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Application of the Licensing Modernization Project Approach to the Authorization of the Versatile Test Reactor

prepared by

David Grabaskas[1], Jason Andrus[2], Dennis Henneke[3], Matthew Bucknor[1], Jonathan Li[3], Doug Gerstner[2], Matthew Warner[3], Thomas Fanning[1]

[1]**Nuclear Science and Engineering Division**
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 208
Argonne, IL 60439-4854

[2]**Idaho National Laboratory**
2525 Fremont Ave
Idaho Falls, ID 83402

[3]**GE-Hitachi Nuclear Energy**
3901 Castle Hayne Rd
Wilmington, NC 28401

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*Argonne National Laboratory, 9700 S. Cass Avenue, Lemont, IL, 60439, dgrabaskas@anl.gov, mbucknor@anl.gov, fanning@anl.gov
**Idaho National Laboratory, 2525 Fremont Ave, Idaho Falls, ID, 83402, jason.andrus@inl.gov, doug.gerstner@inl.gov
***GE-Hitachi Nuclear Energy, 3901 Castle Hayne Rd., Wilmington, NC, 28401, dennis.henneke@ge.com, yunlong.li@ge.com, matthew.warner@ge.com

INTRODUCTION

The Licensing Modernization Project (LMP) has created a risk-informed, performance-based process for non-light water reactor licensing under the U.S. Nuclear Regulatory Commission (NRC). Adoption of the LMP process has been recommended by the Advisory Committee on Reactor Safeguards (ACRS) [2] and the NRC has issued a draft regulatory guide [3]. The LMP process utilizes risk information to justify the regulatory treatment of event sequences, the classification of structures, systems, and components (SSCs), and to assist with the evaluation of defense-in-depth (DID).

The Versatile Test Reactor (VTR) seeks to leverage the efforts of the LMP to develop a risk-informed, performance-based approach for reactor authorization under the U.S. Department of Energy (DOE). Due to differing rules and regulations between the NRC and DOE, modifications to the LMP process are necessary for the VTR authorization approach. However, the goals regarding risk-informed event categorization, SSC classification, and DID evaluation, remain the same.

MODIFICATIONS FOR DOE AUTHORIZATION

Utilization of the LMP process for reactor authorization under the auspices of the DOE requires several key modifications. The following subsections compare and contrast the LMP process and the approach developed for the authorization of VTR. Additional detail on the VTR authorization approach and safety design strategy can be found in ref [4], with a description of the approach to the development of the VTR probabilistic risk assessment (PRA) in ref [5].

Nomenclature

The VTR authorization approach utilizes the nomenclature currently used by the DOE for the oversight of nuclear facilities. A comparison between the VTR approach terminology and comparable terms from the LMP process is provided in Table I. It is important to note that although many of the terms are similar, the definitions may not necessarily be identical. For example, safety significant (SS) SSCs under the DOE may not have the same requirements as non-safety related with special treatment (NSRST) under the NRC.

TABLE I. Terminology Comparison

VTR Term	Comparable LMP Term
Safety Basis Event (SBE) Categories: • Anticipated • Unlikely • Extreme Unlikely	Licensing Basis Event (LBE) Categories: • Anticipated Operational Occurrence (AOO) • Design Basis Event (DBE) • Beyond Design Basis Event (BDBE)
SSC Classes: • Safety Class (SC) • Safety Significant (SS) • Non-Safety (NS)	SSC Classes: • Safety Related (SR) • Non-Safety Related with Special Treatment (NSRST) • Non-Safety Related with No Special Treatment (NST)

Frequency-Consequence Curve

Both the LMP process and the VTR approach utilize a frequency-consequence (F-C) curve, which links event sequence frequency with potential consequence, for decision-making. Satisfying the F-C curve does not necessarily imply satisfaction of regulatory criteria for reactor authorization or licensing but the curve provides guidance for the determination of event sequence categorization, SSC classification, and DID evaluation.

The LMP F-C curve, shown in Fig 1, couples event sequence frequency and offsite consequence (30-day total effective dose equivalent – TEDE – at the exclusion area boundary). The limits of the LMP F-C curve are based on CFR, EPA, and NRC regulatory guidelines. For VTR, the DOE has a different set of regulatory guidelines, provided in Table II, with separate consequence limits for offsite individuals, collocated workers, and facility workers. The DOE F-C curve limits are not linear in log-space, as in LMP, but are constant for each category of SBEs. In general, this results in more conservative offsite consequence limits at low frequencies of the SBE categories for the VTR approach.

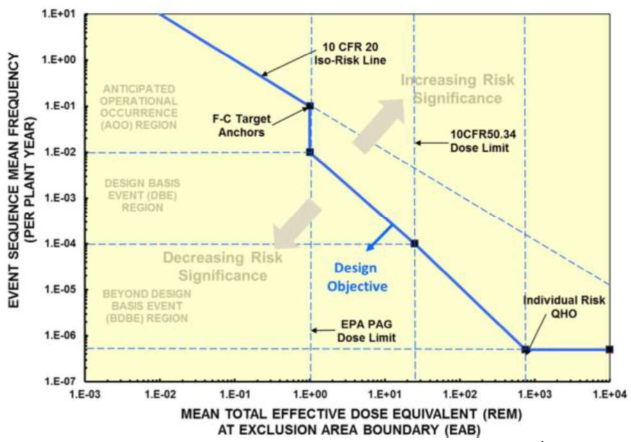

Fig. 1. LMP Frequency-Consequence Curve[1] [1]

TABLE II. VTR Radiological Consequence Guidelines

SBE Category	Frequency Range (/yr)	Radiological Consequence Guideline (TED - rem)		
		Offsite	Onsite	Worker
Anticipated	$F \geq 10^{-2}$	<5	<5	N/A
Unlikely	$10^{-2} > F \geq 10^{-4}$	<5	<25	<25
Extremely Unlikely	$10^{-4} > F \geq 10^{-6}$	<25	<100	<100
Beyond Extremely Unlikely	$F < 10^{-6}$	No Criteria	No Criteria	No Criteria

SSC Classification

The criteria for the classification of SSCs varies slightly between the LMP and VTR approaches, primarily as a result of the use of multiple F-C guidance curves for VTR. In the LMP process, Non-SR SSCs may be classified as NSRST if they perform risk significant functions in terms of offsite consequence or are considered necessary to achieve DID adequacy (see Section 4.1 of ref [1] for complete details on LMP SSC classification). The VTR approach contains similar criteria for the SS classification but with an additional consideration of the worker protection F-C curves, as an SSC necessary to mitigate worker consequences to within the assigned worker limits would be considered SS rather than SC. The inclusion of the worker dose requirements in the VTR approach then results in a potential additional pathway for SSCs to be classified as SS. Although, in practice, there is likely to be substantial overlap between risk significant SSCs and those necessary for the satisfaction of worker dose limits.

CURRENT LESSONS LEARNED

Although the VTR project is still early in the authorization process, several key insights have already been identified regarding the application of the LMP approach. First, since LMP was created to be applicable throughout the design life-cycle of a reactor, it is important that the risk information (*i.e.*, the PRA) is at a level of detail commensurate with the reactor design phase and desired use. For example, early in the design phase, there may be a focus on functionality and system-level reliability design goals, as system designs are in flux and detailed component information is likely unavailable. This analysis must also be at a level consistent with the desired SSC classification. For example, although the PRA may be simplified during the conceptual design phase, systems that may warrant different SSC classifications must be separated and not grouped within the analyses (as is sometimes done in functional event trees).

Regarding DID, development of clear, objectionable criteria is important for the consistent evaluation of DID across diverse system types and functions. For the VTR approach, this involves utilizing LMP DID guidance in conjunction with DOE DID statements in an attempt to develop measures for each of the five layers of DID (see ref [3] for additional information on layers of DID).

An additional difficulty associated with the utilization of a risk-informed approach is the communication of risk information to parties who may not have extensive background in PRA. This is particularly challenging for the LMP approach, as many of the decisions regarding SSC classification and DID evaluation are informed by complex PRA sensitivity analyses and uncertainty assessments, which then must be reviewed by experts from other reactor development domains (system design, operations, maintenance, etc.). The criteria for decision-making must be clearly stated, with a consensus understanding by project participants, to prevent multiple interpretations by experts of differing technical background.

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