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Operational Limitations for Demolition of a Highly Alpha-Contaminated Building - Modeled Versus Measured Air and Surface Activity Concentrations

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Operational Limitations for Demolition of A Highly Alpha-Contaminated Building – Modeled Versus Measured Air and Surface Activity Concentrations

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Abstract

The demolition of a facility historically used for processing and handling transuranic materials is considered. Residual alpha-emitting radionuclide contamination poses an exposure hazard if released to the local environment during the demolition. The process of planning for the demolition of this highly alpha-contaminated building, 232-Z, included a pre-demolition modeling analysis of potential exposures. Estimated emission rates were used as input to an air-dispersion model to estimate frequencies of occurrence of peak air and surface exposures. Post-demolition modeling was also conducted, based on the actual demolition schedule and conditions. The modeling results indicated that downwind deposition is the main operational limitation for demolition of a highly alpha-contaminated building. During the demolition of 232-Z, airborne radiation and surface contamination were monitored. The resultant non-detect monitoring results indicate a significant level of conservatism in the modeled results. This comparison supports the use of more realistic assumption in the estimating emission rates. The resultant reduction in modeled levels of potential exposures has significant implications in terms of the projected costs of demolition of such structures.

Key Words: Building Demolition, Air Dispersion, Modeling, Alpha Exposure

Introduction

A number of facilities historically used for processing and handling transuranic materials are scheduled for demolition. The residual alpha-emitting radionuclide contamination that typically occurs in such facilities poses a potential exposure hazard if any of the contamination is released to the local environment during the demolition. A major cost factor for demolition is the level to which the residual alpha-emitting radionuclide contamination must be reduced to before demolition activities begin. As one approaches lower and lower levels of residual contamination, the removing additional contamination becomes more and more difficult, increasing costs and work exposures. The pre-demolition analysis helps define, and possibly reduce, the amount decontamination required prior to demolition. The demolition of the 232-Z Building, a highly alpha-contaminated building on the Hanford Site, is considered in this paper, which examines the degree of conservatism used in the analysis of potential exposure levels.

Background

Pre- and post-demolition air-dispersion modeling analyses were conducted to support the 232-Z demolition. The frequencies of occurrence of peak air and surface activity levels were modeled using the Environmental Protection Agency's (EPA) ISC3-Prime computer code (U.S. EPA 1995a; 1995b; 2006). The analyses used local meteorological data and accounted for building wake effects.

The demolition planning process considered the potential for worker and other exposures from the various destruction and loading operations. The magnitude of potential exposures depends on several factors: 1) the amount of contamination in the building, 2) the amount of contamination that will become airborne during the demolition activities, and 3) the ambient rates of dispersion and deposition as function of downwind distance. By incorporating these three factors, the modeling analysis helps evaluate potential air and soil exposures. The site-specific analysis of air and soil contamination defined "acceptable" residual levels in the structure for meeting a level of protection at specified boundaries for different demolition options.

Modeling Analyses

Fig. 1 shows the site plan for the 232-Z Building, which was located with a complex and close to occupied buildings. The structure had two main components with contamination: a scrubber cell (located within the southwest corner) and a process room (most of the rest of structure).

Control Boundaries

Fig. 1 shows three control boundaries: the high contamination area (HCA), the contamination area (CA), and the radiation boundary area (RBA). Waste containers were loaded to the south of the building. HCA and CA control boundaries defined areas for various exposure protection practices. At and beyond the CA control boundary, exposures were not allowed to exceed minimal exposure limits of 12 Derived Air Concentrations (DAC)-hr per week for air and 20 dpm/100 cm^2 of total deposition for soil.

Analysis Approach

The pre-demolition modeling results are expressed as frequencies of occurrence of peak air and soil exposures. The approach was to compute the potential exposures over the selected ten years of meteorological data. The highest total air and soil values on each boundary for each case were used to define that case's peak values. The ensemble of these peak values for the ten years of data was sorted to generate a distribution of potential peak occurrences for the air and soil concentrations at each of the control boundaries. To simplify this computation, it was assumed that the same meteorological conditions would occur during all days of the several weeks of demolition activities. The fact that the major portion of potential exposures would occur on one or two days implies that this assumption will give reasonable estimates of the magnitudes of predicted peaks. This assumption also provided upper-limit predictions such that no combination of the ambient meteorological conditions could generate higher air or soil concentrations.

The post-demolition modeling was based on the actual meteorological conditions and provided estimates of the total air and deposition exposures. The peak air and soil on the control boundaries provided post-demolition results that could be compared with the pre-demolition projections of the frequency of occurrence of potential exposures.

The pre-demolition potential frequency of occurrence of air and soil exposures for the planned 232-Z demolition and loading activities were modeled assuming that the activities would occur during June and July 2006. Concentrations were computed for the three concentric exposure boundaries, i.e., HCA, CA, and RBA. For the pre-demolition modeling, the estimated potential release rates were based on a proposed schedule of demolition activities. For post-demolition modeling, potential release rates were based on the actual demolition time table and actual weather conditions.

Emission Rates

The radiological consequences were established using the methods discussed in DOE-HDBK-3010-94 (DOE 1994). This approach was successfully used for Hanford Site's 233-S Building (AlphaTrac 2002) and is particularly appropriate for facilities, such as 232-Z, where the dose from the inhalation pathway will dominate the overall risk. The source term was quantified using a five-factor formula that includes the material-at-risk (MAR), damage ratio (DR), airborne release fraction (ARF), respirable fraction (RF), and leak path factor (LPF).

For these analyses, the MAR was defined as the inventory that was within the room or area being demolished. The inventory of the scrubber cell was surveyed and found to be about 0.349 g of plutonium. The inventory in the main process room was surveyed and found to be approximately 0.159 g of plutonium on the process room walls, fan room walls, and ceiling.

Although the floor was not being removed, the possibility that contamination fixed to the floor could be disturbed and potentially suspended needed to be considered. The inventory on the floor was estimated to be 0.47 g of plutonium. Wet sand on the floor minimized the potential for suspension. The pre-demolition analysis results were based on estimates of emissions from the building structures alone.

The post-demolition analysis, which included the potential suspension of floor contamination, confirmed the pre-analysis assumption that the floor contamination would a minor contributor to the total exposures.

For the pre-demolition analysis, a ten-hour work day (8:00 am to 8:00 pm DST) was assumed with a six-day work week. A sequence of three weeks of demolition operations was assumed, starting with the destruction and loading of the scrubber cell in the first several days, followed by destruction and loading of the process room. Post-demolition air-dispersion modeling was based on the actual schedule of demolition activities. The pre-demolition modeling assumed that all activities would be conducted during dry weather conditions. Post-demolition modeling included the effects of both dry and wet deposition.

Pre-Demolition Modeling Results

The pre-demolition modeling results for the total airborne exposure for the HCA, CA, RBA boundaries from all the building demolition and loading operations are shown on the left side of Fig. 2. For air exposures, the resulting frequency of occurrence distributions of total DAC-hours show that all occurrences of air exposures are well within the 12 DAC-hr exposure limit.

The pre-demolition total soil exposures for the HCA, CA, and RBA boundaries are shown on the left side of Fig. 3. For deposition exposures, most of the occurrences of peak soil exposures are less than the 20 dpm/100 cm^2 limit. The loading emissions from the second day of operations involved the scrubber cell load-out (also shown on Fig. 3), which is clearly the major contributor to the total deposition. The location of the peak deposition value, which occurs on the southeast corner of the CA and RBA boundaries, indicates that the potential suspension during loading of material is the limiting demolition activity. The modeled soil exposure values clearly are the limiting factor. The demolition of 232-Z proceeded with a 95% confidence level that the soil exposures would be less than the exposure limit.

Post-Demolition Modeling Results

The modeling results for actual schedule and meteorological conditions using the pre-demolition modeling assumptions provided predictions of airborne concentrations that consistent with the pre-demolition modeling (Fig. 2). The post-demolition deposition modeling (shown in Fig. 3) predicted a deposition activity of 17 dpm/100 cm^2, which is less than but close to the 20 dpm/100 cm^2. The higher-than-expected magnitude for actual conditions resulted from the operations during one day of rain conditions – a situation not considered in the pre-demolition modeling. As with the pre-demolition results, the modeled soil activity from deposition was the limiting factor.

Fig. 4 shows the modeled deposition patterns over the site with both wet and dry deposition based on the pre-demolition modeling assumptions. Because the monitoring would have easily detected such elevated levels of surface activity if they had occurred, it is obvious that these predictions were overly conservative. Fig. 4 shows two peaks in deposition on the CA boundary: one on the east from the wet deposition and one on the southeast corner from dry deposition near the loading area.

Monitoring During Demolition

During the demolition of the building, four airborne radiation monitors were deployed at the CA boundary to record the exposures in the area around the demolition activities. Surface contamination was monitored throughout the project. Personal dosimeters were used for workers conducting the demolition activities. The airborne radiation monitors provided cumulative readings of DAC-hour exposures on a half-hour basis. All readings were below the detection limit.

The surface contamination measurements also showed no detection of deposited material during direct surveys, during surveys of "cookie sheet" collectors, or after attempts to collect loosen material with sticky tape. The detection limit with the instruments used was about 5 to 10 total dpm/100 cm^2. The exception was one shallow area to which the mist water tended to drain, physically transporting some material from within the building.

The monitoring clearly showed that any exposures from the demolition activities were less than the measurement detection limits. More importantly, the limiting soil concentration levels from the pre- and post-demolition monitoring were not observed at any time or location.

Discussion

The monitored data showed that the actual concentrations were considerably lower (less than detection limits) than the modeled results, implying conservatism in the analysis. The pre-demolition modeling was purposely conservative to make sure that the protection of workers and local populations. Uncertainties in the emission rate estimation were accounted by making conservative assumptions.

Given that the peaks in surface contamination at the control boundary are the limiting factor, it is important to consider the possibility of precipitation conditions in the modeling analyses. Precipitation is an effective mechanism for re-concentrating emissions within localized downwind areas. The dominance of the loading operation in determining the limiting deposition for non-precipitation conditions has important implications in planning future demolition operations. For planning, loading locations should not be located near control boundaries. Also, multiple loading locations (such as for different portions of the structure) would be advisable.

The source terms for specific operations need to be more realistically estimated. In estimating the modeling emissions rate from loading, the use of a moisture content of 0.25% for the rubble to be loaded resulted in the estimation of a high emission rate for the loading operations, which made loading the limiting demolition activity. Field observations noted minimal dust generation during the loading cycle as the result of water content and fixative applied to the debris pile. Future models can use emission factors based on greater moisture content. Because loading was the limiting factor in the current analysis, this change is expected to significantly lower predicted deposition values.

Conclusions

- Surface activity exposures from deposited material are more limiting that air exposures.
- Wet as well as dry deposition needs to be considered.
- Estimation of the duration of demolition activities and the fraction of material disturbed is important.

- Loading materials into cans or other containers can be more limiting than demolishing the building.
- Using more realistic assumptions for estimating the potential emission rates is recommended to make the predicted exposures be more consistent with the monitoring data. Accounting for higher moisture in the rubble being loaded is an example of such an action.

References

AlphaTRAC. Demolition Scenarios and Source Terms for Atmospheric Modeling. Westminster, Colorado: AlphaTRAC, Inc.; 2003.

U.S. Department of Energy (DOE). DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, Volume 1 - Analysis of Experimental Data. Washington, D.C.: DOE-HDBK-3010-94; 1994.

U.S. Environmental Protection Agency (EPA). User's Guide for the Industrial Source Complex (ISC3) Dispersion Models. Volume I - User Instructions. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division; EPA 454/B-95-003a; 1995a.

U.S. Environmental Protection Agency (EPA). User's Guide For The Industrial Source Complex (ISC3) Dispersion Models. Volume II - Description Of Model Algorithms. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division; EPA 454/B-95-003b; 1995b.

U.S. Environmental Protection Agency (EPA). Approved Methods and Guidance for the Modeling and Assessment of Air Pollutants. Available at: http://www.epa.nsw.gov.au/air/appmethods.htm. Accessed 29 October 2006.

Fig. 1. Site Plan for 232-Z Showing 232 Structure Location, Surrounding Buildings, Control Boundaries, and Loading Area

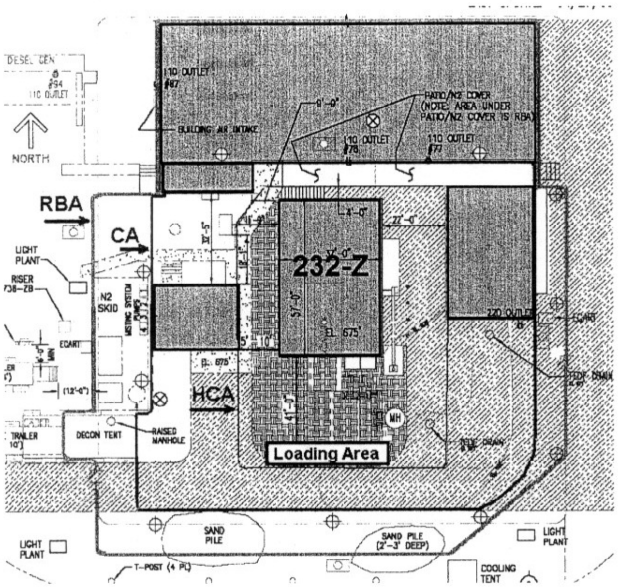

Fig. 2. Air-Exposure Modeling Results

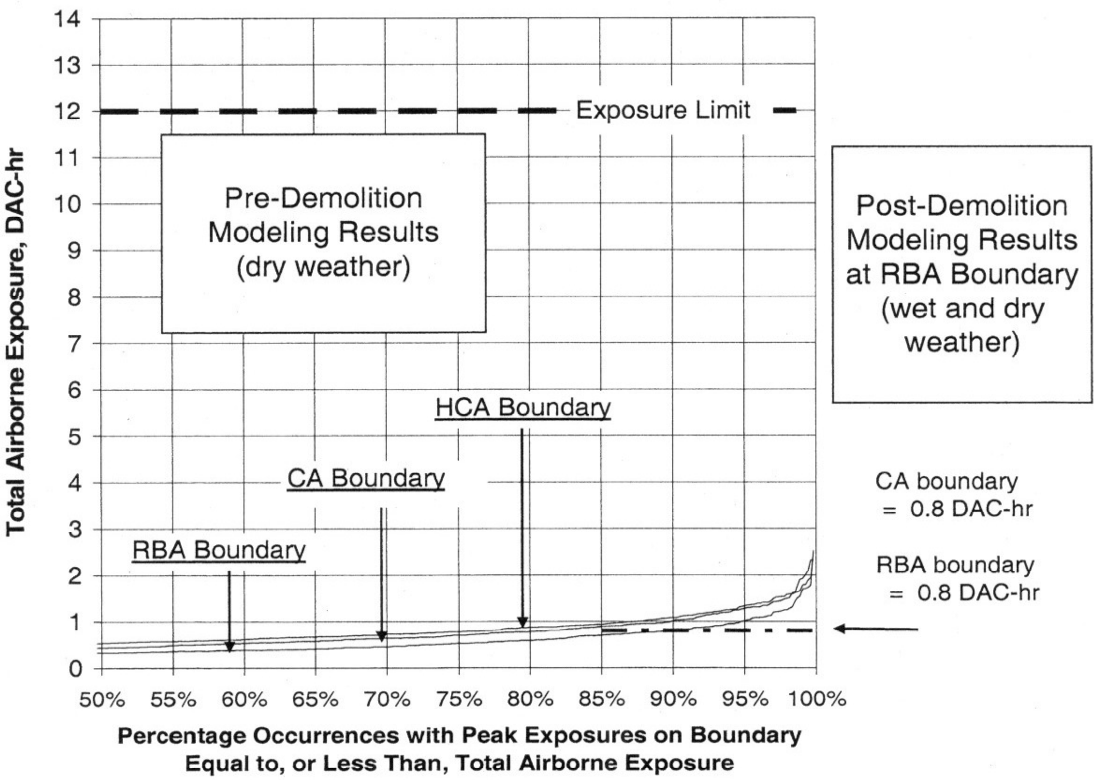

Fig. 3. Pre- and Post Deposition Exposure Modeling Results

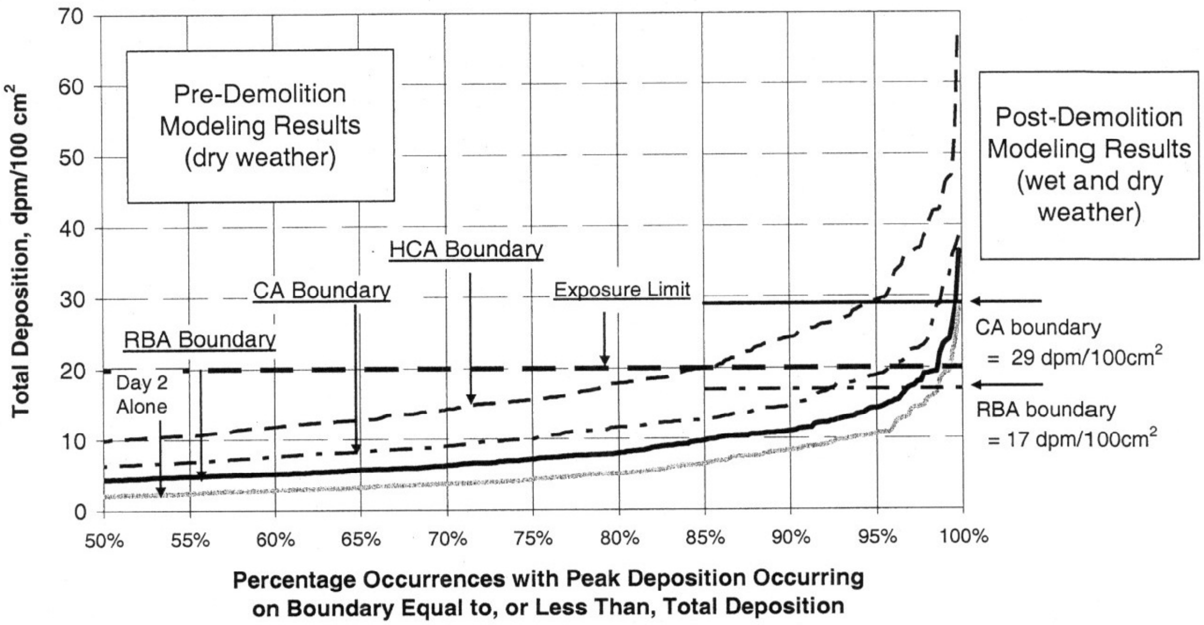

Fig. 4. Predicted Deposition Patterns Using Pre-demolition Emission-Rate Modeling Assumptions (not adjusted for higher moisture in the debris being loaded)