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ICPP RADIOLOGICAL AND TOXICOLOGICAL SABOTAGE ANALYSIS

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ABSTRACT

In June of 1993, the Department of Energy (DOE) issued Notice 5630.3A, "Protection of Departmental Facilities Against Radiological and Toxicological Sabotage," which states that all significant radiological and toxicological hazards at Department facilities must be examined for potential sabotage. This analysis has been completed at the Idaho Chemical Processing Plant (ICPP). The ICPP radiological and toxicological hazards include spent government and commercial fuels, Special Nuclear Materials (SNM), high-level liquid wastes, high-level solid wastes, and process and decontamination chemicals. The analysis effort included identification and assessment of quantities of hazardous materials present at the facility; identification and ranking of hazardous material targets; development of worst case scenarios detailing possible sabotage actions and hazard releases; performance of vulnerability assessments using table top and computer methodologies on credible threat targets; evaluation of potential risks to the public, workers, and the environment; evaluation of sabotage risk reduction options; and selection of cost effective prevention and mitigation options.

INTRODUCTION

The Idaho Chemical Processing Plant is part of the Department of Energy Idaho National Engineering Laboratory (INEL). The ICPP began operations in 1953 as the principal INEL facility for receipt, interim storage, and reprocessing of nuclear fuels from test, defense, and research reactors in the United States and other countries. Although reprocessing was terminated in April 1992, the ICPP still maintains approximately 3800m³ of calcined high level waste and approximately 7600m³ of liquid high level waste. In addition, there are about thirty different types of spent fuels stored in both dry and wet facilities, for a total of approximately 700 metric tons of material.

This paper describes the methodology used to perform the radiological and toxicological sabotage analysis at the ICPP.

TEAM IDENTIFICATION

The Guidance for Protection of Department of Energy Facilities Against Radiological and Toxicological Sabotage recommends using a team consisting of representatives from Emergency Management (Team Leader), Facility Management and Operations, Safeguards & Security, Safety, and Environmental. This recommendation was followed, and provided the well rounded mixture of backgrounds necessary to perform the analysis. The only modification required was identifying the Safeguards & Security representative as the Team Leader to allow for more access to vulnerability assessment expertise.

TARGET IDENTIFICATION AND ASSESSMENT

An identification of radiological, chemical, and other hazards was required. At this time in the process it was decided to include only those hazards which would still be present at the facility by the required implementation date of the DOE Notice.

Radiological hazards were identified from previous radionuclide inventories conducted at the ICPP. The inventory selection was very conservative, and included maximum radionuclide inventories that could be in any facility at a given time. Often these values were identified by reviewing the design basis documents for the facilities. In some cases, it was necessary to determine the radionuclide inventory of spent fuels using the ORIGEN2 code, since several types of the spent fuels in storage had limited information concerning their content. Threshold values of radioisotopes were identified by 10 CFR Section 30.72, Schedule C.

Chemical hazards were identified by expanding a "HAZTRAK" database maintained by the ICPP. The "HAZTRAK" system is a comprehensive database for logging and tracking the receipt and storage of hazardous chemicals. Although this system provided real time monitoring of chemical hazards, it was also necessary to review proposed project documentation to determine if additional chemical hazards were intended for storage and use at the site by the required implementation date of the DOE Notice. Threshold values were identified by SARA Title III, 40 CFR Section 355, Appendix A, and 29 CFR Section 1910.119, Appendix A.

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"Other" hazards, such as gasoline, fuel oil, wastes, and non-process chemicals that did not fall into the radiological or chemical hazard categories were identified by the use of internal documents and facility walkthroughs.

Overall, the ICPP had fifteen radiological hazard areas, three chemical hazard areas, and eleven "other" hazard areas to evaluate.

TARGET RANKING

Two ranking models were utilized to prioritize the radiological and hazardous material targets. A Safety and Health Risk Based Priority Model (RPM), which prioritizes risk through the use of a Priority Planning Grid (PPG), was the first model used to rank the targets. This system is a multi-attribute system that incorporates consideration in Public Safety, Worker Safety, Environmental Protection, Regulatory Compliance, DOE Mission Imperative/Impact, Investment Protection, and Public Perception.

A second ranking model was developed by the assessment team to take into account Target Availability, Expected Length of Storage, Threat Perception, and Threshold Factor. This model was simpler than the RPM model, and weighted most heavily towards the Threshold Factor, which took into account the value the target inventory exceeded the screening threshold dictated by 29 CFR Section 1910.119, Appendix A and 10 CFR Section 30.72, Schedule C. This model allowed the assessment team to use professional judgement to develop a practical ranking. The two models were compared and evaluated to generate the final ranking of targets.

TARGET VULNERABILITY ASSESSMENTS

The Guidance for the Protection of Department of Energy Facilities Against Radiological and Toxicological Sabotage requires the facility to determine the level of protection afforded each potential sabotage target. This includes reviewing each hazard to determine if the current level of protection is the same as that afforded a corresponding hazard in the commercial or private sector. If the level of protection is similar, no further actions are required. If not, a detailed vulnerability assessment is required.

The level of protection required in the commercial or private sector was actually determined by the safety requirements for the hazards, since there are relatively no security requirements associated with the majority of hazards in general industry. Through the use of environmental, safety, and health documentation, and previous appraisal and audit data, the assessment team was able to demonstrate that all chemical and "other" hazards, as well as several radiological targets that involved industrial sources, were protected through safety requirements equal to or greater than commercial or private sector requirements.

For the remaining targets, a viable sabotage scenario and risk formula was developed and examined using the VISA-2 (Vulnerability of Integrated Safeguards Analysis) tabletop assessment method. In all cases, the results of Force-on-Force exercises and Limited Scope Performance Tests (LSPTs) were considered in the analyses to make the vulnerability assessment values as accurate as possible. In addition, it was necessary to take mitigation options into consideration when developing the scenario. These included emergency preparedness and safety actions.

Unlike a typical target requiring a vulnerability assessment, such as a Category I quantity of SNM located in a material access area and protected area, most radiological sabotage targets did not have any installed security systems or protective features. These targets, although usually protected from the public in a property protection area or equivalent, had no further security restrictions placed on ingress or egress, no alarm or assessment capabilities, and monitoring only by safety and operations personnel. The majority of radiological sabotage targets were of little interest to the facility security personnel, including the Security Police Officers (SPOS), so often the values for detection, interruption, and neutralization were very low. This resulted in a very low system effectiveness, making the determination of the consequence value the most critical aspect of the vulnerability assessment. The consequence value drove the risk determination in each of the possible targets at the ICPP.

Although DOE Notice 5630.3 requires facilities to determine the possible consequence of sabotage events to the public, workers, and the environment, at the time of the assessment only the possible consequence to the public had been addressed in DOE guidance documents (the "Format and Content Guide for Site Safeguards & Security Plans," dated January 1995, was issued after the completion of the assessment).

In order to fully evaluate the consequence to the public, workers, and the environment, the assessment team developed a set of radiological and toxicological sabotage consequence values which included public safety, worker safety, and environmental safety.

These consequence values are based upon the 10CFR100 limits, those cited in the DOE Order 6430.1A, Section 0200-1.3, Radiological Siting Guidelines, and a standardized risked based prioritization scheme.

Public and Worker Safety consequence values were based upon received radiological or toxicological dose. Environmental Safety consequence values were based upon estimated remediation costs and repairability of environmental damage caused by the sabotage event. The cleanup costs were determined by estimating the area required for cleanup, and determining the most cost effective method to cleanup property and facilities.

The radiological and toxicological sabotage consequence values used in the calculations for the determination of the conditional risk associated with a sabotage event are presented as an attachment to this paper.

Calculations to determine releases of radionuclides to the atmosphere were performed using the Radiological Safety Analysis Computer Program (RSAC-5), which is an INEL program used for emergency management and safety analysis. RSAC-5 has been subjected to extensive independent verification and validation in accordance with the guidelines presented in ANSI/ANS-10.4, "American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for Nuclear Industry."

RSAC-5 can: calculate a fission product inventory from a reactor operating history or a criticality accident; allow for direct radionuclide inventory input; provide source term modeling to all progeny ingrowth and decay; model the effects of HEPA filters or other cleanup systems; produce Gaussian plume diffusion for Pasquill-Gifford, Hilsmeier-Gifford, and Markee models; and include corrections for plume rise and building wake. Doses can be calculated through inhalation, immersion, ground surface, and ingestion pathways; and cloud gamma doses from semi-infinite plume and finite plume models.

Source terms were developed by using actual sample results, conservative estimates, and, in some cases, inventories used in facility design and operation. Release fractions were based upon the sabotage scenario, the form of the material being released, the construction and location of the facilities involved in the sabotage event, and applicable emergency planning and safety analysis results.

Based upon the above methodology, all radiological and toxicological targets at the ICPP presented a low risk to public safety and the environment. Some of the targets did, however, present a high or moderate risk to worker safety.

RISK REDUCTION EVALUATION

Since the potential risk to the public and the environment was low in all possible sabotage events, high cost or personnel intensive solutions to mitigate possible releases was not warranted. The only way to protect the workers would be to maintain a denial strategy on the targets, which was both cost and operations prohibitive.

In addition, the risk assumed to the worker was no greater than that assumed by any worker in an industrial environment where sabotage is a valid threat. In fact, the degree of emergency preparedness and capability for rapid response to casualties far exceeds typical industrial environments, further mitigating the probability of worker injury or fatality.

PREVENTION AND MITIGATION OPTION SELECTION

Based upon the low risk, no preventative or mitigative options were required. One simple option was, however, recommended by the assessment team. This option involved the training of Security Police Officers (SPOs) on the protective force relative to the recognition of potential radiological and toxicological sabotage, and potential targets, possible scenarios, and potential releases. Although the option will not change the value of any potential risk, it can produce some tangible benefit in the area of emergency response and mitigation times.

SUMMARY

Of the twenty nine potential radiological and toxicological sabotage targets which exist at the ICPP, all but eleven are materials that are commonly used in general industry and protected at the ICPP at an equivalent level. For the remaining eleven targets, vulnerability assessments were performed, and consequence values developed, to determine the level of risk for public safety, worker safety, and environmental safety.

REFERENCES

DOE HDBK 0013-93, Recommended Values and Technical Bases for Airborne Release Fractions (ARFs), Airborne Release Rates (ARRs), and Respirable Fractions (RFs) at DOE Non-Reactor Facilities

INEL Cost Estimating Guide for Environmental Restoration

LA-10294-MS, A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities

NUREG/CR-3011, Dose Projection Considerations for Emergency Conditions at Nuclear Power Plants

NUREG/CR--3332, Radiological Assessment, A Textbook on Environmental Dose Analysis

NUREG Guide 3.33, Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Fuel Reprocessing Plant

The Radiological Safety Analysis Computer Program (RSAC-5) Users Manual, WINCO-1123, October 1993

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RADIOLOGICAL AND TOXICOLOGICAL SABOTAGE CONSEQUENCE VALUES

CONSEQUENCE VALUE	PUBLIC SAFETY CRITERIA	WORKER SAFETY CRITERIA	ENVIRONMENTAL SAFETY CRITERIA
1.00	> 10 x (DOE 6430.1A VALUE) for radiological exposure Or Any loss of public life from toxicological exposure	None	None
0.50	5 x (DOE 6430.1A VALUE) for radiological exposure Or Permanent physical disablement to off-site individuals from toxicological exposure	On-site radiation or toxicological exposure resulting in worker death(s)	Uncontained contamination spread beyond site boundary causing loss of public resource (land use/ property/aquifer). Damage is irreparable and noncontainable
0.20	2 x (DOE 6430.1A VALUE) for radiological exposure Or Multiple excessive exposures off-site due to toxicological exposure	On-site radiation or toxicological exposure much greater than limits and/or serious lost time injury	Excessive on-site ecological damage requiring corrective action (clean up). Damage is irreparable and noncontainable
0.10	= (DOE 6430.1A VALUE) for radiological exposure Or Moderate exposures of public near limits and/or moderate injuries to public due to toxicological exposure	Worker exposure near or above limits, contaminated wound and/or injury requiring emergency room visit	Moderate contamination spread beyond site boundary at levels requiring site response or moderate on-site ecological damage requiring remedial action (stabilization). Damage is irreparable but containable
0.05	None for radiological exposure Or Low level toxicological exposure and/or minor injury to public	None	Measurable minor ecological damage off-site or on-site. Damage is repairable
0.01	< 0.1 x (DOE 6430.1A VALUE) for radiological exposure	Reportable on-site work accident, minor exposure, or significant removable skin contamination	Other minor reportable events affecting the environment

PUBLIC SAFETY CRITERIA

Radiological

The Public Safety Criteria for radiological sabotage is based upon DOE Order 6430.1A, Section 0200-1.3, Radiological Siting Guidelines. The 6430.1A guidelines, which are based upon a 50 year committed dose equivalent, state that the maximum calculated dose shall not exceed 25 rem to the whole body, 300 rem to the thyroid, 300 rem to the bone surface, 75 rem to the lung, or 150 rem to any other organ. If multiple organs receive doses from the same exposure, the effective dose equivalent from all sources shall not exceed 25 rem when calculated by using the ICRP Report No. 26 weighing factors. The consequence values are also representative of those cited in the Format and Content Guide for Site Safeguards and Security Plans, Attachment 2, Table 2-3, April, 1993, and are representative of the INEL standardized risked based prioritization scheme.

Toxicological

The Public Safety Criteria for toxicological sabotage is based upon the INEL standardized risked based prioritization scheme.

<u>Any loss of public life from toxicological exposure</u>:

- This is meant to address immediate deaths or deaths that could occur in the future, resulting from immediate injuries or from cancer or genetic damage that could be directly linked to the sabotage event.

<u>Permanent physical disablement to off-site individuals from toxicological exposure</u>:

- This includes lung damage or other permanent damage (e. g., sterility) due to releases of toxicological materials. The type of event could result in exposing the public to toxicological materials in significant amounts in excess of published, acceptable limits such as those defined in 10CFR20. However, such exposure is not expected to result in a loss of life or permanent disability of any member of the public. Recovery from any injuries sustained as a result of the issue or condition is considered likely.

<u>Multiple excessive exposures off-site due to toxicological exposure</u>:

- This includes events which could result in moderate to low level exposures of the public to toxicological materials at or below published acceptable exposure limits. Loss of life or permanent disability is not expected to result from this event, and the incidence of latent effects such as cancer or leukemia would probably not be selectively observable from among other causes.

<u>Moderate exposures of public near limits and/or moderate injuries to public due to toxicological exposure</u>:

- This includes toxicological exposures near regulatory limits. Off-site impacts are generally low unless toxicological chemicals are involved outside buildings. This criteria means that the potential, undesired result of a sabotage event may lead to the immediate or eventual loss of life or permanent disability (loss of limb, sight, hearing, etc.) of one or more persons.

<u>Low level toxicological exposure and/or minor injury to public</u>:

- This includes exposures to 40% of the established limits and minor injuries to the public which are not permanent.

WORKER SAFETY CRITERIA

The Worker Safety Criteria for toxicological sabotage is based upon the INEL standardized risked based prioritization scheme. This criteria includes radiological and toxicological events.

On-site radiation or toxicological exposure resulting in worker death(s):

- This event includes criticality event, release of toxicological material, or accident from site release which could cause worker death or permanent disability defined as loss of arm or leg, sight, hearing, or permanent paralysis.

On-site radiation or toxicological exposure much greater than limits and/or serious lost time injuries:

- This refers to lost time injuries > 7 days, radiation exposures up to 100 REM, and acute toxicological exposures (short of death).

Worker exposure near or above limits, contaminated wound and/or injury requiring emergency room visit:

- Radiation exposures 1 to 10 rem, toxicological exposures near limits, injury requiring off-site emergency room visit with lost time up to 7 days, and contaminated wound cut or inhalation.

Reportable on-site work accident, minor exposure, or significant removable skin contamination. Work incident requiring lessons learned follow-up:

- Work accidents requiring minor first aid (non-contaminated wounds), radiation or toxicological exposures up to 20% of limits (1 rem).

ENVIRONMENTAL SAFETY CRITERIA

The Environmental Safety Criteria for toxicological sabotage is based upon the INEL standardized risked based prioritization scheme. This criteria includes radiological and toxicological events.

Uncontained contamination spread beyond site boundary causing loss of public resource (land use/ property/aquifer). Damage is irreparable and noncontainable:

- Major releases of radioactive or toxicological materials off-site (from, typically, massive accidents) which cannot be repaired or fully contained and cause major (indefinite) restrictions on use of a public resource (approximately $100,000,000 in partial cleanup and stabilization costs).

Excessive on-site ecological damage requiring corrective action (clean-up). Damage is irreparable and noncontainable:

- Major on-site release or spill of radioactive or toxicological materials which are contained on-site. The event could result in serious and extensive environmental insult that is either sufficiently widespread or of a magnitude to destroy or profoundly imperil entire ecological subsystems or constituents. Those subsystems or elements could be impacted directly or indirectly as a result of damage to their macrocosm. This event also could result in the significant loss of use, for man or animal, of natural resources such as land or water for indeterminable periods. Cleanup, recovery, or restoration required to recover from this event would probably take many years and would result in corrective action and environmental restoration costs in excess of $35,000,000.

Moderate contamination spread beyond site boundary at levels requiring site response or moderate on-site ecological damage requiring remedial action (stabilization). Damage is irreparable but containable:

- Releases of radioactive materials or chemicals causing moderate damage on-site or off-site. Corrective action and environmental restoration costs are between $11,000,000 and $35,000,000.

Measurable minor ecological damage off-site or on-site. Damage is repairable:

- Minor spills either on-site or off-site (reach site boundary) and require a minor cleanup effort or short-term (in days) restriction on use. Corrective action and environmental restoration costs are between $1,000,000 and $11,000,000.

Other minor events affecting the environment:

- Reportable minor releases of radiological or toxicological materials which are less than release limits and do not require stabilization or cleanup are included here.