

SAFETY PRINCIPLES FOR DECONTAMINATION AND DECOMMISSIONING OPERATIONS AT NUCLEAR FACILITIES*

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ABSTRACT

The U.S. Department of Energy is responsible for nearly 1000 nuclear facilities which will eventually be decommissioned. In order to ensure the health and safety of workers and the public in general at such times, the Department is developing a set of principles and criteria against which the decommissioning operations will be evaluated.

INTRODUCTION

The operation of U.S. Department of Energy (DOE) facilities and sites must conform to the health and safety rules and regulations developed and instituted by the Department and, where applicable, by other departments and agencies of the Federal Government. These rules and regulations are designed to ensure that the health and safety of its employees are a prime consideration at all times and that activities are not undertaken which might adversely affect these factors. In addition, the activities should be conducted in such a manner as to ensure that, as far as it is reasonably practicable, persons not employed by the Department but who may be affected by the operation of the site or facility are not exposed to risks to their health and safety.

Within the DOE complex are very many facilities which are or have been involved in nuclear activities. These vary greatly in size and function, and include nuclear reactors, particle accelerators, nuclear processing facilities, analytical and testing laboratories, and storage facilities. As the activities decrease significantly over the next two to three decades, many of these facilities will cease operation. Unless restart operations are visualized, these facilities, which number almost 1000, will require decontamination and/or decommissioning (1).

The status and characteristics of a facility or site undergoing decontamination and decommissioning (D&D) are likely to be significantly different from those present during the operational lifetime of that site or facility. However, the health and safety of employees and others are still major concerns; the rules and regulations in place during normal operations will remain in force, where they are applicable, after it has been decided to cease operations and enter a D&D mode. Thus decisions regarding the development and implementation of D&D plans and the subsequent conduct of operations must be based on assessments which take into account these rules.

The safety of all operations at DOE nuclear facilities are continually being evaluated but the principles and criteria being used are sometimes less well-defined than might be considered desirable. Consequently, in order to ensure a

consistent and uniform approach to the safety of D&D operations, the DOE has committed to developing a set of safety principles and evaluation criteria specifically for use in such activities. These principles and criteria are intended to provide the safety assessment personnel with a framework on which they can base their technical judgement. At the same time, their existence and publication will allow the facility management and contractors to become more aware of the criteria by which their D&D plans and operations will be evaluated.

The development of a formalized set of principles is not, in itself, a new concept in the nuclear arena. The International Commission on Radiological Protection has published over the years some general principles that it believes should form the basis in developing radiological protection programs (2). Similarly, the DOE has in place a fundamental principle which underlies its Radiological Control Manual (3). However, of particular interest in the present case, the Health and Safety Executive in the United Kingdom has published, through its Nuclear Installation Inspectorate, a set of safety assessment principles for nuclear plants (4). This document, which itself represents an updating and combining of two earlier documents that treated safety assessments of nuclear power reactors and nuclear chemical plant, provided a useful platform from which to develop a detailed set of principles and criteria applicable specifically to D&D operations.

GENERAL PRINCIPLES FOR D&D OPERATIONS

The principles and criteria, as they are being developed for DOE's D&D activities, emphasize mainly nuclear safety. However, the importance of overall safety, for example, with respect to hazardous chemicals and to the more conventional type of hazard associated with everyday non-nuclear activities, is being addressed, particularly where the consequences may impact upon nuclear safety.

The principles themselves can be grouped under several headings, headed by a short set of what are considered fundamental principles to be applied when addressing the safety issues associated with the D&D of a facility. These fundamental principles, which underlie all the other principles, are

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derived from internationally-accepted principles developed to ensure the conduct of safe operation at any type of nuclear facility over its lifetime. Their roots lie in the recommendations of the International Commission on Radiological Protection (2). Thus these fundamental principles address the need not only to keep radiation doses beneath the statutory limits but also to keep them as low as reasonably achievable.

- There shall not be any occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure. (DOE's fundamental principle stated in (3))
- No person shall receive radiation doses in excess of the statutory dose limits as a result of normal D&D operations.
- The exposure of all persons to radiation shall be kept as low as is reasonably achievable.
- The collective effective dose to workers and to the general public as a result of D&D activities shall be kept as low as is reasonably achievable.
- All practical steps shall be taken to prevent accidents of any type during D&D activities.
- All practical steps shall be taken to minimize the radiological consequences of any accident that might occur during D&D activities.

The other sets of principles build on these fundamental principles and address specific areas of concern, such as safety analysis, engineering practice and waste management.

Safety Analysis Principles

In performing safety analyses on D&D operations, consideration must be given to essentially two types of situation. The first of these involves the radiation doses likely to be received by the D&D workers, by other workers at the site not performing D&D-related activities and by the general public during the course of normal D&D operations. The second concerns the possibility of accidents which result in release of radioactive materials, leading to radiation doses to the same groups of people.

As stated previously, the status and characteristics of a facility or site during D&D activities are likely to be significantly different from those present during the operational lifetime. However, the fundamental principles espoused above still have validity when forming the principles to be used in assessing the safety aspects of normal D&D operations. Similarly, the types of off-normal occurrences and accidents which may be encountered during D&D operations are also likely to be different in character from those possible during the site or facility operational lifetime. In some instances (for example, at a reactor facility), the potential for severe accidents can be expected to be considerably reduced. Thus a separate set of safety principles is being developed to address the particular types of incidents that may occur during D&D operations. Examples of these principles include:

- The facility or site to be decontaminated and/or decommissioned shall be characterized to the extent practicable, to determine the types and levels of radioactivity and hazardous or toxic materials present.
- An analysis of the plans for D&D of a site or facility shall be performed to estimate the radiation doses

likely to be received by workers and the public during the D&D activities.

- No individual working on D&D activities should receive in any one year from all sources of radiation on the site a radiation dose greater than 5 rem (50 mSv).
- No individual member of the general public should receive in any one year from all sources of radiation on the site a radiation dose greater than 0.1 rem (1 mSv).
- An analysis should be performed of the off-normal occurrences and accidents that might possibly take place during D&D operations. This should take into account all planned activities during the D&D operation and all significant sources of radioactivity and hazardous material which might be encountered.
- The accident analysis should include a list of initiating incidents that have the potential to result in a significant uncontrolled release of radiation.
- For those accidents that lead to a release of radioactive material or a dose of direct radiation, radiological analyses should be performed to determine the maximum effective dose to a worker on the site and to a person downwind of the release.
- Severe accident analyses should be as realistic as possible and based on known information to the extent practicable.
- If uncertainties in a severe accident analysis are judged to have a significant effect on the assessed risk, research should be performed aimed at verifying the modeling assumptions.

Engineering Principles

In the sense that it employs scientific and mathematical principles in the design, construction and operation of equipment and systems, it is appropriate that the act of decontamination and decommissioning be considered as an engineering project. Thus it follows that D&D should be subject to a set of engineering principles, as a matter of good engineering practice. These principles may have elements in common with those used in the original design, construction and operation of the facility or site to be decommissioned but should not be confused with them. The D&D engineering principles being developed are considered to be a whole and separate entity.

Engineering principles themselves represent the foundations on which the safety of the equipment and operations are built, a state which must be verified by analysis using the safety analysis principles mentioned previously. In this respect, the engineering principles and the safety analysis principles are complementary; the former have to be of a sufficiently high standard in order to be able to achieve the needed high level of safety capable of withstanding verification checks against the latter. Thus it is to be expected that there will be some degree of commonality between the two sets of principles.

The umbrella of engineering principles will cover a host of topics, each of which is being addressed separately. These range from general subject areas, such as codes and standards, human factors and radiological protection, to more specific items, such as individual external and internal hazards. At the same time, there are some underlying basic principles which will have application across the spectrum of D&D engineering

practice and are considered of prime importance, to be invoked at all times. These include:

- Potential hazards associated with the D&D of a facility or site should be identified and the designs, plans, etc. should be such that these hazards are avoided.
 - The sensitivity of D&D operations to potential failures and errors should be minimized as reasonably as is practicable.
 - The choice of process materials and conditions, and of the containment and structural materials should be such that the consequences of potential failures are minimized.
 - The design of D&D operations should be such that sufficient containment is provided to prevent the release of radioactive materials to the environment as a result of potentially significant failures.
 - The design of D&D operations should be such that several layers of protection are provided to prevent the breach of any barriers or to mitigate the consequences of a breach, should one occur.
 - The introduction of new processes and designs into D&D operations must be supported by adequate research, development and testing.
 - The layout of safety-related equipment and services should be such as to minimize the effects of internal and external hazards.
 - Provision should be made for monitoring and inspecting safety-related equipment.
- Radioactive wastes should be fully characterized to the extent practical, including the determination and recording of origin, form, type, quantity, volume, isotopic composition and activity.
 - Radioactive wastes should be separated into different categories based on their characteristics. Subsequent storage should be such that the different categories of waste are kept separate.
 - Sufficient facilities and locations should be provided for the storage of wastes prior to permanent disposal. Arrangements should be made, where appropriate, to minimize the potential release of radioactivity from the storage areas to the environment.
 - Radioactive wastes should be stored, monitored and maintained in a safe state until sent for permanent disposal. Appropriate provisions, including physical and administrative arrangements, should be made to ensure that this is so, and that the radiological consequences of storage are minimized.

SUMMARY

The safety principles being developed for application to D&D operations represent a formalization of the methods currently used in the DOE when conducting safety assessments of all operations at nuclear facilities. By documenting them, it is hoped that not only will personnel be able to adopt a more consistent approach but also the facility management and contractors will become more aware of the criteria by which their D&D plans and operations will be evaluated.

REFERENCES

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Waste Management Principles

Inevitably, a major product of D&D operations will be radioactive wastes (including radioactive scrap). This term is intended to include, in the present context, both the primary wastes (that is, activated or contaminated components, structures, etc.) and the secondary wastes (such as the ion exchange resins used in a decontamination process). In addition to the principles already identified as essential to safe D&D operations, another set is being formulated to govern specifically the generation, storage, handling and transport of the waste materials. These principles are designed to reduce the risk of radiation exposure and contamination to those involved in the D&D operations and to the public in general. Among the principles proposed are the following:

- The quantity of radioactive waste generated should be minimized as far as is reasonably practicable.
- All radioactive wastes generated should be of a type or in a form which is compatible with the contemporary storage and/or disposal technologies.