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Radiological/Toxicological Sabotage Assessments at the Savannah River Site (U)

by

H. D. Johnson

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

M. D. Pascal

D. L Richardson

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RADIOLOGICAL/TOXICOLOGICAL SABOTAGE ASSESSMENTS AT THE SAVANNAH RIVER SITE*

H. D. Johnson, M. D. Pascal, D. L. Richardson
Westinghouse Savannah River Company
PO Box 616
Aiken, SC 29803
(803)557-0970

ABSTRACT

This paper describes the methods being employed by Westinghouse Savannah River Company (WSRC) to perform graded assessments of radiological and toxicological sabotage vulnerability at Savannah River Site (SRS) facilities. These assessments are conducted to ensure that effective measures are in place to prevent, mitigate, and respond to a potential sabotage event which may cause an airborne release of radiological/ toxicological material, causing an adverse effect on the health and safety of employees, the public, and the environment. Department of Energy (DOE) Notice 5630.3A, "Protection of Departmental Facilities Against Radiological and Toxicological Sabotage," and the associated April 1993 DOE-Headquarters guidance provide the requirements and outline an eight-step process for hazardous material evaluation. The process requires the integration of information from a variety of disciplines, including safety, safeguards and security, and emergency preparedness. This paper summarizes WSRC's approach towards implementation of the DOE requirements, and explains the inter-relationships between the Radiological and Toxicological Assessments developed using this process, and facility Hazard Assessment Reports (HAs), Safety Analysis Reports (SARs), and Facility Vulnerability Assessments (VAs).

BACKGROUND

DOE facilities are required to perform graded assessments of radiological and toxicological (rad/tox) sabotage vulnerability in order to protect the health and safety of employees, the public, and the environment against the potential adverse impact of radiological or toxicological sabotage incidents involving DOE facilities and hazardous materials. A Rad/Tox Sabotage Assessment (RTSA) is a performance-based evaluation of system effectiveness against sabotage by outsiders, insiders, and insider/outsider combinations. It is a systematic process using quantitative and/or qualitative techniques to determine the system effectiveness level for a specific target. Using the results of the RTSA, the risk of a specific program or facility is determined. A determination is made as to whether the risk posed by the consequence of a particular action is low, moderate, or high, as specified by DOE-HQ. In response to a moderate or high risk, security systems are designed to either prevent or mitigate the consequences of the threat. Performance of the RTSA identifies vulnerabilities in the safety and safeguards and security protection systems, and in response planning for sabotage release scenarios. The RTSA helps management to make cost-effective decisions in protection program planning, provides vulnerability information to the Site Safeguards and Security Plan (SSSP), and aids in the review/evaluation of initial facility design or modification.

PREPARATION

An effective analysis requires the input of the people who best know the facility. Therefore, a first step in the RTSA process is to organize teams of experts. The team concept helps to facilitate the process, provides levels of expertise, promotes ownership in the final product, and speeds the approval process. At SRS, two teams are used; an Oversight Group and a Working Group. The Oversight Group is composed of DOE, and upper management from both WSRC and Wackenhut Services, Inc., - Savannah River (WSI-SR), the security contractor at the SRS. The Oversight Group

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meets periodically throughout the process to receive information on findings and progress, and to provide direction and guidance throughout the process. The Working Group is composed of VA analysts [the WSRC Analysis Group (AG)], facility experts, security experts, and representatives from safety and emergency planning.

Once the teams have been identified, the Working Group begins collecting and reviewing the facility documentation. This includes such information as:

- Safety Analysis Reports
- Hazard Assessments Reports
- Facility Description and Operational Plans
- Facility VAs
- Emergency preparedness documentation
- Chemical inventory listings
- Nuclear material inventory listings
- Radioactive source inventory listings

To the extent possible, the Working Group relies upon existing information and analyses to complete the next step in the process - identifying targets for potential sabotage.

TARGET IDENTIFICATION

This step consists of identifying and assessing the quantities of hazardous materials at the facility, then conducting a screening to identify and rank those that qualify as hazardous material targets. A radiological target in the RTSA is a hazardous material in quantities capable of exceeding 50 rem committed effective dose equivalent (CEDE) from inhalation at the site boundary. The 50 rem limit was identified using the consequence levels described in the DOE "Format and Content Guide for the SSSP," dated April 1993. A toxicological target is a hazardous material in quantities capable of exceeding a specified level of Emergency Response Planning Guidelines (ERPG), specifically ERPG-2, at the site boundary per the DOE "Emergency Management Guide - Hazards Assessment" dated September 1992.

Team members combine information from their areas of responsibility to develop a consolidated list of hazardous materials at each facility. Once the list is developed, it is screened to eliminate hazardous materials and quantities below established thresholds. The screening eliminates from further consideration the types and quantities of material that are considered unattractive as targets of sabotage. This analysis factors in results from SARs that have been completed for accident scenarios, emergency event classification, protective actions and consequence assessment based on the emergency planning guidance. The DOE-HQ guidance instructs the use of these hazards assessments and risk assessments primarily as the basis for developing rad/tox sabotage scenarios. However, many facilities do not have current or complete hazards assessments, and in these cases the screening process is much more complicated.

If a facility does have a current and complete hazards assessment, it identifies and analyzes the hazards that are significant enough to warrant consideration in the facility's operational emergency management program. The hazards assessment process includes a screening step whereby small quantities of hazardous materials commonly used in science and industry can be excluded from detailed consideration. Because the protective action criteria for hazards assessments are much lower than the target criteria for rad/tox assessment, targets screened out by the hazards assessment will usually not require an RTSA. Any target identified in the HA as resulting in a General Emergency (which is defined by an offsite release equal to or exceeding 1 rem for rad, or exceeding ERPG-2 for tox) will be analyzed in the RTSA process.

If a facility does not have a completed HA, or the information is no longer current, the Working Group begins the screening process. This process is outlined in the flowcharts presented in Figures 1 and 2.

Radiological Screening

Radiological screening is less complicated than toxicological screening because there are fewer radiological targets to analyze, and typically more information is available.

Facility inventories and limits for most radioactive materials may be identified

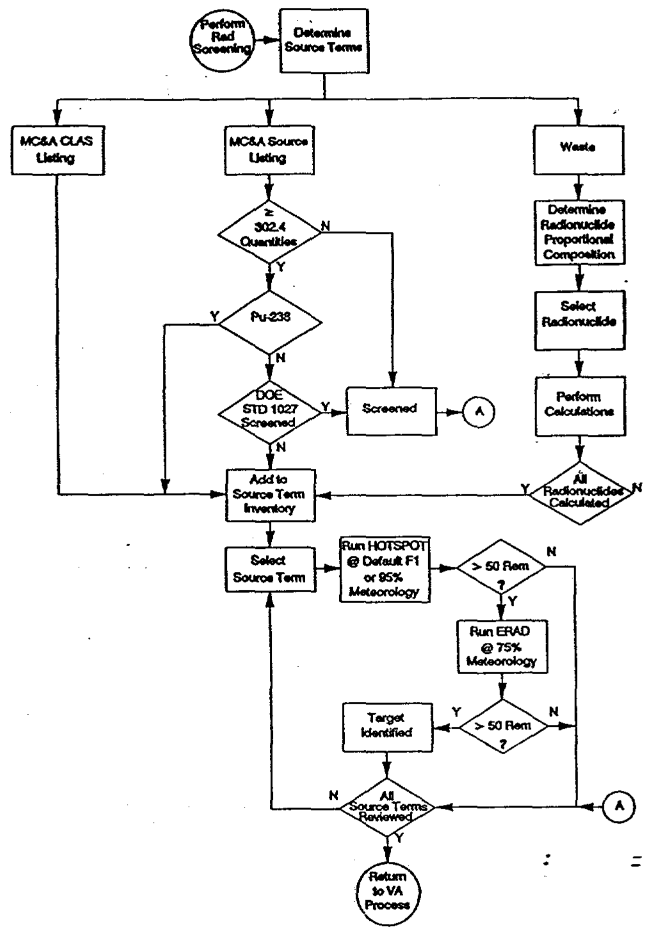

Figure 1. Radiological screening flowchart.

through Safety Analysis Reports, and facility operating procedures. Material control and accountability (MC&A) records are the primary source of information on current holdings of special nuclear material. Test plans, process safety assessments, or other controlling documentation for hazards of a transient or intermittent nature may contain relevant nuclear material inventory information.

The first screen of the radiological inventory is per the Environmental Protection Agency (EPA) Regulations, Title 40 Code of Federal Regulations (CFR), Part 302. The 40CFR302 identifies the reportable quantities (RQs) for substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) that may be hazardous to the public and the environment.

All Pu-238 material is analyzed per DOE Memorandum from the Director of Safeguards and Security, April 22, 1994, "Assessments of Encapsulated Plutonium-238 Sources." This memorandum provides guidance concerning the assessment of the explosive release of Pu-238 from encapsulated sources, and the anticipated respirable release fraction.

Materials exceeding 40CFR302 reportable quantities are then screened using DOE Standard 1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Report." This standard provides the threshold quantities of radiological material inventory below which hazard categorization and accident analyses are not required.

Following these screens, all remaining materials are placed on a Source Term Inventory listing. All of the identified source terms are then analyzed using the HOTSPOT (Homann, 1994) dispersion model. HOTSPOT is a health physics code developed by Lawrence Livermore National Laboratory, to provide a downwind assessment of the radiation effects associated with the atmospheric release of radioactive materials. HOTSPOT codes incorporate the well-established Gaussian plume model that has been recognized as the starting place for analysis due to the large uncertainty associated with a release scenario.

Any material resulting in an offsite release exceeding 50 rem CEDE with HOTSPOT is then analyzed further using the Explosive Release Atmospheric Dispersion (ERAD) model (Boughton, 1992) developed by Sandia National Laboratories. ERAD is a more sophisticated dispersion model than HOTSPOT, and uses a discrete time Lagrangian Monte Carlo method to simulate particle dispersion, including initial cloud dynamics, buoyancy effects, and turbulent diffusion.

Any source term identified through ERAD as exceeding the 50 rem limit at the site boundary is now identified as a target and continues through the RTSA process.

Toxicological Screening

The screening process for toxicological hazards is much more complex. Toxicological targets are less clearly defined hazards than

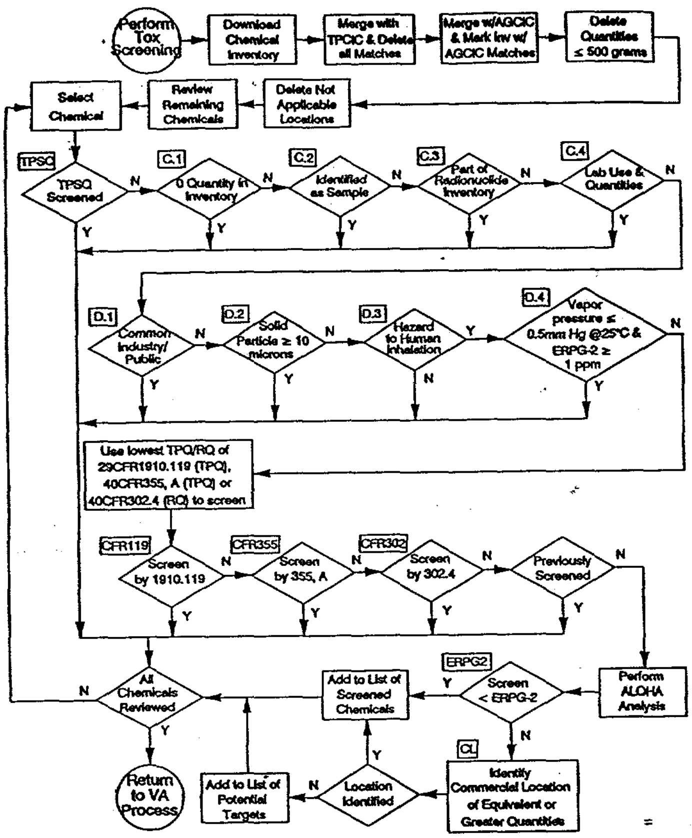

Figure 2. Toxocological screening flowchart.

radiological targets. The process begins with the facility's chemical database, a complete list of all chemicals present in the facility. This database is first screened using the Technical Programs Common Industrial Chemicals (TPCIC) database. The TPCIC database was developed by WSRC Technical Programs for use in conducting screenings for hazards assessments. The TPCIC identifies those chemicals that are not considered for further analysis due to their commercial availability. Chemicals not screened by the TPCIC are further compared to the Analysis Group Common Industrial Chemicals (AGCIC) database. The AGCIC includes additional common chemicals (such as Windex or white-out). All of the chemicals screened through these databases are also evaluated for quantity, i.e., exceptionally large quantities are examined further.

Following the AGCIC screen, chemicals are compared to Technical Program Screening Quantities (TPSQs), also developed by Technical Programs for use in conducting hazards assessments. TPSQs are the minimum quantities of specific chemicals that will yield a concentration of ERPG-2, at a downwind distance of 100 meters. Chemicals with smaller quantities than the TPSQs are then eliminated from further analyses in the RTSA.

Material Safety Data Sheets and *Dangerous Properties of Industrial Materials* (Sax, 1989) are consulted next for remaining chemicals to determine their relative toxicity and whether they represent an inhalation dose threat. Only chemicals with an inhalation dose threat are analyzed during the RTSA process per DOE-HQ guidance. Chemicals consisting of solid particles greater than or equal to 10 microns are considered solids, and eliminated from further analysis. Chemicals with both a vapor pressure less than or equal to 0.5 mm Hg at 25°C and an ERPG-2 value greater than or equal to 1 ppm are also screened. At this point, the guidance also allows the chemical to be screened if the protection afforded to the material in question is equal to or greater than that afforded similar quantities of the material in the private commercial sector.

Next, chemicals are screened through the following CFR threshold planning quantities (TPQs) and reporting quantities (RQs):

- U.S. Department of Labor Occupational Safety and Health Administration (OSHA), 29 CFR Part 1910.119, "Process Safety Management of Highly Hazardous Chemicals," identifies specific TPQs for chemicals which present a potential for a catastrophic event.
- EPA Superfund Amendment and Reauthorization Act (SARA), Title III, 40 CFR Part 355, "Emergency Planning and Notification," Appendix A, also identifies TPQs.
- EPA, Title 40 CFR Part 302, "Designation, Reportable Quantities, and Notification," identifies RQs for substances under CERCLA that may be hazardous to the public and the environment.

The remaining chemicals are analyzed using a dispersion model, Areal Locations of Hazardous Atmospheres (ALOHA) (National Security Council, 1992). Like HOTSPOT, ALOHA uses a Gaussian dispersion model to estimate pollutant concentrations downwind from the source of a spill. If the ALOHA analysis does not result in an offsite release exceeding ERPG-2 values, then no further analysis is required.

Bounding Cases

For both radiological and toxicological dispersion analyses, the maximum quantity (total inventory) of the chemical is analyzed, regardless of how it is stored, in order to perform a bounding case. If all the material released at once does not result in an offsite release exceeding ERPG-2 values (tox) or the 50 rem limit (rad), then no further analysis is required. For example, a facility may have 1 million pounds of nitric acid in 20 different tanks. If the ALOHA analysis showed no offsite release for 1 million pounds, then there is no need to analyze each tank individually. If an offsite release does exceed ERPG-2, then the chemical is analyzed further using refined assumptions. As in the example above, if the total inventory did exceed ERPG-2, then individual tanks would be analyzed separately or in small combinations, depending on their accessibility to each other.

Risk Mitigation

Following identification of all facility targets, the Working Group identifies and documents the protective features that are in place to reduce the probability of successful completion of a sabotage act or to mitigate the consequences. Risk reduction and consequence mitigation actions considered in this process include:

- target material inventory reduction, elimination, or relocation
- established shelters, procedures for emergency notifications/evacuations
- programs to reduce the probability of insider acts, such as personnel clearances and personnel assurance programs
- safeguards and security features which prevent or detect adversary actions
- safety controls such as automatic shutdown systems, backup systems, etc.

If an act can be successfully mitigated, the facility is considered at low risk, and no further analysis is required.

ANALYSIS

Any targets resulting in a moderate or high risk following the evaluation of risk mitigation, are then analyzed further using tabletop methods. Credible threats are identified, and strategies and scenarios are developed for insider, outsider, and colluding adversaries. Exercises are conducted to validate the safeguards and security protection system effectiveness, and the results are analyzed to determine the facility risk. Facilities determined to be at a moderate or high risk then go through an upgrade analysis.

UPGRADES

The Working Group then performs a detailed analysis of options to reduce the risk and/or consequences of sabotage events. Selection of upgrades is based on risk reduction, operational and safety compatibility, and cost-effectiveness. Tabletop scenarios are modified and re-examined. Performance tests are conducted to verify the effectiveness of the upgrade. The facility risk is then re-determined with upgrades in place. The Working Group then documents an upgrade package to present to the Oversight Group, including a cost/benefit analyses of the upgrades.

DOCUMENTING RESULTS

Documenting the RTSA methods and results should be done through the whole process, from beginning to end. Written rationale and justification must be provided for the analysis process, assumptions, and results. The screening process must be documented at each step to provide the rationale for eliminating a potential target. It is vital to ensure the technical basis for every screening step is well documented. Performance test plans must be documented to record the decisions and assumptions made in the planning process. Upgrades analysis reports must provide descriptive information regarding the scope, methodology, assumptions, and conclusions from the analysis. Finally, the RTSA report must document the entire process in a logical sequence. The report must clearly explain and outline the analysis results, any identified upgrades, and conclusions derived during the process.

CONCLUSIONS

This process has identified two important points regarding dispersion analyses. First, the form of the radiological target material is critical. No analytical data is available on dispersion of liquids. This results in having to analyze all liquids at a 100% (absolute) dispersion. In other words, all of the material is released to the atmoshpere, and all of it is respirable. Second, using the models described in this report, all dispersion occurs through either a spill or deflagration of toxicological targets, and an explosive release of radiological targets. Generally, no models explode toxicological targets or spill radiological targets.

The RTSA process was originally designed for emergency management. They are the experts in this field. However, security professionals are conducting the RTSAs. This is why such emphasis is placed on utilizing the existing SAR and HA documentation. Also, there is a considerable potential for duplication of effort; emergency management guidance requires sabotage assessment and VAs require radiological sabotage assessment. It is vital to maintain open communications between safeguards and security, safety, and emergency preparedness. Just as the RTSA references the information from the HAs, SARs, and VAs, the RTSA information must be provided to those groups for reference in their plans and reports.

The SARs, HAs, VAs and RTSAs mentioned in this document are all similar in that the common goal is protecting the health and safety of employees, the public, and the environment. However, there are important differences that make each one necessary. One of these differences is that SARs and HAs look at unintentional events, such as earthquakes and accidental spills. The VAs and RTSAs address intentional events. Taking this into consideration, an event analyzed in the HA may include all material in several tanks being released due to a large earthquake. The same type of event may not be credible in the RTSA due to the inability of the adversary to access all the tanks at one time. Conversely, an HA scenario that results in no offsite release, may be a significant RTSA problem due to explosive release. Another difference is that a HA identifies the problem and the response, but not the fix. VAs and RTSAs must also identify methods to reduce unacceptable risks. And a final difference is that the HAs and SARs are probabilistic risk determinations. The VAs and RTSAs are deterministic. In an RTSA, the probability of an event occurring is always 1.

Ultimately, the rad/tox sabotage threat is more difficult to protect against than accidents and theft, due to the need for a denial strategy. Facilities can be built to withstand accidents, and theft requires an adversary to remove the target from the facility. It is more difficult to protect against an adversary with the intentions of deliberately dispersing material to the atmosphere. The only means of preventing sabotage are to deny access, or to limit or eliminate the target completely. Because these options are not always feasible, much emphasis has to be placed on mitigating the consequences of an act once it has occurred.

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