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NUCLEAR SAFETY

Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved

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The Honorable John Glenn
Ranking Minority Member
Subcommittee on Energy, Nuclear Proliferation,
and Government Processes
Committee on Governmental Affairs
United States Senate

Dear Senator Glenn

On May 1, 1986, your office requested that we provide you with a report on the adequacy of the Department of Energy's (DOE's) safety analysis reviews for its existing nuclear defense facilities. We examined the adequacy of safety analysis reviews for eight nuclear defense facilities as part of a larger request by you on the effectiveness of DOE's efforts to protect workers and the environment at nuclear defense facilities nationwide As agreed with your office, this report addresses the adequacy of the safety analysis review process for these nuclear defense facilities We will provide you a separate report, in the near future, on environmental issues at selected DOE defense facilities nationwide

Because of the Russian accident at Chernobyl, increased congressional and public attention has focused on the safety of DOE's nuclear defense facilities. Safety analysis reviews are important tools used to show that nuclear facilities are safely designed, constructed, and operated. They establish the basis for the operator of a nuclear facility to determine that its facility can operate safely and conclude that operating the facility does not pose an unacceptable risk These reviews are also used to identify potential problem areas so that corrective actions can be taken. They compare the design of a facility against established safety design criteria. Another important aspect of such reviews is to analyze potential accidents in order to provide an overall assessment of the risk in operating the facility In the commercial sector, the Nuclear Regulatory Commission (NRC) uses safety analysis reviews in analyzing the safety of nuclear power plants and other commercial nuclear facilities prior to granting an operating license DOE also requires safety analysis reviews to be completed for its nuclear facilities

DOE has more than 50 contractor-operated nuclear facilities nationwide The contractors are responsible for making safety analysis reviews subject to DOE review and approval Because of the importance of the safety analysis reviews in demonstrating the safety of DOE facilities, we

examined the process for eight operating DOE nuclear defense facilities that reflect the diversity of DOE's defense operations [1] We found that

- safety analysis reviews have not been approved by DOE for three of the eight facilities, each of which has the potential for significant on-site or off-site releases of radioactive material in a major accident,
- the extent to which the facilities were compared against safety design criteria in the reviews varied considerably between the facilities we examined, with some providing a detailed comparison and others providing little or no comparison,
- different approaches were used in the reviews to identify and analyze potential accidents at DOE facilities, with some approaches being more comprehensive than others; and
- all the safety analysis reviews we examined were or are being reviewed and approved internally within DOE, which does not represent an independent review process

These findings are summarized below and discussed in more detail in appendix I. Safety analysis reviews have always been required for DOE reactors but have only been required for DOE's other nuclear defense facilities since late 1976. In 1981 and again in 1983, we examined the safety analysis review process for DOE nuclear facilities.[2] In the 1981 report, we found that DOE had not been completing the reviews in a timely fashion. In the 1983 report, we reported that DOE had made progress but that staffing limitations could delay the process for some existing facilities. While conducting this review, we found that three of the eight facilities did not have approved safety analysis reviews These three were the plutonium fabrication facility at Rocky Flats, Colorado, the fuel fabrication facility at Savannah River, South Carolina; and the reprocessing facility at Savannah River, South Carolina. All three facilities have been designated high-hazard facilities by DOE, which means they have the potential for significant on-site or off-site releases of radioactive material in a major accident In general, DOE officials told us that higher priority work and limited resources have delayed the approval

[1]The DOE facilities included in our review were (1) fuel fabrication facility, Savannah River, S C , (2) N Reactor, Hanford, Wash , (3) plutonium fabrication facility, Rocky Flats Colo (4) plutonium recovery facility, Los Alamos National Laboratory, N M , (5) reprocessing facility, Savannah River S C , (6) reprocessing facility, Hanford, Wash , (7) tritium processing facility, Mound Laboratory, Ohio, and (8) uranium recovery facility, Y-12 plant, Tenn

[2]Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities (EMD-81-108 Aug 4, 1981) and DOE's Safety and Health Oversight Programs at Nuclear Facilities Could Be Strengthened (GAO/RCED-84-50, Nov 30, 1983)

process. DOE officials also told us that all three safety analysis reviews for the aforementioned facilities should be approved by mid-1987

We also examined the content and approach used in preparing the safety analysis reviews for DOE facilities DOE guidance on the preparation of such reviews specifies that they should address, in appropriate detail, design criteria for the facilities' systems, components, and structure, and analyze serious accidents that could happen Design criteria are established standards governing the construction of various types of nuclear facilities. The accident analysis segment examines the probability and consequences of very serious operating accidents or natural catastrophes such as earthquakes DOE field offices, which oversee the preparation of safety analysis reviews, have interpreted DOE guidance on preparing them differently

In regard to the extent that safety analysis reviews address general design criteria, some provide a detailed comparison of the plant against established DOE criteria while others provide little or no comparison. For example, the safety analysis reviews for the N Reactor in Hanford, Washington, compares the facility against NRC general design criteria for commercial reactors The comparison identifies areas where the N Reactor differs from NRC criteria and focuses subsequent analysis on these areas. For other facilities little or no comparison is provided. For some facilities, such as the plutonium fabrication facility at Rocky Flats, Colorado, DOE field office officials told us such a comparison was made but not included in the safety analysis review document. For the uranium recovery facility at Y-12 in Tennessee, no comparison was made in the safety analysis review

We also found that different approaches were used in analyzing accidents. For example, one safety analysis review analyzed the worst earthquake that could occur in 840 years while another analyzed the worst earthquake that could occur in 8,000 years The reviews also differ in their degree of conservatism in predicting consequences. In this regard, one estimated potential releases of radioactive material on the basis of average data from past experience rather than developing a worst-case scenario used in other safety analysis reviews. As a result, it appears that some safety analysis reviews we examined were more comprehensive than others in analyzing serious accidents.

Finally, DOE orders require that independent reviews of safety analysis reviews be performed but allow DOE field offices to carry out this function While DOE headquarters staff and DOE contractors have assisted in

the review process, the process remains an internal DOE function carried out primarily by DOE field offices All the safety analysis reviews we examined were or are being reviewed and approved by DOE field offices In the past, we pointed out the lack of independence that has been associated with DOE's safety oversight program, including DOE's safety analysis review process It is our view that DOE should make appropriate arrangements to have an outside independent organization review its safety analysis reviews. Among other things, it would help prevent safety concerns from conflicting with programmatic interest such as production goals It would also enhance the public's perception of the quality of safety and health oversight for DOE nuclear defense facilities In this regard, we note that the Secretary of Energy requested outside independent review of DOE reactors in view of the Russian nuclear accident at Chernobyl.

An effective and well accepted safety review process is key to DOE's demonstration that its nuclear facilities can be safely operated We are making a number of recommendations to DOE directed at ensuring a credible safety review process These are (1) ensuring that safety analysis reviews for all high-hazard facilities are completed and approved in a timely fashion, (2) requiring that they include a detailed comparison with current design criteria highlighting any deviations, (3) developing more consistent requirements in preparing safety analysis reviews that outline appropriate methodologies and assumptions to be used in analyzing accidents and their consequences, and (4) making arrangements for an outside organization, such as NRC or an independent review panel established by the Secretary of Energy, to review the safety analysis reviews for those facilities that have the potential for significant on-site or off-site releases of radioactive material in a major accident

In addition to examining the completed and draft safety analysis reviews for eight DOE facilities, we examined DOE orders, related DOE studies, reports, and internal documents We interviewed DOE officials at headquarters and in the field. We also talked with contractors who prepared the safety analysis reviews and NRC officials. A more detailed discussion of the objectives, scope, and methodology for this review is included as appendix II

As requested, we did not obtain official agency comments on a draft of this report However, we discussed the contents of this report with agency officials as it was being developed and incorporated their views as appropriate Unless you publicly announce its contents earlier, we do not plan to distribute this report until 30 days from its issuance date At

that time we will send copies to the Secretary of Energy and other interested parties

Sincerely yours,

J. Dexter Peach
Director

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Abbreviations

DOE	Department of Energy
ES&H	Environment, Safety, and Health
NRC	Nuclear Regulatory Commission
SAR	safety analysis review

Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved

The Department of Energy (DOE) produces nuclear material for weapons, naval fuel, and other defense-related purposes These materials are generated and fabricated at numerous DOE nuclear facilities around the country Because many of these facilities, in the event of a major accident, could potentially release radioactive material into the environment and expose people living near the facility, DOE conducts extensive analyses to identify and minimize the risk in operating these facilities Safety analysis reviews (SARS) are important tools DOE uses to show that its facilities are safely designed and constructed Also, SARS can identify problem areas so that corrective action can be taken. To do this, an SAR compares the design of a facility against established safety design criteria and analyzes potential accidents in order to provide an overall assessment of the risk in operating the facility

Because of the importance of SARS in demonstrating the safety of DOE facilities, we reviewed the SARS for eight of DOE's older nuclear facilities We found that

- SARS have been drafted but not approved by DOE for three of eight facilities even though those three were designated high-hazard facilities,[1]
- the extent to which the facilities were compared against DOE's safety design criteria in the SARS varied considerably between the facilities we reviewed, some of which provided no comparison,
- different approaches and assumptions were used in the SARS to identify and analyze potential accidents at DOE facilities, some of which were more comprehensive than others, and
- all the SARS were or are being reviewed and approved internally within DOE, which does not represent an independent review process

An effective and well accepted safety review process is key to DOE's demonstration that its nuclear facilities can be safely operated We are making a number of recommendations to DOE directed at ensuring a credible safety review process

Background

For over 40 years, the federal government has been making and fabricating nuclear material for nuclear defense purposes It is potentially one of the more dangerous industrial operations in the world Not only do the overall industrial operations involve the use of a wide variety of toxic and hazardous substances, but they also generate vast

[1]High-hazard facilities are those designated by DOE to have potential for significant on-site or off-site releases of radioactive material in a major accident

quantities of radioactive material Controlling nuclear reactions is another important aspect of the overall industrial complex.

DOE's Defense Facilities

The basic purpose of DOE's defense activities is to produce and fabricate nuclear material for weapons and naval fuel Research, development, and testing programs for nuclear weapons are also an important part of DOE's defense activities These activities are carried out in numerous complex steps at many sites around the nation, 18 of which are primarily devoted to defense activities. At some sites, such as Savannah River in South Carolina and Hanford in Washington State, many DOE facilities are colocated on the site

Most simply, DOE defense operations begin with enriching uranium This is accomplished at government enrichment plants in Kentucky and Ohio At these facilities uranium-fluoride gas is processed to obtain products that have a higher concentration of U-235 (the fissionable isotope of uranium) than is found in natural uranium. Uranium that is enriched to about 3 percent U-235 is used in commercial nuclear reactors Enriched uranium is also used for defense purposes [2] This uranium is fabricated into nuclear fuel at DOE facilities at Savannah River, S C , and Hanford, Wash., and is used at production reactors to produce special nuclear material (e.g., plutonium) DOE has four operating production reactors at Savannah River and another—the N Reactor—operating at Hanford Plutonium and tritium are two of the principal products produced in these reactors for nuclear weapons

The next important step in DOE's defense operations is the extraction of usable material from the irradiated fuel—commonly referred to as spent fuel To obtain plutonium, uranium (which can be reused), and other products, DOE uses large reprocessing facilities DOE has such facilities at both the Savannah River and Hanford sites. At these facilities the irradiated, or spent, fuel from production reactors is dissolved by nitric acid Radioactive materials such as plutonium and uranium are then separated from the acid solution through various chemical processes The plutonium is sent to a facility, such as the Rocky Flats Plant in Colorado, where it is fabricated into components for weapons Tritium, another important material used for weapons, is extracted from irradiated material in a special facility located at Savannah River Both the tritium and plutonium are then assembled into weapons

[2]Enriched uranium is also used in DOE's research reactors

DOE's nuclear defense operations routinely use and generate hazardous and/or radioactive materials Some of the radioactive material, because of its lethal levels of radiation and high-heat generation, must be handled with specialized shielded equipment to prevent worker exposure Other material, while much less radioactive, is very toxic and can present a health hazard.[3] DOE operations also involve controlling nuclear reactions and handling highly fissionable nuclear material which requires specialized safety systems and controls Many of these plants have the potential for accidentally releasing radioactive materials to the public

Because of the inherent dangers associated with these operations, the safety of these facilities has been a primary concern Numerous safety systems are built into such facilities to prevent or mitigate releases, and extensive analysis is done to ensure that all significant accidents have been anticipated and, to the extent possible, prevented

The Importance of an SAR and DOE Requirements

An SAR is important because it establishes a basis for both the operator of a nuclear facility and DOE to determine that its facility can operate safely and to conclude that operating the facility does not pose an unacceptable risk to public health and safety An SAR does this in two key ways. It shows how a facility's systems, components, and structures meet established design criteria. Secondly, it is a vehicle for analyzing potential accidents that could release radioactive materials Both the comparison with design criteria and accident analysis segments of the SAR are important to identify problem areas (e g , accidents with high probability and severe consequences) so that corrective actions can be taken. An SAR also will include detailed information on the site, building, systems, and operating procedures for the facility Because of their importance, SARs have been used in both the commercial and public sectors.

In the commercial sector, an SAR has been an important vehicle in showing how a facility is built and what would happen in the event of major accidents. The Nuclear Regulatory Commission (NRC) requires an SAR to be prepared for commercial nuclear power plants and other commercial nuclear facilities. Detailed technical review by NRC of the SAR forms the basis for granting an operating license. NRC requires its licensees to include in the SARs detailed comparisons of the facility with NRC

[3]Some transuranic elements—man-made elements that are heavier than uranium—pose unique health concerns if inhaled, ingested, or absorbed into the body through an open wound

design criteria. These criteria are treated as minimum requirements, and the only variances that are allowed are those that can be shown to have minimal safety significance To supplement the review of conformance with design criteria, NRC also requires that SARs include an analysis of major accidents The primary purpose of this analysis is to ensure that the specific combination of plant and site features that are unique to each facility does not result in unforeseen accident consequences

DOE also requires SARs for its facilities DOE order 5481 1A, entitled "Safety Analysis and Review System," sets forth the basic requirements for the preparation of SARs for DOE facilities This order is supplemented by other DOE orders on safety and design criteria for nuclear facilities SARs have always been required for DOE reactors, but have only been required for DOE's other nuclear defense facilities since late 1976 [4]

The purpose of DOE order 5481.1A is to establish uniform requirements for the preparation and review of SARs for DOE facilities According to the DOE order, the objectives of an SAR are to (1) ensure that potential hazards are systematically identified and the consequences analyzed, (2) ensure that reasonable measures to eliminate, control, and mitigate the hazards have been taken, and (3) provide a documented management authorization, that is, officially record DOE's judgment that the facility does not pose undue risks to the public. This order also provides guidance regarding the contents of an SAR For example, it specifies that safety analysis should address, to the extent applicable, established design criteria and potential accidents

A three-tier approach is used for developing and reviewing SARs for nuclear defense facilities The first tier involves the contractor, who develops the technical information for the SAR and prepares a draft of the document following the guidance in DOE orders and supplemental guidance from the DOE field office with responsibility for the facility The contractor has the most direct contact with the actual work carried out at the facility and hence has a high degree of responsibility in ensuring that the analysis contained in the SAR is comprehensive and accurate The second tier is oversight of the contractor by the DOE field office responsible for the work. The field office reviews the contractor's draft SAR to ensure that the design features and administrative controls are adequate to limit the risk to the public. In effect, the field office

[4]DOE officials told us that when first put into operation, all their facilities met the safety criteria that existed at that time

approves the SAR.[5] Finally, the third tier is oversight by DOE's headquarters staff including DOE's environment, safety, and health (ES&H) staff Although headquarters staff do not actually approve the SAR, they are supposed to ensure that field office review is adequate and independent.[6]

We examined how SARs were done for eight of DOE's existing nuclear facilities The following sections discuss the major findings of our review, conclusions, and recommendations The objectives, scope, and methodology of this review are presented in appendix II

Some High-Risk DOE Facilities Do Not Have Completed Safety Analysis Reviews

Our review of the SAR process for eight existing DOE nuclear facilities shows that SARs, although drafted, have not been approved for three These three facilities are all high-hazard facilities. According to DOE officials, higher priority work and limited resources have delayed the SAR review process.

Since 1981, we have made several reviews of the SAR process within DOE. In an August 1981 report,[7] we concluded that DOE had been lax in completing the safety reviews for high-hazard facilities in a timely fashion We noted that DOE had not issued program directives establishing time frames, goals, or priorities and that numerous high-hazard facilities were operating without approved safety analyses That report also concluded that for some of those safety analyses that had been performed, not all potential hazards were identified and, where potential hazards were identified, corrective action was not always taken. In November 1983 we reported again on DOE's SAR review process.[8] We pointed out in that report that DOE had made progress in completing SARs for its facilities since our 1981 report but that staffing limitations might delay completion of SARs for some existing facilities

In our current review, we found that after an additional 2-1/2 years of effort, DOE has yet to approve SARs for some of its existing facilities. Of

[5]Throughout this report approval of a facility s SAR is used to mean the same as reviewing and accepting the SAR

[6]Recent initiatives by DOE to improve its overall ES&H functions may give more responsibility to ES&H staff in the DOE/SAR approval system

[7]Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities (EMD-81-108, Aug 4, 1981)

[8]DOE's Safety and Health Oversight Programs at Nuclear Facilities Could Be Strengthened (GAO/RCED-84-50, Nov 30, 1983)

the eight facilities we examined, SARs have been completed and approved for five. As shown in table I.1, DOE has not completed and approved SARs for the following high-hazard facilities—the fuel fabrication facility and the reprocessing facility at Savannah River, S.C., and the plutonium fabrication facility at Rocky Flats, Colo.

Table I.1: Status of SARs for Selected DOE Facilities

Facility	Status of SAR[a]
N Reactor, Hanford, Wash.	Approved 1978
Plutonium recovery, Los Alamos National Laboratory, N.M.	Approved 1978
Reprocessing, Hanford, Wash.	Approved 1983
Tritium processing, Mound Laboratory, Ohio	Approved 1983
Uranium recovery, Y-12, Tenn.[b]	Approved 1984
Fuel fabrication, Savannah River, S.C.	Review not complete
Plutonium fabrication, Rocky Flats, Colo.	Review not complete
Reprocessing, Savannah River, S.C.	Review not complete

[a]Some portions of SARs that have been approved have been updated to reflect operational or equipment changes.

[b]According to DOE headquarters safety officials, this facility has been designated a moderate hazard facility. This means any off-site impacts are expected to be minor in the event of an accident. They stated that all the other seven facilities have been designated as high hazard.

DOE officials told us that higher priority work and limited resources have delayed the SAR approval process. DOE officials at Savannah River in South Carolina told us that both SARs for the two facilities we reviewed were not formally approved when they were first prepared because higher priority programs had limited the amount of DOE resources devoted to safety review efforts. Because of this, DOE sent the SARs to an engineering firm for review. By the time the firm returned comments to DOE, the operating contractor for these facilities had initiated efforts to update the SARs. Because the new SARs contained significant revisions, DOE officials decided not to complete its review of the old draft SARs. Instead, according to DOE officials, the results of the review were incorporated into the new draft SARs to avoid duplicative reviews. The contractor has since transmitted new SARs for the fuel fabrication facility and the reprocessing facility to DOE officials at Savannah River for review. DOE officials expect these SARs to be approved by the end of 1986.

DOE field officials responsible for Rocky Flats told us that although the draft SAR for the plutonium fabrication plant was completed in 1981, DOE field safety staff were diverted from the SAR review process to perform a major review of the entire complex at Rocky Flats. The officials added,

however, that the draft SARs were used in developing a comprehensive report by DOE on the safety of the Rocky Flats operations.[9] After that report was completed, the operating contractor decided to use new analytical techniques in performing safety analyses. New SARs are in the process of being revised and submitted to DOE The operating contractor plans to submit revised SARs to DOE by the end of 1986 A DOE official told us that the target date for approving these SARs is mid-1987

DOE officials responsible for nuclear safety at headquarters told us they were aware that limited resources were available at the field level to complete the SAR review process They told us, however, that extensive analyses have been performed on all DOE facilities over the years which show that the DOE facilities are safe These officials do not believe that any DOE facilities are operating at a level of unnecessary risk to the public

A delay in approving an SAR for a DOE facility does not show in itself that the facility is unsafe or that it presents an undue risk to the public However, without an approved SAR, DOE does not have a documented basis for stating that potential hazards and accident consequences have been analyzed and that reasonable measures to eliminate and/or mitigate the hazards have been taken. Given the nature of these facilities, it is important that priority attention be given to completing and approving the SARs.

Different Approaches Used to Compare Existing DOE Facilities Against Design Criteria

DOE guidance in its SAR order specifies that safety analysis should address, in appropriate detail, design criteria for the facility's systems, components, and structure Field offices, however, have varied in their implementation of this guidance—some SARs contain little or no comparison of the facility against design criteria

Design criteria are established general standards governing the construction and design of nuclear facilities DOE sets forth these standards in various orders. For example, DOE's general design criteria for nuclear reactors are established in DOE order 5480 1A DOE adopted NRC's general design criteria for commercial nuclear power plants General design criteria for plutonium facilities are established in DOE order 6430 1 The extent to which the criteria are to be used in an SAR is established in DOE order 5481 1A In this regard the latter order specifies as guidance that

[9]Long Range Rocky Flats Utilization Study, U S Department of Energy (Feb 1983) requested by Representative Timothy E Wirth of Colorado

safety analysis should address, in appropriate detail, the design criteria for that facility. However, the SARs we reviewed varied considerably in comparing the facility with general design criteria.

The SAR for the N Reactor at Hanford contains a chapter that provides a comparison between NRC's general design criteria for light-water reactors and the N Reactor site, facility, and systems. This SAR chapter discusses deviations in the plant's construction from the general design criteria and explains the effect of such deviations. The draft SAR for the Rocky Flats fabrication plant, however, does not contain a comparison of the facility against design criteria. However, DOE and contractor officials told us such a comparison was done to support the accident analysis segment of the SAR. They further told us that the comparison will be available to DOE officials reviewing the SAR as a support document. Similarly, the SAR for the Hanford reprocessing plant did not contain a comparison between the facility and general design criteria, but we found that a comparison with requirements that apply to a facility licensed by NRC was done separately. DOE officials at Hanford told us the comparison was considered in the SAR review process.

For other SARs we reviewed, we found the facilities' comparison with design criteria to be either less detailed or nonexistent. For example, the draft SARs for the two Savannah River facilities did not contain comparisons with general design criteria. Instead, it was noted that the facilities conformed to the standards of the operating contractor as they existed when they were built and that subsequent comparisons of the contractor's standards with DOE's standards showed that they were virtually identical. One cannot tell from these SARs how those facilities compare against DOE's current design criteria. In the SAR for the uranium recovery facility at Y-12, no comparison against general design criteria was made.

A comparison with current criteria is important because it provides essential information concerning possible deficiencies of the facility vis-a-vis current design criteria. For example, the N Reactor comparison shows that the reactor does not conform to design criteria for commercial nuclear power plants in the area of independent systems for plant protection. The SAR also identified areas in which the N Reactor only partially conforms to general design criteria (control room design) and areas in which it does not conform to but meets the intent of the criteria (containment design).

These variances with design criteria do not automatically mean that the plant is not safe, rather, they indicate areas for additional study to ensure that the risks associated with the variances are acceptable For example, the containment design criterion requires that " reactor containment and associated systems shall be provided to establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment " In the commercial sector, reactors conform to this criterion by enclosing critical equipment inside a concrete and reinforced-steel containment structure and by including equipment to keep excess pressure from building up after an accident The N Reactor was built without such a containment building Instead, it uses a "confinement" system that allows steam and filtered radioactive gases to be released into the atmosphere following certain accidents Analysis of fuel-melting accidents in the SAR indicates that the release of radioactive gases would not result in excessive doses to members of the public, in large part, because no one lives within 5-1/2 miles of the plant The SAR concludes that the N Reactor's unique confinement system is an acceptable substitute for a containment building

The N Reactor example is important because it highlights a major difference between a DOE facility and applicable design criteria After identifying the differences, subsequent analysis is focused on understanding the significance of the variance so that a determination can be made as to whether the risks associated with the facility are acceptable or require modifications to reduce them. In other SARs we reviewed, such deviations are not highlighted or discussed

Different Approaches Used to Analyze Accidents at DOE Facilities

Another important component of an SAR is analyzing potential accidents that could release radioactive materials This involves identifying accidents that could happen at the facility, estimating the probabilities of such accidents, and predicting the consequences of the accidents This type of analysis is useful for identifying problem areas—accidents with a relatively high probability and/or significant consequences—so that corrective action can be taken Because many of the SARs we reviewed do not compare, in detail, the facilities against design criteria, the accident analysis segment is the principal means used by DOE for demonstrating the safety of the plant Among the SARs we reviewed, we found that different approaches were used to analyze accidents—some of which were more comprehensive in the range of possible accidents analyzed

Key Components of Accident Analysis

The first step in analyzing accidents is to identify all major accident sequences, including those resulting from human error, equipment failure, and external events (e g , earthquakes) Because it is impractical to analyze the probability and consequences of all possible accidents, the general procedure is to analyze selected accidents in detail, including worst-credible, or "design basis," accidents In other words, the accident analysis segment focuses on the worst credible accident that can happen. Such accidents include all credible combinations of equipment failures and/or operator errors and various external events, such as earthquakes, tornadoes, high winds, and floods that may lead to releases of radioactive material One objective of the SAR is to show that the risk associated with design-basis accidents is acceptable

To establish the risk of a design-basis accident, both the probability and consequences of it happening are analyzed The probability can be established by using various scientific techniques in combination with such things as analyses of plant experience and geological and meteorological history of the site. The consequences can be estimated by examining in detail what would happen after the accident—the amounts of radioactive material released from the facility and its subsequent dispersion through the atmosphere until it reaches the public. The risk is then assessed by combining the probability of the accident with the consequences. SARs generally show that accidents with very large consequences are extremely unlikely to occur and accidents that are more likely have minimal safety consequences

The DOE safety review order recognizes the importance of identifying accidents and analyzing the associated probability and consequences of such accidents. However, the order is not specific concerning appropriate procedures and assumptions to be used in this analysis In addition, DOE orders do not specify what level of risk is acceptable in operating a DOE defense facility This allows the contractors who develop SARs and the DOE officials who review them considerable flexibility concerning the extent and detail to which accidents are analyzed and in determining if such analysis shows that the risk in operating the facility is acceptable

Differences in Selecting Accidents to Analyze

Each of the four DOE field offices responsible for reviewing the SARs at the eight facilities has developed supplemental guidance to the DOE orders regarding accident analysis This supplemental guidance differs considerably between field offices For example, one field office instructs its contractors to analyze all accidents of a serious nature that

could occur more frequently than once in a million years Another field office requires the analysis to " convince the reader that all significant hazards have been thoroughly investigated " The third field office refers its contractors to guidance developed by NRC, while the fourth provides little guidance beyond " describe all postulated accidents "

As a result, the potential accidents at various DOE facilities were selected in different ways. For example, at the uranium recovery facility at Y-12, the safety analysis was limited to those operational accidents that could be initiated by no more than two independent events (equipment failure and/or operator error) Any accident that could only be initiated by three or more independent failures was considered too unlikely for detailed analysis In contrast, the safety analysis for the reprocessing facility at Hanford does not limit the number of independent events, but considers any accident that could occur more frequently than once in a million years. As a result, the SAR for the reprocessing facility identifies as one of the most serious for that facility an accident which occurs as a result of three independent events, even though this accident would not have been considered credible using the Y-12 approach [10] Different methods are also used to examine worst-credible or design-basis earthquakes The safety analysis for the plutonium fabrication facility at Rocky Flats examines, as worst-credible, the largest earthquake to occur every 840 years, while the safety analysis for the reprocessing plant at Hanford examines the largest earthquake that can occur every 8,000 years

DOE officials told us that although there are some differences in the ways accidents are selected for detail review, they believe the approved SARs do show the facilities to be safe They point out that many DOE facilities are unique and that their contractors should be allowed some flexibility in preparing SARs They also told us they have efforts underway to standardize some key factors used in SARs. A study being managed by DOE's Lawrence Livermore National Laboratory is aimed at developing uniform criteria for analyzing natural-phenomena hazards. A draft report on this effort proposes standard recurrence intervals for design-basis earthquakes, winds, and tornadoes This study is currently scheduled to be complete by mid-1987, but it has not yet been determined how the standardized criteria will be applied Another effort to

[10]The three independent failures were (1) an operator's failing to fill a tank with enough water before adding radioactive fuel, (2) the failure of instrumentation that transmits warning signs of low water level and high temperature (or the failure of an operator to recognize the warning signs) and (3) the failure of instrumentation to detect the release of radioactive materials through the ventilating system of the building

develop central guidance for a more uniform approach is a recent report prepared by DOE's Los Alamos National Laboratory (A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities, Jan. 1986). It provides guidance on a variety of models and parameters that are used in accident selection and analysis

Differences in selecting accidents to analyze do not mean that facilities are unsafe, but in some instances the risk may not be properly stated For example, at the Y-12 plant, the SAR analyzes the worst earthquake that could occur every 500 years and concludes that no significant damage would occur The aforementioned Lawrence Livermore draft report recommends that earthquake analysis be based on a 1,000-year period. If the proposed Lawrence Livermore computations were applied for the Y-12 plant, the earthquake would be 1.5 times greater. According to a DOE official responsible for the Y-12 SAR, the larger earthquake could result in significant structural damage to the facility and possibly release radioactive material.

Differences in Evaluating the Consequences of an Accident

In estimating the consequences of accidents, numerous assumptions must be made concerning plant operating and weather conditions It is important in such analyses that assumptions be chosen conservatively so that the doses to the public are not understated. NRC instructs its reactor licensees to use conservative assumptions—the worst credible things that can happen—when there is uncertainty. While NRC allows its licensees to include "realistic" analyses in examining potential accidents, worst-credible analyses must always be included

The DOE headquarters orders do not provide detailed guidance on the degree of conservatism to be used in preparing SARs, and we found differences in approaches in the SARs we reviewed. For example, the SAR for the reprocessing plant at Hanford developed worst-case accident scenarios based on a number of worst-credible assumptions concerning the initiation and progression of accidents. In contrast, worst-credible accident scenarios were not developed for the Savannah River facilities.

The approach taken in the Savannah River SARs was to base estimates of accident consequences on a statistical average of the consequences of past operating accidents at the facility For example, records were collected for spills from transfer errors that had historically occurred in each part of the reprocessing plant A statistical analysis of the data produced an average value for the amount of liquid spilled, which was then entered into the calculation of on-site and off-site consequences

resulting from the accident. A more conservative approach which is comparable to that taken in other SARs would be to examine the worst-credible spill and calculate the largest likely consequence. In contrast, the Savannah River method is based on an amount of material spilled that is less than that already experienced at the plant

DOE officials at Savannah River acknowledge that the analysis is based on average estimates of the amount of material released where the accident is initiated, but they note that worst-credible assumptions are applied with regard to filtering systems and meteorological conditions As a result, they concluded that the final calculation of dose to the public is overestimated since the conservatism in the latter portion of the analysis more than compensates for any lack of conservatism in the first part The Savannah River approach appears to be inconsistent with recent DOE guidance For example, the January 1986 Los Alamos report discussed earlier indicates that the analysis should be based on the maximum amount of material that could be released

Differences in calculating consequences can have implications for budgetary decisions. For example, on the basis of a 1983 safety review of Rocky Flats, the Congress appropriated $5 6 million to upgrade three high-hazard facilities, primarily to protect them against high wind, which was then assumed to be responsible for more than 80 percent of the risk to the public Subsequent analyses in support of the revised SARs, however, indicated that much less risk is associated with the design-basis wind, while more risk is associated with the design-basis earthquake The justification for making the wind modifications was reexamined and DOE now intends to use the funds for upgrades that will provide more earthquake protection

Safety Analysis Reports Not Independently Reviewed

DOE orders require that independent reviews of SARs be performed and allows its field offices to carry out this independent review Although DOE headquarters staff and DOE contractors have assisted in some cases in the review process, the process remains an internal DOE function carried out primarily by DOE field offices We believe DOE should increase the independence of the SAR review process for DOE defense facilities by using an outside independent organization to review DOE SARs prior to their approval

SARs Reviewed Internally Within DOE

DOE Order 5481 1A sets forth the basic requirements for DOE's safety analysis and review system. Under this order DOE requires an independent review of each safety analysis and allows DOE field offices to fulfill this requirement. The order also requires that DOE's safety staff at headquarters provide an independent assurance through the appraisal process that SAR activities are carried out in a generally uniform manner

We found that DOE field offices have been delegated the responsibility within DOE for reviewing SARs for defense facilities and approving the facilities for operation DOE field offices, thus, are the primary entity within DOE to determine that the risk in operating a defense facility is acceptable Of the five facilities we reviewed that have approved SARs, all of the SARs were reviewed and approved by field offices For the three remaining facilities that do not have approved SARs, DOE field offices officials told us they will also be the ones to review and approve those SARs.

Although DOE headquarters staff are not routinely involved in the review process, DOE officials told us they have helped field staff in the review process and/or funded special projects to examine the adequacy of a specific SAR or portions of an SAR For example, the Office of the Assistant Secretary for Defense Programs has funded Los Alamos National Laboratory to review selected portions of the SARs for DOE's production reactors located at Savannah River. As a continuation of this project, Los Alamos National Laboratory plans to review the SAR for the N Reactor in Washington State While such reviews can provide additional assurances that an SAR accurately describes the potential hazards in operating the plant, the responsibility for reviewing and approving SARs for nuclear defense facilities lies at DOE's field office level

In the past, we have pointed out the lack of independence that has been associated with DOE's safety oversight programs In a report entitled Better Oversight Needed for Safety and Health Activities at DOE's Nuclear Facilities (EMD-81-108, Aug. 4, 1981), we pointed out a number of problems with DOE safety and health activities, including reviews of SARs. We reported then that (1) many of DOE's existing facilities did not have completed safety analyses and (2) safety analyses did not identify all significant hazards. Further, we pointed out a major underlying factor causing these problems was that DOE's organizational structure did not allow for independent oversight Similarly, some of our other

reports also pointed out the lack of independent oversight that has been associated with DOE safety programs [11]

DOE studies have also expressed concerns about DOE's safety oversight programs For example, one study entitled A Safety Assessment of Department of Energy Nuclear Reactors, dated March 1981, found that independent reactor safety overview within DOE was not functioning to meet current needs The study goes on to recommend the establishment of a Nuclear Safety Advisory Committee made up of non-DOE employees who would report to the Secretary of Energy

Recent actions by DOE may lead to improvements in the SAR review process On September 18, 1985, the Secretary of Energy announced a number of initiatives to strengthen environmental, safety, and health programs within DOE. A number of these initiatives are aimed at enhancing the safety of DOE's operations These are (1) reorganizing DOE's safety functions within DOE, (2) conducting nuclear safety technical appraisals at all of DOE's high-hazard facilities, and (3) revising the DOE order for preparing and reviewing SARs These three initiatives are described below

The reorganization of safety functions within DOE is aimed at strengthening and increasing DOE's safety oversight In this regard, headquarters' safety activities are now under an Assistant Secretary for Environment, Safety, and Health, who reports directly to the Under Secretary of Energy Among other things, this reorganization gives safety activities a more equal footing with DOE program offices (e g , Defense Programs) in establishing DOE policy, provides a more direct channel of communication to the Secretary of Energy for raising safety concerns or issues, and makes safety functions within DOE more visible This reorganization was essentially completed by March 1986

Technical safety appraisals for all DOE high-hazard facilities is another important initiative These appraisals are multidisciplinary, "on the ground" appraisals designed to determine the facilities' compliance with DOE safety requirements DOE anticipates the effort will take over 2 years to complete. The appraisals will be carried out by teams headed by DOE staff with expertise in the nuclear safety area

[11]These reports include Department of Energy's Safety and Health Program for Enrichment Plant Workers Is Not Adequately Implemented (GAO/EMD-80-78, July 11, 1980), DOE's Safety and Health Oversight Program at Nuclear Facilities Could Be Strengthened (GAO/RCED-84-50, Nov 30 1983) and Environment and Workers Could Be Better Protected at Ohio Defense Plants (GAO RCED-86-61 Dec 13, 1985)

The third initiative is revising DOE's order for preparing and reviewing SARs. According to DOE officials, this initiative allows headquarters safety staff to review and concur in the approval of SARs for proposed DOE facilities, thus potentially elevating the review process within DOE for new facilities. The order as drafted does not require DOE headquarters safety staff to approve SARs for existing facilities.

Increasing Independent Safety Oversight

Although DOE's recent initiatives have the potential for improving safety oversight of DOE, this oversight remains an internal function within DOE Thus, programmatic objectives and safety considerations will continue to be assessed internally within DOE Trade-offs between the two, undoubtedly, will have to be made during the budget process. Further, DOE will remain open to criticism in regulating itself in regard to the safety aspects of its operations.

One way DOE can increase independent oversight of the SAR process is by arranging with an outside organization, which is independent of funding by DOE, to review DOE SARs prior to DOE approval. Such an organization can be another federal agency, such as NRC, or an independent review panel not associated with DOE. Under such an arrangement, the outside organization would not approve SARs but only review and make public their assessments. DOE, in turn, could accept and/or rebut the review

Such arrangements have been worked out in the past. For example, under terms of an interagency agreement with DOE, NRC performed a safety review of the Fast Flux Test Facility, an experimental reactor, in DOE's civilian nuclear research and development program. NRC concluded that the startup and operation of the facility was acceptable, provided that due regard was given to the consequences of certain low-probability accidents. In addition, DOE officials told us that NRC also reviews the designs of DOE's naval reactors.

One major advantage to such an arrangement is the increased independence of safety reviews. Because of the independent status of an outside organization, the public's perception of the quality of safety oversight provided for DOE's nuclear facilities would be enhanced. To improve the public's perception concerning the safety of its facilities, DOE has sought the use of outside organizations. Most recently, the Secretary of Energy requested the National Academy of Science and the National Academy of Engineering to independently review DOE reactors in view of the Russian nuclear accident at Chernobyl. In addition to enhancing the public's perception of DOE's safety oversight, an outside organization's review

would help ensure that the safety concerns are not subservient to programmatic interest such as production goals Also, under such an arrangement, DOE would still control safety requirements that might conflict with national security concerns

One drawback to such an arrangement is that DOE would not be required to accept any recommendations However, if the organization's views were made public, the risk or potential problem areas would be better understood by the public. The public and the Congress would then be in a better position to determine if such risks are acceptable. Other drawbacks are that additional staff resources and cost would be needed to perform the reviews and possible duplication of efforts Further, the number of people with access to DOE's classified information may increase Finally, the outside organization may not have sufficient technical expertise to review SARs for all DOE operations Many DOE facilities are unique to the defense program and they differ significantly from nuclear facilities regulated in the private sector These drawbacks, however, could be minimized by carefully structuring the roles and responsibilities between the two organizations

Conclusions and Recommendations

To ensure that nuclear facilities can operate safely, SARs are prepared on the design and construction of the facilities. Among other things, SARs compare the design of the plant against accepted safety standards and analyzes potential accidents and the likely consequences of such accidents, thus documenting the safety of the facility and the risk being taken in operating the facility Our review of DOE's SARs for existing facilities showed that some SARs have not been approved, the approaches used in the SARs to demonstrate safety significantly differ, and the overall review process is an internal DOE function

While SARs have been issued in draft form for all the eight existing facilities we reviewed, three, which have been designated high-hazard facilities, have not been approved even though the contractors completed draft SARs 4 to 5 years ago According to DOE officials, higher priority work has delayed the review process for these facilities. We believe such delays indicate that DOE does not view completing the SAR process for existing facilities as a priority since it has not allocated sufficient resources to ensure that they are completed in a timely fashion

The guidance from DOE headquarters on the methods and content of SARs is interpreted in a variety of ways by the operating contractors and field

offices who prepare and review SARs. This has led to fundamentally different approaches in selecting and analyzing worst-credible accidents, even for similar operations. Some of these approaches are less comprehensive and/or conservative than others The SARs also differ considerably in the extent to which they compare the facilities with design criteria, with some SARs having little or no comparison While none of the SARs conclude that a facility is unsafe, the level of analysis and lack of comparison indicate, in our view, a lack of thoroughness or consistency on the part of DOE in analyzing the design and construction of its older nuclear facilities Since the safety of DOE's plants is not analyzed in the same way, it is impossible to generalize how safe DOE operations are in total or if some facilities are safer than others We believe more standardization of preparing SARs would benefit DOE's SAR process

We also noted in our review that DOE's review process of SARs is internal. In this regard, DOE's field offices have been delegated the responsibility for reviewing and approving SARs for nuclear defense facilities Thus, possible trade-offs between safety concerns and production goals are resolved internally within DOE. For some of DOE's more hazardous facilities, we believe outside independent review would better assure the public and the Congress that DOE's facilities are safe

We recommend that the Secretary of Energy

- Complete and approve SARs for all high-hazard facilities in a timely fashion
- Require that SARs include a detailed comparison of the plant against current DOE design criteria, highlighting and explaining any deviations
- Develop more consistent requirements to be followed in preparing SARs, outlining appropriate methodologies and assumptions to be used in analyzing accidents and their consequences
- Establish an arrangement with an outside independent organization to review those SARs for the most hazardous facilities This could be accomplished either by establishing a working arrangement with NRC or an independent review panel

Objectives, Scope, and Methodology

On April 15, 1985, the Ranking Minority Member, Subcommittee on Energy, Nuclear Proliferation, and Government Processes, Senate Committee on Governmental Affairs, requested that we review how effectively DOE is protecting worker health and safety and the environment a its defense production facilities nationwide As part of that request, we were asked to focus our work initially and report separately on three defense plants in Ohio and in early 1986 were asked to report on DOE initiatives to improve their environmental, safety, and health activities Subsequently, we issued three reports—Information on Three Ohio Defense Facilities (GAO/RCED-86-51FS, Nov 29, 1985), Environment and Workers Could Be Better Protected at Ohio Defense Plants (GAO/RCED-86 61, Dec 13, 1985), and Status of Department of Energy's Implementation of 1985 Initiatives (GAO/RCED-86-68FS, Mar 4, 1986)

In continuing our work on protecting worker health and safety and the environment at DOE defense facilities nationwide, we expanded our worl to include eight nuclear defense facilities that reflect the diversity of DO defense operations, nationwide As agreed with the Ranking Minority Member's office, these were

- the fuel fabrication facility, Savannah River, S C ;
- the Los Alamos National Laboratory, N Mex.,
- the Mound Laboratory, Ohio,
- the N Reactor, Hanford, Wash ,
- the reprocessing facility, Savannah River, S C ,
- the reprocessing facility, Hanford, Wash.,
- the Rocky Flats plant, Colo , and
- the Y-12 plant, Tenn

Soon after the Russian nuclear plant accident at Chernobyl, the office o the Ranking Minority Member asked us on May 1, 1986, to report separately and as soon as possible on our work regarding the adequacy of SARs for these eight facilities.

Our review of SARs for DOE defense facilities focused on the completene and adequacy of the safety analysis We reviewed draft and/or approved SARs and supporting documentation for the more hazardous operations at each of the eight facilities. In reviewing the SARs, we examined the extent to which these documents compare the facilities against established design criteria We also examined and evaluated th approaches used to analyze accidents and consequences of possible acc dents We examined DOE guidance, orders, and related studies and reports on safety analysis reviews and discussed these documents with

DOE officials at headquarters and in the field as well as DOE contractors who prepared the reports Finally, we met with NRC officials to discuss how safety analysis reports for commercial nuclear operations are prepared and reviewed in the private sector. We did not attempt to evaluate the overall safety of any of these facilities

As requested, we did not obtain official comments on the report. We did, however, discuss the contents of this report with agency officials as it was being developed and incorporated their views where appropriate

Our review was conducted between May 1985 and May 1986 and was performed in accordance with generally accepted government auditing standards.

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