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TRANSURANIC WASTE - LONG-TERM PLANNING

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Abstract

Societal concerns for the safe handling and disposal of toxic waste are behind many of the regulations and the control measures in effect today. Transuranic waste, a specific category of toxic (radioactive) waste, serves as a good example of how regulations and controls impact changes in waste processing - and vice versa. As problems would arise with waste processing, changes would be instituted. These changes improved techniques for handling and disposal of transuranic waste, reduced the risk of breached containment, and were usually linked with regulatory changes. Today, however, we face a greater public awareness of and concern for toxic waste control; thus, we must anticipate potential problems and work on resolving them before they can become real problems.

System safety analyses are valuable aids in long-term planning for operations involving transuranic as well as other toxic materials. Examples of specific system safety analytical methods demonstrate how problems can be anticipated and resolution initiated in a timely manner having minimal impacts upon allocation of resource and operational goals.

Introduction

Toxic waste handling and disposal do not pose an inordinately high risk to man and the environment, but potential problems with control and containment are perceived as a great concern. The uncontrolled release of toxic materials - for example, materials possessing properties such as being radioactive, poisonous, and/or reactive - could pose substantial problems to our ecology. Therefore, a systemmatic approach to the acquisition, use, and disposal of toxic materials is necessary.

In this paper, I will discuss transuranic (TRU) waste as an example of a specific category of toxic waste. I will describe the materials and give an historical account of TRU waste disposal up to present times. Then I will discuss the "system safety" view of toxic waste, and give some sample applications of system safety analysis techniques to demonstrate the value of a systems approach to problem resolution.

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Transuranic (TRU) Waste Description

Transuranic (TRU) waste is any material contaminated with TRU nuclides. By Department of Energy (DOE) criteria, transuranics are "man-made" elements with atomic numbers greater than that of uranium (92), emitting alpha particle radiation, and having a half-life of greater than twenty years (ref. 1). Research has shown that contamination by TRU materials at less than 100 nCi/gm (or 100 X 10^{-9} curies of activity per each gram of waste) poses no additional concern than that for Low Specific Activity (LSA) waste; thus TRU waste contains greater than 100 nCi/gm activity level (ref. 2).

TRU waste nuclides from DOE non-reactor activities is comprised of 80% plutonium by mass, with the other 20% containing nuclides such as americium, curium, and neptunium. The activity level of the waste differs in spectrum from the physical make-up - about 80% of the contribution of activity is from americium and curium (ref. 1). The volume of plutonium used as well as its association with nuclear weapons programs gives plutonium the undeserved title - "the most toxic substance known to man." Actually, a number of more toxic substances occur naturally - such as the toxins produced by Clostridium botulinum (botulism) or by Aspergillus flavus and A. paraciticus (aflatoxins). Aflatoxin and botulism poisoning are responsible for deaths and misery each year, but there are no documented deaths caused by exposure to plutonium.

TRU Waste Disposal

As transuranic materials were being developed, the disposal of the waste was not handled separately from other radioactive waste. These wastes were either buried at land disposal sites or buried by submergence at sea. The water disposal seemed to pose the least problem at the time, as the drums were dropped to the ocean floor and were virtually inaccessible. With the realization of the potential for decomposition of the drums, water burial of radioactive waste was discontinued in the early 1960's, and replaced solely by land burial.

Land burial appeared to be the solution for handling the disposal of waste - until the early 1970's. With the advent of federal legislation and enactments (such as EPA and RCRA), the concern for containment was intensified both in the regulatory and the public arenas. Monitoring of hazardous materials dump sites showed that some of the containers of radioactive wastes (including TRU wastes) had been breached - and materials were leeching into the surrounding terrain (ref. 3). The solution to this problem was to bury the waste containers in a contained site to ease monitoring and recovery - if necessary.

In 1974, the National Reactor Testing Station (NRTS) in Idaho opened an above-ground burial site specifically for retrievable storage of TRU wastes. This facility included a 150-foot-wide asphalt pad with a 240-foot-long air-supported building to cover the waste. TRU waste was collected in drums and bales, and stacked sixteen feet high. When enough waste had been collected, a nylon-reinforced plastic cover was installed with three feet of earth over that. The air-supported building was capable of being moved to accomodate the need for increased storage capacity.

Next in sequence, the concept of the Waste Isolation Pilot Plant (WIPP) was born. Located near Carlsbad, New Mexico, the WIPP is comprised of a cavernous underground salt dome with tunnels and support structures for storing containers of TRU waste. The facility is planned to be operational by 1987, so for the interim, waste is being collected and stored much the same as described in the previous paragraph. When the WIPP starts receiving material, the TRU waste will come from two sources - from DOE contractors' present works, and from interim storage sites such as at the Idaho National Engineering Laboratory (INEL - formerly NRTS). In addition, each generator/contractor must package TRU waste to meet specific stringent criteria to minimize the potential for breach of containment (ref. 1,4,5, and 6). The criteria is designed to allow for a fifteen year recoverable period for each container, and maintaining a paper "pedigree" on each container as to its origin and contents. As such, this concept is an improvement over the previous methods of TRU waste management, but it is again an interim measure and not a final solution.

System Safety Approach

In searching through literature and discussing with individuals involved with TRU waste disposal, I could find little formal application of system safety analysis techniques for past waste problem solving. I have found that there are many pathways to be considered between the realization of a problem and the implementation of a solution; but with the constraints of limited resources and time, the path of greatest efficiency is a vital concern.

Conceptually then, the systems approach for toxic waste disposal is somewhat innovative. The previously stated examples of early TRU waste disposal methods show the prevalent thought at that time - that once material is removed from the facility boundaries, it is no longer of concern. When we acknowledge that the facility is a "system" comprised of interacting subsystems - an input of raw materials; various processing operations; and an output of product and waste - it is apparent that problems with the waste stream will have an indirect impact upon product generation. Considering the social and political impacts of toxic waste handling today, health or environment problems may drive a facility - or even a whole industry - out of existence. The systems approach to *problem resolution provides an economy of time and resources.* This may prove essential for DOE contractors as well as for general industry.

Specific system safety tools used to evaluate the toxic waste problem would vary - depending upon the nature and extent of the problem. The following discussion will provide an example of some of the analytical techniques that can be used for evaluating potential problems in toxic waste disposal or similar operations. First is fault tree analysis as an example of deductive logic; then a brief discussion of failure modes and effects analysis as a method of inductive reasoning; and finally, an application of MORT (Management Oversight and Risk Tree) in the form of the Occupancy-Use Readiness evaluation.

An initial fault tree analysis will help to determine the impact of health and environmental problems upon the operation of a facility. For example, consider a fault tree on an operation involving TRU materials with the top undesired event as "Discontinuation of Funding and Operation." It is easy to see that an event under the category of "Mishandling of TRU Waste" could lead almost directly to the top undesired event. Considering the trend in the political arena - requiring more stringent controls through tighter regulations - even a minor incident by engineering standards may be considered a major concern leading to that undesired event. If the facility operation is understood by the analyst, then a fault tree can be developed for specific undesired events - such as "Uncontrolled Release of TRU Particulates" - with the flow of logic to show the basic initiating events. Then the analyst can determine the minimum cut sets and the logical precedent for incorporating mitigating measures.

A failure modes and effects analysis can provide information on the impact of failure of systems, subsystems, and components. As an inductive analytical technique, the analyst can study an individual component (such as a microswitch or a fluid waste pump) or a system (like a barrel conveyor or a fire suppression system) and examine how these items can fail. Failure is an undesired response for a given input. For example, a pump may fail "off" with no flow or "full on" with maximum flow when the desired operation is "on" with minimum flow. The analyst in this case would then determine the effects of each failure mode upon the component and the system(s) it supports. For failures that could have an effect upon health or the environment, this information shows where controls can be implemented to prevent problems from cascading into operation-threatening situations.

By incorporating both of these analytical tools, one method will support further development of the other. The fault tree will identify basic events that could lead to a major undesired event - such as a loss-of-life accident. If any of the basic initiating events were found to be component failures, then a failure modes and effects analysis may aid in establishing controls to prevent or minimize the impact of the initiating event. Similarly, analysis of component or system failure may show an extreme undesired effect - such as an explosion. That effect can be converted into an undesired event and analyzed by using a fault tree. The fault tree can indicate the need for further controls.

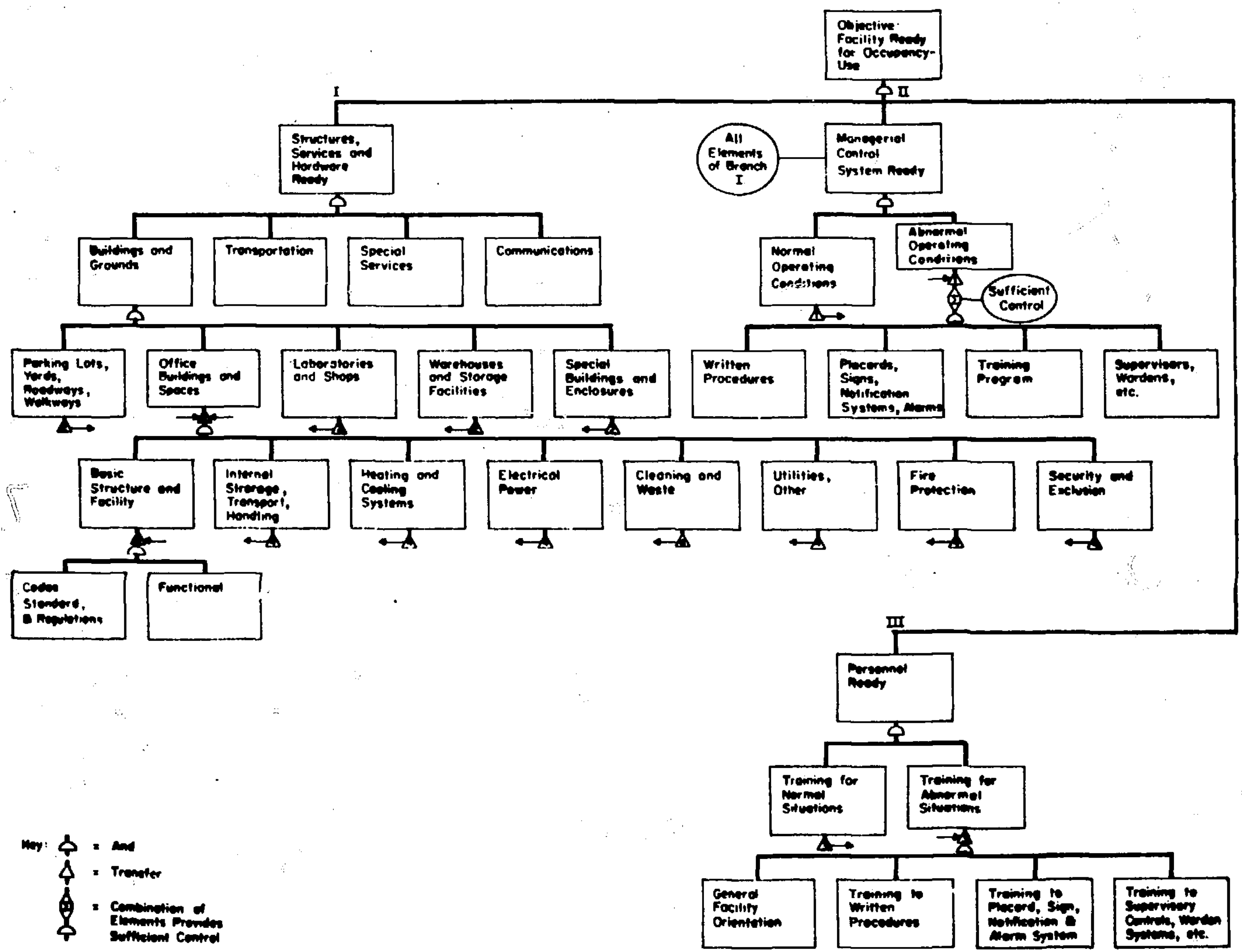
Within the DOE community, the System Safety Development Center has provided guidance on the use of a MORT-based analytical method called Occupancy-Use Readiness (ref. 7). This technique has not been widely used as yet, but it has been effective when applied. The technique uses a positive approach to evaluating a new or modified facility to assure that the facility is ready for occupancy-use. The "Basic Occupancy-Use Readiness Tree" showing the logic flow has been reproduced from the referenced manual on the next page. Essentially, the analyst evaluates from a global perspective the facility and its associated hardware, the managerial/administrative system, and the personnel - as well as their interactions. The goal is to assure that the facility and personnel - with all necessary engineering and administrative controls - are ready for operation. The logic tree can also be used as a "checklist" to evaluate existing operations. If the facility involves work with TRU or other toxic materials, then waste handling is an integral part of the evaluation. This clearly shows that proper waste treatment and handling directly contributes to a "safe-operation" goal.

Conclusion

The three system safety analysis methods briefly discussed can be used effectively to evaluate mitigating controls for toxic waste handling and disposal. The specific examples of TRU waste management show how concepts and controls have changed over the years. Each new method of waste management was an improvement over the previous method, but changes occurred over a period of many years.

The present method of TRU waste handling (WIPP) is an interim solution for containment of one discrete form of toxic waste. Other toxic waste materials are being generated in increasing quantities and varieties - with a noted increase in public concern and legislative controls. Application of system safety analytical techniques does not create a solution to the problem of toxic waste containment and disposal, but the analysis methods will assure that potential problems are approached logically and thoroughly.

Basic Occupancy-Use Readiness Tree



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Biography

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