside line	Employee training Operating procedures Emergency response	Medium	$<10^{-3}$	Ext. low
Sulfur dioxide	2,000 lb	1-ton cylinder at X-346	Employee training Operating procedures Emergency response	Low	$<10^{-3}$	Ext. low

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2.1.2.1 Chemical Hazards

In many respects, the greatest hazard present at the Portsmouth facilities is the hazardous chemicals used in the uranium enrichment processes and ancillary support activities. The task force first reviewed the related site studies to determine the work that had previously been accomplished. The SARs for the site provided a very thorough analysis of the potential accidents involving hazardous chemicals, their probability, and possible consequences. This review also identified some potential initiating events that were not within the scope of the SAR studies. The task force next examined the records of the Hazardous Materials Control System to identify the presence of materials that would have the potential--due to their innate hazardous properties (e.g., toxicity, reactivity, flammability, etc.), quantity stored, and location--to cause a significant health and safety impact if released to the environment in an uncontrolled manner. Over six hundred separate chemicals were evaluated with respect to the above factors. The task force determined that the potential UF_6 accident scenarios had been well addressed in the SARs. All materials other than those addressed in Table 2.1 that are present in large enough quantities to cause significant health impacts if released are listed in Table 2.2. The table also provides information regarding the quantities present, type of containment, and location of these materials.

The task force next evaluated the potential for an accident having significant health impact. For most of the stored chemicals listed in Table 2.2, no feasible scenario for significant health impacts from a release could be determined. These assessments were based on a variety of factors, including the location (which generally was remote from populated areas of the plant and from off-site population centers), the relatively small amounts of chemical in each containment structure, and the type of operations involving the materials. Since the major mode of potential exposure was by a release of airborne material, a mathematical model of plume dispersion--adapted to the materials of concern--was used to estimate potential exposures in the event of a release. Also, the health effects of exposure to various levels of hazardous materials, specifically uranium compounds, HF, F_2, and Cl_2, were evaluated by referencing material found in K/D-5050, Sect. VIII, Part 1. The only scenarios judged to have the potential for significant health impacts are a catastrophic failure of the main HF storage tanks or a massive release of UF_6.

2.1.2.2 Radiation

For the most part, the radiation levels found in normal operations do not present any immediate danger to life and health for plant personnel or the public. The hazards associated with criticality are local, and the risk of a criticality incident has been addressed in many studies and is covered quite thoroughly in the SARs.

Table 2.2. Hazardous chemicals (Portsmouth Gaseous Diffusion Plant)

Chemical	Location	Method of storage	Quantity stored
Copper cyanide solution	X-720	Plating tank	75 gal
Silver cyanide solution	X-710	5-gal cans	8 cans (40 gal)
Hydrogen cyanide	X-720	25-lb cylinder	1 cyl. (25 lb)
Eccofoam EPH (toluene diisocyanate)	X-710	0.5-gal container	12 containers (6 gal)

2.1.2.3 Natural Phenomena

The potential effects of natural phenomena (e.g., tornado and earthquake) possible at the plant location were extensively evaluated in the SARs. A number of studies have been performed regarding the impact of seismic events (earthquakes). It has been determined that the only significant health and safety impact from a seismic event, other than falling debris, would result from the release of UF_6 due to the "predicted" rupture of a number of the process expansion joints in the X-333 Process Building. Under present operating conditions, the amount of UF_6 released would be unlikely to present significant health or safety impacts. However, if CUP operating conditions are projected, the impact of a seismic event could be more significant.

2.1.2.4 Other Hazards

A variety of other hazards--fires, explosions (propane, coal dust, etc.), traffic accidents, and others--were considered with respect to their potential for causing significant health effects. Multiple casualties could primarily occur in office (administrative) buildings.

2.1.3 Site Monitoring and Evaluation Processes

Goodyear Atomic Corporation maintains an extensive program for monitoring and evaluating site operations and activities for health and safety concerns. For example, a comprehensive environmental monitoring program is in place; and over 11,000 samples are collected, analyzed, and evaluated each year to determine the effect of plant operations on the environment. The work environment is also continuously monitored to ensure that a healthful workplace is maintained. Over 100,000 samples, measurements, and bioassays are completed each year. The water discharges, air emissions, and solid wastes from the plant are monitored for radiation and chemical hazards. In most locations in the plant where a release of hazardous materials such as UF_6, F_2, or HF could occur, gas-release monitors and alarms are in operation. In 30 years of operation, no fatalities or life-threatening injuries have resulted from releases of hazardous materials from the plant.

2.1.4 Related Site Studies

Over the years, numerous studies have been conducted concerning the potential for accidents and any attendant health effects. The most rigorous and complete studies have been the SARs and the Environmental Impact Statements previously referenced.

2.1.5 Emergency Response Capabilities

Emergency preparedness has been a high priority at GAT for many years. The DOE-Oak Ridge Operations (ORO) has recognized that GAT maintains an effective program in this area. An extensive, formalized drill program is conducted; mutual assistance agreements have been made with the local municipalities; and an extensive evacuation plan has been developed with the cooperation of the local authorities and emergency response units. In addition, the emergency response forces are very well equipped and trained; and GAT has sophisticated communications capabilities, emergency dispersion modeling and meteorology systems, spill control equipment, and radiation monitoring/response equipment. Results of the SAR will be factored into emergency planning activities.

2.1.6 Conclusions

As recognized in the SAR, a massive UF_6 release could have significant health and safety impacts. Also, this evaluation has identified one additional scenario as having the potential for significant health and safety impacts: a catastrophic rupture of the main HF storage tanks. Plans are under way to phase out the HF Tank Farm operation.

NLO, Inc.

FEED MATERIALS PRODUCTION CENTER

Facility Representative

R. B. Weidner

Review Panel

C. Facemire
M. Boback

2.2 NLO, INC.

2.2.1 Introduction

As a result of the incident at the Union Carbide Plant in Bhopal, India, the Task Group on Evaluation of Potential for Incidents Having Significant Health or Safety Impact was formed. This report was prepared at the request of the Task Group.

The Feed Materials Production Center (FMPC) is located in southwestern Ohio on the county line between Butler and Hamilton counties. It is about 20 miles from the city of Cincinnati, about 8 miles from the city of Hamilton, and within 3 miles of the small communities of Fernald, New Baltimore, Ross, and Shandon, all of which are located in Ohio. In addition, a heavily developed surburban area of Cincinnati that includes a large shopping center stretches to within 6 miles of the FMPC site. A study of the population distribution around the FMPC was performed in the spring of 1981. It indicated that only 88 people lived within 1 mile of the site but that the population increased rapidly beyond that, with over 11,000 people residing within 5 miles of the site. Almost 500 people live in a mobile home park that lies between 1 and 2 miles southeast of the plant; and the town of Ross, located between 2 and 3 miles from the site in an east-northeasterly direction, has a population of over 2000.

State Highways 128 and 126 and Willey Road all pass within 1 mile of the center of the site; however, they are lightly travelled in the vicinity of the plant. Both an elementary school and a high school are located in Ross. The elementary school is about 3 miles from the plant, the high school about 4. Both are located on the opposite side of Ross from the FMPC and would be among the last areas of the town affected by a hazardous material release. At its nearest point, the Great Miami River is about 1-1/4 miles from the site, but it carries only recreational traffic. This traffic would not be extensive enough to increase the population of the area.

Two areas on the FMPC site have the greatest potential for the occurrence of serious accidents: the Tank Farm and the Pilot Plant (UF_6-to-UF_4 reduction facility). The Tank Farm is situated at roughly the center of the FMPC, and the Pilot Plant is some 1100 ft to the southwest. All site facilities that might be occupied by employees are within 1700 ft of the center of the Tank Farm. An FSAR exists for the Tank Farm. Refurbishment of the facility is planned. The Mechanical Shops-Storeroom Building is approximately 125 ft from the Tank Farm; hence, a facility other than the Tank Farm could be affected by any Tank Farm accident with consequences that extend to a distance of 125 ft or more. The estimated plant population, as of January 1985, is 1080.

Most of the potential accidents that have been identified for the Tank Farm and Pilot Plant involve dispersion of hazardous materials by wind or normal air currents. Meteorological data gathered at the FMPC indicate conditions frequently exist which are unfavorable for the dispersion of hazardous materials.

2.2.2 Potential Hazards

Significant potential hazards, with the exception of criticality accidents and natural disasters, are addressed specifically in Table 2.3. Whereas criticality accidents are always a potentiality at facilities either producing or utilizing fissile materials, the chance for such accidents at the FMPC is extremely low. This is true not only because of the low enrichment levels commonly found at the FMPC but also because of the geometry and low density of materials produced. During almost 33 years of operation, the FMPC has never had a criticality accident.

A tornado is the natural disaster most likely to occur; however, the frequency of occurrence of tornadoes and other high winds is low in the region surrounding the FMPC. Earthquakes, while occasionally felt in the area, are not severe; and as there are no active faults close to the FMPC, seismic events are not considered a substantial threat to the integrity of storage tanks, piping, etc.

An additional potential hazard that exists at the FMPC is the K-65 tanks located west of the main production area. They are cylindrical, steel-reinforced concrete structures approximately 80 ft in diameter and 27 ft high. These tanks are used for long-term storage of radium bearing residues resulting from pitchblende ore processing. It has been estimated that a total of nearly 200,000 ft^3 of waste material is stored in these two tanks. While each is enclosed with an earth embankment, they are vulnerable to earthquake and, although unlikely, to damage by a direct impact by an aircraft. An estimated 1600 curies of material is contained in these tanks.

A loss of the integrity of either or both tanks could result in harmful releases of radioactive elements into the atmosphere, notably ^{222}Ra and ^{222}Rn. Dames and Moore, an independent consulting firm headquartered in White Plains, New York, has developed a worst-case scenario involving both an earthquake of major proportions (Modified Mercalli Intensity VIII) and an airplane crash resulting in the top of a tank being sheared off at near ground level.

The probability of occurrence of either has been calculated to be extremely low ($P < 10^{-4}$) during the life of the facility. Based upon the potentialities involved, Dames and Moore have indicated that injury to at least five on-site personnel and one or more fatalities on- or off-site could be expected as a result.

2.2.3 Site Monitoring and Evaluation Processes

The hazardous materials stored at the Tank Farm that have significant vapor pressures are anhydrous hydrogen fluoride (AHF) and anhydrous ammonia (NH_3). Therefore, these materials are judged to be the hazards of interest for this report. Any release of AHF will probably result in airborne vapor because of the low boiling point (68°F) for AHF and the above-atmospheric pressures in the storage system during material transfers. Furthermore, even though the vapor is heavier than air, it will heat and rise as it becomes more dilute and exothermically reacts with moisture in the air. The reaction with moisture also causes the formation of whitish clouds.

Table 2.3. Potential hazards at the Feed Materials Production Center having significant health or safety impact

System/ material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
			Tank Farm			
Anhydrous hydrogen fluoride (AHF)	95,000 lb/17 min	Major break in AHF supply piping during period of AHF demand	Pressure-relief valves, elevated piping, automatic monitoring, visual monitoring	High	10^{-3} to 10^{-2}	Low
	60,000 lb/11 min	Catastrophic failure of transfer hose or piping during unloading of AHF from tank vehicle	Pressure-relief valves, standard operating procedures in place	High	$<10^{-3}$	Ext. low
	900 lb/1 min	Minor leak in AHF supply piping during period of AHF demand	As noted above	Low	10^{-3} to 10^{-2}	Low
	95,000 lb/17 min	Major break in AHF supply piping and storage tank; valve failure during time of no AHF demand	Maintenance and standard operating procedures in place, and other controls as noted above, along with water spray to control tank pressure buildup	High	$<10^{-3}$	Ext. low

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Table 2.3. (continued)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
Anhydrous ammonia (NH_3)	45,000 lb/5 min	Major break in NH_3 supply piping during period of NH_3 demand	Pressure-relief valves, elevated piping to prevent impact, operating and maintenance procedures in place. Vapor pressure controlled by water spray on tank, visual and automated monitoring systems	Medium	$<10^{-3}$	Ext. low
	41,000 lb/6 min	Catastrophic failure of transfer hose during unloading of NH_3 from tank vehicle				
		Catastrophic failure of piping between unloading station and storage tank during unloading of NH_3 from tank vehicle	Pressure-relief valves, elevated piping to prevent impact, operating and maintenance procedures in place. Vapor pressure controlled by water spray on tank, visual and automated monitoring system	Medium	$<10^{-3}$	Ext. low
	45,000 lb/1 min	Catastrophic failure of NH_3 storage tank	Same as above	Medium	$<10^{-3}$	Ext. low
	120 lb/2 min	Leaking NH_3 transfer compressor	Same as above	Ext. low	10^{-1} to 1.0	Low

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Table 2.3. (continued)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
Anhydrous ammonia (NH_3)	2,500 lb/variable	Minor leak in NH_3 supply piping during period of NH_3 demand	Same as above	Low	10^{-1} to 1.0	Low
			Pilot plant			
Uranium hexafluoride (UF_6)	28,000 lb	UF_6 release due to piping failure rupture of cylinders containing liquid UF_6	Administrative control; hot cylinders not removed from autoclaves	Medium	10^{-3} to 10^{-2}	Low
Uranium tetrafluoride (UF_4)	Variable amount and time	UF_4 dust release, product can upset, or dust collector bag rupture	Procedures in place prohibiting movement of filled drums prior to securing lid; automated monitoring of dust collectors--backup collector system implemented; system automatically shuts down if backup fails	Ext. low	10^{-1} to 1.0	Low

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Table 2.3. (continued)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
Hydrogen (H_2)	Variable amount and time	Hydrogen explosion from maintenance or operations from opening system to air	Shutdown system activated upon detection of H_2 coupled with alarm system; alarm at 25% Lower Explosive Limit (LEL), shutdown at 50% LEL	Low	10^{-2} to 10^{-1}	Low

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Anhydrous ammonia (NH_3) has a boiling point of -28°F and is stored under pressure at the Tank Farm, so in the event of a release essentially all of the released material will be vapor or suspended liquid droplets.

The AHF and NH_3 supplies are contained in separate systems of storage tanks and piping. Transfers of NH_3 from storage to process buildings and all transfers of AHF, except for emergency transfers, are accomplished by pressurizing the originating container and opening the proper valves. Sight glasses, pressure gauges, and weighing systems provide information on the status of the systems and in some instances indicate when to terminate an operation.

The AHF and NH_3 containment systems (tanks and piping) are completely separate, so inadvertent mixing of the two chemicals is impossible. Introduction of the wrong substance into a system is precluded by the use of incompatible hoses and attachments for unloading the various materials stored at the Tank Farm. The piping associated with each containment system can be divided into two categories: "Transfer piping" refers to the piping that carries the material being received from the unloading station to a storage tank; "supply piping" refers to the piping that carries material from a storage tank to the plant where it is to be used. The unloading stations are located on a steel catwalk on the west side of the Tank Farm. Each station has two flexible transfer hoses, one for AHF and one for NH_3, through which these materials are transferred from the tank car or truck to the unloading station. The hoses at a station are not the same size, so it is not possible to connect the AHF hose to an NH_3 tank car or vice versa. Valves are located on the tank cars or trucks, at the unloading station, between the receiving piping and the storage tank, and between the storage tank and the supply piping. There are also manual vent valves and rupture disks between the AHF storage tanks and surge tank. In the NH_3 system, there are valves to either include or bypass the compressor that is used in the unloading operation.

The Tank Farm is monitored by direct observation by operators and by periodic visual inspections by Security Officers during off shifts. Additionally, the Tank Farm Sump is equipped with a pH monitor that sounds an alarm in the Water Treatment and the Communications Center if the sump pH is out of specification. Leaks would be automatically detected by this device. The vapors of both AHF and NH_3 form white plumes in the atmosphere, so a significant release would be easily observable. Each tank is also equipped with a pressure gauge. The AHF tanks are on scales and are continuously weighed. The NH_3 tanks are equipped with liquid level gauges. The scales and gauges can be considered as serving a safety function in that they allow operators to determine if a given storage tank has sufficient available capacity to receive the contents of a vehicle tank. This is essential in preventing over-filling of storage tanks. The pressure gauges allow operators to monitor storage tank pressures so that excess pressure can be relieved when necessary. This is accomplished by turning on a cooling water spray or opening the manual vent valves located at the west end of the tanks. The controls for the cooling water spray system are also located at the west end of the tanks.

The primary radioactive material present at the FMPC is uranium in the form of slightly enriched UF_6 and UF_4 and trace quantities of other radionuclides formed during uranium decay. Since radiation levels are low and the radioactive material is held in containers, process vessels, and piping during normal operations, no additional shielding is required. Loss of containment would cause some concern for radiation exposure of workers due to ingestion of uranium-containing material. Standard FMPC procedures for handling uranium contamination will be used to clean up inadvertent leaks or spills.

There is a potential for explosion due to the presence of hydrogen in the facility. The system is designed to detect leakage and buildup of hydrogen and provide warning to prevent a hazardous condition. The Pilot Plant is also provided with an automatic ventilation system to prevent the accumulation of hydrogen.

The hydrogen monitoring system installed in the Pilot Plant will warn the personnel when a concentration of 25% Lower Explosive Limit (LEL) is reached. At 50% LEL, the building will be evacuated and the process will be automatically shut down.

The UF_6-to-UF_4 reduction facility is monitored and controlled by a programmable distributed control system (DCS) located in a central control room. The control room is maintained at a slight positive air pressure to prevent entry of corrosive fumes. Redundancy of the controller power supplies and data links of the DCS ensure reliability and, in the event of subsystem failure, there is a backup system to assume control. The DCS is backed up by an uninterruptible power source such that in the event of site power failure, the DCS will shut down the process in a safe manner and control valves will fail in a safe position.

The reduction facility is designed to provide an adequate level of confinement for all of the hazardous materials known to be in the facility. All equipment parts that come in contact with UF_6 vapors are constructed of Monel--an alloy that is not corroded by UF_6. Confinement is achieved through the design of the autoclave, which is an American Society of Mechanical Engineers pressure vessel. This vessel is capable of withstanding pressures of up to 165 psia. The autoclave shell is secured to the head in a leak-tight manner by a system consisting of a hydraulic locking ring and a captured O-ring seal. If a leak in the UF_6 feed system occurs, it will be readily identified by the white smoke and characteristic odor of HF. In the event of such an occurrence, the facility will be shut down until the leak is corrected. Personnel will not be allowed to enter the area without suitable personnel protective equipment until the fumes are removed. Any UF_6 vapor leak that may occur to the UF_6 cylinder and pigtail will be confined within the autoclave.

The autoclave opening and closing operations are interlocked with pressure and limit switches to provide safe operation. Critical parameters are monitored by redundant transmitters (e.g., autoclave pressure, reactor wall temperature, dust collectors, UF_4-level detectors, condensate-level probes, and cylinder temperature probes). Redundant UF_6 analyzers in the off-gas streams are used to detect unreacted UF_6. Hydrogen and oxygen analyzers monitor the off-gas system and provide indication of adequate purge. Particulate monitoring in the dust collector will indicate bag leakage, and area monitoring for background radiation is provided in the dust collector area.

Confinement systems for UF_4 dust are provided in the UF_4 product drumming enclosure. The drumming station is designed to maximize the control of possible airborne material. The arrangement permits the operator to lid the UF_4 drums and vacuum the surface dust without being exposed to the dust. Thus, the operator will probably not be required to wear respiratory equipment during normal drumming station operation. Ventilation of the enclosure will remove dust generated during filling.

Instrumentation safety features perform the following functions:

1. The process instrumentation is designed to operate in a fail-safe mode if the DCS or the air supply fails.
2. The DCS system is designed with controller and power supply redundancy such that in the event of a subsystem failure, backup controllers and power supplies are provided.
3. In the event of a total power failure, UF_6 feed and dissociated ammonia feed will be terminated.
4. If a massive DCS failure occurs, all control valves will fail in a safe position and the processing operation will be terminated.
5. Manual control is provided for the packaging station, dissociated ammonia supply, and UF_6 flow control valves.
6. Critical parameters are monitored by redundant transmitters through the DCS.
7. Radiation monitoring in baghouse exhausts will indicate any bag leakage.

Administrative controls have also been established to manage the safe operation of the UF_6-to-UF_4 reduction facility. Controls and procedures encompass the following operations:

1. controlling a release of UF_6,
2. loading of UF_6 cylinders into autoclaves,
3. operation of the UF_4 drumming station,
4. transfer of AHF to storage tanks,
5. personnel evacuation plans if UF_6 or HF leaks occur,
6. monitoring of the HF weight tank dike,
7. controlling release of NH_3 from Tank Farm,
8. inspection of dust collectors, and
9. monitoring for adequate purging of oxygen for startup and hydrogen for shutdown.

2.2.4 Related Site Studies

The FMPC impact on the off-site environment is monitored on a regular basis by a wide variety of methods. Currently, the following characteristics of the external environment are being monitored by the means indicated.

1. ambient air quality

   a. Seven high-volume air samplers are in place around the site periphery. Filters are changed and analyzed weekly. Radon-226 and beta radiation levels are also monitored at each of these stations. Negotiations are underway for the placement of two additional stations off-site--one downwind at a nearby elementary school and one upwind in Ross, Ohio, at a similar location.

2. groundwater

   a. Water samples are drawn from on- and off-site wells at monthly intervals (quarterly for on-site wells). Quantitative and qualitative analyses are performed by the FMPC Bioassay Lab for pH, nitrates, uranium, chlorine, and sulfates. Isotopic analyses are performed by an independent testing lab. Additional on- and off-site test wells are presently being drilled.

   b. Water samples from the Great Miami River and nearby streams are also analyzed regularly.

3. soil

   a. Soil samples are taken biannually at each of 15 on- and off-site locations. In addition, 105 samples were taken during the fall of 1984 to facilitate the production of an isotopic map.

4. forage

   a. Grass and other cattle forage plants are sampled three times annually (during the growing season) and analyzed for uranium and fluoride content.

5. milk

   a. Milk samples are collected weekly from nearby dairies and compared with a sample collected concurrently from a remote dairy.

6. aquatic fauna

   a. Fish are collected annually from the Great Miami River and analyzed for uranium content. Plans are being implemented for an in-depth study of aquatic invertebrates during the summer of 1985. River and stream sediments are also collected periodically for analysis.

7. vegetables

   a. Locally grown potatoes are analyzed for uranium content and compared with a composite sample from farms out of the area.

8. terrestrial fauna

   a. Plans are under way for the collection and analysis of small game (mammalian and avian) for uranium uptake. Sampling will begin in the fall of 1985.

2.2.5 Emergency Response Capabilities

The FMPC has in place an extensive plan (FMPC Emergency Plan, NLCO-1129, Rev. 4, April 15, 1984) that covers recognized eventualities, including those listed or discussed in Sect. 2.2.2 of this report. In addition to plant emergency response teams, fire brigade, and ambulance crews, agreements have been made with surrounding community and private facilities for additional help if required. Administrative procedures and controls provide for rapid and accurate dissemination of information if an emergency situation were to develop. Standard operating procedures are in place in each work area to provide written instructions regarding emergency situations. These are tailored to the specific work area and outline the response required of those working in each area. Procedures for evacuation are in place throughout the plant, and each employee is required to be familiar with the procedures and with evacuation routes from his/her work area in case of general evacuation. Both automatic and manual alarm systems are incorporated throughout the plant and are tested weekly.

2.2.6 Conclusions

The probability of a serious material release is very low. Additionally, meteorological conditions that are unfavorable to thorough mixing rarely occur. This review has thus indicated that the risk of experiencing a material release that would have significant impact on the surrounding communities is low.

OAK RIDGE NATIONAL LABORATORY

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2.3 OAK RIDGE NATIONAL LABORATORY

2.3.1 Introduction

On December 10, 1984, Martin Marietta Energy Systems, Inc., initiated a study to identify all activities involving chemical and radioactive materials at ORNL that might pose a major life-threatening accident situation. The study was intended to examine all potential accident situations that could endanger the lives of multiple numbers of employees or members of the public, to assess the magnitude of risk, to evaluate current control measures, and to identify areas where improvements may be made to the current control measures. The ORNL study addresses all of the diverse aspects of the Laboratory's research and support operations, but it is not intended to duplicate existing studies such as those in the safety review and documentation program.

The ORNL site study was directed by a Site Review Panel chaired by D. C. Parzyck and M. W. Knazovich. The members of the Site Review Panel were selected to provide a broad knowledge of the Laboratory's research and support activities and to represent each of the major research and operational units of the Laboratory. The members of the Site Review Panel were appointed by the Laboratory Director on December 12, 1984. In order to provide the members of the Site Review Panel with adequate information on the broad range of activities that could yield significant potential health risk, a formal request for information was mailed on December 14, 1984, to the managers of each of the research and support organizations at the Laboratory.

A meeting was held on December 14, 1984, with the Division Safety Officers, Radiation Control Officers, and Environmental Protection Officers from each of 26 research and support divisions and with representatives from each of the Laboratory's Environment, Safety, and Health disciplines to request their assistance in identifying significant health risks. Representatives of each of nine Director's Review Committees were also brought together on December 14 for their assistance in identifying potential accident situations. The following Director's Review Committees were represented: Accelerators and Radiation Sources Review Committee, Criticality Committee, Electrical Safety Committee, High-Pressure Equipment Review Committee, Radioactive Operations Committee, Reactor Experiments Review Committee, Reactor Operations Review Committee, Transportation Committee, and Biohazards Committee.

These committees are comprised of senior Laboratory staff with extensive technical experience. Committee members perform reviews of Laboratory operations within the areas of committee expertise on a periodic and "as requested" basis and possess unique insights into the operational character of the Laboratory. Requests for information on significant potential health risks were also made to members of the general Laboratory population through the Laboratory's telecommunications medium, "The Inside Line."

Responses were received from Division Safety Officers; Radiation Control Officers; Environmental Protection Officers; members of the Director's Review Committees; representatives of the Laboratory's

Environment, Safety, and Health disciplines; and members of the general Laboratory population during a nine-day period (December 20-28, 1984). Eighty responses representing 43 different potential accident situations were received. A listing of each of the 43 situations reviewed by the ORNL Site Review Panel is shown below.

Nonradioactive hazardous materials

Transportation

- On-site transport of flammables/explosives
- On-site transport of inert gases
- Off-site transport of resource materials
- Off-site transport of waste materials
- On-site transport of resource materials
- On-site transport of waste materials

Storage

- Rupture of CO_2 storage tank
- Rupture of hydrogen supply system
- Breach of Holifield Heavy Ion Research Facility SF_6 containment
- Leak in hydrogen supply system
- Rupture of bulk storage tank
- Bleach/ammonia spill
- Leak in bulk storage tank
- Leak in anhydrous ammonia tank
- Spills/fire in stores or storerooms
- Violent reaction of Tower Shielding Facility shield material

Use

- Rupture of natural gas line
- Failure of nitrogen/water accumulator
- Generation of poisonous gas
- Leaks in natural gas line
- Rupture of inert gas header
- Rupture of large compressor
- Transformer explosion
- Leak in inert gas distribution system
- Leak in polychlorinated biphenyls transformer
- Activation of CO_2 fire system
- Leak in hazardous gas cylinders
- Mixing of reactive chemicals
- Rupture of test vessels

Radioactive materials

Transportation

Off-site transport of irradiated materials
Off-site transport of resource materials
On-site transport of waste materials
On-site transport of resource materials

Storage

Storage of contaminated equipment

Use

Oak Ridge Reactor refueling incident
Breach of Transuranium Research Laboratory glove box
Breach of High Radiation Level Analytical Facility (HRLAF) glove box
Breach of HRLAF hot cell
Failure of process backflow preventers

Other activities

Rupture of steam boilers
Rupture of steam distribution system
Construction accidents
Fire in Laboratory facilities

The 80 responses were distributed to the members of the Site Review Panel immediately upon receipt. A summary of the 80 responses was also provided to the chairperson of each of the Director's Review Committees. The Site Review Panel was convened on January 7, 1985, to review the total list of items received from Laboratory staff, establish priorities in the list on the basis of probability of occurrence and extent of hazard, and provide any additional information on significant health risks that may have been found as a result of their review or personal knowledge. The initial criteria for prioritization of probability of occurrence and extent of hazard are as follows:

Probability of occurrence

High	event likely to occur multiple times in facility lifetime,
Medium	event likely to occur sometime in facility lifetime, and
Low	event will probably not occur in facility lifetime.

Extent of hazard

High	large number of fatalities;
Medium	up to several fatalities, severe injury, or significant worker health concern; and
Low	injury or illness to operating personnel.

Review of the items received from Laboratory staff yielded an assessment of the probability of occurrence and extent of hazard for each of the potential accident situations. The distribution of assessed values for each of the potential accident situations is tabulated below:

Probability of occurrence	Distribution of assessed value
	High hazard potential
High	No significant accident situations identified
Medium	One significant accident situation identified
Low	Eight significant accident situations identified
	Medium hazard potential
High	Two significant accident situations identified
Medium	One significant accident situation identified
Low	Seven significant accident situations identified
	Low hazard potential
High	Two significant accident situations identified
Medium	Twelve significant accident situations identified
Low	Ten significant accident situations identified

The scope of the present study is directed toward those potential accident situations where a high hazard potential is involved. For that reason, the nine accident situations that were identified with a high hazard potential and varying probability for occurrence were given further detailed evaluation. The nine items identified as having high hazard potential are listed below.

Chemical hazard

On-site transport of flammables/explosives
Rupture of hydrogen supply system
Breach of Holifield Heavy Ion Research Facility SF_6 containment
Rupture of natural gas line
Generation of poisonous gas

Radiation hazard

Exposure during Oak Ridge Reactor refueling activities

Other hazards

Rupture of carbon dioxide storage tank
Failure of accumulator vessel
Rupture of steam boilers

Two of the nine items, breach of Holifield Heavy Ion Research Facility (HHIRF) SF_6 containment and exposures from Oak Ridge Reactor refueling activities, are adequately addressed by existing SARs and will not be evaluated further. The remaining seven accident situations are assessed in the next section of this report. The final section of this report includes recommendations directed toward minimizing the potential for occurrence of these high hazard situations as well as several other situations identified in this study.

2.3.2 Potential Hazards

As a result of the ORNL Site Panel's review of the 43 possible accident situations with significant hazard potential, seven situations were identified with potential for multiple fatalities on-site. No situations were identified with potential for fatalities off-site. The seven on-site situations were reviewed in greater depth to assess the appropriate level of hazard and probability of occurrence as defined by OR Order 5481.1B, Safety Analysis and Review System. The situations included on-site transport of gasoline, rupture of a hydrogen supply system, release of an asphyxiant gas, rupture of a natural gas line, generation of poisonous gas, failure of a pressure vessel, and rupture of steam boilers. These situations are discussed below and summarized in Table 2.4.

In a typical year at ORNL, there will be over 25,000 moves of hazardous chemicals, radioactive materials, and hazardous wastes. These activities are covered by well-defined procedures and are reviewed regularly by a variety of environmental, safety, and occupational health professionals, as well as independent review committees. The situation posing the greatest hazard with significant potential was the filling of the underground fuel tanks located north of Building 7005. During this

Table 2.4. Potential hazards at Oak Ridge National Laboratory having significant health or safety impact

System/ material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
			Chemical			
On-site transport of flammables/ explosives	Tanker with 8700 gal of gasoline in 7000 area	Tanker struck by vehicle while filling underground tanks; total inventory released and ignited	Fire Dept. inspection and standby during fuel unloading	Medium	10^{-3} to 10^{-2}	Low
Rupture of hydrogen supply	Release of hydrogen tube trailer contents into occupied building	Break of supply line, allowing trailer contents into building and subsequent explosion	Hydrogen tube trailer inspection for leaks on arrival; pressure drop in supply line shuts off hydrogen supply and initiates inert gas purge	Medium	10^{-3} to 10^{-2}	Low
Rupture of natural gas supply line	Six-in.-diam natural gas main at 100 psig	Vehicle strikes pressure-reducing station at north side of Steam Plant	Pipe barricades to intercept low-energy objects	Medium	10^{-3} to 10^{-2}	Low
		Construction equipment strikes high-pressure line at Steam Plant	Construction contract safety requirements; preconstruction conference; construction safety work permit and site inspection	Medium	10^{-3} to 10^{-2}	Low

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Table 2.4. (continued)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Generation of poison gas	Generation of cyanide gas from potassium cyanide	Addition of acid to dry potassium cyanide or potassium cyanide solution	Posted "No Acid" area; written safety summary; Industrial Hygiene review; list of qualified users; controlled access to material	Medium	10^{-3} to 10^{-2}	Low
			Radiation			
			None			
			Other			
Rupture of CO_2 storage tank	Release of total contents of 6-ton CO_2 tank in the basement of Building 4500N	Catastrophic failure of tank due to material failure	Program maintenance by Plant and Equipment Division	Medium	10^{-3} to 10^{-2}	Low
Failure of pressure accumulator	Failure of 200-ft^3, 3000-psig nitrogen/ water pressure vessel	Catastrophic failure of pressure vessel	Pressure-relief devices; periodic inspection	Medium	10^{-3} to 10^{-2}	Low

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Table 2.4. (continued)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Rupture of steam boilers	Explosion of steam boiler	Loss of feedwater and failure of relief devices	Pressure-relief devices; combustion safeguards; instrumentation; operator training	Medium	10^{-3} to 10^{-2}	Low

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operation, a commercial tank truck with as much as 8700 gal of gasoline is parked by the fill pipes. A runaway vehicle could strike the tanker, causing release and ignition of the contents. The subsequent explosion and fire could involve personnel in the immediate vicinity and the Lead Shop, Garage, Stores, and other buildings. To minimize risk, however, several safety measures are currently in use: (1) the tank truck is met by a Fire Department representative and inspected before being admitted to the Building 7000 area; (2) a Fire Department representative stands by during filling operations; and (3) all tanks and vents must meet fire code requirements. In addition, flammable vapor readings taken at the nearby Lead Shop (where open flames can be present) have shown no significant findings.

Laboratory operations require a variety of flammable gases. Of most concern are bulk supplies of compressed gases (especially hydrogen) in tube trailers. Trailers with 30 tubes have a hydrogen capacity of 38,000 ft^3, and those with 38 tubes hold 48,000 ft^3. The situation submitted for review dealt with a rupture of the hydrogen supply line within Building 4508, allowing a large amount of hydrogen into the building with a subsequent explosion causing a number of casualties. This system is protected by several mechanisms. If the building ventilation fails or if there is a pressure loss in the line (indicating a rupture), automatic interlocks shut off the hydrogen supply and purge the system with inert gas.

The natural gas supply piping to the Laboratory offers a potential for release and subsequent explosion at the Steam Plant, Building 2519. Natural gas is supplied to ORNL by East Tennessee Natural Gas from a 22-in.-diam pipe line operated at 250 psig. Service into the Laboratory proper is by a 6-in.-diam pipe at 100 psig. This pipeline is mostly above ground and goes to the pressure-reducing station at Building 2519. From there, natural gas is distributed underground throughout the Laboratory by low-pressure lines at 10 psig; and additional pressure reduction of the gas takes place before it enters the facility where it will be used. At the Steam Plant the pressure-reducing station is located at grade level on the north side of the building, adjacent to White Oak Avenue. A vehicle traveling at a high rate of speed could knock down the pipe barricades and railing currently in place, causing a large release of natural gas into the steam plant. A subsequent explosion could cause numerous casualties.

Several areas were examined for the potential of generating or releasing poisonous gases. These operations involve both compressed gas cylinders that could release their hazardous contents and a variety of plating-etching operations. The operation with the highest potential for significant health impact is conducted within the Metals and Ceramics Division in Building 4508. The process involves electrolytic cleaning of iridium forming blanks. The cleaning is accomplished by etching the iridium surface with a solution of potassium cyanide (KCN). The most serious concern in this operation is the addition of acid to the KCN, which would cause the release of hydrogen cyanide gas. Written procedures cover the operation, and there is a list of qualified operators. The entire KCN cleaning operation is conducted in a hood. All acid has been removed from this low-traffic area and is prohibited from use in the room. The dry KCN powder (up to 20 lb on hand) used for mixing the etching solution is stored in a metal container inside a locked cage area, as are the spent KCN salts containing iridium.

Argon, nitrogen, carbon dioxide, and sulfur hexafluoride are the four asphyxiant gases in bulk use at ORNL. They provide a variety of operating, inerting, cooling, and insulating functions. Argon and nitrogen supplies are replenished regularly by bulk deliveries from commercial vendors by tank truck. A more detailed description of the SF_6 system at HHIRF and its associated safety measures is contained in Sect. 2.3.6.1. The CO_3 gas is used for fire protection purposes at several locations in the Laboratory. The area of most concern is the 6-ton storage vessel operating at 300 psig in the basement of Building 4500N. This tank provides fire protection for the four-tier record storage vault. There are no indications of inspection of this pressure vessel since its installation in February 1952. Changes in the vessel wall that may have occurred during this period include fatigue cracks due to pressure cycling, corrosion on the vessel interior, and corrosion at the exterior surface under the cork insulation. In the worst scenario, the vessel could fail in a catastrophic manner, releasing its contents into the basement area. This would cause an oxygen-deficient atmosphere in the area around the tank and could result in numerous casualties.

Several pressure vessels were examined because of their large stored energies. Catastrophic failure would result in an explosion with devastating effects. Within Metals and Ceramics Division in Building 4508, the extrusion press operation utilizes a nitrogen and a water accumulator vessel at 3000 psig. The vessels have been inspected by the Quality Assurance and Inspection organization and are scheduled for review by the High-Pressure Equipment Review Committee. The other pressure vessels of concern are the fired pressure vessels (steam boilers) in the Steam Plant. A large boiler explosion would have devastating consequences at the Steam Plant, which is typically occupied by operators and maintenance personnel and occasionally by construction workers. Operation of the boilers is protected by a variety of relief valves, monitors, and safety trips. In addition, there are numerous alarms, flame safeguards, and combustion monitors.

2.3.3 Site Monitoring and Evaluation Processes

The Industrial Hygiene Department has available most of the state-of-the-art detection and measurement capabilities found in a modern, well-equipped industrial hygiene facility. Some 90-100 specific gases and vapors, most of which are toxic or hazardous to some degree, can be detected and quantified instantaneously; and several others can be semi-quantified or estimated by indirect methods. Oxygen concentration and explosive atmospheres can also be evaluated instantaneously. Most other toxic or hazardous gases and vapors can be quantified on a less prompt basis by means of collecting a sample of the contaminated air and subsequently performing the appropriate analyses.

Analyses for toxic metals and mineral-type particulates are handled in the same fashion. Utilizing a light-microscopy technique, airborne asbestos and similar fibers can be determined within minutes after a sample is collected. Most nonionizing radiation sources, such as ultraviolet and infrared, and sound levels can be measured by direct-reading instrumentation.

The Department of Environmental Management (DEM) uses three separate monitoring networks to check for airborne pollutants. These are as follows: The local air-monitoring network consists of 23 stations positioned relatively close to ORNL operational activities. The perimeter air-monitoring network consists of 11 stations located on the perimeter of the DOE-controlled area and provides data for evaluating the impact of all Oak Ridge Operations on the environment and general public. The remote air-monitoring network consists of 9 stations located outside the DOE-controlled area at distances of 19-121 km from ORNL. ORNL has eight major stacks that are continuously monitored. These stacks are also sampled twice weekly and monthly.

At ORNL, 17 stations in White Oak Creek, Melton Branch, First Creek, Fifth Creek, Clinch River, and Tennessee River monitor for waterborne pollutants. These stations use weirs with a continuous monitoring system for sample collection; samples are collected and analyzed daily, weekly, monthly, quarterly, and annually.

A number of other types of samples are also collected on a routine basis. These samples include rainwater, groundwater, milk, soil, vegetation, insects, fish, sediment, and deer.

Environmental data are managed by DEM staff in the Environmental Information System that combines and integrates the three-plant data resources into a single centralized database from which statistical analyses, graphics, and trend reports can be easily generated. Dose calculations are also completed routinely using this data.

2.3.4 Related Site Studies

The ORNL Site Review Study has drawn information from many components of the comprehensive environment, safety, and health program that has been developed at the Laboratory: the ORNL Safety Review and Documentation Program, the Laboratory Director's Review Committees, and the ORNL Hazardous Materials Control Program. These programs and activities are briefly summarized in the sections that follow.

2.3.4.1 Oak Ridge National Laboratory Safety Review and Documentation Program

It is ORNL policy to ensure that the operation of a facility, activity, or project can be undertaken without undue risk to the safety and health of employees or the public and with adequate provisions for the protection of property and the environment. To assist in implementation of this policy, a safety review and documentation program is maintained. For all new and modified facilities, a Safety Assessment is prepared. It identifies potential safety and health problems to facilitate their timely elimination or mitigation in the design process. If the Safety Assessment reveals that additional analysis is needed to document provisions for operational safety or to investigate and quantify operational risks, then an SAR is prepared. The SARs are of two types--Preliminary and Final.

The Preliminary SAR identifies the basic safety systems and/or administrative controls required in the facility design and operation, and it establishes the functional criteria applied to these systems. It documents an accident analysis that examines the behavior of the safety systems for all reasonable accident situations and sets forth the safety systems concerns to be included in the quality assurance assessment and plan for the project.

The FSAR includes specific information about how safety systems were incorporated into the design; detailed analyses showing that the safety systems and/or administrative controls provide an acceptable level of safety, and information regarding operation of the facility, such as responsibilities of the organization directly accountable for the operation of the facility, training requirements, and configuration control plans for the safety systems. In conjunction with the FSAR, Operational Safety Requirements (OSR) are developed. The OSRs define the conditions, safe boundaries (and bases for those boundaries), and administrative controls required to ensure safe operation of a facility.

Existing ORNL facilities have been reviewed to determine which ones will require the development of FSARs. For existing facilities, the FSAR is based on an evaluation of installed equipment and current operating practices. The FSARs receive independent review by the various ORNL environment, safety, and health disciplines prior to submission to DOE for approval. One or more of the nine standing Laboratory Director's Review Committees also participate in the review process. The 26 FSARs that have been completed for ORNL facilities are listed below:

Facility	Description
Low-Level Waste (Formerly ILW)	Radioactive liquid waste handling
Solid Waste Storage	Burial ground operations
Site Generic Document	ORNL site geology, demography, meteorology, hydrology, etc.
3033 West Krypton-Tritium	Radioisotope processing
86-in. Cyclotron	High-current proton accelerator
Building 3508	Radioisotope research laboratory
Building 5505, Transuranium Research Laboratory	Actinide research laboratory
Building 7025	Tritium target facility
Building 3019	Radiochemical processing pilot plant
Building 3028	Fission product development laboratory
Building 3033A	Radioisotope production laboratory
Building 3038	Radioisotope laboratory
Building 7920	Transuranium processing plant
Building 2026	High radiation level analytical lab
Building 4501	Low-level plutonium laboratory
Building 3525	High-radiation-level hot cells
Building 3026C and D	Radioisotope development and hot cells
Building 3047	Isotope technology
Gunite Tank	Radioactive waste removal

Facility	Description
New Hydrofracture	Radioactive waste disposal
3027 Vault	Special Nuclear Materials vault
PUMP	Plutonium-uranium microsphere preparation
Holifield Heavy Ion Research Facility	Electrostatic particle accelerator
3127 Vault	Special Nuclear Materials vault
Consolidated Edison Uranium Solidification Program	Uranyl nitrate solidification
3039 Stack	Radioactive facility ventilation

Safety analyses are being completed for the remaining radioactive facilities and are planned for the remaining ORNL accelerator facilities, the biology complex located at Y-12, and a californium processing operation to be installed in Building 7930.

2.3.4.2 Director's Review Committees

There are nine Laboratory Director's Review Committees whose members are appointed by the Laboratory Executive Director. The primary responsibility of each committee is to perform requested and periodic reviews of the Laboratory's operations denoted by the committee's name and the expertise of its membership. All committee members are senior personnel with extensive field experience in their areas. Each committee operates under the provisions of a charter and is completely independent from management in its review activities. The committees are advisory bodies only and do not have approval authority; they report their review findings and recommendations to management by formal reports and in person.

Any committee may ask for assistance from another committee and also may request the Executive Director to appoint an expert from ORNL or elsewhere to review a specific problem. Laboratory staff members may request committee reviews or consult with committees or committee members at any time. The responsibilities and functions of each committee are briefly summarized in the sections that follow.

Accelerators and Radiation Sources Review Committee

The Accelerators and Radiation Sources Review Committee is concerned with all safety aspects involved in the operation of devices classified as accelerators and irradiation sources, including radiation shielding, interlock systems and lockout devices, and radiation monitoring and warning devices.

Criticality Committee

The Criticality Committee reviews operations that involve the handling, storage, transportation, and disposal of significant quantities of fissionable material. This includes the isotopes 233 and 235 of uranium, all isotopes of plutonium, and the elements neptunium, americium, curium, berkelium, and californium. Prior to operating or changing operations with significant quantities of these materials, a review by the Criticality Committee is required.

Electrical Safety Committee

The Electrical Safety Committee was formed for the purpose of developing a set of Electrical Safety Guides. The guides that were developed represent minimum safety standards to be met by each Laboratory division. The Committee also performs reviews for electrical safety in selected Laboratory facilities.

High-Pressure Equipment Review Committee

The High-Pressure Equipment Review Committee reviews the design, construction, operation, and maintenance of pressurized equipment. High-pressure equipment consists of facilities operating at conditions outside the scope covered by existing pressure system codes (ASME) or containing hazardous amounts of stored energy that present a significant potential hazard. The Committee must review the safety aspects of all systems proposed to operate in excess of 3000 psig or presenting a significant hazard to personnel, facilities, or the environment.

Radioactive Operations Committee

The Radioactive Operations Committee is involved in the design, construction, operation, maintenance, decontamination, or modification of systems or processes containing radioactive materials. The Radioactive Operations Committee has the responsibility to review Laboratory facilities handling or processing significant quantities of radioactive material or disposing of radioactive wastes in the solid, liquid, or gaseous state.

Reactor Experiments Review Committee

The Reactor Experiments Review Committee reviews the design, operation, and reactor interaction of reactor experiments. It also reviews any new or unusual experiments proposed for insertion in the Laboratory's reactor programs. The experiments reviewed are generally of the type where credible failure or malfunction of the experiment cannot create a positive change in reactivity greater than the reactor protection system was designed to accommodate.

Reactor Operations Review Committee

The Reactor Operations Review Committee (RORC) evaluates the design, construction, operation, maintenance, and modification of nuclear reactors. The RORC meets with the reactor-operating groups and examines their procedures, training programs, personnel, and published operating reports that include such data as power levels, shutdown experience, and analyses of unusual occurrences.

Transportation Committee

The Transportation Committee evaluates the safety of radioactive and other hazardous material shipments and has the responsibility to review all safety aspects of any phase of operations involved in the transfer of all hazardous materials from one ORNL facility to another or one ORNL group to another, as well as shipments made off-site from ORNL.

Biohazards Committee

The Biohazards Committee is composed of senior staff personnel chosen to provide a broad spectrum of professional knowledge, qualifications, and experience in the fields of virology, microbiology, medicine, industrial hygiene, and engineering. The Committee performs objective and independent reviews of all aspects of human hazards of work associated with the use of biological agents.

2.3.4.3 Hazardous Materials Control Program

The ORNL Hazardous Materials Management and Control (HMMC) Program is a Laboratory-wide management system for dealing with all the complex situations that accompany hazardous materials and the widely varying research activities at the Laboratory. The DEM's program covers the procurement, use, treatment, storage, transportation, and disposal of hazardous materials. The ORNL HMMC program provides coordination through the ORNL Hazardous Materials Coordinator of personnel concerns, environmental issues, materials management problems, and compliance with laws and regulations. The major portion of the effort is divided between maintaining a smooth, effective health, safety, and environmental protection operation and working on ways of improving the efficiency of the system.

To accomplish its mission, the HMMC program has a set of guidelines written specifically for the user who will procure, use, store, transport, and dispose of hazardous materials and wastes. These guidelines have been incorporated into ORNL Hazardous Materials Management and Control Manual and the ORNL Environmental Protection Manual. To ensure that personnel are familiar with and abide by the guidelines and procedures, each division at the Laboratory selects one of its members to serve as the Environmental Protection Officer (EPO) for that division. Via the EPO, the DEM's Hazardous Materials Coordinator keeps abreast of hazardous materials activities in all divisions at the Laboratory. The hazardous materials are classified by corrosivity, ignitability, reactivity, or toxicity and are monitored by DEM staff using the hazardous materials tracking system.

2.3.5 Emergency Response Capabilities

The Laboratory maintains a comprehensive emergency response capability as outlined in the ORNL Emergency Manual. This capability begins with a defined philosophy of emergency planning and exists throughout all levels of the Laboratory organization. The ORNL emergency capability is made up of many elements, including the individual employee, the line organization, the local emergency organization, various emergency service units, communications systems, and overview groups.

Because of the variety of possible emergencies, prompt local action by the person discovering the emergency and by local emergency squads is the most effective means of emergency control. During an emergency, the Laboratory Shift Supervisor (LSS) on duty becomes the Laboratory Emergency Director and provides overall direction in combatting the emergency. This includes estimating the extent of the emergency, evaluating the hazards, determining the need for further evacuation, cutting off local utilities, making operational changes, establishing road blocks, and summoning additional equipment and manpower. He determines when the emergency is over and orders the "all clear" signal sounded. If the Laboratory Emergency Director is not available, the ranking Laboratory Protection Officer acts in his place.

When notifications of all types of alerts (Weather Bureau, DOE, Martin Marietta Energy Systems, Federal Emergency Management Administration, etc.) and reports of accidents involving fire, explosion, criticality, and radioactive or toxic materials are reported to the Laboratory Communications Center (telephone 911), the dispatcher at the Laboratory Communications Center will report this information immediately to the Laboratory Emergency Director and to all emergency service units affected. For example, the normal response to a fire alarm is to notify the Fire Department, a Guard Department radio car, a Health Physics surveyor, a steam plant operator, a shift electrician, two chemical operators, and the LSS (Laboratory Emergency Director). Those normally responding to an ambulance call are as follows: a driver and assistant furnished by the Guard Department, the doctor and nurse on day-shift (an emergency medical technician on off-shift), and the LSS.

All emergency service units not summoned immediately are put on standby after hearing the alarm, and they report to the scene with equipment and personnel when notified. There are approximately 30 different emergency service units that can be called upon if needed. The emergency service units are drawn from many of the Laboratory's operations and, in addition to the Fire and Guard Departments, include the following:

1. a Materials Unit to direct procurement and issuance of stores materials,
2. an Industrial Hygiene Unit to provide monitoring equipment and personnel,
3. a Medical and Surgical Unit to provide medical care for casualties,

4. a Personnel Survey Unit to survey evacuees for surface contamination and indium foil activation,

5. an Environmental Assessment Unit to evaluate the impact of released radioactivity and other toxic material on the environment, and

6. a Heavy Equipment Unit to provide necessary heavy equipment, operators, and related services.

Members of the Laboratory staff report to locations as instructed to assist in providing input or guidance to deal with the emergency.

Necessary instructions will be given over the public address system. This system can reach most normally occupied areas of the Laboratory as a whole or by selecting designated buildings or zones. A separate radio communications channel has been designated for handling emergency radio transmissions.

Heads of divisions and major departments are charged with maintaining well-trained local emergency squads. These squads consist of local emergency supervisors, wardens, searchers, and other members as needed. The local emergency squad ensures that personnel have been evacuated from the affected area and that equipment and processes are shut down as necessary for safety. The local emergency squad directs personnel to local assembly points and controls their movement. The squad meets emergency service unit personnel, briefs them, and directs them as necessary.

Plans have been established for both local and Laboratory-wide radiation emergencies. In the event of a local radiation emergency, the person discovering the occurrence takes immediate action to protect personnel and property, as outlined in the ORNL Emergency Manual. The immediate area is evacuated; the Laboratory Communications Center is notified, and help is requested as needed. Personnel are directed to the local assembly point or a more distant point of safety and kept there until monitored by Environmental and Occupational Safety personnel. Injured personnel are directed to the Health Division, wardens account for all personnel, and rescue operations are initiated if necessary. The local emergency supervisor evaluates the effect of the following on personnel safety and the spread of contamination: processes in operation; hot cells; air conditioning systems, blowers, and fans; liquid waste discharge; utilities; chemicals; and radioactive materials.

When evaluation of the information received at the Laboratory Communications Center indicates the necessity for Laboratory-wide evacuation, notification will be given over the public address system; and building shutdown plans will be executed. All employees will move to the East or West Portals, unless otherwise instructed, and submit to a health physics survey. Those found free of contamination will remain in the Laboratory assembly points (major parking lots) until given additional instructions. Employees found contaminated and/or in need of medical service will be processed by the Environmental and Occupational Safety Division's or Health Division's emergency service units.

Emergency exercises are designed to provide training in local and Laboratory-wide emergency procedures, to familiarize employees with these procedures, and to evaluate employee and procedural performance. The exercises are also designed to test equipment, logistics, systems, and other physical aspects of emergency resources. All major Laboratory facilities are required to conduct emergency exercises annually. Facilities with fewer than 35 employees conduct emergency exercises at the discretion of the facility manager. Exercises at ORNL include a wide variety of scenarios to test the many elements of the Laboratory's emergency response capabilities. During the course of a year, there may be more than 200 emergency responses (real, planned, or false alarms).

A Laboratory Emergency Review and Advisory Committee reviews and evaluates Laboratory emergency plans and procedures and makes recommendations for changes as needed. In addition to reviewing emergency procedures, the Committee observes and evaluates drills for the various Laboratory emergency organizations. The Committee conducts investigations following serious incidents to determine the cause of the emergency. The members of the Committee are called upon to give advice on actions to be taken during or following an incident, including health physics procedures, cleanup techniques, standards for cleanup effort, funding, work restrictions to be imposed on exposed personnel, and guidance for the reentry phase of radioactive incidents.

2.3.6 Conclusions

The Site Review Panel was convened again on January 14, 1985, to review the list of potential accident situations developed by the group. The panel was also convened to develop a list of conclusions regarding questions that had been raised during the course of the study and to prepare a list of recommendations on steps to be taken to correct potential accident situations within the Laboratory. The questions that were raised during the course of the study dealt with issues that were of concern to Laboratory staff but that were not of higher risk level than those listed in the previous section of this report. These included the asphyxiant properties of the SF_6 inventory at the HHIRF, the extent of fire-related hazards at the Laboratory, the hazard potential of materials used in biological research, the procedures available to address construction-related accident potential, and the possibility of introduction of hazardous materials into building ventilation systems. These concerns are addressed in the sections that follow.

2.3.6.1 Sulfur Hexafluoride Inventory

The HHIRF and its inventory of SF_6 were of particular concern to a number of survey participants. (This issue is addressed in an FSAR.) The facility is adjacent to and south of Building 6000 and contains a 25-MV tandem electrostatic accelerator enclosed in a vertical, grounded, steel pressure vessel containing the electrostatic accelerator and the 280,000 lb of SF_6 insulating gas. Pure SF_6 is very heavy, very stable, and completely nontoxic. Its hazard is in displacing air, reducing the oxygen content of the atmosphere to dangerously low levels and causing asphyxiation. Since the hazard is oxygen deficiency, oxygen-level monitors have been placed in strategic locations in the facility. Emergency breathing apparatus are also on hand. Several SF_6 detectors have also been placed in low areas of the facility and alarm at very low levels, providing an additional measure of safety. The most serious SF_6 accident would result from a major pipe break or tank rupture. Hazard to operating and user personnel would be reduced by rapid evacuation of personnel. This type of incident would present moderate hazard to operators, unless members of the public were in the facility--as in the case of a group tour.

2.3.6.2 Fire Hazards

During the past several years, fire protection appraisals and surveys have been conducted by ORNL fire protection engineers, DOE-ORO appraisers, and DOE-contracted Factory Mutual personnel. The Laboratory maintains an "improved risk" level of fire protection. The most significant property loss potential identified by the collective group is in Building 4500N. This building has combustible duct wrapping on ventilation systems throughout the building. Fire sprinkler systems were not installed above the ceilings, and other areas are currently unprotected.

Property loss and personnel health threats are not necessarily related. However, in this case, the postulated fire would spread rapidly throughout large areas of 4500N, generating blinding smoke and suffocating gases. Although some danger exists in any fire, this postulated event should not seriously threaten large numbers of personnel because existing contingency plans would be activated.

Other potential fire-related life safety threats discussed during the study were failures of protective systems. Failure of fire alarm and fire protection systems rarely occur, due to rigid maintenance and testing requirements. At ORNL the most likely system failure could be the 24 preaction sprinkler systems that have been in service more than 12 years.

2.3.6.3 Biological Research Materials

Biological materials are used in the form of cultured cells and various components of these cells, animals, and microbiologicals, consisting of bacteria, viruses, yeasts, and protozoans. The bacteria used consist of organisms that are common to man and animals and also Legionella (organism associated with "Legionnaire's Disease"), which is found throughout our environment. To date, all cases of Legionnaire's Disease have been caused from Legionella bacteria from our environment; no laboratory-acquired infections are known.

Viruses worked with consist of small amounts of animal virus that are used as tools in cells kept in flasks or dishes and handled in biological safety cabinets. The viruses pose no health risk to humans. In addition to bacteria and viruses, small amounts of yeasts and protozoans are used, again with no health risk. Recombinant DNA activities are done in several laboratories. These activities are done at the P-1 and P-2 levels of containment (P-1 being the lowest level of containment), and as such the materials produced pose no health risk to humans.

Research is conducted with chemicals, some of which are classified as carcinogens, mutagens, and teratogens. Small amounts (microgram or microliter quantities) are used in the test systems. There are no large bulk quantities of any chemical of the above nature. Radioisotopes used in the Biology Division consist of low-level materials, and all isotopes are handled by accepted safety procedures. Biological research utilizes biologicals, chemicals, and radioisotopes, none of which poses a significant health hazard to humans. All materials are used according to accepted safety and health procedures.

2.3.6.4 Construction Accident Potential

Within the DOE system of operating contractors and at ORNL, a variety of construction activities takes place on a regular basis. At ORNL these activities can be characterized as ORNL (Martin Marietta Energy Systems, Inc.) subcontract construction, DOE prime contractor construction, and cost-plus-award-fee (CPAF) construction. Each of these categories of construction work has associated safety activities designed to prevent any occurrence of significant accidents.

The ORNL subcontract construction projects are governed by fixed-price construction contracts that contain standard safety and health clauses covering safety of the construction activity. The clauses refer to the prescribed construction safety standards that will apply to the project and are supplemented by Special Conditions that call out specific additional safety requirements directed at conditions peculiar to the specific construction job. The contract requires that the construction contractor submit a written safety program geared toward the individual construction project and outlining the safety measures to be implemented. These contract requirements are supplemented by preconstruction discussions that include safety and health requirements. Construction safety information booklets are distributed to the construction contractor. The ORNL construction engineer is responsible for ensuring compliance with all safe construction practices.

The DOE prime construction projects have the same type of safety assurances as noted above. In this instance, however, the primary responsibility for monitoring construction safety rests with the DOE Construction Division engineers as opposed to Energy Systems Construction Engineering. A construction engineer from the architect-engineering firm or from ORNL is responsible for ensuring compliance with all safe construction practices.

The CPAF construction is performed by Rust Engineering Company under contract with DOE. As such, they are required to follow the prescribed DOE safety and health standards as outlined in the various DOE orders covering safety and health requirements. Rust Engineering Company maintains a full-time construction safety staff to administer its construction safety program. A construction engineer from the architect-engineering firm or from ORNL is responsible for ensuring compliance with all safe construction practices.

2.3.6.5 Building Ventilation Systems

Because the survey for potential hazards with significant health and safety impact had identified several scenarios involving the release of toxic or inert gases, the review team felt it necessary to evaluate those well-occupied buildings having ventilation systems that would be particularly vulnerable to intake of outside materials. The information requested dealt primarily with the location of the ventilation system intakes and the mode of operation. Intakes located on building roofs and recirculating systems are generally less vulnerable than ground-level intakes and systems using 100% outside air. This information is tabulated below.

Building number	Mode of operation	Intake location
4500S[a]	100% outside	Four vertical, ground-level intakes along south side of building
4500N[a]	100% outside	One long, horizontal, ground-level intake along north side of building
4508[a]	100% outside	Vertical, ground-level intakes along south side of building
4501, 4505	100% outside	Three floors up, north and east side
5500		
west	100% outside	Ground level, north side
east	100% outside	Second floor, south side
5505	100% outside	Second floor, west corner
3500	Recirculating	On roof
2000, 2001	Recirculating	Elevated
2010	Recirculating	On roof
1505	Recirculating/outside	On roof
1000	Through-wall units	
7600		
office	Recirculating	Second floor
experimental	100% outside	Second floor
7900	100% outside	Second floor
3508, 3517, 3503, 3504	100% outside	
Isotopes Area	100% outside	
7001, 7002, 7012	Partial exhaust	In-leakage make up
6010	Most 100% outside	On roof, northwest corner
6025	Through-wall units	Some roof intakes
6000	Recirculating/outside	On roof
6007	Recirculating	Ground level
6008	Recirculating	Roof level

[a]Most vulnerable systems serving large numbers of personnel.

If necessary, all major ventilation systems could be shut down using the Master Fan Shutdown located in the LSS's office or the guard communications center. This could have significant operating impact if done without advance notification. Typically, operators for various buildings could respond to local fan shutdown equipment in 5-10 min, depending on their location when notified.

2.3.7 Recommendations

The recommendations made by the Site Review Panel are tabulated below. These recommendations fall into two categories: high-potential hazards and other recommended actions that have been identified during the course of the study. Both sets of recommendations are provided in the interest of reducing the potential for accident situations at all hazard levels. The organization responsible for implementing each of the recommended actions is also listed.

Recommendation	Responsible organization
Potential hazard situations	
Remove from service and empty the 6-ton CO_2 storage tank in the basement of Building 4500N until an internal nondestructive inspection can be made.	Fire Department/ Quality Assurance and Inspection
Examine alternatives for the removal and replacement of the 6-ton CO_2 storage tank in the basement of Building 4500N.	Fire Department
Evaluate potential spread of gasoline spill during underground storage tank fill operations in the 7000 area.	Safety Department
Review operating and inspection procedures for hydrogen tube trailer operations.	Safety Department
Evaluate additional protective measures for the natural gas pressure-reducing station at Building 2519, Steam Plant.	Operations Division
Evaluate the continued need for natural gas services in Laboratory buildings.	Safety Department/ Division Safety Officers
Evaluate and report on the feasibility of replacing the KCN etching process in Building 4508 with a less potentially toxic process.	Metals and Ceramics

Recommendation	Responsible organization
Provide thorough review of the safety of continued operation of the nitrogen/water accumulator located in Building 4508.	High-Pressure Equipment Review Committee
Other recommended actions	
Evaluate measures to limit access of non-essential personnel to the ORR area during removal of spent fuel.	Operations Division
Evaluate measures to prevent access by members of the general public to Building 6000 during operation of the HHIRF or during SF_6 transfer operations.	Physics Division
Evaluate the adequacy of existing devices to detect oxygen deficiency, explosive gases, and high water levels and to relieve excess pressure. Determine the need for additional devices.	Ad Hoc Committee
Evaluate the safety of the eight underground, bellows-type, steam-line expansion joints in the west end steam distribution system.	Ad Hoc Committee
Review all Laboratory facilities for continued need of current inventory of compressed gas cylinders.	Safety Department/ Division Safety Officers
Perform a safety review of all phases of bulk cryogenic- and inert-gas-handling operations at the Laboratory.	Safety Department
Perform an evaluation of the vulnerability of the ventilation systems for Buildings 4500N, 4500S, and 4508 to intake of inert or toxic materials.	Safety Department
Perform an evaluation of the feasibility of disposing of the sodium shielding material at the Tower Shielding Facility.	Environmental Management

Recommendation	Responsible organization
Take prompt action to dispose of old resin columns in the basement of Building 4501.	Chemical Technology Division
Take prompt action to dispose of excess reactive metals in T-26, Building 4500S.	Metals and Ceramics
Take action to ensure that all tanks or vessels greater than 55-gal capacity are labeled in accordance with Laboratory procedures to indicate health, flammability, and reactivity hazard.	Environmental Management

Y-12 PLANT

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2.4 Y-12 PLANT

2.4.1 Introduction

2.4.1.1 General Site Information

The Y-12 Plant is located at the eastern end of Bear Creek Valley in the valley-and-ridge section of East Tennessee. It was built on a valley floor approximately 950 ft above sea level and is bounded on the northwest and southeast by parallel ridges that rise approximately 300 ft beyond the valley floor. The overall Y-12 industrial complex is about 0.6 miles wide by 3.2 miles long and encompasses 811 acres, 600 of which are enclosed by a perimeter security fence. Approximately 4860 acres are occupied by the plant and its buffer area (also fenced). The site is within the corporate city limits of Oak Ridge, Tennessee.

Y-12 contains 233 principal buildings. Of these, 43 are dedicated to ORNL functions ranging from complex biological research to thermonuclear fusion experimentation and isotope separation facilities. About 66% of Y-12-dedicated floor space is given to production, 13% is used for storage, and the remainder contains offices and support activities. The site also houses the Martin Marietta Energy Systems, Inc. president, members of the Energy Systems General Staff, site-supporting personnel from the centralized Engineering Division and Computing and Telecommunications Division, some DOE personnel, and DOE's construction contractor (Rust Engineering Company).

Four principal missions are performed at the Y-12 Plant: (1) production of nuclear weapons components and associated support of DOE's weapons design laboratories; (2) processing of special materials; (3) support of other Oak Ridge and Paducah, Kentucky, operations; and (4) support of other government agencies as requested by DOE.

2.4.1.2 Scope of Survey

In carrying out its specific missions, Y-12 handles and generates enriched and depleted uranium, as well as a number of nonradioactive hazardous materials. In addition, as with any major industrial facility, the plant depends on large-scale utilities systems that present a number of routine yet significant safety concerns. A comprehensive review of such materials and systems resulted in the data presented in Sect. 2.4.2 of this chapter; the principal criteria used to select materials for inclusion in that section were that the materials be of such quantity or inherent health/safety risks that they pose a threat of producing multiple fatalities (on-site or off-site) if involved in a release, fire, or explosion incident.

Materials reviewed but not presented in Sect. 2.4.2 were of such quantity or inherent health/safety risk that they pose (1) only a localized, isolated threat of death or serious injury to on-site personnel if involved in a release, fire, or explosion or (2) an environmental insult but not an immediate threat to human lives on-site or off-site.

Materials meeting the latter criteria [e.g., small quantities of hazardous liquids and compressed gases; reactive metals and flammable liquids stored in remote warehouses; location-limited (production) quantities of hazardous materials; oils, mercury, and other environmental concerns; low toxicity substances; etc.] were reviewed for current inventories, locations, safety controls, and incident potentials. Such reviews will provide the impetus for any needed upgrades in the safe transportation, use, storage, and disposal of these materials, as well as those detailed in Sect. 2.4.2.

The survey process involved personnel from Y-12's health and safety disciplines, operating and development divisions, and top management. Materials in use or generated at Y-12 were reexamined for hazard characteristics (toxicity, flammability, reactivity). Also reviewed were locations of materials; storage quantities and conditions; procedures and practices for transport, use, and disposal; personnel training; and incident history of materials at Y-12 and in general industry. The SARs and other site studies related to hazardous materials were also reexamined (see Sect. 2.4.4).

The resultant data compiled on each material were analyzed to evaluate the potential for a significant (multiple fatalities) threat to on-site and/or off-site personnel. Those materials considered credible sources of such incidents are detailed in the section that follows.

2.4.2 Potential Hazards

Table 2.5 details those Y-12 systems and materials judged to present the potential for significant health or safety threats to multiple personnel on-site or off-site. The table identifies the quantity of the material or the relative size of the system in question, and the most credible scenario for the worst-case incident. A listing of Y-12's existing administrative and engineering controls to prevent or mitigate such a scenario is also presented. Finally, the projected consequences of incidents, probabilities of occurrence, and risk levels are assigned.

2.4.3 Site Monitoring and Evaluation Processes

The Y-12 Plant has sophisticated monitoring equipment to detect and evaluate unusual occurrences within its perimeters. These detection systems are designed to stimulate response to plant emergencies in their earliest stages, thus reducing the potential for personnel injury. In addition, Y-12 is prepared to monitor local atmospheric conditions and determine needs for personnel protection measures or evacuation.

2.4.3.1 Monitoring Processes

A variety of dependable, tested systems for the early detection of an evolving emergency are available to Y-12. The goal of such systems is to provide accurate data to plant personnel prepared to analyze and act on that data. A listing and brief description of Y-12 emergency detection systems follows. Emergency response activities related to the systems will be detailed in Sect. 2.4.5.

Table 2.5. Y-12 potential hazards having significant health or safety impact

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
Hydrogen fluoride	850-lb cylinder (20 min for release of all material); up to 20 cylinders stored in outdoor, fenced, bulk chemical yard; three cylinders each at two processing areas	A large, sudden HF release is most credible during routine handling of cylinders where dropping or mishandling damages a valve stem; HF is a highly corrosive material with a threshold limit value of 2.5 mg/m^3 and a short-term exposure limit of 5 mg/m^3; given contributory atmospheric conditions, personnel in vicinity of release could be fatally affected by resulting vapor cloud	Cylinders are generally received, banded singly to a pallet, and handled and stored in this way; when cylinders are received free-standing, they are unloaded with a forklift using a special lifting device. They are then placed on a pallet in designated storage yard. When transported, cylinders are placed on cylinder truck with a raised liftgate and sides; they are kept on a pallet, either banded to the pallet or chained to side of truck, during transport. Loading onto truck is done by forklift; off-loading at facility is done by hoist. Cylinders have protective valve cover comprised of same material as cylinder.	Medium	10^{-2} to 10^{-1}	Low

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Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
			Cylinders are inspected by Mechanical Inspection Department upon receiving; they are hydrostatically inspected by manufacturer and this certification is checked upon receipt of cylinder.			
			All HF system relief valves inspected and tested annually; ruptured disks replaced at use facilities; evaporators inspected and tested at facility.			
			Emergency Reporting and Response Procedures (see Sect. 2.4.5)			
Enriched uranium solids	Open rack storage of parts in production area	Safety analysis studies currently being reviewed for approval (Y/TS-54) postulate a seismic-induced criticality event involving this material where solid parts stored on a wall-mounted rack fall into a critical arrangement	Safe storage array designs and parts dollies to prevent accident-induced criticality.	Medium	10^{-3} to 10^{-2}	Low
			Administrative controls such as procedures and extensive personnel training to prevent accident-induced criticality.			
			Criticality safety analysis of any proposed modifications in enriched uranium handling areas.			

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U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
			Criticality safety factors built into all design and procedures. Criticality alarms and response procedures to ensure limiting of personnel in radiation zone should a criticality occur. Emergency Reporting and Response Procedures (see Sect. 2.4.5). Planned (currently in design engineering) installation of a vault in the seismically vulnerable area and elimination of open storage racks.			
Steam boilers at Y-12 Steam Plant	Four main boilers equipped with four burners each	A steam boiler system is vulnerable to explosion from overpressurization during operation or startup	A Steam Plant operator is in the Steam Plant Control Room at all times. Boilers constructed to American Society of Mechanical Engineers and National Boiler codes. Instrumentation provides readout of boiler pressures and temperatures constantly.	Medium	10^{-3} to 10^{-2}	Low

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Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
			System is overhauled and tested annually.			
			High and low water conditions stimulate an alarm in the control room.			
			"Trip Coils" for the forced-draft and induced-draft fans provide automatic activation of these fans in the event of a high- or low-pressure situation.			
			Induced- and forced-draft fan systems are provided with a pressure-relief device and implosion damper, respectively, which will prevent overpressurization or implosion; when these devices are automatically activated, the boiler is shut down. (Boilers 3 and 4 do not have implosion dampers.)			

U.88.I

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
			Maxon-valve safety interlock system provides automatic combustion controls for burner startup; system designed to National Fire Protection Association standards. Overspeed of a turbine results in automatic boiler shut down. Emergency Reporting and Response Procedures (see Sect, 2.4.5).			
Propane (LPG)	One 10,000-gal mobile tanker; one 2,000-gal mobile tanker. Above are vendor-owned and driven; tankers enter the plant periodically for refilling Y-12 propane storage tanks	A credible scenario would entail an explosion/ Boiling Liquids Expanding Vapors Explosion (BLEVE) incident involving a vendor tanker on-site filling a Y-12 storage tank; the initiating event would be a fire impinging on the tanker; such a fire could be caused by ignition of propane vapors possibly leaked during storage tank filling; results of BLEVE incidents include wide circumference	Vendor tankers are inspected by firemen at portal entrance and accomplished by fireman while in Plant. 10,000-gal vendor truck is protected by Fire Department with hose lines and turret nozzle standby during filling. Smaller vendor tanker is escorted but equipment does not stand by. Radio contact to emergency squad/ Plant Shift Superintendent (PSS) is available at all times.	Medium	10^{-3} to 10^{-2}	Low

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
		fires, high-energy explosions, and projectiles from ruptured tanker; the route of the vendor tanker is currently from East Portal entrance, through Plant site, to west area filling station; one 30,000-gal underground tank is filled at an unloading station south of 9204-4; another 500-gal above-ground tank is filled east of 9995; a third unloading area lies southeast of Building 9420 (Rust)	Emergency Reporting and Response (see Sect. 2.4.5)			
Bulk, concentrated acid storage	Outdoor, bulk tanks containing from 4,000 to 25,000 gal of concentrated acids: hydrochloric, nitric, sulfuric	The sudden, catastrophic rupture of an acid storage tank and resultant release of corrosive acid vapors; depending on contributory atmospheric conditions, personnel in vicinity of release could be fatally affected; initiating event would likely involve an outside force	Tanks, pipes, and fittings were built to specification for type of material to be bulk stored. Tanks are visually inspected by operating personnel on a continual basis.	Medium	10^{-3} to 10^{-2}	Low

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
		(construction activity, motor vehicle accident) seriously damaging a tank or the pipes leading from it and allowing the contents to be released rapidly; limestone placed in tank dikes for small leaks could not neutralize great volumes of acid, and heat of reaction would produce vapor cloud	Dikes around tanks provide barrier to routine vehicle traffic and increase safe perimeter around tanks. (The dikes, and in some cases handrails, serve as awareness barriers but are not intended to protect against deliberate impact.) Pipes leading from tanks are visually inspected on a monthly basis by operating personnel. Credible initiating event is due to outside forces; thus incident would likely be during day operating hours and would be rapidly reported. Emergency response would provide mitigation to limit vapor cloud, monitor area, and evacuate nearby personnel as needed. Study of seismic and wind effects on tanks reported no concern for rupture from these sources			

U.88.I

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
Coal dust	Tonnage quantities, crushed and pulverized for use in coal-fired boilers in Y-12 Steam Plant	Lump-form coal is carried by conveyor belt from an outdoor storage pile, run through a crusher, and then conveyed to one of four hoppers in the Y-12 Steam Plant; this coarse, crushed coal is then pulverized into a combustible dust and fed into a fired boiler; dust explosion is a potential faced by all such coal-dependent operations; one credible scenario for a coal dust explosion in the Y-12 Steam Plant could originate in the uppermost-level tripper room where the crushed coal rolls off the conveyors and into the hoppers; accumulations of the combustible coal dust on fixtures, conduit, and beams jarred from these locations and ignited could initiate an explosion of the entire	West-to-east exhaust across the tops of the hoppers carries dust out of the building as it is generated from coal falling off conveyor and into hoppers. Tripper room is swept or vacuumed on a daily basis to prevent accumulations of dust; this dust is disposed of in a wet ash hopper (kept wet to prevent dust cloud) or placed into hoppers for movement to pulverizer. Electrical service in tripper room is explosion-proof and meets codes for such an application. Transfer system between pulverizer and boiler are part of a yearly equipment inspection and overhaul; any signs of wear in the transfer piping would require replacement	High	10^{-3} to 10^{-2}	Low

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
		Steam Plant; another source of a coal dust cloud in the Steam Plant could originate from a leak in the transfer system between the pulverizer and the boiler; a third source of explosive dusts lies with the conveyor system itself, wherein an explosion starting on the conveyor is carried into the tripper room and involves the entire complex				
Hydrogen gas distribution system	Six pressurized tube trailers, each with a capacity of 39,000 ft^3 of gas (2000 psi); average of two trailers received per week; hydrogen distribution throughout Y-12 at 50 psig; trailers are parked near 9977-2 where distribution to plant originates	A rupture in a hydrogen distribution line could result in an accumulation of hydrogen inside a facility; accumulations between 4% and 74% hydrogen in air are explosive; such a condition, undetected, could be easily ignited and the resultant force of	Mechanical Inspection Department inspects all tube trailers upon receipt; checks include pressure readings; soap test of valves, rupture disks, and tubes; trailer soundness (tires, suspension, etc.). All shipments are certified for quality and content.	Medium	10^{-3} to 10^{-2}	Low

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
		explosion could prove fatal to persons in the vicinity	Hoses and regulators at distribution facility are inspected and certified annually; trailers are electrically grounded at facility and lighting at facility is spark-proof.			
			All hydrogen lines are cathodically protected.			
			Lines are socket welded to minimize leak potential and pressure leak tested to certify soundness.			
			Where lines must be jointed by threaded pipe, engineering specifications require a change from schedule 40 to schedule 80 pipe.			
			Regulators at hydrogen points are checked every three years.			
			All pressure-relief devices checked visually every six months and operationally every year.			

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
			Hydrogen monitors in facilities to detect small leaks and any accumulations. Critical gas low-pressure alarm at distribution facility hooked to PSS's office. Automatic sprinkler systems to reduce fire spread and signal PSS of emergency. Emergency Reporting and Response Procedures (see Sect. 2.4.5)			
Deuterium gas production facility and distribution system	Five tube trailers at 33,000 ft^3 each; one tube trailer at 42,000 ft^3 (2000 psi) at Building 9805 (deut. gas storage garage and distribution facility); distributed from 9805 to 9204-2 (2nd floor) via a pipeline 9805-1, deuterium gas production facility with gas being produced at a rate of 1000 ft^3/h	A leak or rupture of a deuterium distribution line could result in a buildup of the gas inside a facility; given a lower explosive limit of 5% and an upper explosive limit of 75%, explosion conditions could be reached quickly and, if ignited, could result in death to nearby personnel	Tubes, rupture disks, and valves are soap tested upon filling at the storage and distribution facility. Hoses and regulators are inspected and certified annually. Trailers are electrically grounded and lighting at storage facility is explosion-proof. Lines are socket welded to minimize leak potential and pressure leak tested to certify.	Medium	10^{-3} to 10^{-2}	Low

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
	and piped to storage facility trailers		Where lines must be joined by threaded pipe, engineering specifications require a change from schedule 40 to schedule 80 pipe.			
			Regulators at use points are checked every three years.			
			Permanent, redundant exhaust fans maintain high air exchange inside production facility; equipment in production facility shuts down if exhaust is low.			
			Local monitors alarm to foreman's office if a leak is detected in production facility.			
			Unaccounted for loss of material is investigated.			
			High-temperature limit controls will shut down production system automatically if overheating.			
			Emergency Reporting and Response Procedures (see Sect. 2.4.5)			

U.88.I

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
Acetonitrile (waste drum storage yard)	Up to 220 55-gal drums (10,400 gal)	An unmitigated fire situation involving this highly flammable liquid (compare gasoline) wherein combustion is incomplete and oxygen-limited and liquid is converted to HCN; fire could be initiated through ignition of leaked vapors or by rupture of a drum during movement by forklift. Slow heating of liquid <u>without</u> ignition is source <u>of HCN</u> evolution (120 °C or greater)	Waste Storage Yard is in low traffic area of the plant and is adjacent to Guard Tower 22 (24-h observation of Plant). Drums are segregated on gravel pad. Emergency initiated by forklift would be reported and responded to immediately (see Sect. 2.4.5).	High	$<10^{-3}$	Ext. low
ACN bulk chem storage	Up to 100 drums	Same scenario as in waste storage yard	Material is beneath a deluge sprinkler system. Emergency Reporting and Response (see Sect. 2.4.5)			

U.88.I

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
ACN facility	1,000 gal in closed system	Same scenario as in waste storage yard	Material under inert purge, electrical equipment is explosion-proof. ACN detectors in facility Sprinkler system present in facility			
Sodium hypochlorite	Fixed, outdoor bulk storage tanks: one 10,000-gal capacity; one 6,500-gal capacity; mobile tankers: two 4,000-gal capacity	The sodium hypochlorite storage tanks are located in a commonly diked area with two 25,000-gal hydrochloric acid tanks; there is a dike wall separating areas for the HCl and hypochlorite solutions; a sudden, high-volume, simultaneous release of these materials, and their subsequent mixing, would result in the generation of chlorine gas vapors; such a scenario could credibly be initiated by an outside force (construction activity, motor vehicle accident) seriously damaging both	Tanks, pipes, and fittings were built to specification for type of material to be stored. Dike for each solution should hold contents of tank until cleanup begins. Dikes around tanks provide barrier to routine vehicle traffic and increase the safe perimeter around tanks. Tanks and pipes are visually inspected on a continual basis. Credible initiating event would likely be during day operating hours and would be rapidly reported.	High	$<10^{-3}$	Ext. low

U.88.I

U.82.J

Table 2.5. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls	Consequence level	Probability range (per year)	Risk level
		tanks, or the pipes leading from them, at once; contributory atmospheric conditions could yield fatal effects on personnel in vicinity	Emergency response would provide mitigation to limit vapor cloud, monitor area, and evacuate nearby personnel as needed (see Sect. 2.4.5). Study of seismic and wind effects on tanks reported no concern for rupture from these sources			

U.88.I

Instrumentation relayed directly to Plant Shift Superintendent

1. Low-water-pressure alarms indicate sprinkler head/system activation. A readout of specific building and location is given.

2. Critical gas alarms monitor the Y-12 gas distribution facility (9977-2). Hydrogen, helium, argon, nitrogen, and oxygen systems will alarm if a low-pressure condition exists. The Plant Shift Superintendent's (PSS) office dispatches a utility operator to check the system immediately.

3. Radiation monitors are used in all facilities handling enriched uranium. Monitors give constant readout of millirems from all applicable facilities and will alarm at a reading of 50 millirems (alarm in facility and PSS's office).

4. Seismic activity detectors are in Building 9206 (1 detector each on first and second floors), Building 9204-2E (1 detector each on first and third floors), and Post 16 (1 detector penetrated to bedrock). The level of seismic activity that would be detected and alarmed in the PSS's office is currently being reviewed.

5. Gamewell alarms can be activated by personnel observing an emergency or unusual occurrence.

6. Radio transmissions (via guard headquarters) from guards observing unusual occurrences from towers, posts, or while on vehicle or foot patrol.

7. Emergency calls (911) can be made by personnel in the vicinity of unusual occurrences.

8. Current weather data (from the National Oceanic and Atmospheric Diffusion Laboratory) warn of impending storms and other weather emergencies.

Facility alarms to warn local personnel of emergency situation or system breakdowns

1. Very loud criticality alarms (and magenta lights for high noise areas) warn personnel of emergency situations.

2. On-off fire system alarms are used in special production areas.

3. Plant public address system is available for PSS-directed notifications and evacuations (tested daily).

4. Oxygen deficiency alarms are in argon pits and at Large Coil Test Facility.

5. Hydrogen alarms report hydrogen leaks at use points.

6. Acetonitrile detectors monitor for system leaks at production facility.

Observation and reporting capabilities 24 hours per day

1. Visual detection from elevated guard towers (five currently operating, five additional planned) of fire situations, vapor clouds, etc. can be relayed to headquarters and PSS's office.

2. Vehicular and walking guard patrols observe critical plant areas on a regular basis such that unusual conditions could be radioed to guard headquarters and relayed to the PSS's office for inquiry.

3. Y-12 Plant personnel are trained to use local Gamewell alarms or 911 emergency number to report any unusual condition in Plant. Location and details are transmitted to PSS.

2.4.3.2 Evaluation Processes

Following the accidental release of hazardous materials, a criticality incident, or a fire/explosion, Y-12 is prepared to evaluate the local environment and prescribe protective measures to employees; appropriate protective measures for the surrounding community would be recommended to ORO. This evaluation process includes trained industrial hygiene and health physics personnel, along with the necessary instrumentation to measure toxic, oxygen deficient, explosive, or radiation-contaminated atmospheres.

These measurement and evaluation activities would be requested by the PSS directing the emergency response. A "spider net" phone to all health and safety offices (or the Plant public address system) would be used to summon the needed monitoring personnel. Industrial hygiene and health physics personnel would assist in setting up safe perimeters around the emergency and would prescribe protective equipment for persons entering the affected area. Emergency response personnel (firefighters, maintenance workers, etc.) would respond initially with fresh-air respiratory protection and gray-lite chemical suits if appropriate. This response equipment would be downgraded only after Industrial Hygiene and Health Physics evaluation of conditions.

Airborne concentrations of toxic materials or radiation would be determined at or near the site of release. Wind direction and velocity data, available constantly at the PSS's office, would be used to evaluate any need for downwind evacuations. Monitoring points would be established downwind to maintain safe zones for other plant personnel and the community. For radiation releases, air-sampling points have been preestablished throughout the valley.

[NOTE: Plans are underway to construct two meteorological towers at Y-12. When these are operational, they will significantly improve the wind and temperature data available. In addition, a software package (CARE) will allow rapid analysis and prediction of plumes and vapor dispersion.]

2.4.4 Related Site Studies

The following documents contain more detailed information regarding the safe use, transport, storage, and disposal of hazardous materials at Y-12. The findings and recommendations of these documents were reviewed and used in this survey but details were not reproduced.

Analysis of Release of Uranium Oxide from Several Y-12 Stacks. (Letter report, October 1984, M. V. Helrich).

Communication Guide for Y-12 and Civil Authorities in the Event of a Y-12 Emergency. (Draft report, January 1985).

FSAR for the Assembly, Disassembly, and Warehouse Operation. (Y/TS-49). CLASSIFIED.

FSAR for the Depleted Uranium Production Facilities. (In progress, January 1985).

FSAR for the Enriched Uranium Parts Manufacturing Project. (Y/TS-54, September 1984). CLASSIFIED.

FSAR for the Transportation and Certification of Enriched Uranium Weapons Parts. (Y/MA-6398, June 1983). CLASSIFIED.

FSAR for the Y-12 Chemical Processing Systems, Building 9212 and 9206. (Y/MA-6290, April 1982). CLASSIFIED.

FSAR for Y-12 Fogbank Production. (In progress, January 1985). CLASSIFIED.

FSAR for the Y-12 Salt Production Project. (In progress, January 1985). CLASSIFIED.

Safety Assessment Document for Hazardous, Toxic Substances Stored at the Y-12 Plant. (Y/MA-6246, December 1981). CLASSIFIED.

Safety Assessments for Existing Miscellaneous Facilities. (Planned). Some classified assessments.

Y-12 Stack Sampling Project: Summary of Completed Project (U). (ORNL/CF-84/407, December 11, 1984, T. W. Oakes). CLASSIFIED.

Mercury at the Y-12 Plant: A Summary of the 1983 UCC-ND Task Force Study. (Y/EX-23, November 1983).

Safety Analysis, Spill Prevention, Waste Collection, and Transfer System for Building 9401-2. (SA-964, June 6, 1984).

Y-12 Accident Analysis Committee Review Report Safety Analysis of Building 9206 and 9212. (a. H&R81-1, Rev. 1; b. XEA Memo 81-12.1, August 1981).

Seismic and Wind Resistance Analysis of 9204-2, Y-12. (Y/SUB/82-17606/1; Fluor; September 1982).

Seismic Resistance Capacity of 9212/9206, Y-12. (SAI-148-020, Rev. 1; March 1981).

Seismic/Wind Analysis of 9215 and 9998, Y-12. (P-8224-5424, October 1982).

Safety Analysis on Mercury Flasking. (Y/MA-5556, J. S. Anderson).

Safety Analysis on Mercury Flasking, Addendum I. (Y/MA-5556, J. S. Anderson).

Seismic Resistance Capacity Evaluation of Skull Caster, Y-12. (Y/SUB/83-13861/1&68, January 30, 1984).

Seismic Resistance Capacity of Y-12 Plant Facilities 9212/9206. (SAI-148-023, August 1980).

Seismic Resistance Capacity of Y-12 Plant Facilities 9212 E-Wing. (SAI-148-025, September 1980).

Seismic Resistance Capacity of Y-12 Plant Facilities 9212 E-Wing, Rev. 1. (SAI-148-025, Rev. 1; April 1981).

Seismic Effects on Seven Y-12 Plant Waste Disposal Sites. (Y/MA-6470, June 1984).

Wind/Tornado Resistance Capability of Y-12 Plant Facilities 9212/9206. (SAI-148-023, August 1980).

2.4.5 Emergency Response Capabilities

The Y-12 Plant maintains an aggressive emergency response system tailored to meet the specific needs of the industrial complex itself and prepared to support the Oak Ridge community and other Oak Ridge DOE facilities. Response equipment is on a par with state and local capabilities; and response squads are trained and drilled in current techniques of firefighting, hazardous material spill response, and emergency medical aid.

Details of Y-12 emergency response procedures are available in the 40 Series, Emergency Preparedness Procedures for the Y-12 Plant. General details of the major response capabilities and procedures follow.

An unusual occurrence (e.g., an accident, release of hazardous material, fire or explosion, critical system breakdown, radiation emergency, or any unusual event that constitutes or presents potential for an emergency) in the Y-12 Plant can be reported in a number of ways:

1. instrument detection alerts such as radiation alarms, fire protection system activation alarms, critical gas alarms tied to the PSS's office;

2. employee reporting through use of one of the Gamewell alarm boxes tied to the PSS's office;

3. employee reporting through use of 911 emergency phone system tied to PSS's office, Guard Headquarters, Health Center, Industrial Safety Department, Industrial Hygiene Department, and Health Physics; and

4. employee reporting through a call to the PSS's office, where a constantly manned clerk's desk will collect caller's information and transmit it to the shift superintendent on duty.

Response activity following a report of an unusual occurrence in Y-12 varies with the reported nature of the emergency and the method of reporting. Since the Gamewell alarm is a generic call for attention to a specific location, the entire emergency squad will be dispatched when it is used. The 911 number or a call to the PSS's office will allow for specific detailing of the unusual occurrence/emergency. Appropriate equipment will then be dispatched.

Once personnel are dispatched with equipment, the PSS's office maintains two-way radio contact with the response squad and keeps them informed of any additional information, developments, and special precautions or needs. The shift superintendent will summon any needed support from safety and health disciplines (monitoring capabilities included). Conditions of the emergency will dictate any need for personnel evacuation. Such activity will be initiated by the PSS using the plant public address system.

Radiation emergencies in Y-12 mobilize special response activities and evacuation processes. In addition to air monitoring in and outside of facilities, personnel-monitoring depots will be available for checking personnel who have possibly been exposed to radiation. Immediate decontamination facilities and appropriate medical attention will also be available.

The following principal emergency response equipment is maintained for immediate use in Y-12:

1. three water pumpers containing 500 gal of water each at all times (each pumper is equipped with a deluge hose capable of delivering 1000-1250 gal/min of water);

2. Cardox truck with 3 tons of liquid CO_2;

3. three ambulances with emergency medical equipment;

4. chemical suits, fireman's fallout gear, fresh-air and air-purifying respiratory equipment;

5. maintenance and utility equipment (stored in vehicles for rapid availability) to address electrical shutoffs, utility hold-offs, emergency repairs, etc;

6. remote-controlled robot with mounted cameras and material handling capabilities that can be sent into dangerous, life-threatening atmospheres to evaluate or mitigate emergency conditions;

7. chemical pumps to clean up spills;

8. earth-moving equipment and sandbags to contain spills; and

9. vehicles (15 pre-dedicated and involved in drills) to perform emergency transport of employees.

Y-12 personnel on call for the emergency response squad include

1. a core squad (to respond to all Gamewell alarms and be available for specific emergency needs):

   a. PSS on duty,
   b. shift captain for fire and guard department,
   c. fire captain,
   d. three firefighters (emergency truck driver is certified emergency medical technician),
   e. maintenance shift supervisor,
   f. electrician,
   g. electrical instrument person,
   h. outside machinist,
   i. pipefitter,
   j. utility supervisor,
   k. two stationary engineers (utility operators), and

2. personnel on call for monitoring, air sampling, and technical advice:

   a. Medical personnel (physicians, nurses),
   b. Industrial Hygiene personnel,
   c. Health Physics personnel,
   d. Criticality Safety personnel,
   e. Environmental Monitoring personnel,
   f. Industrial Safety Department personnel,
   g. Fire Protection Engineering personnel, and
   h. any additional personnel needed.

In the event that a Y-12 emergency constitutes a threat to off-site personnel, DOE will be informed and will direct the notification of off-site authorities.

2.4.6 Conclusions

Based on this survey of hazardous materials used or generated in the Y-12 Plant, the following conclusions were drawn:

1. Y-12 maintains highly effective controls over systems and materials that present a significant threat (multiple fatalities) to on-site and off-site personnel. The Plant's operation since 1943 without such an incident bears witness to the effectiveness of these programs. Comprehensive studies of major plant chemical and uranium processes and bulk storage systems have been carried out to identify and mitigate risk exposures to the Plant and public. Health and Safety Readiness Reviews are performed on new or modified operations and facilities to ensure that safe designs and processes continue.

Designs of Y-12 systems and the materials of construction meet national standards for safety. Trained mechanical inspection personnel test and certify critical hardware (regulators, relief valves, cylinders, gas manifolds, pressure vessels, lifting devices, etc.) on an established schedule that meets or exceeds national and industry recommendations.

2. Y-12 has developed and tested systems for detection, response to, and evaluation of emergency incidents within the plant. These systems are designed to stimulate early, well-equipped, trained response to evolving emergencies. Further, the Plant is prepared to objectively monitor local and off-site conditions and direct activities for personnel protection. Sophisticated detection instruments and alarms, up-to-date emergency response equipment, highly skilled emergency squads, and trained plant personnel are integral to the monitoring and emergency response processes.

3. Eleven systems/materials that present a potential for significant threat (multiple fatalities) to on-site and off-site health and safety were identified in the Y-12 site survey (see Sect. 2.4.2). Based on existing engineered features and administrative controls, along with proven, rapid emergency response capabilities, the risk level of an incident involving these systems/materials was judged low to extremely low. However, the review process of this survey recognized additional measures to decrease further the likelihood of certain significant incidents. Therefore, the following actions will be taken:

   (NOTE: The absence of recommended actions for some materials/systems outlined in Sect. 2.4.2 indicates that existing controls were judged to be appropriate and sound.)

   a. Hydrogen Fluoride. Material handling and transport procedures for HF cylinders will be reevaluated to determine if any improvements can be made to prevent any accidental release. Documented, job-specific training in the handling of this hazardous material will be developed and implemented for all personnel who handle HF.

b. Enriched Uranium Solids. Provisions for enclosed storage areas for enriched uranium solids are being planned and will proceed as quickly as possible.

c. Steam Boiler Combustion Controls. The current system for combustion control during steam boiler startup will be reevaluated to determine if any improvements can be made in the safety interlock systems or the administrative controls for safe startup. Operations management, Fire Protection Engineering, and the Industrial Safety Department will provide written recommendations for any identified needs. Implosion damper systems will be installed on Boilers 3 and 4.

d. Propane (LPG). Procedures for propane tank filling will be revised to include fire equipment standby at all filling sites. In addition, the vendor tanker routes will be evaluated and modified, if necessary, to reduce the tanker travel through high traffic/high exposure areas of the Plant. Finally, the need for the 30,000-gal propane storage site will be reevaluated in light of a reduced demand for this gas.

e. Concentrated Acid and Sodium Hypochlorite Bulk Storage Tanks. Inspection of bulk storage tanks will be upgraded to provide ultrasonic and/or internal inspection of such tanks. The need for improved protective boundaries will be evaluated on a location-by-location basis. During heavy construction activity, the proximity of the tank will be considered on the Safety Work Permit.

f. Coal Dust. Existing conveyor belt wetting system at the Steam Plant will be made fit for immediate use, and wetting solution will be maintained at the facility.

PADUCAH GASEOUS DIFFUSION PLANT

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2.5 PADUCAH GASEOUS DIFFUSION PLANT

2.5.1 Introduction

An evaluation of the potential for significant environmental insult resulting from Paducah Gaseous Diffusion Plant (PGDP) operations has been conducted. Although not restricted to airborne chemical releases, emphasis has been placed upon this type of environmental excursion. For the purpose of this study, a significant incident has been defined as one in which multiple fatalities would be expected either on or off the PGDP site.

It should be noted that this document draws heavily upon work performed by others. Safety Analysis Reports, Quality Assurance documents, Emergency Procedures and Environmental Control documents generally form the basis of much of the referenced in-depth documentation. The assessment of risk associated with any incident was determined using the basic guidelines found in OR 5481.1B

This evaluation considers three major types of incidents that could directly or indirectly have significant health/safety impact. They are (1) inadvertent chemical releases, (2) criticality incidents and (3) natural phenomena. Each of these major types of events is addressed below.

2.5.2 Potential Hazards

2.5.2.1 Chemical Hazards

The items listed below were identified at PGDP for consideration in this study:

1. Uranium hexafluoride,
2. Hydrogen fluoride,
3. Chlorine,
4. Chlorine trifluoride,
5. Fluorine (F_2),
6. R-114 (Freon),
7. Ammonia,
8. ClF_3, F_2 mixture,
9. Cyanide storage,
10. Trichloroethylene,
11. Nitric acid,
12. Sulfuric acid,
13. Sodium bisulfite,
14. Fuel oil storage,
15. Gasoline storage,
16. Phosgene,
17. Propane,
18. Pesticides,
19. Polychlorinated biphenyls,
20. Hydrogen gas,
21. Acetylene,
22. Chromic acid,

23. Hydrochloric acid,
24. Natural gas, and
25. Hydrogen sulfide.

The major criteria for inclusion in the list are either (1) the material is of known and high toxicity or (2) the material is known to be present in large quantities at PGDP. Some are obviously of potentially significant health/safety impact if released to the environment in sufficient quantities. Others would have significant impact only indirectly and under unusual circumstances. For example, R-114 was included to help ensure that accident scenarios consider possible chemical interactions/oxidation processes that could convert this nontoxic material into a highly toxic one. Additionally, R-114 is recognized to be an asphyxiant.

Only five of the items in the list were determined to have accident scenarios that could involve multiple fatalities and at the same time have any real potential for occurrence. Although the risk assessments for even these five show low or extremely low risk associated with the events described, individual evaluations and discussions for each of these (UF_6, HF, Cl_2, NH_3, and ClF_3) are presented in the following pages. They are so treated because they fit both criteria for inclusion: they are highly toxic and present at PGDP in large quantities. This, in essence, designates these materials as most likely to be involved in any hazardous situation and, therefore, as potentially significant hazards.

A summary of the accident scenario, risk assessment, and other relevant information for each of the five chemical species identified as potential hazards is presented in Table 2.6.

Uranium hexafluoride (UF_6)

An accident analysis of all gaseous diffusion plant facilities with regard to UF_6 releases has been done (FSAR-ORGDP, K/D-5050); and an FSAR specifically for PGDP dealing with this issue was published in April 1985 (KY-734, Sects. 4 and 5). This analysis reveals that the most credible accident at PGDP would involve the dropping and rupture of a UF_6 cylinder containing 28,000 lb of liquid UF_6. The potential for such an accident has been recognized for several years and much effort and expense devoted to reducing the probability of such an incident. Safety systems, design features, and administrative controls have been identified that prevent or mitigate the consequences of such UF_6 handling accidents.

The result of this analysis suggests that there is some probability of a significant off-site hazard from a very large UF_6 release. On-site, the plant population is at some risk, especially those located downwind of the release. Provided that personnel are not trapped, they would not be expected to remain in the plume, and evacuation of the affected area would greatly mitigate the consequences.

In any event, whether tank rupture or operator error, it is assumed that reasonable operator reaction would occur and that safety systems will respond, thus making the relative risk low to extremely low to individuals both on- and off-site.

Table 2.6. Potential hazards at Paducah Gaseous Diffusion Plant having significant health or safety impact

System/material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Uranium hexafluoride	28,000 lb	Liquid UF_6 cylinder ruptured	1. Improved handling techniques/studies 2. Standard operating procedures 3. Safety Studies 4. FSAR for PGDP 5. Inspection of cylinders	Medium	10^{-3} to 10^{-2}	Low
Hydrogen fluoride	36,000 lb	HF spill due to tank rupture, pipe or valve failure	1. Internal tank inspections on periodic basis 2. Deluge system 3. ESO-16133 in progress; updating of valves, etc., in progress 4. Diked	Medium	$<10^{-3}$	Ext. low

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Table 2.6. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Steam boilers and water heaters	-	Rupture	1. Constructed to appropriate codes 2. Regular overhaul and testing program	Medium	$<10^{-3}$	Ext. low
Ammonia	720 lb	Release via valve breakage or manifold break	1. Cylinder chained 2. Externally vented relief valves 3. Health and safety reviews 4. Standard practices and procedures	Medium	$<10^{-3}$	Ext. low
Liquid chlorine	2000 lb	Breakage of cylinder valve/rupture	1. Chlorine detection system 2. Safety procedures/ system 3. Emergency training/response	Medium	10^{-3} to 10^{-2}	Ext. low

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Table 2.6. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Chlorine trifluoride	1000 lb	Valve breakage with ignition-rupture of nearby cylinders	1. ClF_3 detection/warning system CC-350 2. Cylinder inspections 3. Standard practices and procedures 4. Emergency training	Medium	$<10^{-3}$	Ext. low

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· Hydrogen fluoride

Hydrogen fluoride is used at PGDP in F_2 production with a maximum of 36,000 lb in inventory at any time. The worst accident scenario is a tank rupture with an instantaneous release of approximately 36,000 lb of anhydrous HF. This incident, the associated probabilities, and expected on-site and off-site impacts are described in detail in the PGDP Battelle Safety Study report, Accident Analysis for HNO_3, H_2SO_4, HF, F_2, and ClF_3 Systems, dated October 30, 1981. Multiple fatalities are postulated both on and off the PGDP site. However, the risk level of this event is considered extremely low.

A more credible event would be pipe or valve failure with a postulated release of 160 lb of HF. In this case, the probability is greater. However, the risk level is extremely low.

Ammonia (NH_3)

Ammonia is used at PGDP for processing of scrap prior to smelting in the C-746A building. Four cylinders are manifolded together to provide a continuous uninterrupted supply to the process. Each cylinder contains 150 lb of anhydrous NH_3 when full. The worst-case scenario would involve the release of 600 lb of ammonia into the C-746A building via a manifold or valve breakage with subsequent exposure of 10 to 20 employees to possibly lethal concentrations of ammonia gas. The hazard level is considered extremely low.

Chlorine

Chlorine is used at the PGDP for algae and bacteria control in the process recirculating water (RCW) system. Chlorine is fed into the RCW system from 2000-lb cylinders. The worst-case release scenario with any reasonable probability of occurrence would involve the release of the entire contents of a 2000-lb cylinder due to either rupture or valve failure. Rough dispersion estimates used to estimate downwind concentrations indicate no off-site hazard. On-site hazards resulting in serious injuries appear possible. The resultant risk level associated with this scenario is extremely low.

Chlorine trifluoride

Chlorine trifluoride is used at the PGDP primarily as a drying agent. The worst-case scenario for ClF_3 would involve a valve breakage in the C-350 building with ignition of nearby cylinders and the potential release of as much as 1000 lb of ClF_3. Rough dispersion estimates indicate no off-site hazards, but some on-site serious injuries appear possible. The risk level of this event is considered to be extremely low.

2.5.2.2 Radiation

The probability of an accidental nuclear criticality at the PGDP is extremely low, probably less than 10^{-5} per year. This estimate is based upon the 100 years of operating experience of the three GDPs where no incident has created conditions that were near critical and in consideration of the low enrichment of the uranium processed at PGDP.

Should a criticality occur, it would have a very high probability of being detected. Detectors and alarm systems are located in all areas where fissile material is processed. Alarm systems would cause personnel to evacuate from an affected area before life-threatening radiation doses would be received. If local alarm systems fail, none of the areas in which a criticality is considered possible has a high population density. An incident involving multiple fatalities via life-threatening radiation is not a credible event at PGDP.

2.5.2.3 Natural Phenomena

Tornado/extreme winds

The probability of accident scenarios involving hazards to on-site and off-site personnel resulting from tornadoes or extreme winds is predicted to be extremely low. This is based upon the occurrence of the type of tornadoes necessary to cause damage great enough to rupture the UF_6 enrichment process with subsequent UF_6 release.

For UF_6 to be released during a tornado or an extreme wind event would require structural steel damage. The windspeed associated with such structural failure would exceed 170 mph. The probability of this speed occurring is less than 1 in 10,000 years. Windspeeds great enough to generate and sustain missiles that could penetrate housings and rupture UF_6 piping would exceed 200 mph and have a probability of occurring approximately once in 100,000 years. Therefore, it is concluded that tornadoes or extreme wind damage is a negligible hazard.

The hazards associated with meteorological events involving other chemical species at PGDP are considered less than that from UF_6 and thus are also considered negligible.

Floods

The PGDP has an average elevation of 380 ft above mean sea level; and the maximum historical flood was only 347 ft above mean sea level, making flooding an extremely low probability event.

Earthquake

Seismic vulnerability studies have been made to estimate equipment damage and health hazards at the evaluation base earthquake (0.18 g). These studies are now covered in an FSAR.

2.5.3 Site Monitoring and Evaluation Processes

Numerous detection and warning systems are used throughout the PGDP to ensure that releases of hazardous materials are recognized and that appropriate emergency responses are taken to minimize the magnitude of the release. Administrative controls in the form of inspections, Standard Practice Procedures, and various audits (e.g., quality assurance) are used to ensure that these systems are maintained and fit for their intended use. A brief description of the warning/detection systems for each chemical identified in Table 2.6 is given below.

2.5.3.1 Uranium Hexafluoride

At product and tails withdrawal points where liquid UF_6 is present and where the greatest potential for a significant UF_6 release has been identified, ionization-type detectors (PYRA-LARM) are used for UF_6 leak detection. At feed points, electrical conductivity systems are used to help ensure UF_6 containment. In addition to warning/detection systems, extensive inspection and testing of systems designed to reduce the probability of a UF_6 release are carried out. The PGDP Major Chemical Release Audit Committee, whose charter relative to UF_6 has been to ensure compliance with acceptable and agreed upon operating practices, has been very effective in evaluating and addressing UF_6 containment systems and concerns.

2.5.3.2 Hydrogen Fluoride

The hydrogen fluoride storage tank and its associated containment auxiliaries are ringed with air-sampling devices interfaced with an electrical-conductivity-type detector. In the event of an HF release, alarms are sounded in area control rooms as well as the central C-300 control room. Regular testing of these systems is conducted by Instrument Maintenance. A water-deluge system can be manually activated if necessary to minimize any HF release. The storage tanks are surrounded by a concrete pit of sufficient volume to accommodate the tank contents and reduce the HF surface area in the event of a spill.

2.5.3.3 Ammonia

The C-746A smelter area is not equipped with an ammonia detection system. However, ammonia may be detected by smell at extremely low concentrations. The Threshold Limit Value (TLV) for NH_3 is 25 ppm and the threshold of smell is nearly the same. In the event of an ammonia release, it is reasonable to assume it would be detected in its early stages and thus be minimized. It is recommended, however, that some form of ammonia detection be installed in the smelter area.

2.5.3.4 Chlorine

Chlorine is fed at the various process building pump houses into the RCW system for control of algae and bacterial growth. A solid-state electronic detection system is located inside all of the chlorine feed stations just above the feed point. Alarms are sounded outside the separately housed feed station. Roof-mounted emergency lights activated by the chlorine detector alert emergency response crews or other personnel to the chlorine release. Monthly testing of the alarm system is carried out by Instrument Maintenance.

2.5.3.5 Chlorine Trifluoride

The C-350 ClF_3 feed station is fitted with air-sampling devices interfaced to an electrical-conductivity-type detection system. In the event of a release, alarms are sounded at C-350 as well as the C-300 central control room. The conductivity cell is tested bi-monthly using a surrogate gas. Test procedures and a record of the date of all tests are located at the conductivity meter control panel in C-350. The building is also fitted with smoke alarms and a sprinkler system.

2.5.4 Related Site Studies

A listing of hazardous materials, PGDP Listing of Hazardous Materials, dated June 1984 and compiled by the PGDP Industrial Hygiene Department, is an excellent reference document for use in identifying chemical hazards as well as defining their quantities and location. Inventories of and relevant information on polychlorinated biphenyls are not included in this listing but are treated separately in the PGDP "Inventory of Polychlorinated Biphenyls." Other relevant documentation is listed below:

Reporting, Controlling, and Cleanup of Oil and Hazardous Chemical Spills, SPP-72.

Waste Management and Environmental Pollution Control (with Paducah Supplement), SPP-D-5-15.

Unusual Occurrences Notification, Investigation, and Reporting, SPP-D-5-16.

Protecting the Environment from Spills, QA Plan MISC-3.

Audit of QA Plan MISC-3, Power, Utilities, and Chemical Operations Division, October 27, 1980.

Chemical Spill Prevention, Control, and Countermeasure Plan, KY/B-233, August 5, 1982.

Oil Spill Prevention, Control, and Countermeasure Plan, KY/B-235, February 1983.

Audit of C-600 Fuel Oil Storage and Handling Facilities, Major Chemical Release Audit Committee, April 30, 1984.

Control of Hazardous Materials, SPP-D-2-18.

FSAR for the Paducah Gaseous Diffusion Plant, KY-734, April 1985.

In addition to those chemical hazards identified in Table 2.6, two other potential hazards were identified for consideration in this study: water heaters and boilers. No additional safeguards were required in either case.

2.5.5 Emergency Response Capabilities

2.5.5.1 Emergency Equipment

Emergency equipment is any equipment that may be used to measure, control, and mitigate the consequence of an emergency. On every emergency run at PGDP, there are basically three pieces of emergency equipment that respond. They are (1) a Pierce 106-ft aerial platform, which is capable of delivering 1500 gal/min of water; (2) a Star of Life Ambulance that is fully equipped and meets or exceeds all Department of Transportation regulations; and (3) the Plant Emergency Truck which is equipped with many pieces of emergency gear, including turnout suits for all the squad members; monitoring instruments for radiation, UF_6, etc.; ropes; extra first aid emergency items; and the new Jaws of Life equipment.

In addition to the above equipment, there is a 1000-gal/min pumper that is used as backup. There are two backup ambulances; one is completely furnished. The other would be used for transporting patients to Medical or a hospital.

At selected locations in each process building, there are emergency equipment cabinets that are stocked with pertinent equipment such as air packs, acid master suits, and emergency cylinder patches, as well as equipment that pertains to the particular hazards unique to that location.

2.5.5.2 Emergency Documentation

In both C-300 and the Plant Emergency Director's vehicle is a complete emergency procedures manual where all of the emergency operating procedures are detailed. These deal with toxic releases, fires, or other operating-type emergencies. In addition, there is also the Paducah Plant Emergency Manual (PPEM), which addresses the various hazards and contains an actual listing (kept in C-300 and many other locations in the plant) of hazardous materials and how to combat them during an emergency. There is also a listing of all hazardous materials and their quantities for each building. The Plant Emergency Squad receives training from the Emergency Information and Training Manual; it deals with all of the hazards in the plant. There are also maintenance procedures and Job Hazards Analyses that deal with preventing these releases or spills. Releases of UF_6, Cl_2, HF, NH_3, and ClF_3 are specifically addressed in the PPEM.

Also included under the category of documentation are the PGDP Mutual Aid Agreements that were made with the West McCracken County Fire and Rescue, Lone Oak Fire Department, Paducah Fire Department, the state and local police departments, the Disaster and Emergency Services Organization, Angels of Mercy, and the Western Baptist and Lourdes Hospitals. In the event of a major release of some toxic material, both the West McCracken Fire and Rescue Squad and the Sheriff's Department in particular, would be notified to aid in the evacuation of off-site personnel in the affected area.

2.5.6 Conclusions

Risk assessments were performed for all hazards identified in this report, and none were found to have a risk level [as defined in OR 5481.1B (see Appendix A)] more severe than low. Of those chemicals identified as most likely to be involved in a significant hazardous release (HF, UF_6, ClF_3, NH_3, and Cl_2), only one, HF, was of serious concern. The risk level of this accident scenario involving HF was determined to be extremely low.

Even though all assessments made during this survey resulted in low or extremely low risk levels, some risks were considered such that additional controls or actions are deemed prudent (generally due to a high population density in the area). They are as follows:

1. The installation of an ammonia detector in the C-746 smelter is recommended.

2. The ammonia cylinder located in C-710 should be removed from the building.

3. The phosgene cylinder in C-710 should be returned to the vendor.

4. Guarding at the C-600 natural gas station should be reevaluated to ensure adequate protection is provided for all vehicle types.

These recommendations should not detract from the fact that the overall release prevention and employee protection effort at PGDP is considered excellent. This is supported by the PGDP historical record (30 years) of no on- or off-site serious injuries or fatalities as the result of a chemical release.

OAK RIDGE GASEOUS DIFFUSION PLANT

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2.6 OAK RIDGE GASEOUS DIFFUSION PLANT

2.6.1 Introduction

The purpose of this report is to examine all aspects of potential incidents that could cause large numbers of casualties, to assess the risks, to evaluate the adequacy of existing preventive response actions, and to identify areas for improvement.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) has been in operation for about forty years. During this period, many actions have been taken to ensure operation under safest attainable conditions. In 1975, a hazardous materials program was established whereby greater control was placed on materials used at ORGDP. This program served to evaluate, inventory, and control usage and disposal procedures for materials. Those materials within the plant that were no longer of use were disposed of in this program. Not only has this program served to minimize employee exposure and risk, but it also has increased the awareness of chemical handling and usage.

Another action that reduced chemical storage and minimized the risk to the employee was the discontinuing of both fluorine production and the storage of large quantities of hydrogen fluoride at ORGDP. Due to a decrease in usage, it was feasible to purchase bottled fluorine from outside vendors and to reduce the stored quantity of HF from 100,000 lb to single cylinders containing 850 lb per cylinder.

About 1976, a safety analysis program was initiated by DOE. In this program a structured evaluation is made of new, modified, and existing facilities to identify potential safety and environmental risks, to determine the adequacy of preventive or mitigative design features and administrative controls provided to limit the risk, and to ensure proper review and authorization for operation of the facilities. It is the goal of DOE-ORO that facilities be designed and operated such that risk levels are kept as low as reasonably achievable. Such a system serves to indicate facilities that require further evaluation or attention to improve overall plant safety. There have been approximately 225 safety assessment reviews completed to date at ORGDP. The major report for ORGDP is K/D-5050. Since 1978, increased emphasis has been placed on UF_6 containment. Approximately $30 million was spent at the three diffusion facilities for improved UF_6 containment to decrease the probability of releases.

The most recent (October 31, 1984) hazardous material survey has been used to determine the hazard potential of materials used at ORGDP. The evaluation included identifying those chemicals meeting one or more of the following qualifications: a low TLV, an IDLH exposure limit, a designated Department of Transportation/Environmental Protection Agency reportable quantity in the event of a spill or release, and a large quantity of the material on hand. Using the above information, paired with quantity of material in use and the operational conditions of use, the review panel evaluated each material for its potential hazard. Attention was also given to all existing emergency preparedness activities (drills and tests), existing major detection and warning systems, and emergency and facility manuals to ensure that adequate protective measures were in place for any recognized hazard potentials.

Further, hazard potentials resulting from radiation, natural phenomena, transportation, and various miscellaneous areas were reviewed. Site monitoring and evaluation processes were examined, along with existing documents and procedures so that any necessary areas of improvement might be noted. Based on these findings, the assessment given in the following sections was compiled (see also Table 2.7).

2.6.2 Potential Hazards

2.6.2.1 Chemical Hazards

Uranium hexafluoride

An accident analysis of all gaseous diffusion plant facilities with regard to UF_6 release has been done (FSAR-ORGDP, K/D-5050). This analysis shows that the maximum credible accident at ORGDP would involve the dropping and rupturing of a UF_6 cylinder containing 28,000 lb of liquid UF_6. The potential for such an accident has been recognized for several years, and much effort and expense has been devoted to reducing the probability of such an incident. Safety systems and design features have been identified to help prevent or mitigate the consequences of UF_6 handling accidents. Extensive training of process operators has also been done to ensure safe handing of UF_6.

Since the possibility of such an accident cannot be completely eliminated, the health effects have been studied for a 28,000-lb release of UF_6. These studies used the results of new toxicology data (Report on Toxicological Studies Concerning Exposure of UF_6 and UF_6 Hydrolysis Products, K/D-5573, Rev. 1) and a reactive plume code (FSAR, K/D-5050) that were generated in the safety analysis project.

The results of the analysis show that there are potential health effects, including lung irritation and renal damage for a few off-site people. On-site, however, the plant population is at some risk, especially those personnel located downwind within about 2500 ft of the release. The prevailing winds at ORGDP are southwest, which would transport the released materials away from the center of on-site and off-site populations. With other directions of wind, the dispersion characteristics, the toxicity of the plume, and the buffer area around the plant combine to limit the off-site consequences.

On-site lethal concentrations of gases would exist near the UF_6 release. The acrid characteristics of the gases are readily noticeable; and, provided that personnel are not trapped, they would not remain in the plume. Individual employee actions and evacuation of downwind areas by the Emergency Director would greatly mitigate the consequence on-site. In a worst case, if the wind is in a southerly direction, the plume could encompass the K-1007 building, which has a maximum occupancy of 425 people. Those who do not or cannot evacuate the area may receive health effects. Fatalities could occur for employees unable to evacuate the plume area.

Table 2.7. Oak Ridge Gaseous Diffusion Plant potential hazards having significant health or safety impact

System/material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Uranium hexafluoride	28,000 lb	Dropping and rupturing a cylinder inside the building	Safety systems Design features Employee training Emergency response	Medium	10^{-3} to 10^{-2}	Low
	28,000 lb	Dropping and rupturing a cylinder outside the building	Improved handling techniques/studies Standard operating procedures Safety studies Inspection of cylinders	Medium	10^{-3} to 10^{-2}	Low
Hydrogen fluoride	850 lb	Failure of cylinder valve Failure of connector Knock off cylinder valve during cylinder changeout	Employee training Emergency response	Medium	$<10^{-3}$	Ext. low
Chlorine	2,000 lb	Failure of cylinder valve Failure of connector Knock off cylinder valve during cylinder changeout	Employee training Emergency response	Medium	$<10^{-3}$	Ext. low
Chlorine trifluoride	180 lb	Leaking cylinder valve Knock off cylinder valve during cylinder changeout	Cylinder inspections Standard practices and procedures Employee training Emergency response	Medium	$<10^{-3}$	Ext. low

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Table 2.7. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Ammonia	300 lb	Manifold failure Valve failure	Cylinder chained Health and Safety reviews Standard practices and procedures Employee training Emergency response	Medium	$<10^{-3}$	Ext. low
Fluorine	240 lb	Rupture of outside line	Standard operating procedures Design features Employee training Emergency response	Medium	$<10^{-3}$	Ext. low
Steam boilers	100,000 lb/h (runs on gas or oil)	Boiler failure resulting in explosion, cut steam lines, super-heated steam in building	Relief valve Routine maintenance ET&I routine inspection and test Design features Employee training Emergency response	Medium	$<10^{-3}$	Ext. low
Steam-heated hot water heaters or electric water heaters		Hot water heater failure results in explosion in K-1008-A changehouse	Safety systems (double relief valves) Routine maintenance ET&I routine inspection and test Design features Employee training Emergency response	Medium	$<10^{-3}$	Ext. low

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Table 2.7. (continued)

System/material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Natural gas line header		Vehicle strikes main natural gas header resulting in rupture; may explode wall of Steam Plant, K-1501	Surround by steel posts Earthquake shut-off valves Employee training Emergency response Shut-off buttons (two at each end of building)	Medium	$<10^{-3}$	Ext. low
CO_2 storage tank	4,000 gal	Leaking cylinder	Design features Employee training Emergency response	Low	$<10^{-3}$	Ext. low

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Hydrogen fluoride

The HF used within the ORGDP facility at present is procured in cylinders that contain approximately 850 lb of HF per cylinder. Normally only one cylinder would be in inventory at the using site.

The maximum credible incident is considered to be failure of a cylinder valve or connector on an HF cylinder. If the cylinder temperature is above 68°F, the pressure will be above atmospheric pressure and pressurized leakage will occur. Any personnel downwind and in the immediate vicinity of the leakage will be endangered and severe injury, perhaps fatal, could be expected for unprotected individuals. The presence of HF is readily detectable by the visible white cloud and strong odor. The population density is very low in the area of use, and those personnel in the area are trained in the use and handling of the material; therefore, multiple casualties would not be expected. Based on the quantity of HF, existing emergency response capabilities, employee training, and existing emergency procedures for specific areas, no on-site or off-site fatalities should be expected. Additional information on HF is provided in K/D-5050.

Chlorine Trifluoride

Chlorine trifluoride is used at ORGDP in 180-lb cylinders, which limits the potential release quantity. The TLV is 0.1 ppm (0.4 mg/m^3), while the IDLH exposure limit is 20 ppm.

Although a release is unlikely to happen, a leaking cylinder valve or a broken cylinder valve can be hypothesized. In either case, the release of the material would be slow due to the relatively low vapor pressure of the ClF_3 at room temperature. Even on a hot day, the release of a 180-lb cylinder of ClF_3 would take approximately 4 h. The heat loss resulting from vaporization would cool the cylinder, and it is not probable that a full cylinder would empty. The odor of the material would be sufficient to prevent a person from being unknowingly exposed. To stop the leak, the cylinder could be sprayed with CO_2 to cool the material to a temperature where the vapor pressure would be below atmospheric pressure.

Existing emergency response, capabilities, employee training, and operating procedures would be be used to mitigate results; and no casualties on- or off-site would be expected to occur.

Ammonia

Ammonia is used in the production of copies of engineering transmittals within ORGDP. Between the C and D wings of K-1001 there is a storage shed containing four 150-lb cylinders of ammonia. Two of these cylinders are typically in use at one time, with the other two on standby.

The following occurrences might result in employee exposure to NH_3 fumes: either from the leak of NH_3 through a cylinder valve or from the breaking of a cylinder valve during changeout of tanks. In either event, a maximum of 150 lb of NH_3 could be released to atmosphere. Due to the pungent odor of NH_3, the leak would be detected in early stages, thus minimizing the release. In the event that a valve would be knocked off and 150 lb released, personnel in close proximity might be exposed to levels greater than the short-term exposure level, 35 ppm. However, due to the odor of NH_3, it is not expected that employees would be exposed to levels in excess of the TLV, 25 ppm, or the IDLH exposure limit, 500 ppm. The lowest lethal exposure for humans has been determined to be 10,000 ppm for 3 h. Off-site effects for these scenarios would be insignificant.

Chlorine

Chlorine is used for standard water and sewage treatment at ORGDP. Liquid chlorine for those applications is stored, transported, and used from 1-ton cylinders. Nine feed stations and one spare are in service. Approximately 20 full cylinders are stored at K-1058-N by ORGDP Stores.

Concentrations of 0.3 ppm of Cl_2 in air are detectable by odor. A very strong odor will exist at 3 ppm. At 15 ppm, personnel would experience a burning sensation in the throat and eyes. Levels of 50 ppm are considered dangerous, but the lowest lethal exposure level is 430 ppm for 30 min.

The most severe credible incident would involve releasing the entire content of a full cylinder (about 2000 lb of Cl_2). This might occur if a cylinder valve broke off. The initial exposure to such a release could cause some severe health problems for personnel working in close proximity. It is doubtful, however, that multiple fatalities would result. The odor would cause physical distress at relatively low concentrations and force personnel to leave the area. During the operational handling of Cl_2 cylinders, respirator protection is required for the persons handling the cylinders.

There are existing emergency procedures, operator training programs, and standard operating procedures for these areas that would serve to mitigate the severity of the release. No off-site health effects would be expected to occur from the incident resulting from a broken cylinder valve.

Fluorine

Fluorine is used at ORGDP primarily for cascade operations, and some smaller quantities are used in developmental work. Demands for F_2 are low at present. The maximum quantity of F_2 that could be released from a single storage tank (K-1302 storage tank) is 240 lb. This could result from operator error, such as inadvertent venting of a full storage tank, or from failure of the tank rupture discs. The released F_2 would be mixed with 32,500 scfm of air from the stack system and discharged. Preliminary plume analysis indicates maximum ground concentrations are not of serious toxicological concern. A noticeable odor would result as far as 25,000 ft downwind for some atmospheric conditions; hence, the odor would be detected at the nearest public road (approximately 1000 ft). The TLV and IDLH values for F_2 are 0.2 mg/m^3 and 39 mg/m^3 respectively.

Other F_2 releases could be postulated but involve lower quantities or are less likely to happen, such as release in a cell room (gram quantities F_2), vehicular accident (approximately 8 lb F_2), rupture of transfer line (up to 80 lb), failure of a laboratory distribution system (up to 8 lb), and rupture of high-pressure line (up to 240 lb). All of these accidents are considered highly unlikely, but the rupture of the high-pressure line could be very harmful to plant personnel in the vicinity of the release. Lethal concentrations could develop locally and up to 1/2 mile; but most personnel should be able to escape, having detected the release visually or by odor. This high-pressure line is used about once every three months for intra-plant F_2 transfer.

In summary, in all cases an exposed person may require medical attention, but no deaths should occur unless a plant employee is unable to escape and is subject to a lethal concentration for an extended time. No off-site health effects are expected.

2.6.2.2 Radiation

The probability of an accidental nuclear criticality at the ORGDP is extremely low, probably less than 10^{-5} per year. This estimate is based upon the 100 years of operating experience of the three GDPs where no incident has created conditions that were near critical and in consideration of the low enrichment of the uranium processed at ORGDP.

If a criticality were to occur, it would have a very high probability of being detected. Detectors and alarm systems are located in all areas where fissile material is processed. Alarm systems would cause personnel to evacuate from an affected area before life-threatening radiation doses would be received. If local alarm systems fail, none of the areas in which criticality is considered possible has a high population density. An incident involving multiple fatalities via life-threatening radiation is an extremely low risk on site for ORGDP and essentially no risk off site.

2.6.2.3 Natural Phenomena

Winds, tornadoes

Based on past studies of tornadoes or high winds, the probability of winds in the area achieving a velocity that would cause structural damage is extremely low; and, therefore, the risk of structural damage is very small (FSAR K/D-5050, Sects. III and V).

Flood

The ORGDP is above flood level projected by the Tennessee Valley Authority. One depleted cylinder storage yard may be flooded, but cylinders are not vulnerable to flood damage.

Seismic events

A number of studies have been done regarding the impact of earthquake. It has been determined that the only significant safety hazard, other than falling debris, will be the predicted rupture of some process expansion joints in K-33. Under present operating pressure, the amount of UF_6 that would be released should be sufficient to cause only local hazards. IF CUP operating conditions were projected, the impact of a seismic event would need to be reexamined.

Explosion

Mixtures of Freon and strong fluorinating agents such as F_2 and ClF_3 can explode if ignited. The operating conditions at ORGDP are established to avoid obtaining explosive mixtures of these materials. If these conditions were to occur and an ignition source were available, only a local hazard would be created and no multiple casualties would be expected. Off-site consequences would not be significant.

Another explosion mechanism is the reaction of UF_6 and hydrocarbon oils when they are in a UF_6 container. The principle UF_6-hydrocarbon explosion hazard arises from the use of oil-filled vacuum pumps for air evacuation of containers that are to be later filled with UF_6. Oil from the vacuum pump can find its way into the UF_6 container, especially if the pump is shut down or trips off without being valved off or isolated from the container. The controls used at ORGDP for the prevention of this incident include prohibiting oil-filled vacuum pumps for such service or the inclusion of an oil trap between the pump and the container.

A residual risk of unknown proportions exists in the stockpile of UF_6 cylinders that were filled at ORGDP before the rigid application of the administrative controls (about 1975). There may be some cylinders that now contain a small amount of hydrocarbon oil along with their UF_6 inventory; and if such a cylinder is heated for transfer sometime in the future, an explosion hazard can be created. There is no fully developed method for detecting the presence of a hydrocarbon oil prior to heating the solid-filled cylinder.

Since all cylinder heating is done in autoclaves (which provide secondary containment), some protection is afforded; however, the energy released in the reaction is highly unpredictable, and little assurance can be given that an explosion would be contained. The maximum credible release is the contents of one cylinder, which has been evaluated in the UF_6 section.

Both explosion hazards are well recognized and administrative controls are in place to minimize the probability of occurrence.

2.6.2.4 Other Potential Hazards

Natural gas header

Natural gas is piped into various areas of ORGDP in an underground network. Although natural gas is a commodity widely used in industry and residential areas, the plant system was reviewed.

The main header for the natural gas supply system is located on the northwest corner of K-1501. If an incident were to occur in which the header was struck, a leak occurred, and an explosion resulted, the likelihood exists that individuals in the immediate vicinity would be endangered and severe injury, perhaps fatal, could be expected. The maximum number of persons in the K-1501 building at any one time is about twelve. The severity of the explosion would determine the number of fatalities. No off-site fatalities would be expected.

The natural gas header is on the side corner of the building and is enclosed in a steel cage. There are two manual shutoff valves located at the east and west ends of the building. The header is also equipped with seismic valves that would automatically shut off the supply in the event of an earthquake. These design features, along with existing operating procedures and emergency procedures, tend to further minimize the probability of such an occurrence.

Water heaters

Some of the water heaters used at ORGDP are relatively large in size (up to 1250 gal) and some are located in high population density areas.

An incident that might occur would be explosion of the water heater in K-1008-A, which is in close proximity to a changehouse area for about 200 employees. Those individuals in the immediate vicinity would be endangered and severe injury, perhaps fatal, could be expected. No off-site fatalities are expected. Due to built-in safety devices (dual relief valves, regulators), routine test and inspection (annually), and maintenance (as deemed necessary), it is highly unlikely that an explosion would occur.

Steam boilers

Within ORGDP, there are seven steam boilers--one oil-fired, five coal-fired, and one which may be operated using either coal or natural gas. The steam supply pressure for these boilers is maintained at 100 psig with a temperature of 460°F.

The maximum credible incident is considered to be failure of safety devices, resulting in a boiler explosion that would set off a chain reaction. In the event of such an occurrence, the building would be filled with super-heated steam. Any personnel in the immediate vicinity would be endangered and severe injury, perhaps fatal, could be expected. It would be difficult to predict the number of affected individuals, but as many as twelve persons may be in the area at one time. No off-site fatalities would be expected. Based on built-in safety design of the boiler, test and inspection procedures, and employee training, the possibility of such an occurrence is highly reduced.

The steam boilers are inspected on an annual basis. The relief valves are removed, the pressure is checked, and two or three months later, the valves are checked on-line. Three in-series relief valves are used and each triggers alarm systems. The operator is thoroughly trained in what to do if these alarms are activated. In addition, an internal and external inspection is performed on each boiler.

Even though steam boiler explosions do occur, the probability of such an occurrence is highly unlikely because of the multiple safety devices, operator training, routine test and inspection, and emergency response and training procedures.

CO_2 storage tank

A 4000-lb tank containing CO_2 (used for fire extinguishing) is located on the second floor of the K-1007 Computer Services Building. The tank must be manually valved in order to be activated.

In the event of a fire and subsequent actuation of the system, the entire 4000 lb of CO_2 would be discharged. The potential threat is asphyxia. However, since CO_2 is heavier than air and should collect in low-lying areas, the personnel should be able to evacuate the area without serious injury. If an individual were to be overcome by smoke, pass out, or fall to the floor, the possibility would exist that this person(s) could possibly be asphyxiated. In the event of a tank rupture, the existing situation would be similar. In either event, it is highly unlikely that fatalities either on- or off-site would result.

Due to the potential risk involved in using the CO_2, the area was reevaluated and other types of fire-extinguishing media for a computer area were reviewed. Based on the findings of this evaluation, plans to change the CO_2 system to a Halon system have been made, but this change is awaiting final design. When completed, these actions will serve to further lower the risk and lessen the potential hazard for the facility.

Possible yet highly unlikely occurrences

The question of possible yet highly unlikely occurrences yielded two situations perhaps worthy of mentioning. The potential does exist that the large water tower (K-1206-F) located within ORGDP could collapse and fall. The structural integrity of this tank and its support structure are inspected annually, with internal inspection every five years. The tank is more than 200 ft high and is located in a low population area. The probability of this incident is extremely low, and no multiple fatalities would be expected from a structural failure of this tower. Analyses indicate that an earthquake of 0.33 g would have only minor impact on this tank.

Another potential risk is the transporting of flammable materials. The largest movement/transport of flammable materials inside ORGDP is associated with gasoline trucks similar to the ones used to deliver gasoline to service stations.

2.6.3 Site Monitoring and Evaluation Processes

Within ORGDP, various site monitoring and evaluation processes are used to evaluate plant systems/materials and monitor plant materials to minimize potential health risk to the employee.

Monitoring systems located within the plant perform a wide spectrum of functions. These systems have been located in areas where potential concerns have been previously identified. These alarm systems include oxygen-deficiency alarms, laser interlock systems, pressure alarms, temperature alarms, leak detection systems, and many others. The following monitoring systems are related specifically to this study. There are some 60 radiation-cluster alarm/monitoring devices located throughout ORGDP such that a criticality incident might be detected and plant personnel evacuated. In all plant areas where UF_6 is used at above-atmospheric pressures, detection devices are present. In plant areas where F_2 is handled and where storage tanks exist, detection systems are present. The quantities of HF handled at the ORGDP are primarily laboratory quantities; however, at the K-1131 area where 850-lb cylinders are in use, detection systems are present.

Leak detection systems are also present in those buildings housing 2000-lb chlorine cylinders and in the water treatment facility where chlorine is piped into the building. Two chemicals (NH_3 and ClF_3) mentioned in this study are used in areas where no leak detection equipment is present. An area of improvement may involve installation of such systems in these areas, even though an evaluation of materials, quantities, properties, use, and employee training has indicated that the chemicals pose no potentially serious threat on- or off-site.

Site evaluation at ORGDP includes such precautionary activities as routine test and inspection of systems within ORGDP by the Equipment Test and Inspection Group. Their duties include boiler test and inspection, water heater test and inspection, rupture disc inspection, evaluation of proposed vessels and systems, evaluation of existing vessels and systems, safety valve test and evaluation, and many other functions. A computerized data management system is used to provide inspection schedules and deficiency control.

Many health and safety disciplines within the plant routinely review systems for potential hazards. Committees (Environmental, Health and Safety Council, Safety Steering Committee, and others) function to review and approve plant facilities, operations, and activities to ensure existing safe and healthy conditions. These activities are in addition to the line management function of ensuring safe operating conditions. Such extensive plant monitoring and evaluation and the review of facilities and operational activities greatly reduce the potential for hazardous occurrences.

2.6.4 Related Site Studies

The safety evaluation of new and modified facilities is an ongoing activity that is thoroughly and timely integrated into the design, operation, and funding of ORGDP facilities. A list of references which are most directly related to this study follows:

HF/F_2 Systems Safety Study, GAT-988, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, May 1981.

Oak Ridge Gaseous Diffusion Plant Safety Assessment, Fluorine Storage and Distribution System, K/D-SA-644, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, November 27, 1982.

W. H. Moon, Jr., Safety Assessment, Control of Gaseous Effluents K-631 Fluorine Manifold, K/D-SA-174, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, June 13, 1980.

FSAR Technology Test Facilities, Building K -1600, K/D-SAR-10, February 24, 1984.

Final Safety Analysis Report, Oak Ridge Gaseous Diffusion Plant, K/D-5050, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

J. E. Beavers, et al., Recommended Seismic Hazard Levels for the Oak Ridge, Tennessee; Paducah, Kentucky; Fernald, Ohio; and Portsmouth, Ohio, Department of Energy Reservations, K/BD-1025/R1, Union Carbide Corporation-Nuclear Division, Oak Ridge, Tennessee, December 1982.

R. A. Just, Report on Toxicological Studies Concerning Exposures to UF_6 and UF_6 Hydrolysis Products, K/D-5573, Rev. 1, Oak Ridge, Tennessee, July 1984.

ORGDP Operations Division Standard Operating Procedure 115.56 Configuration Control, September 1984. Unclassified.

ORGDP Standard Practice Procedure 353, Safety Analysis, Documentation, and Review System, November 2, 1984. Unclassified.

Relocation and Improvement of Plant Fire Alarm System, K/D-SA-495, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, January 1983.

Power System Protection Improvements, K/D-SA-511, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, February 1982.

K-25 Dual Broad-Band Cable Network, K/D-SA-626, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, October 1982.

Interplant High Speed Communication Line, K/D-SA-627, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, October 1982.

Fluorine Storage and Distribution System, K/D-SA-644, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, December 1982.

Sanitary Water Cross Connection System, Phase I, K/D-SA-823, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, September 1983.

Steam Plant, K/D-SA-864, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, Draft.

Sanitary Water Plant, K/D-SA-865, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, Draft.

Sewage Plant, K/D-SA-866, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, Draft.

Sanitary Water Cross Connection System, Phase II, K/D-SA-898, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, June 1983.

Environmental Protection and Safety Modifications, Phase I, K/D-SA-985, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, May 9, 1984.

Hazard to Human's Health from UF_6 Release, K/D-SA-81, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, August 1979.

Fire Protection Alarm System, K/D-SA-136, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, November 1979.

Master Radio Plan ORGDP, K/D-SA-142, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, January 1980.

HF Acid System Reliability Study, K/D-SA-172, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, June 1980.

Steam Plant Reliability Study, K/D-SA-175, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, March 1980.

Compliance with Toxic Substance Control Act, K/D-SA-385, -386, -387, and -388, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, March 1981.

2.6.5 Emergency Response Capabilities

Existing drills and emergency response activities are designed to mitigate the results of any potentially harmful incidents that might occur at ORGDP. These activities not only serve to protect the plant population but also to reduce the potential for off-site individuals to be affected.

The safety measures and emergency preparedness capabilities include

1. Alarm and warning systems. These serve to notify plant personnel of an emergency situation. These plant systems include the radiation alarm systems, fire and sprinkler alarm systems, pull-box alarms, plant whistle, plant public address system (inside and outside the plant), smoke alarms for detection of gaseous releases, three separate radio networks, the Bell phone, 911 phone system, PAX system, plant effluent alarm system, and the plant take-cover alarm system.

2. Emergency preparedness. Plant manuals, drills, procedures, and training serve to prepare workers in the event of any emergency, whether this occurs at their work location or at some other site in the plant that may result in potentially harmful conditions. These items or activities include

   a. written emergency procedures;
   b. facility training manuals;
   c. K-25 emergency manuals;
   d. fire preventive measures and fire drills;
   e. explosion preventive measures;
   f. emergency preparedness equipment checks;
   g. nuclear criticality/radiation drills and training;
   h. mock drills for chemical spills, radioactive spills, UF_6 releases, and others (involves plant health, safety, and environmental groups, medical emergency teams, and plant personnel); and

i. emergency squad training (trained approximately 1944 work-hour/year).

All of the above-mentioned alarms, warning systems, and emergency preparedness activities serve to familiarize, prepare, and direct the worker for any potentially hazardous conditions that might occur during the course of his work.

2.6.6 Conclusions

Although the operation of a gaseous diffusion plant requires storage and handling of large quantities of hazardous materials, the continued, thorough, and deliberate safety planning at ORGDP has reduced the relative risk to a low level. Further, the safety analysis program provides the methodology for maintaining safe operations as new or modified facilities/operations are adopted.

As noted in this report, certain areas were identified for further emphasis as a result of this review. However, based on the results of this study and on plant experience, operation of ORGDP under current safeguards and conditions does not present a significant risk of injury to employees or the public.

RUST ENGINEERING COMPANY
(Activities at the Oak Ridge
Water Treatment Plant and the Y-12 Plant)

Facility Representatives

J. E. Hall
F. M. Manginelli

2.7 RUST ENGINEERING COMPANY (OAK RIDGE WATER TREATMENT PLANT AND Y-12 PLANT ACTIVITIES)

2.7.1 Introduction

The Rust Engineering Company operates and maintains the Water Treatment Facility for DOE in Oak Ridge, Tennessee. Additionally, the Rust Engineering Company stores fuels at their facilities located at the Y-12 Plant.

2.7.2 Potential Hazards

Chlorine is used in the treatment of water to make it potable within the standards set down by legal guidelines. The chlorine is used and stored in two locations, with a maximum storage of twelve 1-ton containers at each: the river pump house at Melton Hill Lake and the treatment plant on the hill near Y-12. The use and storage practices follow those established by The Chlorine Institute, and DOE regularly inspects the facilities for compliance with all applicable standards.

Because of existing safety practices and procedures, accident potential for chlorine storage, use, and transport in these facilities has been rated as low. Two flammable liquids stored at the Y-12 site have been identified as potential hazards, although the risk of a multifatality accident is low. Shown in Table 2.8 are the amounts, possible initiating events, current preventive controls, and risk levels.

Table 2.8. Potential hazards at Oak Ridge Water Treatment Facility sites and Y-12 Plant activities (Rust Engineering Company)

System/ material	Source term, release quantity	Initiating events scenario	Existing controls (physical and/or administrative)	Consequence level	Probability range (per year)	Risk level
Chlorine	24,000 gal	Release	Stored in 2,000-lb cylinders at two different sites	Medium	10^{-3} to 10^{-2}	Low
Gasoline tanks above ground	500 gal	Ignition of flammable liquid	Fire extinguisher in immediate area	Low	10^{-3} to 10^{-2}	Low
Gasoline tanks underground	Total of 20,000 gal	Ignition of flammable liquid	Dry sprinkler system and alarm at pumping station; fire extinguisher available	Low	10^{-3} to 10^{-2}	Low
Diesel fuel tank	12,000 gal	Ignition to combustible liquid	Dry sprinkler system and alarm at pumping station; fire extinguisher available	Low	10^{-3} to 10^{-2}	Low
Fuel truck	800 gal gas 1,000 gal diesel	Ignition to flammable or combustible liquid	Fire extinguisher available and safety cutoff valves in tanks	Low	10^{-3} to 10^{-2}	Low

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3. FINDINGS

3. FINDINGS

The conclusions from this survey were based on the facility reviews and on extensive group discussions with both the site representatives and other personnel at each facility and are listed below:

1. Despite the outstanding safety records that have been achieved, situations exist throughout the facilities surveyed that have the potential for causing serious injury or death to the few employees who are either working on a specific job or are within the immediate work area. These situations include moving and connecting gas cylinders, electrical switching and maintenance operations, maintenance and operation of heavy or rotating equipment, operations involving toxic or corrosive chemicals, and other generally recognized industrial hazards. Local safeguards are effectively used to reduce the risk of accidents or injuries in these situations, and programs to continually improve the safety of these routine operations are vigorously developed and executed at all facilities. Thus, while efforts to avoid injuries from these situations are of high priority to DOE and its contractors, such situations generally do not involve the potential for multiple fatalities.

2. Existing safety, environmental, and risk analyses have been very effective in identifying concerns and prompting actions to reduce risk to human life. Given the size and complexity of these facilities, there are relatively few materials or situations at the sites for which credible scenarios for multiple fatalities were developed.

3. This survey indicates, almost invariably, that the lower the quantity of material on hand, the lower the risk of large, serious releases or events. Attention should be given to formally adopting and using an optimum working inventory* philosophy for all potentially hazardous materials, even though procedures and safeguards are in place that cause the probability of an accident to be evaluated as low.

4. The facilities surveyed have high levels of surveillance through continuous on-site coverage by security, utility, operational, and supervisory personnel. Additional surveillance is provided by sophisticated detection systems, especially in the area of radiation detection. Consequently, there is a high probability that a large release or major event would be detected. Most instrumented

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*Optimum working inventory is defined as the minimum feasible inventory considering operational requirements and resulting frequency of material transfer activities. For example, a working inventory that is too low could increase the risk of a release by requiring excessive cylinder changeout or material transfer operations.

detection systems for chemical releases, however, are specific to recognized materials and discharge points; hence, a lower level of confidence exists that releases of unusual materials would be detected quickly.

5. Several materials or situations present potential hazards of general concern:

   a. Anhydrous hydrogen fluoride, chlorine, and ammonia are present in sufficiently large quantities to present significant hazards in the event of massive tank or cylinder failures.

   b. Uranium hexafluoride is utilized at all of the gaseous diffusion plants, and the rupture of a cylinder containing liquid UF_6 could have severe impact. (Other situations, especially if the cascades were at CUP conditions, could lead to the release of UF_6.) Extensive analyses have been performed to analyze the risk of this event and to evaluate and improve cylinder handling procedures. This concern is being addressed through the SAR program; however, employee awareness of actions to be taken in the event of a large UF_6 release should be given greater attention.

      Due to the somewhat isolated locations of the facilities and their large area, on-site consequences of materials are of greatest concern. However, studies of dispersion models indicate that the combination of worst weather conditions and large releases has the potential for significant off-site impact.

   c. Gaseous and liquid fuels, as well as other hazardous materials, are widely used and transported throughout all of the facilities. Leakage or spills of these materials present the potential for impacting relatively large numbers of employees. These situations represent common industrial hazards and are not addressed through the SAR program.

   d. The stockpile of UF_6 cylinders, filled before the rigid application of administrative controls to ensure that cylinders are free of hydrocarbon oil, represents an unknown risk.

6. The impact of seismic events on the reactors at ORNL was not included in the original SARs, and there appears to be no firm schedule for updating the SARs to include seismic evaluations, although such actions are planned for reactors that are expected to remain in operation. The impact of seismic events on stored enriched uranium at the Y-12 Plant is receiving increased attention. Corrective actions are planned, and engineering design is currently in progress.

7. Much of the emergency planning at the facilities presupposes that mass evacuation would not be the correct action if large material

releases were to occur. However, the degree to which employees would correctly and rapidly respond to instructions to remain indoors, secure buildings, etc. has not been determined in large-scale drills. Additionally, whether the large-scale evacuation of employees beyond the facility parking lots could be effectively accomplished is unknown. While most employees routinely exit the facilities in less than 30 min, the amount of confusion that would accompany an unexpected evacuation--with essentially no time for telephone calls to arrange car pools, ride pick-ups, meeting points, destination, etc.--is untested.

8. Emergency access to plant public address systems is limited to intrafacility buildings that are relatively close together. No remote tie-in capability exists at some facilities (e.g., access from mobile units or from locations considerably removed from the facilities).

9. Large numbers of visitors who are unfamiliar with warning signals and emergency response procedures present a unique concern, especially at ORNL.

10. Biological work (ORNL at Y-12) was assessed by the ORNL review committee as posing no risk within the context of the multiple fatality criteria used in this survey.

11. Events that develop at slow or moderate rates can likely be managed by facility personnel so as to avoid large scale, multiple person impacts. Rapidly developing events, simultaneous events, or a rapid series of events present the most serious situations.

4. RECOMMENDATIONS

4. RECOMMENDATIONS

This survey resulted in fresh and comprehensive internal reviews of each facility. Follow-up actions by the individual facilities should be taken to reduce risks by disposing of unused materials and reducing inventories when possible.

Additionally, the following recommendations are made:

1. An optimum working inventory policy should be established and seriously implemented for all potentially hazardous materials. Such a policy has the potential for cost control benefits as well as for reducing the impact if a material release occurs. Special consideration should be given to scheduled reviews and inspections to ensure that unused and unnecessary inventories, however small, of hazardous materials are not retained. When required, contractor policies and procedures should be revised to formally include this action.

2. The present survey reflects a material and inventory evaluation at a single time. Programs at all of the facilities are dynamic and variable. In addition to routine hazardous materials management activities, each facility should maintain a current listing of materials where releases have the potential for multiple (five or more) fatalities. A report listing the materials, inventory quantities, and changes in the inventories from the last review should be provided to senior management annually.

3. Plans for protection of the facility population and the public in the event of major material releases should be reevaluated. The need for enhanced employee awareness or for conducting emergency drills involving employees should be evaluated by each facility. Specific attention should be given to plans to ensure visitors' safety in the event of a serious event. Assurance of a functional and available public address system should be given additional attention.

4. Facility emergency drills and training exercises should be structured to provide greater training and instruction for the general facility population and to include some simulated situations involving multiple and rapidly progressing events. The rate-of-development component (e.g., a very dense and rapidly expanding cloud of toxic gas) should be given greater attention in emergency response training.

5. Each facility should give deliberate attention to managing intrafacility transfers of gaseous and liquid fuels (and other hazardous materials) so as to minimize risk to the facility population.

APPENDIX A

Risk Matrix Concept Definition (OR 5481.1B)

"The residual risk associated with facility operation should be identified. Determination of the probability of the occurence of incidents and the associated consequences should be based on engineering experience, operating history, and, when practical and appropriate, calculations. Table A-1-1 provides a probability rating scale to be used to subjectively determine probability for the purpose of evaluating risk. Similarly, Table A-1-2 provides consequence definition to be used to subjectively determine maximum consequences and associated hazard levels. The level of risk assigned to a particular event or to the overall operations can then be determined from the risk matrix depicted in Figure A-1-1. Note that the matrix essentially identifies risk by assigning a subjective rating to the product of the two levels: (Probability) x (Hazard) = Risk. It is the goal of ORO that facilities be designed and operated such that risks are maintained at the lowest possible level. The risk matrix not only provides a mechanism for ranking ORO facilities according to risk, but also serves to indicate those facilities which require further evaluation or attention to improve overall plant safety."

Table A-1-1

PROBABILITY RATING SCALE

Probability Scale	Description	Estimated Range of Probability of Accident Occurence, Per Year
E Extremely High	Likely to occur one or more times per year	$p \sim 1.0$
D High	Likely to occur once every ten years	$10^{-1} \leq p < 1.0$
C Medium	Likely to occur once every 100 years	$10^{-2} \leq p < 10^{-1}$
B Low	Likely to occur once every 1000 years	$10^{-3} \leq p < 10^{-2}$
A Extremely Low	Occurence is expected to be less than once every 1000 years	$p < 10^{-3}$

Table A-1-2

HAZARD RATING AND CONSEQUENCE DEFINITION

Hazard Level	Maximum Consequence
7 Catastrophic	* Extremely serious impact onsite and offsite for lengthy periods of time * Large geographical areas as well as large population groups affected * Large numbers of fatalities, both onsite and offsite
6 Extremely High	* Extremely serious impact onsite, on large numbers of people and to the environment * Many fatalities onsite and possible fatalities to the public located on adjacent property * Moderate impact beyond the exclusion area[a]
5 High	* Extremely serious impact onsite and considerable impact on the environment * Multiple fatalities to operating and other onsite personnel * Moderate health and safety concerns to the public located close to the site * Minor impact offsite beyond the exclusion area
4 Medium	* Serious onsite impact and significant impact within the exclusion area and to the environment * Fatality, severe injury, or severe illness to operating personnel * Significant health concern to workers at nearby facilities * Few people offsite seriously affected
3 Low	* Significant onsite but only minor offsite impact * Moderate injury or creation of moderate health concerns for operating personnel * Minor health and safety concerns for nearby facility workers * Slight contamination of offsite environs
2 Extremely Low	* Minor onsite but no offsite impact * Slight injury or illness to operating personnel * Local facility contamination which requires only routine procedures to control or correct * No health and safety concerns for workers at nearby facilities

Table A-1-2 (continued)

Hazard Level	Maximum Consequence
1 Negligible	* Detectable onsite and no offsite impact * No identifiable safety and health consequences * Negligible contamination of the environment

[a]Exclusion area: The area surrounding the facility in which the owner has the authority to determine all activities including exclusion or removal of personnel and property from the area.

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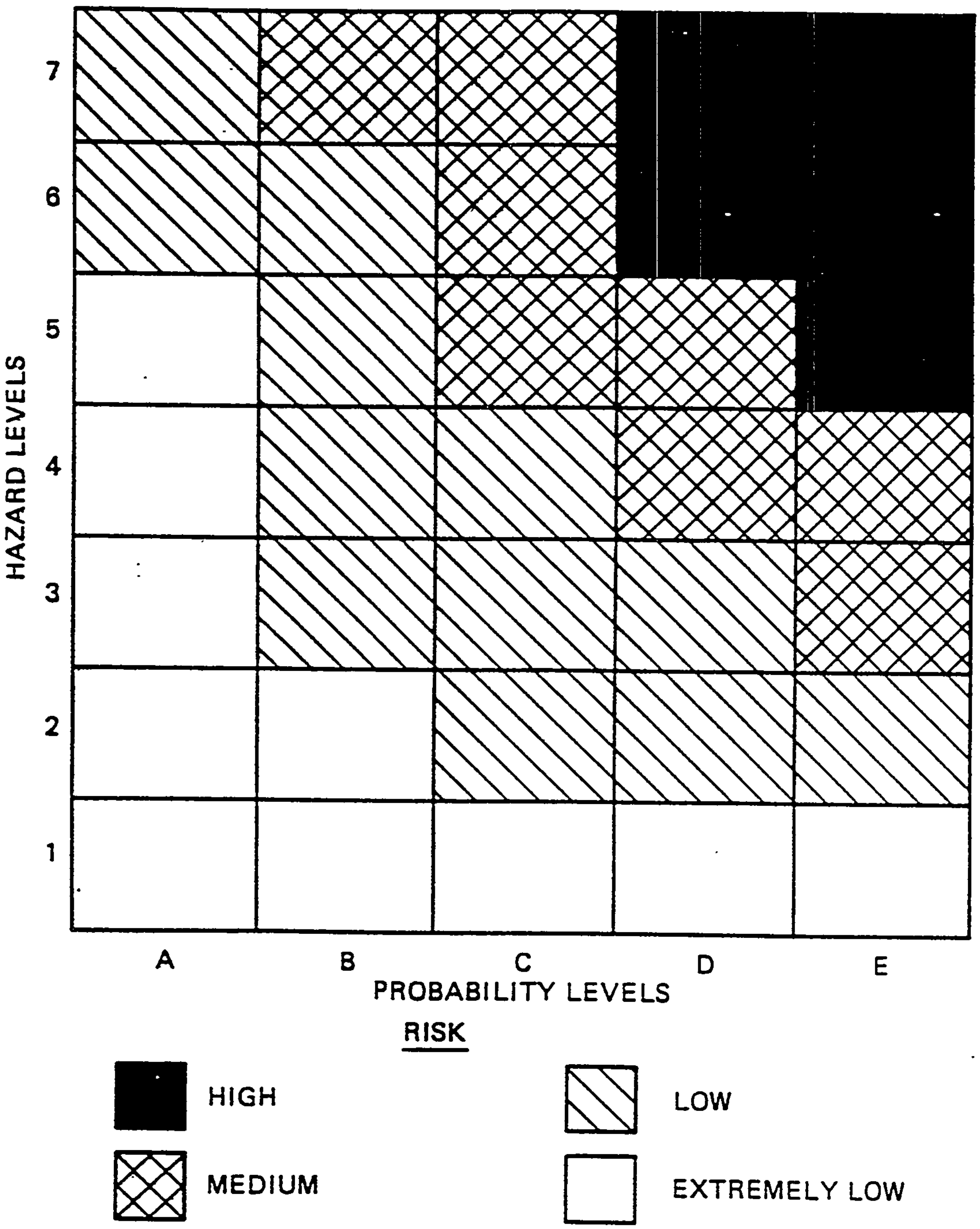

Figure A-1-1
RISK MATRIX