Office of Environment, Health, Safety and Security
Operating Experience Level 3

OE-3: 2019-03 **July 2019**

Pressurized Spray Leak Technical Report

PURPOSE

The purpose of this Operating Experience Level 3 document is to inform the complex of the issuance of AU-30-RPT-02, *U.S. Department of Energy (DOE) Pressurized Spray Release Technical Report,* and the information therein that addresses data from DOE-Handbook-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*.

BACKGROUND

DOE-Handbook (HDBK)-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, was originally issued in December 1994 and reaffirmed most recently in 2013. It provides acceptable methodologies for various postulated events, and bounding values of airborne release fraction (ARF) and respirable fraction (RF) to be used to determine the source term (i.e. amount of radioactive material driven airborne at the accident source that is effectively inhalable) from various accident stresses. Such values are used to estimate the potential accident consequences from a given facility or activity.

DOE-HDBK-3010-94's ARFxRF analytical approach for pressurized spray releases was established more than two decades ago, based on limited data from commercial hollow cone spray nozzles with three different orifice diameters at three different upstream pressures. DOE-HDBK-3010-94 (hereafter referred to as "the Handbook") recommends a bounding ARFxRF value of 1E-4 for respirable droplets.

In 2009, concerns were identified regarding the validity of the Handbook's approach for all spray scenarios. To address these concerns, Pacific Northwest National Laboratory (PNNL) conducted testing to provide additional information in areas of uncertainty.

The Office of Nuclear Safety (AU-30) within the Office of Environment, Health, Safety and Security, compiled the *U.S. Department of Energy Pressurized Spray Release Technical Report* (hereafter referred to as "the technical report"), to document the Department's work on this topic and provide future recommendations for the Department, including a proposal to revise the Handbook. AU-30 has committed to revising the Handbook in a Project Justification Statement issued December 2017.

DISCUSSION

The technical report documents DOE's analytical and experimental work on spray leak phenomena from 2009 to the present, and provides technical findings and recommendations based on that work. The report evaluates DOE's technical basis for the Handbook Section 3.2.2.3.1, "Venting Below the Liquid Level," and provides both a clarification on the application of the bounding 1E-4 ARFxRF and a new analytical method for evaluating pressurized spray leak phenomena based on testing conducted by PNNL.

Section 3.2.2.3.1 in the Handbook recommends a bounding ARF value of 1E-4 with a RF of 1.0. The bounding value from the Handbook was originally selected because the larger orifice (0.128") produced the coarsest spray, and it was "not anticipated that drops formed from breaches, cracks, and leaks would generate finer drop size distributions than equipment specifically designed for that purpose." The bounding ARFxRF value of 1E-4 is associated with pressures of 100-200 pounds per square inch gauge, which are relatively low compared to what is used in the DOE complex.

The experimental testing at PNNL culminated in the development of a conservative correlation for aerosol generation rate.

The technical report recommends revising the Handbook to incorporate the PNNL correlation. Using the PNNL correlation, the mass fraction (and thus the ARFxRF value) increases with increasing pressure and decreasing orifice size (for the same pressure). In general, the PNNL correlation and the associated ARFxRF is more strongly tied to pressure than the data set originally presented in the Handbook, which was collected over a narrower pressure range.

The technical report concludes that the ARFxRF value of 1E-4 provided in the Handbook is not sufficiently conservative for all potential spray leak phenomenology. The PNNL correlation calculates an aerosol generation rate, which when converted to an ARFxRF, may not be bounded by the 1E-4 value. Given the strong correlation to pressure, accident scenarios under high pressures are most likely to calculate higher source terms compared to those calculated using an ARFxRF of 1E-4. The conservative correlation developed by PNNL is believed to provide a reasonable bounding estimation of ARFxRF, consistent with the approach to providing values in the Handbook. Use of conservative values is also consistent with the methodology described in DOE-Standard (STD)-3009-2014[1], *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, which requires bounding estimates of ARF x RF be used "unless a different value is provided in an applicable standard or is otherwise technically justified."

The PNNL correlation was originally developed for the Waste Treatment Plant project at Hanford but has since been evaluated and used at other facilities at Hanford and Oak Ridge.

RECOMMENDATIONS

DOE nuclear facility technical and safety analysts that currently use the ARFxRF value provided in the Handbook Section 3.2.2.3.1, should review the information contained within the *U.S. Department of Energy Pressurized Spray Release Technical Report*, and where applicable, use the information to:

1) Understand the limitations of the bounding 1E-4 ARFxRF currently in the Handbook.
2) Understand the most recent testing conducted in the area of spray releases and aerosol generation that provides the technical basis for the new analytical model developed by PNNL.
3) Assess the methodology developed by PNNL for use at other DOE facilities. The PNNL methodology as presented in Appendix E of the technical report may assist analysts in evaluating whether the Handbook's ARF x RF value, 1E-4, is appropriate for analyzing spray scenarios at their facility, or whether the PNNL correlation is more applicable for analyzing facility conditions.

REFERENCES

AU-30-RPT-02, U.S. *Department of Energy Pressurized Spray Release Technical Report,* U.S. Department of Energy, Washington, D.C. April 2019: https://www.standards.doe.gov/related-items/u-s-department-of-energy-pressurized-spray-release-technical-report

DOE-Handbook (HDBK)-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities.*

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This OE-3 document requires no follow-up report or written response.

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[1] It is also required by Appendix A of DOE-STD-3009-94, Change Notice 3.