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OPERATIONAL ACCIDENTS & RADIATION EXPOSURES

AT DOE FACILITIES / FISCAL YEAR 1978

U.S. Department of Energy
Assistant Secretary for Environment
Office of Environmental Compliance and Overview
Operational and Environmental Safety Division

MASTER

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SUMMARY

During its first year, the U.S. Department of Energy (DOE) injury and property loss rates, with the exception of the fire at the West Hackberry Site of the Strategic Petroleum Reserve, were similar to the annual rates of the Energy Research and Development Administration (ERDA).

Injury Experience

The DOE incidence rates per 200,000 work hours were 1.2 lost workday cases and 17.6 lost workdays compared to 1.05 lost workday cases and 17.8 lost workdays for ERDA.* These rates were about one-third of the national rates.** The recordable occupational illness rate, based on only 103 cases, was 0.07 cases per 200,000 work hours, or about one-fourth of the national rate.

Ten fatalities occurred at DOE facilities or as a consequence of DOE operations resulting in an annual rate of 6.7 deaths per 100,000 workers. Although double the ERDA rate, this was only one-half the national rate of 14 deaths per 100,000 workers.

Property Damage Experience

DOE's total reported property loss during FY 1978 was \$16.35 million: \$12.6 million by fire, and \$3.75 million by non-fire. The non-fire loss rate of 0.85 cents per \$100 property valuation was about one-half the ERDA rate. The fire loss rate of 2.86 cents per \$100 property valuation was much higher than the ERDA rate, but the increase resulted entirely from the \$12 million fire at the Strategic Petroleum Reserve.

Vehicle Accident Experience

DOE operations required 119 million vehicle miles of travel during FY 78. The resulting 689 accidents caused one fatality and \$353,000 property damage. The loss rates of 5.8 accidents per million vehicle miles and \$2.97 per 1000 miles were less than half the rates reported for all vehicle travel in the United States by the National Safety Council.

Radiation Exposures

The 102,020 monitored DOE and DOE contractor employees received a total dose of 9380 rem*** in CY 1978. Both the total dose and the 1826 employees exceeding 1 rem in 1978 represent a continuing downward trend from the 1977 total dose of 10,400 rem and the 2255 employees who received more than 1 rem.

*Operational Accidents and Radiation Exposures at ERDA Facilities from 1975 to 1977.

**Accident Facts, 1979 Edition, National Safety Council.

***A rem is a unit of radiation dose to man which includes quality factors and is equivalent to one roentgen of X-ray or gamma radiation. A worker is permitted a maximum of 5 rem per year.

INTRODUCTION

The Department of Energy (DOE) was established by Congress on October 1, 1977 to more effectively and efficiently administer national energy policy and programs by integrating into one department the separate energy policies, programs, and organizations that had evolved within the Federal Government. It was formed by combining seven agencies or portions of agencies or departments.

The DOE owns or supports an extended network of research, development, and demonstration facilities involved in energy technologies. Programs include magnetic and inertial fusion, plutonium production, electrical power transmission, uranium separation, coal gasification and liquefaction, energy conservation, solar, geothermal, and other advanced systems.

Comprehensive safety programs are maintained at DOE facilities in order to protect both personnel and property from accidents. To ensure compliance with safety standards and regulations and maximize effectiveness of the safety programs, an extensive inspection and appraisal program is conducted at the contractor and field office levels by both DOE field and Headquarters safety personnel. When accidents do occur, investigations are conducted to identify causes and determine managerial or safety actions needed to prevent similar occurrences.

The Emergency Operations Center at DOE Headquarters is notified immediately of all significant field accidents. Formal DOE investigations are conducted when fatalities occur, the property loss exceeds \$50,000, or the radiation dose exceeds dose standards. At least one member of the investigation board must be a formally trained accident investigator.

DOE safety requirements include the reporting of personnel injury, property and motor vehicle losses on a quarterly basis, and radiation doses on an annual basis. The radiation dose data for CY 1978 are presented and reviewed in this report. All other data in this report are for FY 1978.

OCCUPATIONAL INJURY AND ILLNESS

Although the work environments at DOE facilities vary with the nature of the operation, emphasis is placed on the safety and health of all employees. Concerted safety efforts are devoted to risk management, hazard reduction, safety procedures, and resource management.

The DOE administers a system for recording all cases of occupational death, injury and illness. A case is considered occupational if it arises from exposure or other causes related to employment. Recordable cases include all occupational deaths and illnesses and those injuries which result in or require:

- Transfer to another job or termination of employment.
- Medical treatment other than first aid.
- Loss of consciousness.
- Restriction of work or motion.

Cases are recorded in a log which is kept at each reporting unit and include the following types:

- Fatality: Any death caused by an occupational illness or injury, regardless of the elapsed time between the injury and death or the duration of the illness.
- Lost Workday Case(s):
 - (1) Injured or ill employee misses one or more full days of work.
 - (2) Injured or ill employee is restricted from performing all of the assigned duties of his job for one or more full days at the workplace, regardless of whether those duties are required during the restriction.
- Nonfatal Case Without a Lost Workday(s):
 - (1) All other cases.

Transfer to another job or termination of employment because of occupational injury or illness is also indicated in the log. All recordable cases are reviewed, and efforts are initiated to correct conditions causing the injury or illness. All fatalities are formally investigated.*

During FY 1978, 10 fatalities occurred in seven accidents, as shown in Table 1. The DOE fatality rate** (deaths per 100,000 workers) of 6.7 was approximately one-half the national industrial average of 14, as reported by the National Safety Council.

*The DOE criteria for accident investigations are given in Appendix A.

**Based on an estimate of 150,000 employees.

TABLE 1
FATAL ACCIDENTS DURING FY 1978

Accidents*	Number of Accidents	Number of Fatalities
Asphyxiation	2	3
Burns	2	4
Fall	1	1
Crane	1	1
Automobile	1	1
Total	7	10

Figure 1, based on data in the World Almanac, compares the DOE fatality rate during fiscal year 1978 with various hazards and activities. The rate for the DOE worker includes both Federal and contractor personnel. The hourly probability of a DOE worker being fatally injured at the workplace is only one-thirtieth of the hourly probability that the average citizen would be killed while traveling in an automobile. The DOE fatality rate is also much smaller than the fatality rate for commercial aviation or natural causes, indicating that the DOE workplace is very safe.

Table 2 gives the occupational injury and illness incidence rates for each category of DOE operation expressed in terms of 200,000 employee-hours (approximately 100 employee-years, a rate base specified by the Occupational Safety and Health Administration (OSHA)).

Occupational illnesses are acute and chronic conditions caused by inhalation, absorption, ingestion, or direct contact with a harmful substance. Of 3635 recordable cases, only 103, or less than 3 percent, were illness-related. The illness incidence rate of 0.07 per 200,000 work-hours is about one-fourth of the national rate.** Moreover, only about one-fourth of the illness cases resulted in a lost workday(s) while nearly one-half of the injuries constituted a lost workday case. The number of occupational illness cases by reporting category is given in Table 3. Nearly one-half of the occupational illnesses were skin diseases or disorders resulting from minor incidents and were of a temporary nature causing few lost workdays.

*Summary accounts of these fatal accidents are given in Appendix B.

**Reporters to the National Safety Council; Accident Facts, 1979 Edition.

FIGURE 1. FATALITY PROBABILITIES

TABLE 2
FY 1978 INJURY AND ILLNESS INCIDENCE RATES

Operation	Number of Recordable Cases	Incidence Rate		
		Recordable Cases	Lost Workday Cases	Lost Workdays
Architectural and Engineering	8	1.0	0.4	0.8
Production	664	1.7	0.4	11.4
Government	332	1.9	0.9	9.0
Research	1312	2.2	1.1	14.0
Service	186	4.0	2.0	33.4
Cost Construction	880	8.4	3.9	60.3
Lump Sum Construction	253	14.5	3.6	68.4
All DOE Reporting Facilities	3635	2.7	1.2	17.6
United States Private Industry*	----	7.8	3.5	61.0

TABLE 3
OCCUPATIONAL ILLNESSES REPORTED DURING FY 1978

Category	Number of Cases
Skin Diseases or Disorders	48
Disorders Due to Physical Agents	0
Respiratory Conditions Due to Toxic Agents	10
Disorders Associated with Repeated Trauma	12
Poisoning (Systemic Effects of Toxic Materials)	17
Dust Diseases of the Lungs	10
Other	6
Total Cases	103

*Reporters to the National Safety Council; Accident Facts, 1979 Edition.

PROPERTY LOSS

During 1978, the DOE's reported* property loss was \$16.355 million. The largest single loss, an oil well blowout and subsequent explosion and fire at the Strategic Petroleum Reserve storage site, accounted for \$12 million or 74 percent of the total property loss. The second largest loss, \$1,088,000, resulted from mechanical damage to an in-vessel-handling machine and reactor internals at Hanford. The predominance of large losses in the total property loss, was also typical during the AEC and ERDA periods. For example, from the beginning of ERDA, January 11, 1975, until the end of FY 1978, 4 accidents (out of 486 reported) resulted in more than two-thirds of the total property loss (\$19 million of the approximately \$28 million loss).

Table 4 list all FY 1978 accidents with property losses greater than \$50,000. Investigations are performed for all major accidents occurring at facilities where the DOE has contractual safety responsibility. Summaries of these accident investigations are given in Appendix B.

The DOE's FY 1978 losses for property damage are shown by category in Table 5. The transportation category of Table 5 consists of damage to cargo during routine transit and not damage to cargo or vehicles resulting from vehicular accidents which is shown in Table 6. As can be seen from Table 5, fire accounted for 78 percent of the total loss, while mechanical damage accounted for 10 percent. Natural and nuclear-related causes accounted for only 3 percent and 2 percent, respectively. The \$16.355 million loss is a large dollar amount, but is actually a small percentage of the \$44 billion in properties at risk. The loss rate of 3.71 cents per \$100 valuation was less than one-half of the insurance rate for the best class of insured properties.

*Accidents causing \$100 or more property damage are reported.

TABLE 4
ACCIDENTS CAUSING MORE THAN \$50,000 PROPERTY DAMAGE DURING FY 1978

<u>Property Damage (Dollars)</u>	<u>Date</u>	<u>Location</u>	<u>Description</u>
12,000,000	Sept. 21, 1978	Strategic Petroleum Reserve Oil West Hackberry, Louisiana	Oil well blowout, explosion, and fire
1,088,000	April 9, 1978	Fast Flux Test Facility Richland, Washington	Damage of reactor in-vessel handling machine and re- actor internals caused by mechanical failure
440,000	Sept. 21, 1978	Synthane Pilot Plant South Park Township, Pennsylvania	Explosion of high-pressure boiler
400,000	June 22, 1978	HYGAS Plant Chicago, Illinois	Oil fire in liquid-methanation unit
261,200	Oct. 25, 1977	Naval Petroleum Reserves Elk Hills, California	Oil well blowout, explosion, and fire
250,000	Feb. 1978	Naval Petroleum Reserves Elk Hills, California	Roads damaged by heavy rain
245,600	March 7, 1978	Portsmouth Gaseous Diffusion Plant Piketon, Ohio	14-ton cylinder of UF ₆ dropped by saddle carrier
200,100	Jan. 3, 1978	Paducah Gaseous Diffusion Plant Paducah, Kentucky	Equipment damage caused by chemical explosion
197,300	Nov. 1, 1977	Sandia Laboratories Albuquerque, New Mexico	Release of pressurized- combustible gases
180,000	Sept. 20, 1978	Sandia Laboratories Albuquerque, New Mexico	38,000-lb. test weight fell onto elevating module
150,000	March 6, 1978	Western Area Power Administration	Aircraft damaged on landing
140,000	Sept. 12-13, 1978	Fermi National Accelerator Laboratory Batavia, Illinois	Damage caused by wind, lightning, and flood
100,000	Aug. 1978	Cresap Pilot Plant Cresap, West Virginia	Fire damaged processing unit
100,000	March 24, 1978	Fast Flux Test Facility Richland, Washington	Four compressors failed during testing
97,000	July 27, 1978	Brookhaven National Laboratory Upton, New York	Electrical short-circuit caused fire in wooden hood
94,800	Feb. 16, 1978	Bigas Plant, Hoover City, Pennsylvania	Pressure vessel leak, explosion in reactor

TABLE 5
FY 1978 PROPERTY LOSS

Type	Loss (\$1000)	Loss Rate (Cents/\$100 Property Evaluation)
Fire	12,600	2.86
Mechanical Causes	1,600	0.36
Explosions	895	0.20
Natural Causes	550	0.13
Nuclear-Related Causes	400	0.09
Aircraft	150	0.03
Miscellaneous Causes	100	0.02
Electrical Damage	40	0.01
Transportation (Cargo Damage)	20	<0.01
TOTAL	16,355	3.71

The following motor vehicle losses reported during FY 1978 are listed in Table 6. One fatality and \$353,000 of property damage occurred as the result of 689 vehicle accidents during 119 million miles of travel on official business. The frequency rate of 5.8 accidents per million vehicle miles, and the property loss rate of \$2.97 per 1000 miles are less than half the comparable rates for all nationwide vehicle travel, as reported by the National Safety Council.

TABLE 6
FY 1978 MOTOR VEHICLE LOSS

Number of Vehicles	15,700
Miles Traveled	119 million
Number of Accidents (>\$100)	689
Accidents per Million Miles	5.8
Dollar Loss	\$353,000
Dollar Loss per 1000 Miles	\$2.97

RADIATION EXPOSURE

The DOE radiation protection policy, like the earlier policy of the Atomic Energy Commission (AEC) and ERDA, is based on recommendations by the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiation Protection (ICRP), and the Federal Radiation Council (FRC). It is applicable to all DOE and DOE contractor operations not licensed by the Nuclear Regulatory Commission (NRC).

One of the basic policy objectives is to conduct operations in a manner to limit both cumulative and individual radiation exposures to individuals and population groups to the lowest levels technically and economically practicable. This means that, in addition to maintaining exposures below radiation protection standards,* every effort is made to keep exposures As Low As Reasonably Achievable (ALARA). Radiation protection activities include monitoring programs for evaluating exposures to personnel and environmental radiation levels, and radioactive waste effluent controls, which provide essential information for evaluating and controlling in-plant radiation hazards.

Various types of instruments are used to monitor the different kinds of radiation in the environment and the workplace. Radiation levels are measured with handheld instruments and/or continuous automatic monitoring equipment. Passive devices, such as film badges or thermoluminescent dosimeters, are used to measure the accumulated dose to radiation workers. The concentrations and total quantities of radioactive waste effluents are measured and documented at the point of release to the environment. Potential radiation hazards are evaluated and controlled by the design of the facilities and equipment to reduce the potential radiation exposures to the lowest reasonably achievable levels.

All personnel entering areas where the potential exists for radiation exposure in excess of 10 percent of the Radiation Protection Standards are required to wear monitoring devices for external radiation.

In some contractor operations, badging all employees is more convenient than separating those with no exposure potential. Hence, monitoring of personnel with low exposure potential is not consistent among the contractors. The readings obtained from these devices form the cumulative external dose record of the radiation worker. Internal radiation doses are determined by periodic bioassay analyses and/or in-vivo counting.

Maintaining radiation dose records is an important element of a radiation protection program. Thorough and accurate documentation of an employee's radiation dose history is essential for regulating future radiological exposure. Other monitoring data include:

- Contamination levels recorded at restricted area control points.
- Accumulated doses recorded on monitoring devices.
- Doses monitored by special devices.
- Doses received by employees working under special work permits.
- Doses received by visitors.

*DOE Order 5480.1, reference ERDAM 0524, Standards for Radiation Protection.

Records are also maintained for the following data:

- Contamination levels in the workplace and in the environment.
- Radiation surveys of the workplace and the environment.
- Instrument calibration and repair records.
- Emergency actions and reports.
- Incident and near-miss reports.

The distribution of whole body radiation dose equivalents for the 102,020 DOE and DOE contractor employees monitored during CY 1978 is shown in Figure 2. Forty-four percent of the DOE and DOE contractor radiation workers received no measurable occupational dose and 98 percent of the radiation workers received less than 1 rem each. These workers received 65 percent of the total DOE dose for 1978. The remaining 2 percent of the radiation workers received doses as shown in the top four bars of the graph.

The number of employees in the higher dose ranges and the total dose received by all DOE and DOE contractor employees declined in 1978, continuing the general downward trend. This effective application of the ALARA principle can be seen in Table 7 which gives the employee dose distributions from 1964 through 1978. In Figure 3, the percentage of monitored employees who received more than 1 rem and more than 2 rem are given for the years 1964-1978. In 1978, only 2 percent and 0.5 percent of all workers monitored received a dose greater than 1 rem and 2 rem, respectively. Compared with 1964, this represents a 50 percent reduction in the percentage of workers receiving higher range doses.

The total occupational dose received by all DOE and DOE contractor employees has also decreased, as shown in Figure 4. For comparison, the accumulated background dose for all employees (based upon the estimated 80 mrem/year/person average received by the United States population) is also given in Figure 4. The substantial decreases in individual and total occupational doses are attributable to the implementation of the ALARA principle throughout DOE.

Airborne contamination or direct radiation is detected by various monitoring devices. Periodic or continuous monitoring, a basic part of radiation protection programs, is used to determine the intensity of radiation from various sources in working areas. Portable and stationary monitoring systems are used and have preset alarms which give an easily recognized warning signal when the radiation intensity exceeds a predetermined level, alerting personnel to the need for action to reduce the radiation problem.

FIGURE 2. DOE TOTAL PENETRATING RADIATION DOSE DISTRIBUTION CY 1978

TABLE 7
DISTRIBUTION OF WHOLE BODY RADIATION EXPOSURES FOR DOE AND DOE
CONTRACTOR EMPLOYEES
1964 – 1978

<u>Year</u>	<u>Dose Ranges (rem)</u>										
	<u>0-1</u>	<u>1-2</u>	<u>2-3</u>	<u>3-4</u>	<u>4-5</u>	<u>5-6</u>	<u>6-7</u>	<u>7-8</u>	<u>8-9</u>	<u>9-10</u>	<u>>10</u>
1964	122,711	3583	1823	575	176	43	20	10	7	6	11
1965	128,360	4158	1704	515	294	70	32	26	25	22	8
1966	131,522	3706	1630	593	313	88	47	24	6	2	1
1967	102,510	3472	1572	555	168	35	29	23	17	4	1
1968	103,206	2799	1408	425	144	3	1	---	---	---	---
1969	98,625	2554	1313	335	86	4	---	---	---	---	1
1970	92,185	2698	1329	279	158	5	4	2	---	1	---
1971	90,640	2380	888	275	118	8	3	---	---	---	3
1972	86,077	2130	929	219	95	8	2	---	---	---	---
1973	89,071	1944	727	172	60	2	1	---	---	---	---
1974	75,684	1667	688	149	40	4	---	---	---	---	---
1975	85,451	1846	753	232	142	---	---	---	1	---	---
1976	87,969	1679	475	70	6	1	---	---	---	---	---
1977	92,965	1579	545	103	23	---	---	1	2	---	2
1978	100,194	1323	439	53	11	---	---	---	---	---	---

FIGURE 3. TREND OF DOE INDIVIDUAL RADIATION DOSES

FIGURE 4. OCCUPATIONAL RADIATION DOSE VERSUS BACKGROUND DOSE

Radiation concentration guides are used to evaluate the adequacy of health protection measures against airborne radioactivity in occupied areas. Concentrations of radioactive isotopes in drinking water are also maintained within specified concentration guides. Radioactive effluents and levels in the environment and the biota are monitored to assure that doses to the public are maintained at the lowest reasonably achievable level and are consistent with the radiation protection standards.

There were four accidents involving radiation exposure during 1978 which were investigated.* Four workers received radiation doses of 5, 6, 11, and 15 rem when irradiated fuel elements were accidentally discharged onto their work platform. Stray X-ray radiation in a second accident was responsible for estimated doses of 7.55, 30, and 46.6 rem to the right eyes of three experimenters in a DOE laboratory. Two separate accidents resulted in lung depositions: a technologist received a relatively small deposition of plutonium oxide after the failure of one glove in a glovebox; and a chemist received an internal deposition of 1.6 lung burdens after plutonium-238 was released from a ruptured plastic bag.

*Summaries of the investigations of these accidents are given in Appendix B.

APPENDIX A

DOE CRITERIA FOR ACCIDENT INVESTIGATION

Events which require Types A or B investigations are defined in DOE Order 5480.1, Reference ERDAM 0502, "Notification, Investigation, and Reporting of Occurrences".

TYPE A

Incident (Accident)

1. Any fatal or imminently fatal occupational injury or occupational illness involving a DOE or DOE contractor employee or a member of the public due to an occurrence associated with DOE or DOE contractor operation.
2. Any lost workday case due to an occupational injury or illness of five or more persons as a result of one occurrence in DOE or DOE contractor operation.
3. An occurrence resulting in an estimated loss or damage to DOE or other property amounting to \$250,000 or more, or requiring an estimated \$250,000 or more for cleaning (including decontamination), renovating, replacing or rehabilitating structures, equipment or property.
4. Any occurrence involving a nuclear weapon or device (under jurisdiction of DOE) where there is personal injury or damage to private property.

Loss of Material

Any apparent loss or theft of byproduct or other radioactive material in such quantities and under such circumstances that it could constitute a hazard to the health and safety of individuals. Where this involves the possible theft of Government property, the FBI shall be notified (for a decision as to acceptance of investigation jurisdiction).

Radiation Exposure

1. A single or annual accumulated whole body exposure of an individual to 25 rem or more of radiation, a single exposure of the skin of the whole body of an individual to 75 rem or more of radiation, a single exposure of the forearms of an individual of 150 rem or more, or a single exposure of the hands or feet of an individual to 375 rem or more of radiation.
2. Any internal uptake of radioactive material which, on the basis of early assay data, will result in a dose commitment in excess of five times the annual standard set forth in DOE Order 5480.1, Reference ERDAM 0524.

Other

1. Any nuclear criticality in a system not intended to reach criticality.
2. Any accidental release of pollutants which results in or could significantly affect the public or the offsite environment, or which requires activation of the Environmental Protection Agency or the U.S. Coast Guard National Contingency Plan.

TYPE B

Incident (Accident)

1. Any loss or damage to DOE or other property of \$50,000 to \$250,000 where loss or costs are incurred for cleaning (including decontamination), renovating, replacing, repairing, or rehabilitating structures, equipment, or property.
2. An occupational illness which requires hospitalization, involves five or more persons of which one is a lost workday case, or results in more than five days away from work.

Radiation Exposure

1. Any radiation exposure to an individual which in one calendar quarter exceeds the following:
 - 5 rem to the whole body.
 - 15 rem to skin of whole body or thyroid.
 - 30 rem to the forearms.
 - 75 rem to the hands or feet.
2. Any internal uptake of radioactive material which, on the basis of a small number of early assay data, will result in a dose or dose commitment in excess of the pertinent annual standard set forth in DOE Order 5480.1, reference ERDAM 0524.

Other

1. Any unplanned nuclear excursion in a reactor which is clearly outside routine experience.
2. Any release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5000 times the limits specified for such materials in DOE Order 5480.1, reference ERDAM 0524.
3. Any release of radioactive material offsite where it is believed any member of the general population may have received an exposure greater than the annual standard set forth in DOE Order 5480.1, reference ERDAM 0524.

APPENDIX B

SUMMARIES OF ACCIDENT INVESTIGATION REPORTS

Fatalities

1. Blowout, Fire and Explosion – Elk Hills, California
October 25, 1977 Three Fatalities
Property Loss:
 Government \$261,200
 Hydraulic Workover Inc., \$224,600

Five employees of Hydraulic Workover, Inc., were attempting to run a packer string into a well. This string was incompatible with the blowout prevention equipment and snubbing assembly stack. The resulting blowout of oil and gas into the air was followed by ignition and explosion. Three of the men were fatally injured. The well was controlled and shut off on October 27.

Two major contributing factors were the lack of an adequate stripper in place at the time of the accident, and the operation of a diesel generator within the area of the blowing oil and gas, which was not equipped with appropriate spark arresters or a suitable water injection system in the exhaust system.

2. Excavation Cave-In – Idaho Falls, Idaho
November 15, 1977 Two Fatalities

Two workers on a construction site at the Idaho National Engineering Laboratory were working on an excavation floor near a vertical bank which had been cut at the bottom of a sloped excavation. A self-propelled vibratory roller at ground level approached within 20 feet of their position causing the vertical bank to collapse. The men were buried and suffocated.

A primary cause was the failure to maintain the slope at the required angle of sloping when widening the bottom of the previous excavation. A contributing factor was the absence of adequate barriers in the work area.

3. Fatal Fall – Nye County, Nevada
February 20, 1978 One Fatality

A driller helper fell through a 30-inch diameter emplacement hole at the Nevada Test Site. He was assisting another worker in the routine removal of the plywood sheet covering the hole. At the time of the accident, the hole had been drilled to a depth of 1172 feet. The fall resulted in fatal fractures and internal injuries.

One or more of the following factors could have contributed to the accident:

- Distraction of the victim by something seen or heard.
- Preoccupation with past or contemplated activities as a result of a shortened work shift.
- Incorrect assumption that the hole was still covered by another sheet of plywood.

Use of a safety belt and attachment would have limited the distance of the fall and prevented the fatality.

4. Inert Atmosphere – Los Alamos, New Mexico
June 9, 1978 One Fatality

An employee entered a van de Graaff tank at the Los Alamos Scientific Laboratory to perform maintenance work and collapsed in the tank. A second employee entered the tank to help him and also collapsed. Although both men were removed from the tank within a few minutes, the first employee died on June 17.

The most probable cause of the accident was the employee's entry into the tank before it had been adequately purged of a nitrogen atmosphere. The following contributory causes were identified:

- Failure to ventilate the tank for an adequate period of time combined with the use of a fan smaller than specified.
- Failure to monitor oxygen level prior to entry.
- Failure to revise standard operating and safety procedures when a change was made from using air to using nitrogen for the backfill.
- Failure to recognize this particular hazard.

5. Automobile Accident – State of Washington
July 24, 1978 One Fatality

An employee of Bonneville Power Administration was fatally injured in an automobile accident while on official business in the State of Washington.

6. Fatal Accident – Richland, Washington
August 22, 1978 One Fatality

A nuclear chemical utility operator was pinned between a crane counterweight and the edge of a flatbed truck at the 241 TX tank farm on the Hanford Site. The operator was standing between the flatbed truck and the crane. While leaning over the truck bed and unwrapping equipment he was struck by the counterweight of the crane and was pinned between it and the edge of the truck bed. The operator died from his injuries on the following day.

The immediate causes of the accident were the failure to barricade the crane counterweight swing radius and the failure to observe safe practices for operation of the crane. The investigation board concluded that a contributing cause of the accident was the failure of management to provide a safety system that would have prevented the occurrence of this hazardous situation.

7. Explosion, Fire, and Oil Spill – West Hackberry, Louisiana
September 21, 1978 One Fatality; One Serious Injury
Total Loss: \$12 million

During a workover operation at the oil storage site of the Strategic Petroleum Reserve where a casing was being pulled out of a well, a flow of mud from the well could not be controlled by the workers on the rig. It continued unchecked until the packer blew out of the casing releasing a flow of oil.

An estimated 67,510 barrels of oil were expelled from Cavern 6. Of this total, 34,620 barrels were accounted for: 31,200 barrels recovered from Black Lake, 2100 barrels pumped to Cavern 7, 790 barrels in the soil, and 530 barrels in a shell on the pad. The remainder (32,890 barrels) was assumed to have burned. Because of the rapid and effective containment and cleanup of the oil spill by the Rapid Response Team, it appears that Black Lake will not sustain any permanent environmental damage.

- A higher priority for oil storage than for adequate safety and contingency planning.
- Lack of established standards, review approval, monitoring procedures, and oil field expertise.
- Assignment of onsite responsibility to several different organizations.

1. **Blowout, Fire, and Explosion – Elk Hills, California**
October 25, 1977 **Three Fatalities**
Property Loss:
Government \$261,208
Hydraulic Workover, Inc., \$224,600

2. Accidental Release of Gases – Albuquerque, New Mexico
November 1, 1977
Property Damage: \$197,300

3. Explosion – Paducah, Kentucky
January 3, 1978
Property Loss: \$200,100

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The force of escaping gases caused siding to be blown from the walls of the upper story. The explosion caused the spread of reaction products into equipment and the room. Analysis indicated that the quantity of uranium hexafluoride released was less than 30 pounds.

The direct cause of the explosion was the failure of the automatic recycle valve control in the uranium hexafluoride gas compression loop to operate properly during a large inventory shift in the cascade. Mechanical damage, chemical reactions, and hydraulic rupture of the gas coolers permitted release of the coolant inventory and the combustion of some of the release.

4. Release of Uranium Hexafluoride – Piketon, Ohio
March 7, 1978
Property Loss: \$245,600

A 14-ton, thin-walled cylinder containing liquid uranium hexafluoride ruptured when dropped 8 to 10 inches from a straddle carrier at the Portsmouth Gaseous Diffusion Plant. The release of 6477.5 kilograms of uranium hexafluoride occurred in less than five minutes. Emergency notification and response were extremely rapid. The reestablishment of containment of the material was accomplished in 153 minutes.

The total cost of this release included emergency response, lost material, decontamination, and the reprocessing of recovered material. There were no injuries or exposures of personnel to radioactive materials in excess of allowable standards. The probable causes of the accident were:

- The handling of cylinders with unreliable equipment.
- Poor safety attitude on the part of personnel.
- The failure of management to correct conditions discovered after previous accidents.

5. Drop of Reactor Fuel Handling Equipment – Richland, Washington
April 9, 1978
Property Loss: \$1,088,000

The Fast Flux Test Facility (FFTF) In-Vessel Handling Machine (IVHM) No. 1 was undergoing troubleshooting by Hanford Engineering Development Laboratory test engineering for faulty armjack operation when the grapple and rigid arm assembly were driven together, causing failure of the bolts connecting the grapple hoist chain to the chain load equalizer. The grapple and rising stem (3450 pounds) dropped approximately 12 feet onto the thermal baffles above the FFTF core support structure.

Following the incident, photographs taken by periscope through fuel transfer ports showed damage to a thermal baffle plate and possibly its support structure as well as to the grapple. Other potential damages, as well as confirmation of IVHM No. 1 console and hardware status at the time of the incident, was assessed during removal of IVHM No. 1 and diagnostic analysis of the IVHM console.

The principal cause of the accident was management approval of operation in a mode contrary to test instructions. This change permitted troubleshooting activities to be conducted without control procedures.

6. Oil Fire — Chicago, Illinois
June 22, 1978
Property Loss: \$400,000

An oil fire occurred at the HYGAS Pilot Plant when hot oil leaked through double block valves into the cavity of an oil filter. The filter had been withdrawn from service for the replacement of filter cartridges which were plugged with catalyst. The oil filter was open for a longer duration than necessary due to lack of proper tools, lighting, and supervision.

Damage to the liquid phase methanation unit was estimated at \$200,000. Although the HYGAS Pilot Plant was essentially shut down at the time of the fire, it also sustained damage estimated at \$200,000.

The investigation board concluded that neither the operating procedure nor the double block valves were adequate to remove the filter from service while operation of the pilot plant continued at high pressure and temperature.

7. Building Fire — Upton, New York
July 27, 1978
Property Loss: \$97,000

A fire occurred at Brookhaven National Laboratory in a room in which printed circuit boards were manufactured. The probable cause of the fire was an electrical short circuit in the line cord supplying power to the controller for a tin solution in a plywood fume hood. After the hood ignited, burned, and collapsed, fire spread to materials in the room. The intense heat caused damage to the room, equipment, and supplies.

The major contributing factors to the fire were the construction of the hood from combustible materials and the lack of an automatic fire extinguishing system within the hood and the building. The storage of combustible plastic tanks in front of the hood further contributed to the loss.

8. Severe Thunderstorm — Batavia, Illinois
September 12-13, 1978
Property Damage: \$140,000

A recordbreaking thunderstorm caused a lengthy power outage at Fermi National Accelerator Laboratory. Sump pumps in underground facilities were rendered inoperable; consequent flooding resulted in extensive equipment damage.

9. Accidental Drop of Test Weights — Albuquerque, New Mexico
September 20, 1978
Property Loss: \$180,000

During the testing of a hoisting system intended for use in the erection of a solar receiver assembly in the Solar Thermal Test Facility at Sandia Laboratories, structural failure in the hoisting equipment allowed approximately 40,000 pounds of test weights to fall 40 feet upon the elevating module. The test weights penetrated the top surface of the elevating module and came to rest on the floor of the top room in the module. Although the main tower structure was unharmed, the elevating module sustained major damage.

No personnel were injured. The effect on the overall program was a delay in the test program for the Solar Thermal Test Facility.

The investigation board concluded that the probable primary cause of the incident was failure of the winch spool flange and the resultant breaking of the cable. Probable contributory causes were the design of the winch (with insufficient strength in one flange), the use of a hoisting system that did not conform to standards of the American National Standards Institute, and the failure to consider the consequences of possible winch failure.

10. Explosion, Fire, and Oil Spill – West Hackberry, Louisiana
September 21, 1978 One Fatality
Property Loss: \$12 million

A summary of this accident is given above in "Fatalities."

11. Boiler Explosion – South Park Township, Pennsylvania
September 21, 1978
Property Loss: \$440,000

An explosion occurred at the Synthane Pilot Plant while attempts were being made to relight a high pressure boiler. A fuel oil fire resulting from the explosion was extinguished within 10 to 15 minutes.

No employees were injured. The explosion caused extensive damage to the boiler and related systems as well as the building housing the boiler.

The most probable cause of the explosion was improper operation of the flame-scanner amplifier. Other possible contributory factors included malfunctions in the pilot system, improper pressure conditions in the fuel oil or atomizing steam supply lines, and improper combustion air feed. Contributory causes also included the operation of the facility without a preventive maintenance program, and the absence of a safety inspection or testing program for the boiler.

Radiation Accidents

1. Inhalation of Plutonium – Miamisburg, Ohio
December 1, 1977

A chemist accidentally inhaled a very small amount of plutonium-238 released from a plastic bag containing radioactive waste ash after the bag ruptured during its removal from a glovebox. The chemist was leaning over the bag when it ruptured; contamination was localized on his gloves and the lower part of his shirt.

He received an initial internal deposition of 1.6 lung burdens (~24.5 nanocuries). No other employee received an internal deposition. The release was contained in the immediate work area. There was no property damage or loss of equipment associated with the release.

2. Accidental Discharge of Irradiated Fuel Elements – Richland, Washington
December 16, 1977 Four Radiation Exposures

Sixteen irradiated fuel elements were accidentally discharged from the front face of the N Reactor onto the “C” work platform where four employees were performing maintenance work on a pressure tube assembly. The employees received whole body radiation doses of 5, 6, 11, and 15 rem. These values were based on personnel dosimeter results and calculations to account for body shielding characteristics. The four employees returned to work on their next scheduled shifts, and the reactor resumed operation on December 27, 1977.

The accident was caused by a higher than normal pressure in the reactor primary coolant system resulting in fuel being expelled when a closure was removed from a pressure tube. The abnormal pressure resulted from an erroneous closure of an electric circuit breaker which energized heaters in the reactor pressurizer.

Failure of personnel to detect abnormal pressure conditions permitted the primary coolant system to pressurize over a period of time. Procedural violations and inadequacies allowed entry into the primary coolant system when it was under pressure. The lack of visual indicators on equipment prevented recognition of the equipment status.

3. X-Ray Exposures – Alameda County, California
March 24 - April 11, 1978 Three Radiation Exposures

On several occasions, three experimenters at the Lawrence Livermore Laboratory received X-ray exposures to the right eye while observing an electron beam through a viewport from which the leaded glass shield had been removed. Other persons were not exposed to radiation during the accident period.

Estimates of the probable doses were 7.55, 30.0 and 46.6 rem. None of the experimenters is expected to develop any disability from the exposures.

Probable causes of the accident were:

- The leaded glass shield was not permanently installed or interlocked to prevent unauthorized access to the X-ray field.
- Operational safety procedures did not identify the X-ray hazards or contain X-ray safety provisions.

4. Inhalation of Plutonium Dioxide – Richland, Washington
May 23, 1978 One Radiation Exposure

A senior chemical technologist received an internal deposition of a relatively small quantity of plutonium dioxide at the plutonium processing facility on the Hanford Site. He was performing a routine analytical process to determine the density of sintered plutonium dioxide pellets in a glovebox.

The cause of the accident was fatigue failure of one glove. The movement of removing the hand from the glove caused the release of a small quantity of plutonium dioxide.

Contamination was deposited on the exterior surface of the employee's protective clothing, the floor of the room, and the exterior of the glovebox. Skin contamination of the employee was limited to the right hand and nostrils.

The employee was decontaminated and immediately restricted from further work in a radiation zone. He reported for work the following day. Decontamination of the room in which the accident took place was completed within 3 days.

Other Investigations

1. **Bicycle-Tractor Trailer Accident – Berkeley, California**
March 24, 1978 One Fatality (Nonoccupational)

A tractor trailer from Lawrence Livermore Laboratory had left the Lawrence Berkeley Laboratory when it was involved in an accident with a bicyclist. Physical evidence indicated that the rider was attempting to pass on the right side of the tractor trailer as it was negotiating a right turn. The bicyclist sustained fatal injuries.

The investigation board did not find any shortcomings in the management system that might have prevented this accident. The tractor involved was less than 1 year old and was properly equipped according to Department of Transportation requirements. The professional driver was competent with a very good safety record and was following an approved truck route.

2. **Excavation Cave-In – Upton, New York**
March 24, 1978 One Occupational Injury

A cave-in occurred in a trench that was being cut across a roadway for replacement of a steam condenser pipe at the Brookhaven National Laboratory. Two workers in the trench were pinned beneath an unsecured section of the shoring when one face of the trench wall broke.

One worker was hospitalized for treatment of a dislocated shoulder and superficial burns of the leg. The other man was treated for a laceration of the right ear and returned to work. His injuries were nonrecordable.

The primary cause of the accident was the use of improper procedures during shoring installation, which subjected workers to the hazards of a cave-in. Contributory factors included the absence of a job safety review and the failure of management to delegate the responsibility for safety to one individual.

3. **Failure of Airplane Engine – Albuquerque, New Mexico**
April 19, 1978

A DHC-6 airplane operated by Ross Aviation Incorporated experienced a complete left engine failure during a flight between Albuquerque and Los Alamos, New Mexico. The failure resulted in an explosion and a burst of flame. The engine was shut down, an emergency declared, and the aircraft made a normal landing upon returning to Albuquerque. There were no injuries

to employees or passengers. The National Transportation Safety Board (NTSB) and the local General Aviation District Office conducted an external inspection of the engine. NTSB personnel identified the engine for teardown to determine the cause(s) of the engine failure. The DOE did not suffer a property loss because the engine failed while under warranty.

4. Electric Shock and Burns – Menlo Park, California
July 5, 1978 One Occupational Injury

A construction worker on the Positron Electron Project Site at the Stanford Linear Accelerator Center was steadying a load for a crane operator when the extended boom of the crane either struck or came within arcing distance to a 60-kV powerline. The worker's clothing was ignited; he suffered first-, second-, and third-degree burns over 90 percent of his body. His subsequent lost workdays were recorded as caused by an occupational injury.

Probable causes of the accident included:

- The attempt to move the load without a truck.
- Extension of the crane boom beyond the level which would permit it to pass safely under the 60-kV line.
- Inattention of the crane operator to the location of the crane boom.

5. Skin Rash – Los Alamos, New Mexico
August 16, 1978 One Occupational Illness

An employee of the Engineering Support Group MP-8, Los Alamos Scientific Laboratory, experienced a rash and allergy symptoms after exposure to various adhesives, paint, and an elastomeric potting compound. Seven lost workdays were charged to this apparent occupational illness.

The probable cause of the rash and allergy symptoms was presumed to be exposure to the organic vapors. Contributing factors were crowded conditions in the shop, a heavy workload resulting in several jobs being performed at the same time, the accidental handling of contaminated tools and equipment, and higher than normal shop temperature.

6. Incorrect Disposal of Radioactive Waste – Alameda County, California
August 24-28, 1978
Recovery Costs: \$16,909

Twenty-one paper sacks containing a total of 43 millicuries of radioactive material were trucked to the East Alameda County disposal site with other nonradioactive waste on August 25, 1978. A custodian had removed the sacks from yellow radioactive waste cans in the Nuclear Chemistry Building of the Lawrence Livermore Laboratory the previous night and placed them in a dumpster designated for nonradioactive waste.

The absence of the radioactive waste sacks was discovered on August 28, 1978. An emergency response team from Lawrence Livermore Laboratory located and recovered the radioactive waste at the county disposal site. There was no exposure of laboratory personnel or the general public to nuclear radiation above established limits.

The causes of this occurrence were:

- A custodian performed an unassigned task, which resulted in the improper handling and disposal of radioactive waste.
- Administrative controls were inadequate to prevent offsite disposal of radioactive solid waste.

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