Using a Risk-Informed, Graded Approach for Decommissioning Small Facilities

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Abstract. Decommissioning small facilities differs from large facilities in that small facilities are generally less hazardous and require more limited actions or controls than large facilities to keep risk to an acceptable level after decommissioning. Such actions or controls should be commensurate, or "graded," with the hazards posed by the facility. This graded approach, based on risk and complexity, should be used to accommodate the risks posed by small facilities and should provide a clear and consistent approach for both safe and cost-effective decommissioning. Although small facilities generally pose lower risks, some small facilities may have significant contamination because of the type and form of the material used at those sites. Unlike large facilities (e.g., commercial nuclear power plants), licensees of such facilities may not possess sufficient financial resources to adequately clean up their sites. Therefore, attention should be paid to ensuring that small facilities possess sufficient financial resources to adequately clean up and decommission.

1. Introduction

Facilities to be decommissioned range from commercial nuclear power plants, to materials facilities of varying sizes, to laboratories, users of sealed sources, research reactors, and irradiators. Generally, commercial nuclear power plants are considered to be "large" facilities, regardless of the rated power output. Materials facilities can range from "large" to "small," depending on their sizes. Laboratories, users of sealed sources, research reactors, and irradiators are generally considered to be "small" facilities. Decommissioning small facilities differs from large facilities in that small facilities are generally less hazardous and require more limited actions or controls than large facilities to keep risk to an acceptable level after decommissioning. Such actions or controls should be commensurate, or "graded," with the hazards, which are related to potential consequences (e.g., doses) posed by the facility. In this paper, the term "small facilities" refers to small manufacturing facilities, laboratories, research reactors, irradiators, and users of sealed sources.

Although large facilities generally present higher hazards and thus higher potential consequences (e.g., doses) than small facilities, this is not always the case. The type, quantity, and form of the radioactive materials the facility used when it was operating and the past management of the material together determine the hazard of the facility after shutting down and before cleanup. Small materials facilities can pose higher hazards and consequences than large facilities because of the type and form of the material used at the site.

In the United States, commercial nuclear power plants have been able to clean up their facilities to allow for unrestricted release, even in cases with significant residual radioactivity. In those cases, the licensees possessed the financial resources and technical capability to clean up the contamination to a level allowing unrestricted release of the site. On the other hand, some relatively small materials facilities in the United States have had extensive contamination after shutdown and required extensive cleanup, but the licensees did not have sufficient financial resources to perform the cleanup. Thus, the size of the facility is not the true discriminating factor in determining the complexity and cost of decommissioning. Large facilities may pose low consequences and small facilities may pose high consequences. Grading the approach to decommissioning and the extent of cleanup should be based on the type, quantity, and form of the radioactive materials the facility used and the amount of contamination after shutdown, not on the size of the facility.

2. Graded approach

The U.S. Nuclear Regulatory Commission (USNRC) applies a risk-informed approach to regulatory decisionmaking. According to this philosophy, risk insights are considered, together with other factors in the regulatory process, to better focus licensee and regulatory attention on design and operational issues, commensurate with their importance to public health and safety. The process is considered risk informed rather than risk based because the decision considers a number of factors and does not depend solely on the numerical results of a risk assessment.

Risk can be defined by the "risk triplet" of (1) a scenario or set of scenarios with a combination of events and/or conditions that could occur, (2) the probability or likelihood that the scenario(s) could occur, and (3) the consequences (e.g., the dose to an individual) if the scenario were to occur. Quantitatively, risk is defined as the likelihood of an event times the consequences of the event. Conceptually, the graded approach attempts to achieve approximately the same level of risk for each event or groups of events, which results in an efficient application of resources. To achieve a desired level of risk if the current level is deemed to be excessive, one must take actions to either lower the potential consequences of an event(s), or to lower the likelihood of the event(s). The actions that are taken should be graded to the potential consequence—the higher the potential consequence, the more stringent the actions. The foremost decision is whether a site will be released with or without restrictions on future site use. If a site seeks unrestricted release, then a reduction of the hazard (i.e., radioactivity) that is related to the potential consequence may be necessary. This can be accomplished by cleaning up the site. If a licensee seeks to obtain restricted release of a site, it must demonstrate that further cleanup is neither necessary nor feasible and then take actions, such as establishing institutional controls or engineered barriers, to reduce the likelihood that an unacceptable consequence will occur. Whether for unrestricted or restricted use, actions may need to be taken to reduce risk (i.e., the consequences or the likelihood) to achieve an acceptable level of risk. In decommissioning, both USNRC staff and licensees use risk insights, along with the results of dose assessments. However, rigorous risk analyses are not the norm.

The USNRC applies a graded approach in decommissioning materials facilities by binning or grouping facilities (i.e., "decommissioning groups") based on the nature and extent of the radioactive material present at a facility. The groups are generally related to the potential hazards associated with the facility, in that less complex facilities with limited distribution of radioactive material may pose lower hazards to individuals and populations during and after decommissioning. The decommissioning process, which may include taking action to reduce risk, proceeds down a path commensurate with the hazard posed by each group.

Activities to decommission a facility depend on the type of operations the licensee has conducted, the residual radioactivity after shutdown, and the complexity of the contamination and cleanup. The USNRC has divided various facility conditions into seven decommissioning groups with the following characteristics:

(1) Group 1 facilities have used licensed materials in a way that would preclude their release into the environment, would not cause the activation of adjacent materials, nor would have contaminated work areas above a decommissioning screening level. Examples

include (a) licensees who possessed and used only sealed sources, such as radiographers and irradiators, and (b) licensees who possessed and used relatively short-lived radioactive materials in an unsealed form.

(2) Group 2 facilities may have residual radiological contamination present on building surfaces and in soils. However, licensees are able to demonstrate that their facilities meet unrestricted release criterion [i.e., dose is less than 0.25 millisieverts per year (mSv/year) (25 millirem per year (mrem/year))] by applying the screening criteria dose analysis. Examples include licensees who used only quantities of loose radioactive material that they routinely cleaned up (e.g., research and development facilities).

(3) Group 3 facilities are essentially Group 2 facilities that require development of a decommissioning plan because the licensee did not incorporate remediation procedures into the license before license termination. Examples include licensees who may have occasionally released radioactivity within USNRC limits.

(4) Group 4 facilities have residual radioactivity present in building surfaces and soils, but the licensee cannot meet screening criteria and the ground water is not contaminated. Licensees are able to demonstrate that residual radioactive material may remain at the facility, but within levels for unrestricted release [i.e., less that 0.25 mSv/year (25 mrem/year)]. Examples include licensees whose facilities released loose or dissolved radioactive material within USNRC limits and may have had some operational occurrences that resulted in releases above USNRC limits (e.g., waste processors).

(5) Group 5 facilities are Group 4 facilities that have ground water contamination. Examples include licensees whose facilities released, stored, or disposed of large amounts of loose or dissolved radioactive material on site (e.g., fuel cycle facilities).

(6) Group 6 facilities are those that have residual radioactive contamination present on building surfaces, in soils, and possibly in the ground water. The licensees are able to demonstrate that the proposed residual radioactivity exceeds the criterion for unrestricted release [i.e., 0.25 mSv/year (25 mrem/year)] but within levels for restricted use [i.e., 0.25 mSv/year (25 mrem/year)] with institutional controls in effect to restrict land use. Examples include licensees whose facilities would cause more health and safety or environmental impact when cleaning up to the unrestricted release limit than could be justified (e.g., facilities where large inadvertent releases occurred).

(7) Group 7 facilities are the same as Group 6 facilities, except that the residual radioactive material remaining at the facility exceeds the level for restricted use [i.e., greater than 0.25 mSv/year (25 mrem/year) with institutional controls in effect]. Examples include licensees whose facilities would cause more health and safety or environmental impact when cleaning up to the unrestricted release limit than could be justified (e.g., facilities where large inadvertent releases occurred).

The simplified flowchart in Fig. 1 shows the key characteristics of each group and the placement of a facility into a group.

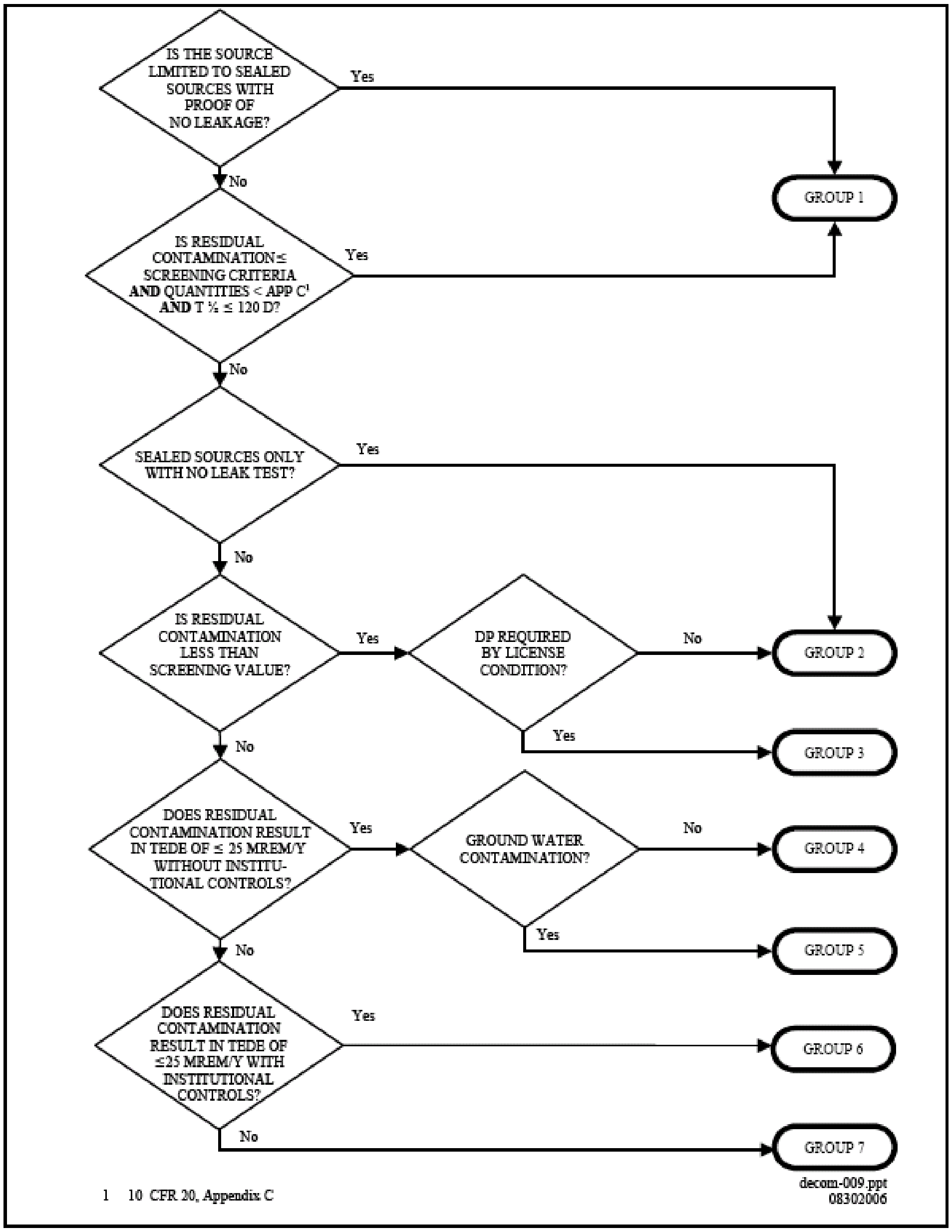

FIG. 1. Determination of decommissioning group.

The graded approach, both in terms of the review process and the necessary cleanup, is manifest by binning facilities into groups and by the application of actions as described below.

3. How small facilities benefit from applying a graded approach

Unrestricted release versus restricted release—Facilities in Groups 1–5 are eligible for unrestricted release if they demonstrate that residual contamination results in a dose less than 0.25 mSv/year (25 mrem/year) without restrictions on future site use. Facilities in Groups 6–7 are restricted release facilities that require institutional controls to restrict future site access and land use. The institutional controls must ensure that a dose limit of 0.25 mSv/year (25 mrem/year) is achieved with the controls in place. Furthermore, the licensees must show that a dose limit of 1.00 mSv/year (100 mrem/year) is achieved if the institutional controls fail. A gradation is applied to restricted release facilities, depending on the consequences if the controls were to fail. This gradation is such that if the estimated dose is greater than the 1.00 mSv/year (100 mrem/year) dose cap when institutional controls are not in effect, then additional, durable institutional controls must be in place to provide further protection for these higher risk facilities. The graded approach allows the use of conventional deed restrictions for lower risk facilities and durable institutional controls (e.g., government ownership or USNRC monitoring or licensing) for higher risk facilities. It also allows the duration of the controls and specific-use restrictions to be tailored based on hazard duration and dose estimates.

Screening criteria versus dose modeling—Facilities in Groups 1–3 may be evaluated by comparing residual contamination to predetermined conservative screening values, issued by the USNRC, for site-specific radionuclides instead of performing a site-specific dose assessment. Facilities in Groups 4–7 must perform a site-specific dose assessment.

Decommissioning plan—Facilities in Groups 1–2 are not required to submit a site-specific decommissioning plan because the decommissioning activities will not pose a potential risk to the public or workers. Groups 3–7 must submit a site-specific decommissioning plan because they will pose a potential risk to the public or workers.

Environmental review—Group 1 facilities are not required to perform an environmental review. Groups 2–5 must perform an environmental review, referred to as an environmental assessment. Groups 6–7 are required to perform an environmental review and prepare an environmental impact statement. An environmental impact statement is a much more detailed environmental review than an environmental assessment, with more extensive public involvement.

As described above, both licensee and USNRC actions are graded according to the hazard, which varies by group. A graded approach based on risk and complexity attempts to achieve approximately the same level of risk for each event or group of events by requiring less stringent actions for lower risk facilities. A graded approach to decommissioning allows facilities to decommission in a safe and cost-effective manner.

4. Lessons learned from decommissioning small facilities

Most of the license terminations in the United States are routine and fall into Groups 1–3. For example, the USNRC terminated approximately 900 licenses between 2003 and 2006. Of these terminations, most would be considered small, and less than 30 would be considered to be complex (i.e., requiring regulatory review before beginning decommissioning). Most terminations were routine not because of the size of the facilities, but because of the type, quantity, and form of the radioactive materials used by the facility when it was operating.

Although many lessons learned apply to both large and small facilities, one that particularly applies to small facilities relates to having sufficient financial resources to clean up a site. Although most license terminations of small facilities are routine, some are complex and require extensive cleanup. When such cases occur, the licensee may lack the funds and sufficient financial assurance to accomplish the cleanup, unlike large commercial power reactors that have sufficient financial resources to clean up facilities for unrestricted release. When the private company has exhausted all avenues for obtaining funds, Federal and State agencies often become involved. On the Federal level, the U.S. Environmental Protection Agency (EPA) serves as one potential source of cleanup funding through the Comprehensive Environmental Response, Compensation, and Liability Act, also known as "Superfund."

In some cases in the United States, relatively small manufacturing facilities required extensive cleanup but lacked the funds to do so. For example, a relatively small manufacturing facility contaminated its site from manufacturing operations associated with self-luminous watches and instrument dials and other items involving radium-226 (^{226}Ra), cesium-137 (^{137}Cs), strontium-90 (^{90}Sr), and americium-241 (^{241}Am). Primary soil contamination included ^{226}Ra and ^{137}Cs, with small amounts of ^{241}Am. The ground water on site was also contaminated with tritium, ^{90}Sr, and ^{137}Cs. The licensee estimated the cost of cleanup to be approximately $29 million. The USNRC estimated that it would cost between $94 and $120 million, and $50 and $78 million, to decommission for unrestricted release and restricted release, respectively. The licensee's decommissioning fund falls far short of the amount needed to clean up the site, and the licensee had not been contributing to the decommissioning trust fund for some time. The site has since been turned over to EPA for remediation.

In another example, a small uranium mine and mill that ceased operations more than 30 years ago has buildings and soils contaminated with uranium and thorium. The company that owned the site sold it to a couple who plan to live on the site, but possess insufficient resources to adequately clean up the site. The USNRC estimates that it will cost approximately $6.6 million to adequately clean up the site so that the couple can live there. This amount far exceeds the financial resources available to the couple. EPA is also considering this site for remediation.

The USNRC continues to change its financial assurance regulations to better ensure that sufficient resources exist to accomplish decommissioning and prevent future legacy sites. The revisions may include (1) requiring licensees to provide, for USNRC approval, a decommissioning funding plan based on unrestricted release, (2) requiring a licensee to reevaluate its decommissioning cost estimate and, if necessary, provide additional financial assurance to cover higher costs after an operational event (e.g., spills) that indicates a potential for increased decommissioning costs, and (3) providing collateral for undefined guarantees.

5. Conclusion

A graded approach based on risk and complexity should be used to accommodate the low risk posed by most small facilities. Doing so provides a clear and consistent approach for both safe and cost-effective decommissioning.

Although most small facilities pose low risks, some small facilities may have significant contamination and thus represent higher risks that make them more complex to decommission. Unlike large facilities (e.g., commercial nuclear power plants), small facilities that are contaminated may not possess sufficient financial resources to adequately clean up their sites. Attention should be paid to ensuring that small facilities possess sufficient financial resources to adequately clean up and decommission.

REFERENCES

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