From:	Maloney, Moira
To:	Snyder, Amy
Subject:	[External_Sender] RE: Request
Date:	Wednesday, January 27, 2016 4:22:51 PM
Attachments:	367067.pdf

Hi Amy,

Hope that you are staying warm! Attached is our request to EPA for approval to use alternative methodology for radionuclide source term calculations for demolition activities at the WVDP. If I haven't answered your request, please don't hesitate to call me.

Thanks,

Moira

From: Snyder, Amy [mailto:Amy.Snyder@nrc.gov]
Sent: Tuesday, January 26, 2016 8:51 AM
To: Maloney, Moira
Subject: Request

HI Moira,

Working at home today- snowed in.
I think we got more snow than you this time.

Request that DOE send NRC the information (safety report/calculations) related to the alternative methodology for radionuclide source-term calculations for air emissions from demolition activities at the West Valley Demonstration Project.

If you have any questions, the quickest way to contact me is via my NRC email.

Thank you
A

Amy M. Snyder, Senior Project Manager
Materials Decommissioning Branch
Division of Decommissioning, Uranium Recovery,and Waste Programs
Office of Nuclear Material Safety and Safeguards
301 415-6822

Department of Energy
West Valley Demonstration Project
10282 Rock Springs Road
West Valley, NY 14171-9799

January 25, 2016

Mr. Oleg Povetko, PhD
United States Environmental Protection Agency, Region II
Radiation and Indoor Air Branch
290 Broadway, 28th Floor
New York, NY 10007-1866

SUBJECT: Request for Approval for Alternative Methodology for Radionuclide Source Term Calculations for Air Emissions from Demolition Activities at the West Valley Demonstration Project

Dear Mr. Povetko:

Enclosed for your review and approval is an alternative source term calculation methodology for calculating the radiological emissions from demolition activities at the West Valley Demonstration Project (WVDP). The WVDP requests that approval be granted for the alternative source term calculation methodology presented in the enclosed. The approved alternative calculations will be used in lieu of Appendix D to determine maximum abated, potential, and realistic abated (if needed) emissions for the future planned demolition activities as allowed for by 40CFR Part 61.96(b).

The WVDP believes that the proposed alternative calculation is more appropriate for the estimation of emissions of radionuclides from demolition activities, as demolition activities were not considered when the regulations were originally promulgated.

The WVDP is respectfully requesting approval of these alternative calculation methods 60 days from U.S. Environmental Protection Agency's receipt of this letter. If you have any questions regarding this request for approval, please contact Moira Maloney of my staff at (716) 942-4255.

Sincerely,

Bryan C. Bower, Director
West Valley Demonstration Project

Enclosure: Methodology for Radionuclide Source Term Calculations for Air Emissions from Demolition Activities

cc: J. J. Hoch, CHBWV, WV-4PLEX, w/enc.
J. R. Fox, CHBWV, WV-4PLEX, w/enc.
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J. D. Rendall, CHBWV, AC-EA, w/enc.
M. P. Krentz, DOE-WVDP, AC-DOE, w/enc.
M. N. Maloney, DOE-WVDP, AC-DOE, w/enc.
Paul Giardina, EPA, Region 2, w/enc.
B. M. Frank, NYSERDA, AC-NYS, w/enc.

MPK:367067 – 454.2.2

Rev 0
01/14/16

Methodology for Radionuclide Source Term Calculations for Air Emissions from Demolition Activities

Prepared by: ____________ **Date:** 01/14/16
B.C. Blunt

Reviewed by: ____________ **Date:** 01/14/16
J.R. Fox

WD:2015:0598

Table of Contents

Glossary

AED	aerodynamic equivalent diameter
ARF	airborne release fraction
CF	Control Factor
Ci	Curie
cm	centimeter
DOE	Department of Energy
DR	Damage ratio
EF	Emission factor
EPA	Environmental Protection Agency
ER	Emission Reduction
I	Inventory
Kg	kilogram
lb	pounds
LPF	Leak path factor
m	meter
m/s	meters per second
MAR	Material-at-risk
PS	Physical State
RF	Respirable fraction
ST	Source Term
UDCF	Unit dose conversion factors
WVDP	West Valley Demonstration Project
µm	Micrometer

Demolition Activities
Source Term Determination

Purpose

This calculation estimates the emissions of radionuclides from the Demolition activities. The calculation includes emissions due to physical demolition by various methods, moving debris to process piles, processing the piles and loading the rubble from the piles into sealed packages (containers).

Background

Demolition of facilities can involve several activities such as

- the demolition of the main building,
- moving debris and rubble from the demolition area to a processing area,
- sorting and processing of the debris and rubble, and
- loading the debris and rubble into containers for storage.

Each of these activities is analyzed in this document.

Methodology Description

When demolition of the main building is undertaken, the physical demolition can involve equipment such as mechanical shears, saws, hydraulic hammers, and other means that are appropriate for the type of structure. This document analyzes those physical demolition activities that might be used at the West Valley Demonstration Project (WVDP).

Once the building or portions of the building are demolished, the debris or rubble is often moved to a processing area where the debris or rubble is size reduced and sorted. Finally the sorted debris or rubble is loaded into containers that are generally sealed. Radionuclides contained in a sealed container of package are not included in the building inventory for purposes of estimating emissions.

In general, misting, watering, and fixatives are used throughout the demolition and load-out processes to minimize airborne contamination spread. Other methods that minimize emissions, and which are implemented on a case-by-case basis, are the use of windscreens or limiting demolition and load-out activities to times when the wind speed is below an acceptable limit. For example, at the Hanford Site, the air operating permit [Hanford 2013] limits soil excavation activities to times when sustainable wind speed are less than 20 mph (8.8 m/s). At the WVDP, such limitations will be specified in work documents per industry practices.

Each step in the process will be evaluated separately in the following discussions.

Demolition Methods

DOE facilities typically estimate airborne source terms using the following five-component linear equation [DOE 1994]:

$$ST = MAR \times DR \times ARF \times RF \times LPF \qquad \textit{Equation 1}$$

where: ST = Source Term	=	the total quantity of respirable material released to the atmosphere during the demolition
MAR = Material-at-risk	=	the total quantity of radionuclide - in pounds (lb.) or curies (Ci) of activity for each radionuclide - available to be acted on by a given physical stress
DR = Damage ratio	=	the fraction of the MAR actually impacted by the demolition conditions
ARF = Airborne release fraction	=	the fraction of a radioactive material suspended in air as an aerosol and thus available for transport due to a physical stress from a specific activity
RF = Respirable fraction	=	the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-μm aerodynamic equivalent diameter (AED) and less. When RF = 1, all the particulate material is included in the calculation, and not just the respirable portion.
LPF = Leak path factor	=	the fraction of the radionuclides in the aerosol transported through some confinement deposition system.

In AP-42, *Compilation of Air Pollutant Emission Factors* [EPA 1995], airborne emissions or the source term is determined with Equation 2.

$$E = A \times EF \times \left(1 - {ER}/{100}\right) \qquad \textit{Equation 2}$$

where: E = Estimated emissions	=	the total quantity of material released to the atmosphere during the demolition
A = Activity Rate	=	the total quantity of radionuclides (in grams or curies of activity for each radionuclide) available to be acted on by a given physical stress
EF = Emission factor	=	relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant, in this case radionuclide.
ER = Emission Reduction	=	the percent reduction of the pollutant due to some type of effluent control device or process.

Equation 2 is a form of Equation 1 where

E = ST

A = MAR

EF = DR x ARF x RF

(1-ER/100) = LPF

A similar comparison can be made between Equation 1 and the emissions estimation method described in Appendix D to 40 CFR Part 61 [EPA 1989b], here after called the Appendix D method. The Appendix D method can be described mathematically as Equation 3

$$E_D = I \times PS \times CF \qquad \textit{Equation 3}$$

where:	E_D = Estimated emissions	=	the total quantity of material released to the atmosphere during the demolition
	I = Inventory	=	the total quantity of radionuclides (in grams or curies of activity for each radionuclide) available to be acted on by a given physical stress.
	PS = Physical State Factor	=	relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant, in this case radionuclide.
	CF = Control Factor	=	the fraction of the radionuclides in the aerosol transported through some confinement deposition system.

Equation 3 is a form of Equation 1 where

E_D = ST

I = MAR

PS = DR x ARF x RF

CF = LPF

The Appendix D method was developed by the US Environmental Protection Agency (EPA) based on emission estimates from various processes typical of that time [EPA 1989a]. However, none of these processes involved demolition activities. The primary factor that is often missing when performing the Appendix D method is a control factor for the effluent controls used at Department of Energy (DOE) facilities. This is the case for demolition processes, i.e. there are no control methods listed in Appendix D that are used in demolition operations. In addition, the demolition techniques used can have varying degrees of impaction on the facility, resulting in varying sizes of debris and rubble and varying degrees of aerosol creation. By using the more detailed Equation 1 the estimated emissions from the various demolition techniques can be refined and described

mathematically. This calculation method is a mechanistic approach, much like AP-42, to calculation of radionuclide emissions from demolition activities.

Emission factors for several demolition techniques are derived in the following sections.

Demolition with Mechanical Shears

Shears are two-bladed cutters acting as scissors. They are generally pneumatically or hydraulically operated. Mechanical shears are often used during demolition to perform "Cut; Shear; Break; Drop" operations. The "Cut; Shear; Break; Drop" approach can generally be described as cutting or shearing, breaking and dropping the building pieces to the ground within the controlled/regulated work area (drop zone). "Drop" would generally be "to lower carefully" based on strict procedural controls and conduct of operations.

Emissions using this demolition technique are estimated using an emission factor developed for similar activities by the Pacific Northwest National Laboratory (PNNL). PNNL has been involved in estimating and verifying the emissions from demolition of several building at the Hanford site. One such demolition was the 224-U and 224-UA Buildings on the Hanford Site [Napier 2009]. PNNL used an emission factor of 5.00E-05 lb. released per lb. of material demolished or in terms of radioactive contamination the units would be Ci released per Ci processed in the demolition. This emission factor accounts for the fugitive emissions resulting from demolition using mechanical shears when water misting is used as a control mechanism. After completion of the demolition, PNNL evaluated the emission estimates for this project against ambient monitoring conducted during the demolition and found that the calculated predicted emissions were similar to that measured on the ambient systems. Of note is the fact that most measured ambient emissions were at or below detection limits during demolition. [Napier 2010]. The following discussion describes how PNNL developed each term, with the exception of the MAR, in Equation 1.

Damage Ratio (DR)

When mechanical shears are used to demolish the buildings, it is assumed that the MAR is evenly distributed over the entire contaminated area being worked on (wall segment, floor area, etc.). The DR is that portion or percentage of the contaminated area acted on by the shear force. Jaws are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. For a concrete block and reinforced concrete construction, the equipment is assumed to reduce essentially the entire portion of wall or floor being worked on to small pieces. For metal structures, including pipes and ventilation ducts, large portions of the metal remain intact and not converted to particle sizes that could be airborne easily. For this analysis, half of the surfaces are assumed to be rubblized and will remain too large to become airborne during demolition operations. Napier [Napier 2009] uses a DR of 0.5 for the demolition of the 224-U and 224-UA buildings at the Hanford site. As noted by Napier, this value is greater than that used for the Hanford Site 232-Z Building which was based on pulling down a block wall, and slightly smaller than that used for the analysis of the reinforced concrete walls of the Hanford Site 233-S Building.

Airborne Release Fraction (ARF)

For demolition of walls and floors, DOE's factors for impaction stress due to vibration shock were selected as the most representative release fractions for the crushing processes; the factor selected was 0.001 for removable contaminants [DOE 1994[1]]. EPA's [EPA 1995] compilation of airborne release fractions includes a range of uncontrolled release fractions for crushing of ores and rocks that range from 0.012 to 6 pounds per ton of ore, which relates to an ARF of 6E-06 to 3E-03 lbs. released per lb. of ores or rocks processed (in radiological terms, Ci released per Ci processed). As these ranges overlap, thus supporting the selection of the DOE values.

Respirable Fraction (RF)

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-micrometer (μm) Aerodynamic Equivalent Diameter (AED) and less. For this analysis, more than the respirable fraction is involved. Therefore, as a conservative measure, the RF is set to 1 in all cases. This practice effectively assumes all particulate mater is released with no reduction based on size.

Leak Path Factor (LPF)

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this calculation method, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition. The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The efficiency of the mist varies with each application and depends on, among other variables, mist particle size, water flow rate, and the size of potential airborne particles. OSHA [OSHA 2009] cites several case studies where misting during grinding and while using vehicle-mounted rock drilling rigs resulted in a 90% decrease in dust generation. EPA [1995[2] and 2004[3]] also lists watering as an effective dust control measure. Both references stated that up to a 90% reduction in emissions can be achieved by wetting of rubble piles.

For the purpose of this calculation, the water-mist application is assumed to reduce the quantity of airborne particulates by 90%, which results in a LPF of 0.1. The efficiency of the water-mist process must be weighed in light of the generated waste stream and the need to confine and capture runoff from the misting process. Thus, the LPF for concrete crushing is assumed to be 0.1. As noted by Napier [Napier 2009] this value is slightly lower than that used for the Hanford Site 233-S Building (0.3), based on observations of the effectiveness of the misting on that facility and during demolition of the Hanford Site 232-Z building. As previously discussed, the emissions when using this factor and the other factors discussed above for demolition with mechanical shears has been validated with ambient air sampling [Napier 2010].

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[1] Section 4.4.3.3.1
[2] Section 13.2.4
[3] Section 4.3

Emission Estimation Equation

By substituting the above factors into Equation 1 the emissions when using mechanical shears for "Cut; Shear; Break; Drop" demolition operations are found. The final equation is presented below:

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

$$ST = MAR \times 0.5 \times 0.001 \times 1 \times 0.1$$

$$ST = MAR \times 5.00\text{E-}05 \qquad \textit{Equation 4}$$

Demolition with a Hydraulic Hammer

A hydraulic hammer may be used to demolish structures constructed of non-reinforced or lightly reinforced concrete. The equipment generally consists of a hydraulically or pneumatically driven chisel or hammer.

The following discussion describes the development of each term, with the exception of the MAR, in Equation 1 for this demolition operation.

Damage Ratio (DR)

When a hydraulic hammer is used to demolish buildings, it is assumed that the MAR is evenly distributed over the entire contaminated area being worked on (wall segment, floor area, etc.). The DR is that portion or percentage of the contaminated area acted on by the hammer or chisel force. In the case of the hydraulic hammer, the momentum, resulting energy imparted on the structure, and impact and vibration forces act on the entire structure being worked. Therefore, the DR for this operation is set to 1.0.

Airborne Release Fraction (ARF)

The hydraulic hammer can be used on both vertical and horizontal surfaces. Emission factors for both operations are evaluated separately and then the most conservative factor is used. This approach allows the equipment operator the flexibility to operate as needed and still be bounded by the emissions calculations.

The DOE's factors for large falling object impact were selected for this operation on horizontal surfaces [DOE 1994[4]]. The highest measured ARF was 1E-03, while the "median" value for all experimental configurations is 4E-04. However, DOE states that the data may not be bounding and suggests as a conservative measure that a bounding value of 1E-02 be used for the ARF.

When operating on a vertical surface the emissions from this action are due to Impact Stress. DOE's factors for Impact Stress on surface contamination were selected for this operation [DOE 1994[5]]. The bounding ARF is given as 1E-03.

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[4] Section 4.4.3.3.2

[5] Section 5.1 provides a summary of ARFs

For this type of operation, the conservative approach is to use the bounding ARF for the scenario where the hydraulic hammer is acting on a horizontal surface. This ARF is 1E-02.

Respirable Fraction (RF)

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-μm Aerodynamic Equivalent Diameter (AED) and less. For this analysis, more than the respirable fraction is involved. Therefore, as a conservative measure, the RF is set to 1 in all cases. This practice effectively assumes all particulate mater is released with no reduction based on size.

Leak Path Factor (LPF)

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this calculation method, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition. The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The efficiency of the mist varies with each application and depends on, among other variables, mist particle size, water flow rate, and the size of potential airborne particles. OSHA [OSHA 2009] cites several case studies where misting during grinding and while using vehicle-mounted rock drilling rigs resulted in a 90% decrease in dust generation. EPA [1995[6] and 2004[7]] also lists watering as an effective dust control measure. Both references stated that up to a 90% reduction in emissions can be achieved by wetting of rubble piles.

For the purpose of this calculation, the water-mist application is assumed to reduce the quantity of airborne particulates by 90%. The LPF is then 0.1.

Emission Estimation Equation

By substituting the above factors into Equation 1 the emissions when using a hydraulic hammer for demolition operations are found. The final equation is presented below:

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

$$ST = MAR \times 1.0 \times 0.01 \times 1 \times 0.1$$

$$ST = MAR \times 1.0\text{E-}03 \qquad \textit{Equation 5}$$

[6] Section 13.2.4

[7] Section 4.3

Demolition with a Diamond Wire Saw

A diamond wire saw typically involves the pulling of a multi-strand wire threaded with diamonds through the material to be cut. The diamond wire is threaded through a hole drilled at the top and bottom of the structure and guided through it via a series of pulleys. The process itself eliminates vibrations, does not weaken surrounding structures, and produces very little dust or flying debris.

The following discussion describes the development of each term, with the exception of the MAR, in Equation 1 for this demolition operation.

Damage Ratio (DR)

The DR is that portion or percentage of the contaminated area acted on by the wire saw. The wire saw removes a kerf of material the length of the cut. The material removed is then found as "width of kerf" times the "length of cuts". Typically, a maximum of four cuts are required to produce a slab of material. The "length of cuts" would include all cuts needed to produce the slab. The damage ratio is then found by dividing the material removed by the area of the slab produced or

$$DR = \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab}$$

For example:
Assume the kerf is 1.0 centimeter (cm) wide and the slab produced is 91.40 cm by 91.40 cm (3 feet by 3 feet). Also assume 4 cuts are required, and all of the same length. Then the DR is

$$DR = \frac{4(91.4\ cm)(1\ cm)}{(91.4\ cm)(91.4\ cm)} = 0.044$$

Airborne Release Fraction (ARF)

The wire saw airborne release fraction results from the suspension of the contaminated material in an aqueous solution, which becomes a slurry. DOE's factors for free falling spill of slurries was selected for this operation [DOE 1994[8]]. The bounding value of the ARF is 5E-05.

Respirable Fraction (RF)

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-µm Aerodynamic Equivalent Diameter (AED) and less. For this analysis, more than the respirable fraction is involved. Therefore, as a conservative measure, the RF is set to 1 in all cases. This practice effectively assumes all particulate matter is released with no reduction based on size.

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[8] Section 3.2.3.2

Leak Path Factor (LPF)

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. There are generally no controls associated with this process. An LPF of 1.0 will be used for this calculation method.

Emission Estimation Equation

By substituting the above factors into Equation 1, and then rearranging, the emissions when using a diamond wire saw for demolition operations are found. The final equation is presented below:

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

$$ST = MAR \times \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab} \times 0.00005 \times 1 \times 1$$

$$ST = 5.0\text{E-}05 \times MAR \times \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab} \qquad \textit{Equation 6}$$

Demolition with a Wall Saw

Wall and floor saws use circular diamond or carbide blades to cut a kerf in the material being cut. The blade is rotated by air or hydraulic motors. Floor saws, also called slab saws feature a blade that is mounted on a walk-behind machine. Walls saws, also called track saws, use a blade on a track-mounted machine. The dust produced by the cutting action is controlled using a water spray.

The following discussion describes the development of each term, with the exception of the MAR, in Equation 1 for this demolition operation.

Damage Ratio (DR)

The DR is that portion or percentage of the contaminated area acted on by the wall saw. The wall saw removes a kerf of material the length of the cut. The material removed is then found as "width of kerf" times the "length of cuts". Typically, a maximum of four cuts are required to produce a slab of material. The "length of cuts" would include all cuts needed to produce the slab. The damage ratio is then found by dividing the material removed by the area of the slab produced or

$$DR = \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab}$$

For example:
Assume the kerf is 1.0 centimeter (cm) wide and the slab produced is 91.40 cm by 91.40 cm (3 feet by 3 feet). Also assume 4 cuts are required, and all of the same length. Then the DR is

$$DR = \frac{4(91.4\ cm)(1\ cm)}{(91.4\ cm)(91.4\ cm)} = 0.044$$

Airborne Release Fraction (ARF)

The wall saw airborne release fraction results from the suspension of both fixed and removable contaminate into air. DOE's factors for venting of pressurized gases over a solid were selected for this operation [DOE 1994[9]]. The bounding value of the ARF is 5E-03.

Respirable Fraction (RF)

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-μm Aerodynamic Equivalent Diameter (AED) and less. For this analysis, more than the respirable fraction is involved. Therefore, as a conservative measure, the RF is set to 1 in all cases. This practice effectively assumes all particulate matter is released with no reduction based on size.

Leak Path Factor (LPF)

Although the dust produced by the saw is controlled with a water spray, the degree of control is unknown. Therefore, as a conservative measure, the LPF will be set to 1.0 for the technique.

Emission Estimation Equation

By substituting the above factors into Equation 1, and then rearranging, the emissions when using a wall saw for demolition operations are found. The final equation is presented below:

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

$$ST = MAR \times \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab} \times 0.001 \times 1 \times 1$$

$$ST = 5.0\text{E-}03 \times MAR \times \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab}$$ *Equation 7*

[9] Section 5.3.2.3

Equipment with Internal Loose Contamination (Segmenting)

Facilities destined for demolition often contain large pieces of equipment that are too large to remove as a single item, and have loose internal contamination. This equipment is decontaminated and de-inventoried to remove the majority of the internal contamination prior to demolition, however some contamination will be very difficult to remove and will remain after the decontamination process is complete.

The following discussion describes the development of each term, with the exception of the MAR, in Equation 1 for this demolition operation.

Damage Ratio (DR)

The demolition process for this type of equipment can fall into two categories, which are discussed below. A DR of 0.10 is selected for both cases.

1. The equipment is too large to handle with another process and requires that it be broken into smaller pieces, but not completely size reduced. Assuming that the equipment is decontaminated and de-inventoried prior to beginning the demolition, the material that remains will be the most difficult to remove. It is assumed that the process of breaking the equipment into smaller pieces will impact 10% of the remaining internal contamination.

2. A mechanical shear, or similar type equipment can be used to break up the equipment. This will result in tears and holes in the piece of equipment. Assuming that the equipment is decontaminated and de-inventoried prior to beginning the demolition, the material that remains will be the most difficult to remove. It is assumed that the tears and holes will impact 10% of the remaining internal contamination.

Airborne Release Fraction (ARF)

Internal contamination released due to tears, holes or segmenting of the equipment will be released to the air and then fall to the work area. The DOE handbook [DOE 1994] discusses several sets of experimental observations directly related to airborne releases from falling powders. Based on work done by Sutter et al., the DOE handbook[10] selected a bounding ARF of 2E-03 for the spill of UO_3 and TiO_2 powders freely falling into moving air from a height of 3 meters.

Another method of estimating powder releases due to falling in moving air presented in the DOE handbook[11] is that of Ballinger, which is presented below as Equation 8:

[10] Section 3.4.3.1.2
[11] Section 4.4.3.1.3

$$ARF = 0.1064(M^{0.125})(H^{2.37})/\rho^{1.02}$$ *Equation 8*

where: M = mass spilled, kilograms (kg)
H = height of spill, meter (m)
ρ = density of material, kg/m^3

For a 1-kg release of UO3 powder, of density 7.29 g/mL (7290 kg/m3), from a height of 3 meters, the estimated ARF using Equation 8 is 1.65E-04. Similarly, for PuO2 with a density of 11.50 g/mL (11500 kg/m3) dropped from a height of 3 meters, the estimated ARF is 1.04E-04.

Once the powders fall to the ground, the ongoing demolition activities will result in rubble falling onto it. The DOE Handbook[12] indicates an ARF of about 1E-03 for suspension caused by objects falling into powder. Some data suggest that the release fractions could be as high as 1E-02, but as noted in the DOE handbook, when these ARF values are corrected for burial by fallen rubble, the ARF is bounded by 1E-03. Based on these observations, an airborne release fraction of 0.001 is selected for these demolition operations.

Respirable Fraction (RF)

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-µm Aerodynamic Equivalent Diameter (AED) and less. For this analysis, more than the respirable fraction is involved. Therefore, as a conservative measure, the RF is set to 1 in all cases. This practice effectively assumes all particulate mater is released with no reduction based on size.

Leak Path Factor (LPF)

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this calculation method, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition. The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The efficiency of the mist varies with each application and depends on, among other variables, mist particle size, water flow rate, and the size of potential airborne particles. OSHA [OSHA 2009] cites several case studies where misting during grinding and while using vehicle-mounted rock drilling rigs resulted in a 90% decrease in dust generation.

For the purpose of this calculation, the water-mist application is assumed to reduce the quantity of airborne particulates by 90% resulting in an LPF = 0.1.

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[12] Section 4.4.3.3.2

Emission Estimation Equation

By substituting the above factors into Equation 1 the emissions from demolition (segmenting) of larger equipment with internal contamination operations are found. The final equation is presented below:

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

$$ST = MAR \times 0.1 \times 0.001 \times 1 \times 0.1$$

$$ST = MAR \times 1.00\text{E-}05 \qquad \textit{Equation 9}$$

Rubble Pile Emissions

Demolition of a building or structure will result in the formation of rubble and debris piles. EPA [EPA 2004][13] recommends the use of the aggregate handling and storage pile formulas for AP-42 [EPA 1995][14] to estimate emissions from operations on open waste piles. The AP-42 formula is reproduced below as Equation 10.

$$EF = 0.0016\,k\,\frac{\left(U/_{2.2}\right)^{1.3}}{\left(M/_{2}\right)^{1.4}} \qquad \textit{Equation 10}$$

Where:
- EF = Emission factor, mCi released per Ci in the pile[15]
- k = particle size multiplier, dimensionless
- U = Mean wind speed, m/s
- M = Material moisture content, percent

The particle multiplier varies with the aerodynamic particle size range. AP-42 lists a value of 0.74 for particles < 30 µm in size. For demolition, there can be particles with the potential to become airborne that are larger than 30 µm. To account for this, a value of 1.0 will be used for k.

The piles will be wet, due to the misting, when they are produced. The piles will be maintained in a wet condition with water spray and misting. In addition, fixative may be applied to the rubble piles. A 1% increase in moisture content will assumed when fixative is applied.

Setting k = 1 in Equation 10 results in the following equation for estimating emissions from rubble piles.

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[13] Section 4.1.1

[14] Section 13.2.4

[15] The AP-42 units are kg released per Mg material processed. If the units for contaminated material is Ci/Mg, the units then become mCi released per Ci processed

$$EF = 0.0016 \frac{\left(U/_{2.2}\right)^{1.3}}{\left(M/_{2}\right)^{1.4}}$$

This emission factor can then be substituted into Equation 2 to determine the source term. Since the spraying and wetting of the pile is accounted for in the EF equation the ER term is set to 0. Keeping in mind that A = MAR and E = ST, the resulting equation is

$$E = A \times EF \times \left(1 - ER/_{100}\right)$$

$$ST = MAR \times 0.0016 \frac{\left(U/_{2.2}\right)^{1.3}}{\left(M/_{2}\right)^{1.4}} \times \left(1 - 0/_{100}\right)$$

$$ST = MAR \times 0.0016 \frac{\left(U/_{2.2}\right)^{1.3}}{\left(M/_{2}\right)^{1.4}}$$ *Equation 11*

Load Out Emissions

Load-out activities include picking up rubble with a front-end loader, a thumb and bucket on the excavator or similar equipment and dumping of rubble and larger pieces into transfer containers. The EPA [EPA 2004][16] suggests an emission factor of 0.029 kg released per Mg processed. Using a conversion factor of 1000 kg/Mg, the factor becomes 2.9E-05 Mg released per Mg processed. For radionuclide operation, the average radionuclide content of the waste material (Ci/Mg) will convert the emission factor to a Curie based factor. This mathematical operation results in an emission factor 2.9E-05 Ci released per Ci processed.

This emission factor can then be substituted into Equation 2 to determine the source term. As a conservative measure no credit is taken for emissions reduction or controls, therefore ER = 0. Keeping in mind that A = MAR and E = ST, the resulting equation presented below is

$$E = A \times EF \times \left(1 - ER/_{100}\right)$$

$$ST = MAR \times 2.9\text{E-}05 \times \left(1 - 0/_{100}\right)$$

$$ST = MAR \times 2.9\text{E-}05$$ *Equation 12*

[16] Section 4.1.4 Equation 4-4

Miscellaneous Source Emissions

During the demolition, it is possible that other processes could be used. For those processes not addressed in this calculation method emission estimates will be handled by the U.S. EPA approved method presented in 40CFR61 Appendix D [EPA 1989] or with a revision to this method, followed by EPA approval prior to using any newly proposed calculation methods. The Appendix D method has previously been presented as Equation 3, which is reproduced below.

$$E_D = I \times PS \times CF$$

where: E_D = Estimated emissions	=	the total quantity of material released to the atmosphere during the demolition
I = Inventory	=	the total quantity of radionuclides (in grams or curies of activity for each radionuclide) available to be acted on by a given physical stress.
PS = Physical State Factor	=	relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant, in this case radionuclide.
CF = Control Factor	=	the fraction of the radionuclides in the aerosol transported through some confinement deposition system.

Some cutting of metal may be required during demolition activities. At the end of chapter 12 of AP-42 [EPA 1995], EPA provides information on emissions from cutting operations. The document provided, "Emissions of Fumes, Nitrogen Oxides and Noise in Plasma Cutting of Stainless and Mild Steel", contains a table that provides emissions based on the material removed in the cut. For example, with dry cutting of a 35 mm thick steel plate, 1% of the material removed is vaporized and emitted. The remaining 99% remains on the cutting table. The PS factor for dry cutting of 35 mm thick steel plate is 0.01 for the material removed. The highest emission rate is 7% of the material removed. Therefore, as a bounding value, a PS factor of 0.07 will be used for cutting operations.

Metal fumes from welding operations are similar to cutting emissions. Chapter 12.19.2.2 of AP-42 discusses controls for welding fumes. Typical controls listed in this chapter include high efficiency filters, electrostatic precipitators, carbon filters and particulate scrubbers. Therefore, when control devices are used to capture cutting fumes, the Appendix D control factor should be applied.

Should contaminated haul roads be used for the demolition project, the methods described by EPA [1995[17] and 2004[18]] for unpaved roads will be used to estimate emissions from such uses.

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[17] Section 13.2.2
[18] Section 4.2

Example Calculation

The following example illustrates how the above methodology would be used to calculate the demolition activities. The input data are hypothetical and the results are not assumed to represent any activities currently in progress.

Based on characterization of a facility the following inventory has been established at the time that demolition will occur. Note that the inventory is presented based on the demolition means and methods that are planned for various portions of the hypothetical facility. As stated above, this is a hypothetical example and is only presented to demonstrate the use of the alternative methods presented for approval.

Table 1:Inventory or MAR[1]

Radionuclide	Mechanical Shearing Inventory (Ci)	Diamond Wire Saw Inventory (Ci)	Wall Saw Inventory (Ci)	Segmenting Large Equipment Inventory (Ci)	Hydraulic Hammer Inventory (Ci)	Facility Total Activity (Ci)
Am-241	2.35E-03	5.04E-04	1.68E-04	1.68E-04	1.68E-04	3.36E-03
Cm-243	3.13E-06	6.72E-07	2.24E-07	2.24E-07	2.24E-07	4.48E-06
Cm-244	7.89E-05	1.69E-05	5.63E-06	5.63E-06	5.63E-06	1.13E-04
Cs-137	4.20E-01	8.99E-02	3.00E-02	3.00E-02	3.00E-02	5.99E-01
Ba-137m	4.20E-01	8.99E-02	3.00E-02	3.00E-02	3.00E-02	5.99E-01
I-129	6.94E-11	1.49E-11	4.96E-12	4.96E-12	4.96E-12	9.91E-11
Np-237	2.50E-07	5.37E-08	1.79E-08	1.79E-08	1.79E-08	3.58E-07
Pu-238	6.96E-04	1.49E-04	4.97E-05	4.97E-05	4.97E-05	9.95E-04
Pu-239	3.86E-04	8.26E-05	2.75E-05	2.75E-05	2.75E-05	5.51E-04
Pu-240	2.94E-04	6.30E-05	2.10E-05	2.10E-05	2.10E-05	4.20E-04
Pu-241	6.50E-03	1.39E-03	4.65E-04	4.65E-04	4.65E-04	9.29E-03
Sr-90	5.08E-02	1.09E-02	3.63E-03	3.63E-03	3.63E-03	7.25E-02
Y-90	5.08E-02	1.09E-02	3.63E-03	3.63E-03	3.63E-03	7.25E-02
Tc-99	1.50E-05	3.21E-06	1.07E-06	1.07E-06	1.07E-06	2.14E-05
U-232	1.68E-05	3.60E-06	1.20E-06	1.20E-06	1.20E-06	2.40E-05
U-233	6.00E-06	1.29E-06	4.29E-07	4.29E-07	4.29E-07	8.57E-06
U-234	2.84E-06	6.10E-07	2.03E-07	2.03E-07	2.03E-07	4.06E-06
U-235	8.89E-07	1.91E-07	6.35E-08	6.35E-08	6.35E-08	1.27E-06
U-238	5.71E-06	1.22E-06	4.08E-07	4.08E-07	4.08E-07	8.15E-06

1) Material at Risk

In this example, most of the structure can be demolished using the mechanical shearing method, but some walls will require both types of sawing, and there is large contaminated equipment to be removed. It is also anticipated that some structures will require processing with a hydraulic hammer. The rubble produced by the demolition will be moved from the demolition area to a processing area where the rubble will be sorted. Finally, the sorted rubble will be loaded into containers, sealed and shipped to final storage. The methods described previously will be used to determine the demolition emissions.

For a mechanical shearing operation with water misting, the source term for that part of the demolition operation is found with Equation 4. The following example is presented for the Am-241 inventory given in Table 1.

$$ST_{Mech\ Shear} = MAR \times 5.00\text{E-}05$$

$$ST_{Mech\ Shear,\ \text{Am-241}} = 2.35\text{E-}03\ Ci \times 5.00\text{E-}05$$

$$ST_{Mech\ Shear,\ \text{Am-241}} = 1.18\text{E-}07\ Ci$$

When using a diamond wire saw, the source term for that part of the demolition operation is found with Equation 6. Assume the kerf is 1.0 centimeter (cm) wide and the slab produced is 91.40 cm by 91.40 cm (3 feet by 3 feet). Also assume 4 cuts are required, and all of the same length. The following example is presented for the Am-241 inventory given in Table 1.

$$ST_{Diamond\ wire} = 5.0\text{E-}05 \times MAR \times \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab}$$

$$ST_{Diamond\ wire,\ \text{Am-241}} = 5.0\text{E-}05 \times 5.04\text{E-}04 \times \frac{4(91.4\ cm)(1\ cm)}{(91.4\ cm)(91.4\ cm)}$$

$$ST_{Diamond\ wire,\ \text{Am-241}} = 1.11\text{E-}09\ Ci$$

When using a wall saw, the source term for that part of the demolition operation is found with Equation 7. Assume the kerf is 1.0 centimeter (cm) wide and the slab produced is 91.40 cm by 91.40 cm (3 feet by 3 feet). Also assume 4 cuts are required, and all of the same length. The following example is presented for the Am-241 inventory given in Table 1.

$$ST_{Wall\,saw} = 5.0\text{E-}03 \times MAR \times \frac{(Length\ of\ cuts)(width\ of\ kerf)}{Area\ of\ slab}$$

$$ST_{Wall\,saw,\ \text{Am-241}} = 5.0\text{E-}03 \times 1.68\text{E-}04 \times \frac{4(91.4\ cm)(1\ cm)}{(91.4\ cm)(91.4\ cm)}$$

$$ST_{Wall\,saw,\ \text{Am-241}} = 3.70\text{E-}08\ Ci$$

For the segmentation of large equipment operation, the source term for that part of the demolition operation is found with Equation 9. The following example is presented for the Am-241 inventory given in Table 1.

$$ST_{Segmenting} = MAR \times 1.00\text{E-}05$$

$$ST_{Segmenting,\ \text{Am-241}} = 1.68\text{E-}04\ Ci \times 1.00\text{E-}05$$

$$ST_{Segmenting,\ \text{Am-241}} = 1.68\text{E-}09\ Ci$$

When using a hydraulic hammer, the source term for that part of the demolition operation is found with Equation 5. The following example is presented for the Am-241 inventory given in Table 1.

$$ST_{Hydraulic\ hammer} = MAR \times 1.00\text{E-}03$$

$$ST_{Hydraulic\ hammer,\ \text{Am-241}} = 1.68\text{E-}04\ Ci \times 1.00\text{E-}03$$

$$ST_{Hydraulic\ hammer,\ \text{Am-241}} = 1.68\text{E-}07\ Ci$$

The results of these calculations for each radionuclide in the facility inventory and for each demolition technique are presented in Table 2.

Table 2: Demolition operations emissions

Radionuclide	Releases due to Mechanical Shearing (Ci)	Releases due to Diamond Wire Saw Operations (Ci)	Releases due to Wall Saw Operations (Ci)	Releases due to Segmenting Large Equipment (Ci)	Releases due to Hydraulic Hammer Operations (Ci)	Demolition Total Release (Ci)
Am-241	1.18E-07	1.11E-09	3.70E-08	1.68E-09	1.68E-07	3.26E-07
Cm-243	1.57E-10	1.48E-12	4.93E-11	2.24E-12	2.24E-10	4.34E-10
Cm-244	3.94E-09	3.72E-11	1.24E-09	5.63E-11	5.63E-09	1.09E-08
Cs-137	2.10E-05	1.98E-07	6.59E-06	3.00E-07	3.00E-05	5.80E-05
Ba-137m	2.10E-05	1.98E-07	6.59E-06	3.00E-07	3.00E-05	5.80E-05
I-129	3.47E-15	3.27E-17	1.09E-15	4.96E-17	4.96E-15	9.60E-15
Np-237	1.25E-11	1.18E-13	3.94E-12	1.79E-13	1.79E-11	3.46E-11
Pu-238	3.48E-08	3.28E-10	1.09E-08	4.97E-10	4.97E-08	9.63E-08
Pu-239	1.93E-08	1.82E-10	6.06E-09	2.75E-10	2.75E-08	5.33E-08
Pu-240	1.47E-08	1.39E-10	4.62E-09	2.10E-10	2.10E-08	4.07E-08
Pu-241	3.25E-07	3.07E-09	1.02E-07	4.65E-09	4.65E-07	9.00E-07
Sr-90	2.54E-06	2.39E-08	7.98E-07	3.63E-08	3.63E-06	7.02E-06
Y-90	2.54E-06	2.39E-08	7.98E-07	3.63E-08	3.63E-06	7.02E-06
Tc-99	7.48E-10	7.05E-12	2.35E-10	1.07E-11	1.07E-09	2.07E-09
U-232	8.39E-10	7.91E-12	2.64E-10	1.20E-11	1.20E-09	2.32E-09
U-233	3.00E-10	2.83E-12	9.43E-11	4.29E-12	4.29E-10	8.30E-10
U-234	1.42E-10	1.34E-12	4.47E-11	2.03E-12	2.03E-10	3.93E-10
U-235	4.45E-11	4.19E-13	1.40E-11	6.35E-13	6.35E-11	1.23E-10
U-238	2.85E-10	2.69E-12	8.97E-11	4.08E-12	4.08E-10	7.89E-10

The next step in the process is to move the rubble pile to a sorting area. This process is considered rubble handling. Emissions from rubble handling are determined with Equation 11. The following example is presented for the total Am-241 inventory given in Table 1.

Typically, rubble piles will be processed when the wind are low, however as a bounding condition for this example assume a wind speed of 20 miles per hour (8.8 m/s). Also assume that the rubble piles are maintained wet at about 2% moisture and that fixative is applied. Therefore, the moisture factor is set to 3%.

$$ST = MAR \times 0.0016 \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}}$$

$$ST_{Am\text{-}241} = 3.36\text{E-}03\ Ci \times \left(0.0016 \frac{(8.8/_{2.2})^{1.3}}{(3/_{2})^{1.4}} mCi/_{Ci} \right)$$

$$ST_{Am\text{-}241} = 3.36\text{E-}03\ Ci \times \left(5.50\text{E-}03\ mCi/_{Ci} \right)$$

$$ST_{Am\text{-}241} = (1.85\text{E-}05\ mCi)\left(1\text{E-}03\ Ci/_{mCi}\right) = 1.85\text{E-}08\ Ci$$

The results of this calculation for each radionuclide in the facility inventory are presented in Table 3.

Table 3: Rubble handling and sorting emissions

Radionuclide	Rubble Handling Emissions (Ci)
Am-241	1.85E-08
Cm-243	2.46E-11
Cm-244	6.20E-10
Cs-137	3.30E-06
Ba-137m	3.30E-06
I-129	5.45E-16
Np-237	1.97E-12
Pu-238	5.47E-09
Pu-239	3.03E-09
Pu-240	2.31E-09
Pu-241	5.11E-08
Sr-90	3.99E-07
Y-90	3.99E-07
Tc-99	1.18E-10
U-232	1.32E-10
U-233	4.71E-11
U-234	2.23E-11
U-235	6.99E-12
U-238	4.48E-11

The next step is to process the rubble by sorting into piles of similar waste category. Again this process is a rubble handling operation. The emission would be calculated with Equation 11, as described above for moving the pile. Emissions resulting from this process would be the same as that presented in Table 3.

The final step is load the rubble in containers for shipment. Emissions from load out are determined with Equation 12. The following example is presented with the Am-241 inventory given in Table 1.

$$ST = MAR \times 2.9\text{E-}05$$

$$ST_{Am\text{-}241} = 3.36\text{E-}03\ Ci \times 2.9\text{E-}05$$

$$ST_{Am\text{-}241} = 9.75\text{E-}08\ Ci$$

The results of this calculation for each radionuclide in the facility inventory are presented in Table 4

Table 4: Load out emissions

Radionuclide	Load Out Emissions (Ci)
Am-241	9.75E-08
Cm-243	1.30E-10
Cm-244	3.27E-09
Cs-137	1.74E-05
Ba-137m	1.74E-05
I-129	2.87E-15
Np-237	1.04E-11
Pu-238	2.89E-08
Pu-239	1.60E-08
Pu-240	1.22E-08
Pu-241	2.69E-07
Sr-90	2.10E-06
Y-90	2.10E-06
Tc-99	6.20E-10
U-232	6.95E-10
U-233	2.49E-10
U-234	1.18E-10
U-235	3.68E-11
U-238	2.36E-10

The total emissions from this demolition project are found as the sum of each process and are presented in Table 5.

Table 5: Emissions by process and as a total for the demolition project

Radionuclide	Demolition Emissions (Ci) [See Table 2]	Moving Debris Emissions (Ci) [See Table 3]	Rubble Sorting Emissions (Ci) [See Table 3]	Load Out Emissions (Ci) [See Table 4]	Total Demolition Project Emissions (Ci)
Am-241	3.26E-07	1.85E-08	1.85E-08	9.75E-08	4.60E-07
Cm-243	4.34E-10	2.46E-11	2.46E-11	1.30E-10	6.13E-10
Cm-244	1.09E-08	6.20E-10	6.20E-10	3.27E-09	1.54E-08
Cs-137	5.80E-05	3.30E-06	3.30E-06	1.74E-05	8.20E-05
Ba-137m	5.80E-05	3.30E-06	3.30E-06	1.74E-05	8.20E-05
I-129	9.60E-15	5.45E-16	5.45E-16	2.87E-15	1.36E-14
Np-237	3.46E-11	1.97E-12	1.97E-12	1.04E-11	4.90E-11
Pu-238	9.63E-08	5.47E-09	5.47E-09	2.89E-08	1.36E-07
Pu-239	5.33E-08	3.03E-09	3.03E-09	1.60E-08	7.54E-08
Pu-240	4.07E-08	2.31E-09	2.31E-09	1.22E-08	5.75E-08
Pu-241	9.00E-07	5.11E-08	5.11E-08	2.69E-07	1.27E-06
Sr-90	7.02E-06	3.99E-07	3.99E-07	2.10E-06	9.92E-06
Y-90	7.02E-06	3.99E-07	3.99E-07	2.10E-06	9.92E-06
Tc-99	2.07E-09	1.18E-10	1.18E-10	6.20E-10	2.92E-09
U-232	2.32E-09	1.32E-10	1.32E-10	6.95E-10	3.28E-09
U-233	8.30E-10	4.71E-11	4.71E-11	2.49E-10	1.17E-09
U-234	3.93E-10	2.23E-11	2.23E-11	1.18E-10	5.56E-10
U-235	1.23E-10	6.99E-12	6.99E-12	3.68E-11	1.74E-10
U-238	7.89E-10	4.48E-11	4.48E-11	2.36E-10	1.12E-09

The emissions determined by this method can now be modeled with CAP-88, or other approved dose calculation method, to determine the dose to the public or worker. Although not part of this method, this step is performed below using unit dose conversion factors (UDCF). UDCFs are determined by modeling 1 curie of a radionuclide with a dose model. The resulting dose is of the form mrem/Ci and can be used in calculation of doses in spreadsheets. Table 6 presents the results of applying UDCF values to the total emissions from Table 5.

Table 6: Dose estimation for demolition project

Radionuclide	Total Demolition Project Emissions (Ci)	UDCF (mrem/Ci)	Total Demolition Project Dose (mrem)
Am-241	4.60E-07	1.96E+02	9.02E-05
Cm-243	6.13E-10	1.48E+02	9.07E-08
Cm-244	1.54E-08	1.25E+02	1.93E-06
Cs-137	8.20E-05	6.26E+00	5.13E-04
Ba-137m	8.20E-05	1.44E-01	1.18E-05
I-129	1.36E-14	1.31E+01	1.78E-13
Np-237	4.90E-11	1.09E+02	5.34E-09
Pu-238	1.36E-07	2.17E+02	2.95E-05
Pu-239	7.54E-08	2.36E+02	1.78E-05
Pu-240	5.75E-08	2.36E+02	1.36E-05
Pu-241	1.27E-06	4.25E+00	5.40E-06
Sr-90	9.92E-06	1.06E+01	1.05E-04
Y-90	9.92E-06	3.57E-02	3.54E-07
Tc-99	2.92E-09	3.81E+00	1.11E-08
U-232	3.28E-09	4.73E+01	1.55E-07
U-233	1.17E-09	1.80E+01	2.11E-08
U-234	5.56E-10	1.76E+01	9.79E-09
U-235	1.74E-10	1.58E+01	2.75E-09
U-238	1.12E-09	1.46E+01	1.63E-08
		Total	7.89E-04

Summary

Since demolition activities were not considered when 40 CFR 61, Appendix D was promulgated, the use of the alternative calculation method described above is preferred, as it more accurately estimates emissions from demolition activities.

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