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Advanced Reactor Stakeholder Public Meeting

October 1, 2020

Microsoft Teams Meeting
Bridgeline: 301-576-2978
Conference ID: 894 701 300#

Advanced Reactor Program

Time	Agenda	Speaker
10:00 - 10:20 am	Opening Remarks	NRC
10:20 - 11:30 am	Update on Regulatory Analysis Review of Applicable Regulations for Non-Light-Water Reactors	B. Travis, NRC
11:30 am - 12:00 pm	Status Update on the Advanced Reactor Generic Environmental Impact Statement (GEIS)	M. Sutton and J. Cushing, NRC
12:00 – 1:00 pm	BREAK	All
1:00 - 2:00 pm	Discussion of Advanced Reactor Fuel Qualification White Paper	T. Drzewiecki, NRC
2:00 - 2:30 pm	Assessment of the MACCS Code Applicability for Nearfield Consequence Analysis	D. Clayton, SNL
2:30 - 2:45 pm	Update on NRC Endorsement of ORNL Report on Preparing and Reviewing a Molten Salt Non-Power Reactor Application	W. Kennedy, NRC
2:45 – 3:00 pm	Concluding Remarks and Future Meeting Planning	NRC/All

Advanced Reactor Integrated Schedule of Activities

Advanced Reactor - Summary of Integrated Schedule and Regulatory Activities

Summary of Integrated Schedule and Regulatory Activities (updated 08/18/2020)

Advanced Reactor Program - Summary of Integrated Schedule and Regulatory Activities*

Strategy 1	Knowledge, Skills, and Capability
Strategy 2	Computer Codes and Review Tools
Strategy 3	Flexible Review Processes
Strategy 4	Consensus Codes and Standards
Strategy 5	Policy and Key Technical Issues
Strategy 6	Communication

Legend

- Concurrence (Division/Interoffice)
- Federal Register Publication
- Public Comment Period
- Draft Issuance of Deliverable
- Final Issuance of Deliverable
- ● EDO Concurrence Period
- Commission Review Period**
- ▼ ACRS SC/FC (Scheduled or Planned)
- External Stakeholder Interactions
- ↓ Public Meeting (Scheduled or Planned)

Version 8/18/20

Present Day

Strategy	Regulatory Activity	Commission Papers	Guidance	Rulemaking	NEIMA	Complete	2020												2021											
							Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Development of non-Light Water Reactor (LWR) Training for Advanced Reactors (Adv. Rxs) (NEIMA Section 103(a)(5))																													
	FAST Reactor Technology				x	x																								
	High Temperature Gas-cooled Reactor (HTGR) Technology				x	x																								
	Molten Salt Reactor (MSR) Technology				x	x																								
	Competency Modeling to ensure adequate workforce skillset					x																								
	Identification and Assessment of Available Codes					x																								
	Development of Non-LWR Computer Models and Analytical Tools																													
	Code Assessment Reports Volumes 1 (Systems Analysis)					x																								
	Reference plant model for Heat Pipe-Cooled Micro Reactor					x																								
	Reference plant model for Sodium-Cooled Fast Reactor					x																								
	Reference plant model for Fluoride-Salt-Cooled High-Temperature Reactor																													
	Reference plant model for Gas-Cooled Pebble Bed Reactor																													
	Reference plant model for Molten Salt Fueled Reactor																													
	Code Assessment Reports Volumes 2 (Fuel Perf. Anaylsis)					x																								
	FAST code assessment for metallic fuel																													
	FAST code assessment for TRISO fuel																													

https://www.nrc.gov/reactors/new-reactors/advanced.html

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NRC Staff Draft White Paper Analysis of Applicability of NRC Regulations for Non-Light Water Reactors

October 2020

Advanced Reactor Program

Purpose

- Discuss "NRC Staff Draft White Paper - Analysis of Applicability of NRC Regulations for Non-Light Water Reactors"
- Provide staff position on the presumed applicability of various regulations to non-LWR applicants under either Part 50 or Part 52
- Discuss expected exemptions from regulations identified by NRC staff in specific areas applicable to non-LWRs

Background

- NRC published “Draft Non-Light Water Review Strategy Staff White Paper” in September 2019
- Intended to facilitate discussion on possible approaches for NRC staff review of the licensing basis information of non-LWR applications independent of the specific design or methodology; no plans to finalize.
- Attachment 1 of that review strategy provided preliminary NRC position on regulatory applicability for discussion

Analysis

- Providing an expanded standalone version of regulatory applicability was perceived as a priority, so NRC staff reviewed existing regulations with an eye towards non-LWR reactors

- White paper presents the NRC staff's generic analysis of regulations; does not constitute a new interpretation.

- Regulations were evaluated generically. If it was not possible to preclude all non-LWR designs from the regulation, it was denoted as applicable.

- In a few cases, the NRC conclusion regarding applicability differs from the Appendix of the draft review strategy as a result of a more rigorous review

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Analysis

- As part of any future application review, NRC staff will continue to evaluate current NRC regulations that do not apply to non-LWR designs to ensure that any particular non-LWR design satisfactorily meets adequate protection of public health and safety or common defense and security

- NRC staff acknowledges that some of the regulations identified as applicable in the tables may not be required to meet the underlying purpose of the rule when applied for certain non-LWR designs.

Exemptions

- Applicants may request exemptions from the NRC's regulations on a case-by-case basis
- In reviewing an exemption request, the NRC must determine that the proposed exemption
  - is authorized by law,
  - will not present an undue risk to the public health and safety,
  - is consistent with the common defense and security.
  - meets at least one special circumstance identified in 10 CFR 50.12(a)(2).
- The NRC staff anticipates that non-LWRs applicants will request exemptions from some of the NRC's regulations. This should not be perceived as a negative.

Exemptions

- An exemption request may not always be required – in many cases, NRC staff expects that non-LWR designs may meet a rule through design- and application-specific implementations.
- In other cases, such as in applying definitions or listing codes and standards, the regulations may be applicable but not impose a requirement.
- For straightforward exemptions, NRC staff believes it is possible to simplify the applicant's exemption process (example preceding Table 2 in the white paper)
  - Involves NRC staff applying 50.12 or 52.7, as appropriate

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Tables

Table	Title	Purpose – Intended Use
1	**Areas with anticipated exemptions**	For all non-LWR applicants; Provides additional context regarding probable exemption areas
2	**Part 52 Regulations Referencing Part 50 Regulations Limited to LWRs**	For Part 52 applicants - application of Part 52 requirement differs from Part 50 for non-LWRs
3	**10 CFR Part 50 Requirements, as applicable to applications under Part 50 for non-LWRs**	For Part 50 non-LWR applicants
4	**Applicability of 10 CFR 50.34(f) "TMI Requirements" to non-LWRs under Part 52**	Provides a list of TMI-items including "entry conditions" for technical relevancy listed for some items
5	**Selected 10 CFR Part 52 Requirements, as applicable to non-LWR DCs, COLs, and SDAs**	For Part 52 non-LWR applicants
6	**Other regulations (excluding 10 CFR Parts 50 and 52) that may apply to non-LWRs at some stage in licensing**	For all non-LWR applicants

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Table 1: Fission Product Release

- 10 CFR 50.34(a)(1)(ii)(D), 10 CFR 52.47(a)(2)(iv), 10 CFR 52.79(a)(1)(vi) require an applicant assume a fission product release from the core into the containment and that the applicant perform an evaluation of the release

- This language is LWR-centric and the prescriptive nature of the implementation of the regulation is not consistent with Commission policy regarding non-LWRs; underlying purpose of the rule remains applicable

- One focus of the regulation is on demonstrating mitigation of consequences of a radiological release (vs. prevention); Not intended to be a non-representative fission product release derived from LWR operation, however

- Possible approaches could include:
  - Using LMP and the associated comprehensive evaluation of potential events to select sequences for consequence evaluation
  - Demonstrably limiting event sequence(s) (not limited to design basis) with corresponding mechanistic evaluation of consequences

Table 1: Criticality Requirements

- 10 CFR 50.68 provides two options for monitoring to detect criticality for stored nuclear material.
  - 10 CFR 70.24
  - 10 CFR 50.68(b), which contains LWR-specific considerations for fuel storage

- Non-LWR fuel differs significantly in form from traditional fuel types used in LWRs and in many cases have higher enrichment.

- Staff expects that applicants may elect to provide an alternative to 10 CFR 70.24 similar to 50.68(b) for their specific fuel type.

Table 1: Reactor Coolant Pressure Boundary

- The reactor coolant pressure boundary for an LWR provides a fission product retention barrier for the release of radionuclides.
- However, in some non-LWRs, the reactor coolant boundary may not serve this function – may instead use a functional containment.
- For these designs, references to "the integrity of the reactor coolant pressure boundary" may not be applicable and an exemption is anticipated.
- How these exemptions are addressed will depend on the importance of a coolant boundary to demonstrating the specific reactor's safety.

Table 2 – Part 52 References to Part 50

- Table 2 provides a list of the regulations in 10 CFR Part 52 that apply to all power reactors, but reference a 10 CFR Part 50 regulation that refers specifically to LWRs.
- To address the regulations as written, an exemption would be required.
- Justification for these exemptions should be straightforward as the referenced 10 CFR Part 50 regulations do not apply to non-LWRs.
- Without rulemaking, this issue cannot be resolved generically, so in the white paper NRC staff has proposed a streamlined exemption path

Table 2 – Part 52 References to Part 50

- In order to process these exemptions expeditiously, staff requests applicants provide the following:
  - a statement that the design need not comply with the requirements of a specific subsection or subsections below; and
  - a statement or reference to associated docketed application material explaining why the design need not comply with the regulation (e.g., a design overview that makes it clear the reactor is not an LWR and the technology type employed need not include the safety function required by the regulation or accomplishes a required safety function through a means other than that required by the regulation).
- In performing the exemption review, NRC staff will provide the information necessary to comply with the applicable exemption regulations in 10 CFR 52.7 and 50.12

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Tables 3, 5 and 6 – Regulatory Applicability

- Table 3 provides a list of regulations with presumed applicability for non-LWR designers applying under 10 CFR Part 50.
- Table 5 provides a list of regulations to be considered by non-LWR designers applying under 10 CFR Part 52.
- Table 6 provides a list of regulations outside of 10 CFR Part 50 and Part 52 that may apply to non-LWRs. This list does not assess specific regulations within each part.
- Although the lists are intended to be comprehensive, lack of inclusion of any regulation should not be interpreted as a non-applicability.

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Table 4 – TMI Requirements

- TMI-related requirements written considering LWRs (operating experience and lessons learned):
  - Some requirements are clearly only technically relevant for specific reactor types. These were omitted from the table;
  - Some requirements may be narrowly applicable to some technology types but not to others – staff provided "entry conditions" for some of these, and
  - Some requirements are general high-level programmatic requirements that are technology-neutral.
- "Technically relevant" as it applies in this case allows for a greater degree of flexibility. If the requirement in question can be justified as not technically relevant to a design under review, the requirement is satisfied without a need for an exemption.
- In some cases, may also be met through application of a different regulation (e.g. Appendix E requirements)
- An exemption may nonetheless be required in some cases

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Questions/Discussion

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Status Update on the Advanced Reactor Generic Environmental Impact Statement

Jack Cushing

Senior Environmental Project Manager

Environmental Center of Expertise

Status of ANR GEIS

- Staff Requirement Memorandum 20-0020 issued September 21, 2020 directing the staff to codify the results of the ANR GEIS (ADAMS Accession No. ML202065A112)
- Scoping Summary Report issued on September 25, 2020 (ADAMS Accession No. ML20260H180)
- Chairman response to Senator Barrasso letter on GEIS (ADAMS Accession No. ML20225A074)
- Staff is drafting sections of the GEIS

Scoping Summary Report

- GEIS will use a technology neutral, performance-based plant parameter envelope (PPE) and site parameter envelope (SPE) approach that is inclusive of as many advanced reactor technologies as possible.
- Power level will not be used in most resource areas.
  - Reactor of any size can use the GEIS provide that it is bounded by the performance measures and assumptions.

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Scoping Summary Report cont.

- Reactor applications can reference individual resources that it meets and evaluate the ones it does not meet in its application.
- Goal is to develop an effective GEIS to disposition generically as many issues as practicable.

Advanced Reactor GEIS Status

- The staff is evaluating the schedule impacts of rulemaking on issuance of the GEIS.

Questions

Break

Meeting/Webinar will resume shortly

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Fuel Qualification (FQ) for Advanced Reactors

Advanced Reactor Stakeholder Meeting

October 1, 2020

Outline

- Background/Review of past engagement
- Activity affecting FQ guidance
- FQ report overview
- Incorporation of comments from May 7th stakeholder meeting
- Next steps and discussion

NEIMA

- SEC. 103. ADVANCED NUCLEAR REACTOR PROGRAM
  - (c) REPORT TO INCREASE THE USE OF RISK-INFORMED AND PERFORMANCE-BASED EVALUATION TECHNIQUES AND REGULATORY GUIDACNE

(4) REQUIRED EVALUATIONS.—Consistent with the role of the Commission in protecting public health and safety and common defense and security, the report shall evaluate—

(A) the ability of the Commission to develop and implement, where appropriate, risk-informed and performance-based licensing evaluation techniques and guidance for commercial advanced nuclear reactors within existing regulatory frameworks not later than 2 years after the date of enactment of this Act, including policies and guidance for the resolution of—

(i) issues relating to—

(I) licensing basis event selection and evaluation;

(II) use of mechanistic source terms;

(III) containment performance;

(IV) emergency preparedness; and

(V) the qualification of advanced nuclear reactor fuel; and

(ii) other policy issues previously identified; and

Regulatory Aspects of Nuclear Fuel Qualification

- Regulations
  - No requirements specific to nuclear fuel qualification
  - Requirements on fuel qualification are provided by top level requirements attributed to the facility
    - 10 CFR 50.43(e) – Demonstrate safety features (e.g., data)
    - GDC/ARDC 2, *Design bases for protection against natural phenomena*
    - GDC/ARDC 10, *Reactor design*
    - Coolable Geometry/Dose:
      - GDC 27/ARDC 26 – *Reactivity control systems*
      - GDC/ARDC 35 – *Emergency core cooling system*
      - 10 CFR 50.34(a)(1)(ii)(D), 10 CFR 52.47(a)(2)(iv), and 10 CFR 52.79(a)(1)(vi)

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Regulatory Aspects of Nuclear Fuel Qualification

- Guidance
  - NUREG-0800, Standard Review Plan
    - Section 4.2, Fuel System Design
      - Identifies acceptance criteria derived from know fuel failure/degradation mechanisms for light water reactor fuel
  - ATF-ISG-2020-01
    - Significant changes to fuel design must be assessed for potentially new failure/degradation mechanisms
  - Reg Guide 1.233, Licensing Modernization
    - Emphasis on risk – requires understanding of accident sequence consequences (i.e., source term)

May 7, 2020 Advanced Reactor Stakeholder Meeting

- NRC presented framework:
  - Top-down approach with ~58 terminal goals identified
  - Supporting/clarifying language was still being developed
  - Standards for evidence with clarifying examples were still being developed
- Input from stakeholders has been incorporated into the draft report:
  - Union of Concerned Scientists (UCS)
  - United States Nuclear Industry Council (USNIC)
  - Southern Nuclear Company (SNC)
  - Kairos Power
  - Public stakeholder

Outline

- Background/Review of past engagement
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FQ Activity

- NRC reviewed and approved:
  - EPRI-AR-1, "Uranium Oxycarbide (UCO) Tristructural Isotropic (TRISO) Coated Particle Fuel Performance," May 2019
  - ANL/NE-16/17, Rev. 1, "Quality Assurance Program Plan for SFR Metallic Fuel Data Qualification," May 2019
- NRC supported activity:
  - MSR fuel qualification:
    - ORNL/LTR-2018/1045, "Molten Salt Reactor Fuel Qualification Considerations and Challenges," 2018 (ML18347A303)
    - ORNL/TM-2020/1576, "MSR Fuel Salt Qualification Methodology," 2020 (ML20197A257)
  - Source term:
    - SAND2020-0402, "Simplified Approach for Scoping Assessment of Non-LWR Source Terms," 2020 (ML20052D133)
    - INL/EXT-20-58717, "Technology-inclusive determination of mechanistic source terms for offsite dose-related assessments for advanced nuclear reactor facilities," 2020 (ML20192A250)

FQ Activity

- White paper assessment:
  - TerraPower, *Advanced Fuel Qualification Methodology* (ML20209A155)
- White paper development:
  - General Atomics – Accelerated Fuel Qualification (AFQ)
- NEA – Working Group on the Safety of Advanced Reactors (WGSAR)
  - Fuel Qualification Report (Draft)

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FQ Framework - Literature

- JNM 2007 Paper

Available online at www.sciencedirect.com

ScienceDirect

Journal of Nuclear Materials 371 (2007) 232–242

journal of nuclear materials

www.elsevier.com/locate/jnucmat

An approach to fuel development and qualification

Douglas C. Crawford *, Douglas L. Porter, Steven L. Hayes, Mitchell K. Meyer, David A. Petti, Kemal Pasamehmetoglu

Idaho National Laboratory, Idaho Falls, ID 83415-6140, USA

- JNM 2020 Paper

Contents lists available at ScienceDirect

Journal of Nuclear Materials

journal homepage: www.elsevier.com/locate/jnucmat

Accelerating nuclear fuel development and qualification: Modeling and simulation integrated with separate-effects testing☆

Check for updates

Kurt A. Terrani [a, *], Nathan A. Capps [a], Matthew J. Kerr [b], Christina A. Back [c], Andrew T. Nelson [a], Brian D. Wirth [a, d], Steven L. Hayes [b], Chris R. Stanek [e]

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FQ Framework - Scope

- Broad interpretation of fuel qualification (many aspects of nuclear safety are impacted by the fuel)
  - Neutronic performance
  - Thermal-fluid performance (e.g., margin to critical heat flux limits)
  - Seismic behavior
  - Fuel transportation and storage
- Need to restrict the scope of the report

  The scope of this report focuses on the identification and understanding of ***fuel life limiting and degradation mechanisms*** *that occur as a result of* ***irradiation*** *during reactor operation.*

FQ Framework - Other Considerations

- Definition of fuel qualification (from JNM 2007)

  The objective of nuclear fuel qualification is ***the demonstration that a fuel product fabricated in accordance with a specification behaves as assumed or described in the applicable licensing safety case****, and with the reliability necessary for economic operation of the reactor plant*

- Clarify "safety case"
  - The role of nuclear fuel in the safety case can vary significantly between different reactor designs (e.g. TRISO fuel contains fission product barriers within the fuel itself)

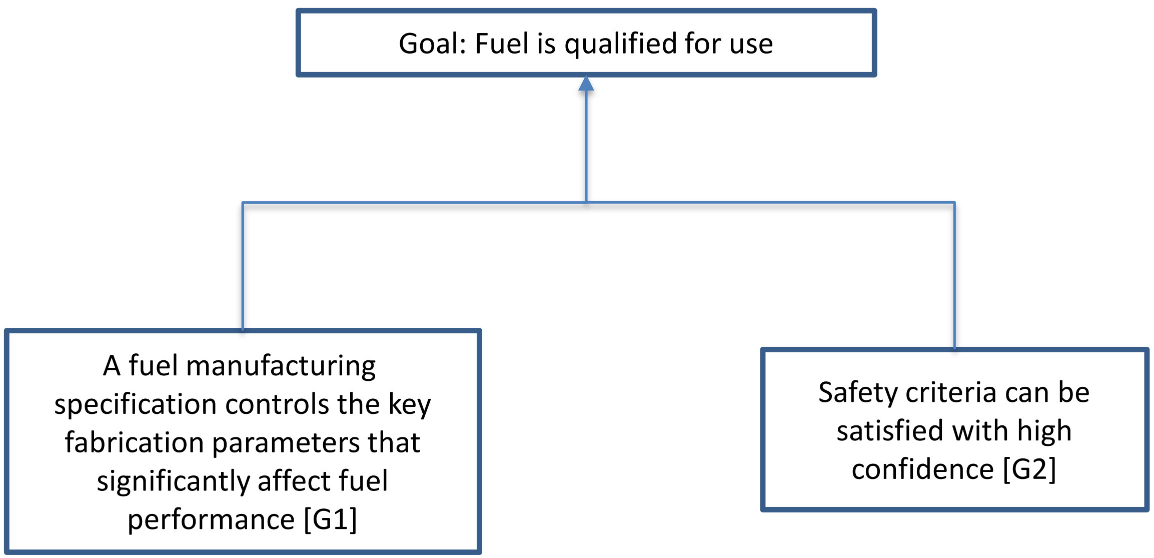
FQ Framework

- Development of a generic assessment framework for fuel qualification:
  - Top-down approach used to decompose the top level goal of "fuel is qualified" into lower level supporting goals
  - Lower level supporting goals are further decomposed until clear objective goals are identified that can be satisfied with direct evidence
- NRC has used assessment framework approach to evaluation thermal-margin models (Evaluations similar to NUREG/KM-0013)
  - Significant reduction in review time
  - Comprehensive/transparent review

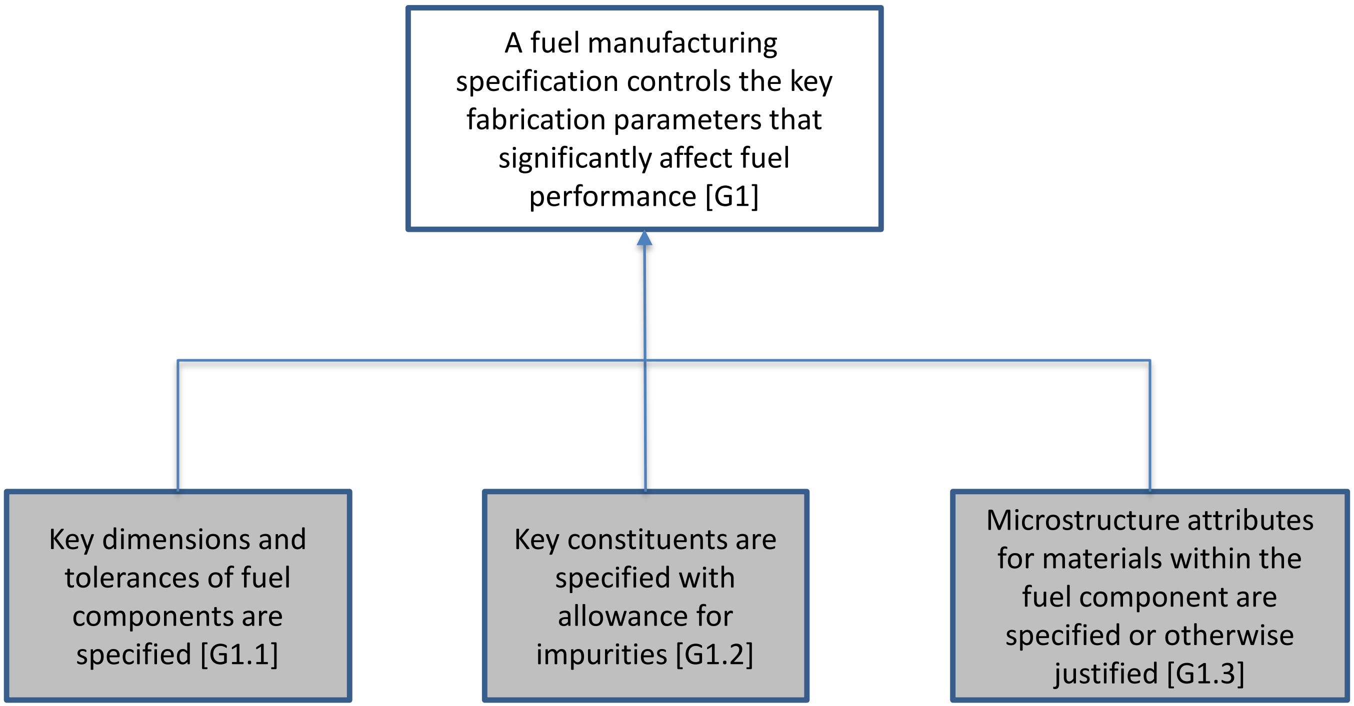
FQ Assessment Framework: Goal

- Goal: Fuel is qualified for use

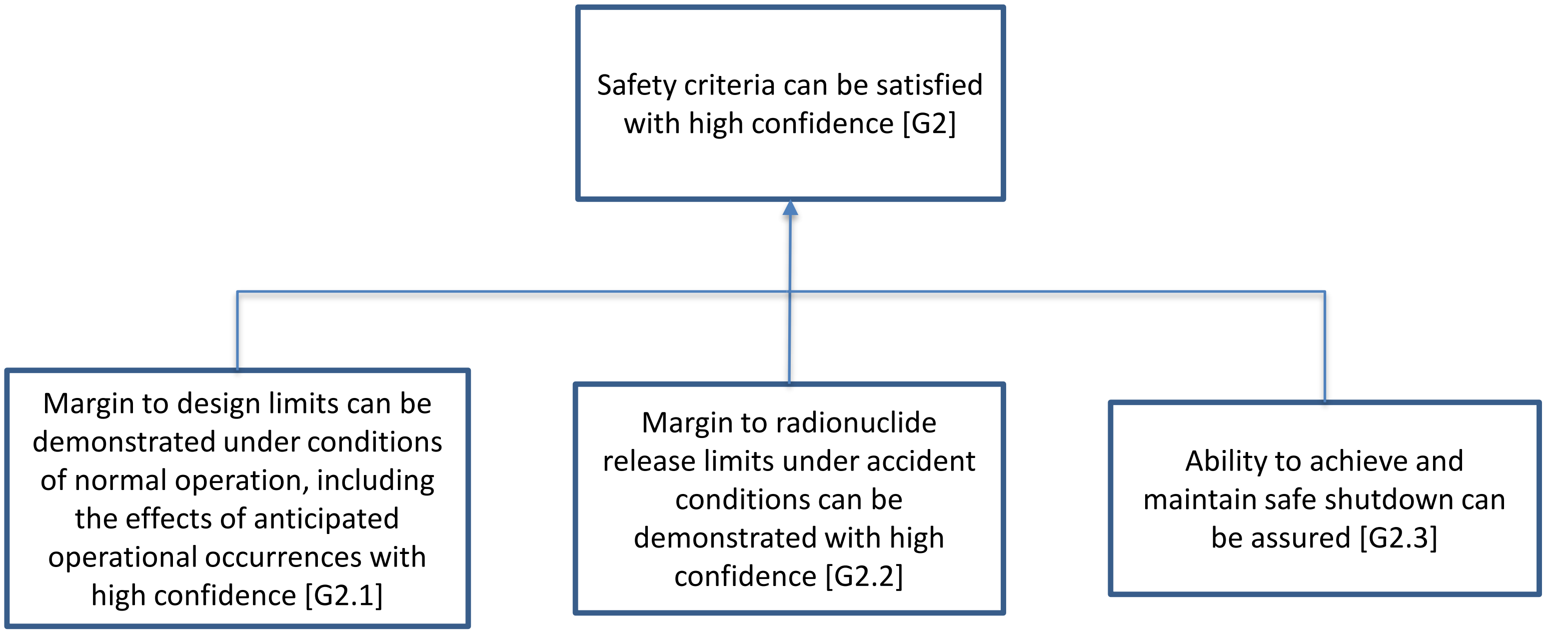
  = High confidence exists that the fuel **fabricated in accordance its specification** will **perform as described in the applicable licensing safety case**



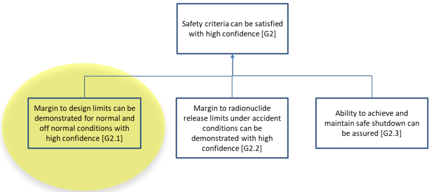
G1: Manufacturing Specification

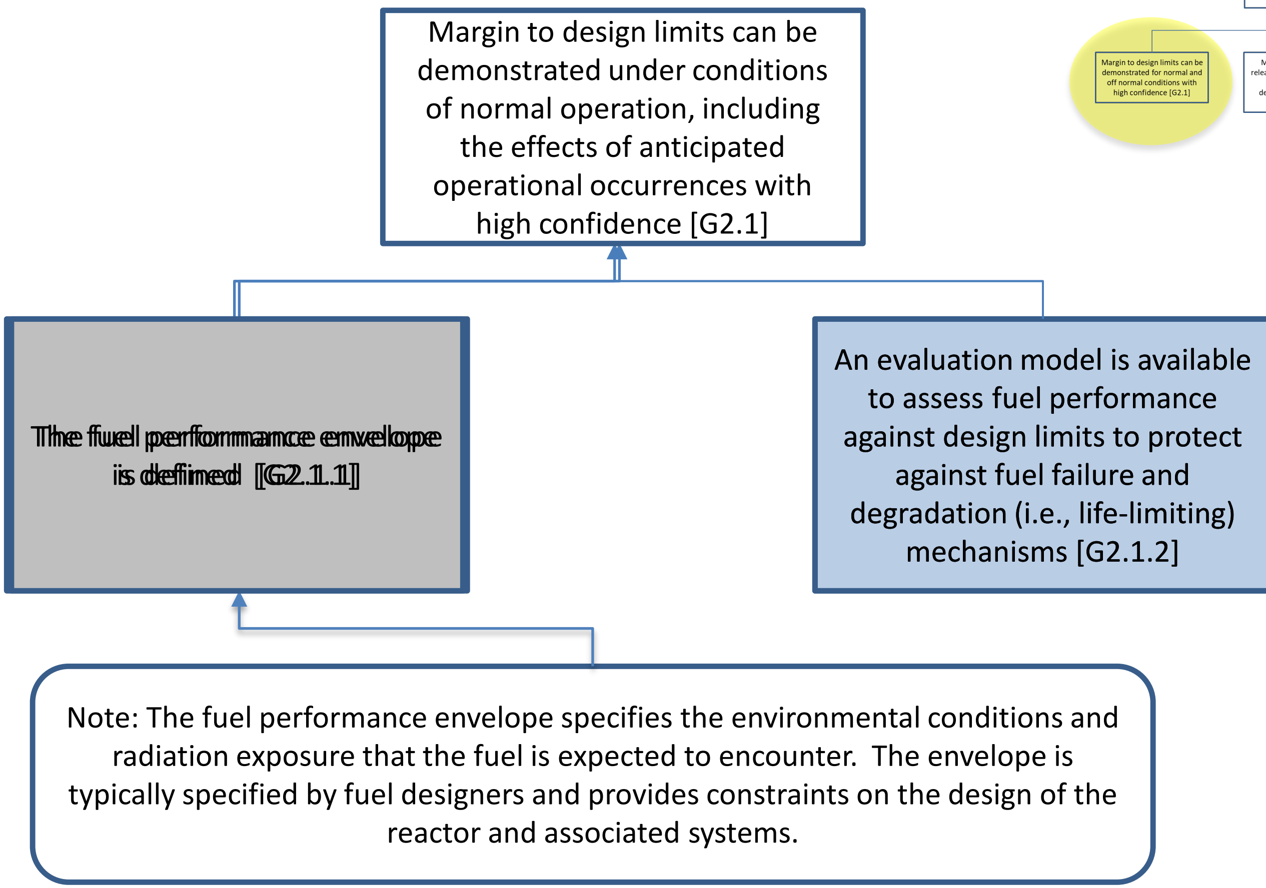


G2: Safety Criteria



G2.1: Design Limits for Normal and Anticipated Operational Occurrences





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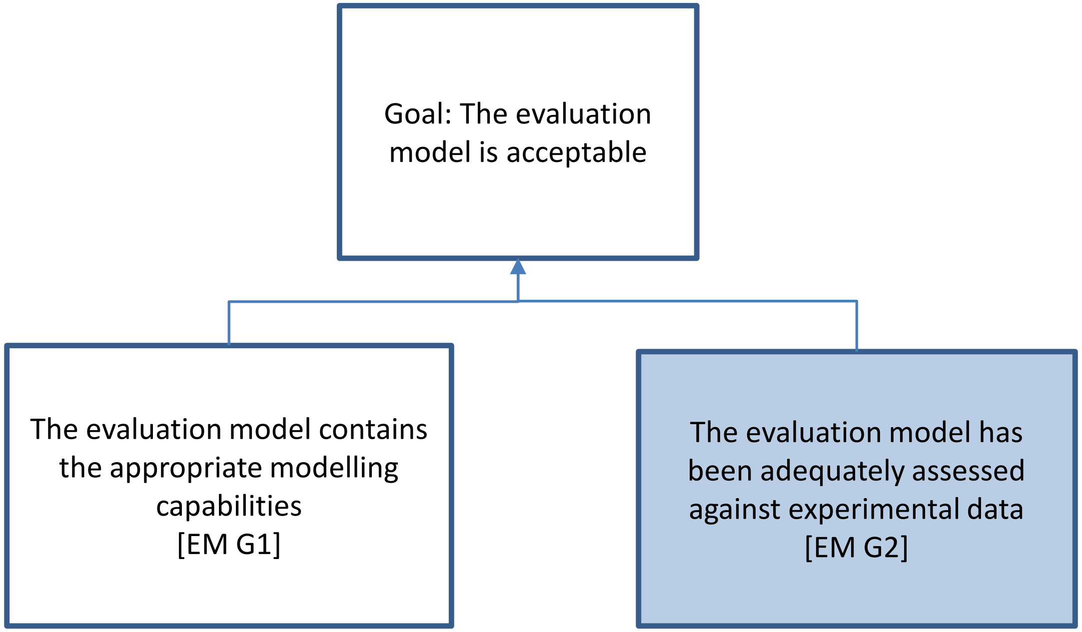
Evaluation Model (EM) Assessment Framework



Experimental Data (ED) Assessment Framework

Goal: Experimental data used for assessment is appropriate

Assessment data is independent of data used to develop/train the evaluation model [ED G1]

Data has been collected over a test envelope that covers the fuel performance envelope [ED G2]

Experimental data have been accurately measured [ED G3]

Test specimens are representative of prototypical fuel [ED G4]

Summary of FQ Assessment Framework

- Supported by two additional assessment frameworks
  - Evaluation Models
  - Experimental Data
- A total of 60 terminal goals
  - 11 in the main FQ Assessment Framework
  - 2 x (14 in the Evaluation Model Assessment Framework)
  - 3 x (7 in the Experimental Data Assessment Framework)

Outline

- Background/Review of past engagement
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- Incorporation of comments from May 7th stakeholder meeting
- Next steps and discussion

Incorporation of Stakeholder Feedback

- Clarify how to make judgements against the criteria, Ed Lyman (UCS)
  - Added language to support criteria and to provide clarifying language/examples to demonstrate how criteria can be satisfied
- Need adequate data to account for uncertainties, Cyril Draffin (USNIC)
  - Added language in support of the evaluation model goal EM G2, "The evaluation model has been adequately assessed against experimental data," which includes considerations of error quantification (i.e., uncertainty)
- Align safety criteria with fundamental safety functions, Clint Medlock (SNC)
  - Added Section 2.2.3 to clarify interfaces between fuel qualification and RG 1.233

Incorporation of Stakeholder Feedback

- Address lead test specimens, Darrell Gardner (Kairos)
  - Added Section 2.4, “Lead Test Specimens,” and supporting language in Section 3.4.2, “ED G2 Test Envelope,” to address the use of lead test specimens
- Clarify the use of the term “prototype” as to not confuse with the prototype provisions of 10 CFR 50.43(e), Darrell Gardner (Kairos)
  - Updated FQ framework and report to replace “prototypical fuel” with “proposed fuel design” as needed
- The assessment framework is similar to the “objective hierarchy” concept established in NUREG/BR-0303
  - Added reference to the “objective hierarchy” in Section 2.5, “Assessment Frameworks”

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Next Steps

- Legal reviews
  - Congressional Review Act (CRA)

- Convert report into a regulatory document (e.g. NUREG)

Contact Information

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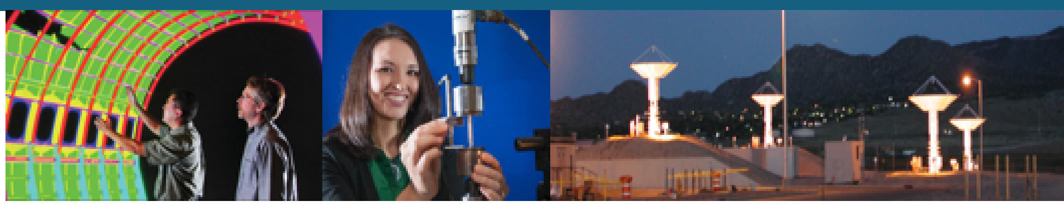
Assessment of the MACCS Code Applicability for Nearfield Consequence Analysis



PRESENTED BY

Dan Clayton, Nate Bixler

Sandia National Laboratories

Presented at the Advanced Reactor Stakeholder Meeting, October 1, 2020

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SAND2020-8592 C

Outline

Introduction/Setup

Code Trends

Code Comparisons

Wrap up

Introduction (1/2)

1. The **adequacy** of the MELCOR Accident Consequence Code System (**MACCS**) **in the nearfield** is discussed in a **non-Light Water Reactor (LWR) vision and strategy report** that discusses computer code readiness for non-LWR applications developed by the Nuclear Regulatory Commission (NRC)

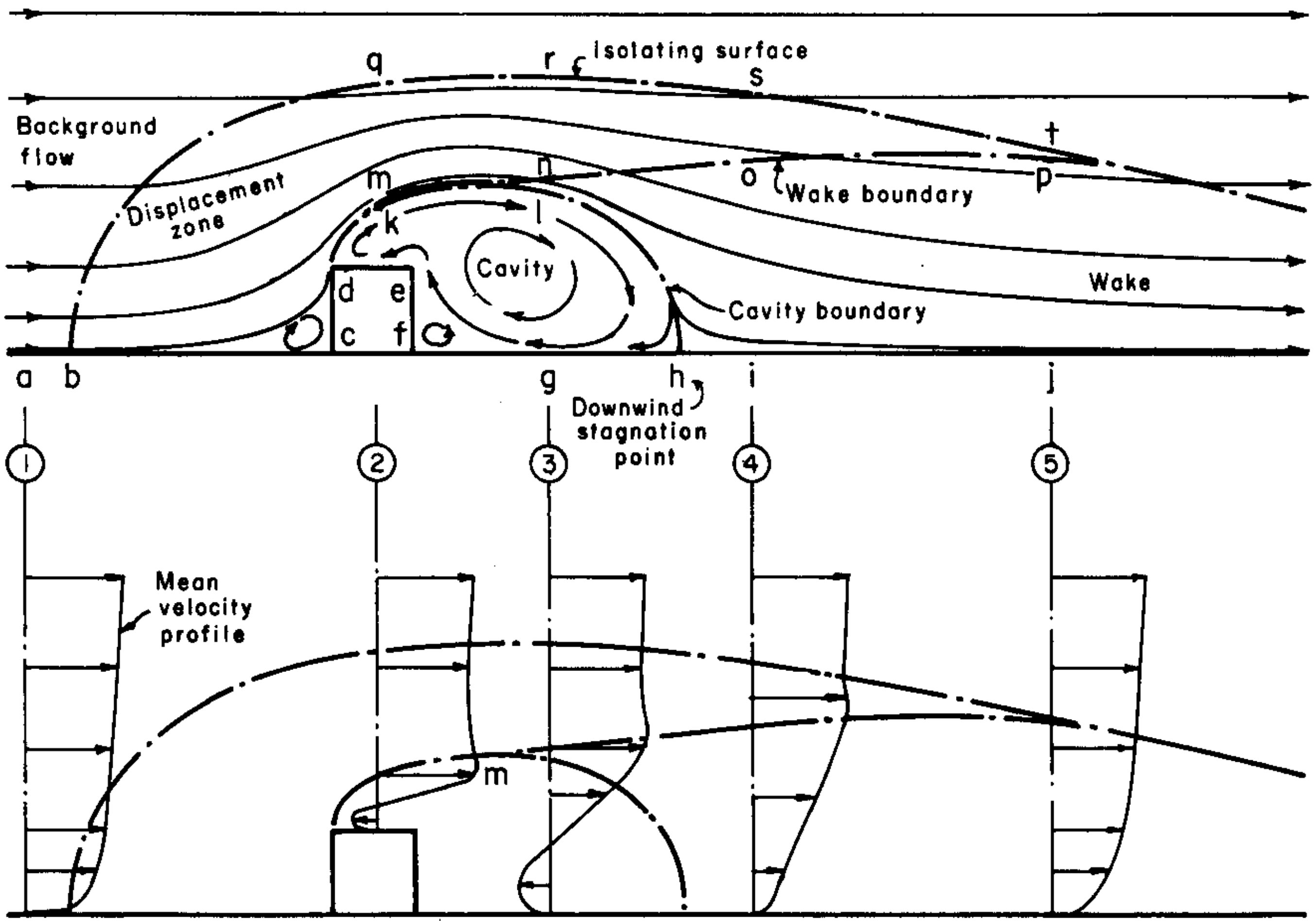
2. MACCS currently includes a **simple model** for building wake effects. The MACCS2 User's Guide suggests that this simple building wake model **should not be used at distances closer than 500 m**. This statement raises the first question of **whether MACCS can reliably be used to assess nearfield doses**, i.e., at distances less than 500 m

Introduction (2/2)

3. MACCS is a **highly flexible** Gaussian model and the **user can choose whether to model a variety of physical phenomena**, including such things as building wake effects, plume buoyancy, and plume meander. Furthermore, the user has flexibility in choosing how to model the Gaussian dispersion parameters

4. So, a **second question** goes beyond the first question of whether MACCS can be used in the nearfield to the related question of **how can MACCS be used to generate results that are bounding** of other codes intended for nearfield analysis

General Arrangement of Flow Zones Near a Sharp-edged Building



Meteorology and Atomic Energy, 1968

Objective

An **evaluation of modeling approaches** (**methods**) to estimate nearfield air concentrations and depositions **was performed** where several **candidate codes** were **ranked for comparison** and potential incorporation into the MACCS code

In this report, it is **assumed** that the **results from the selected codes** are all **adequate in the nearfield**, which is reasonable because these codes are specifically intended to be used in the nearfield

Hence, by **comparing the results** of these codes to the results from MACCS, the **adequacy of MACCS for assessing exposures in the nearfield can be evaluated**, along with determining how **MACCS can be used to generating bounding results**

Nearfield Code List

Four **candidate codes** were selected from the three **main methods** of atmospheric transport and dispersion (ATD) in the nearfield and evaluated

- CFD models – OpenFOAM
- Simplified wind-field models – QUIC
- Modified Gaussian models – AERMOD and ARCON96

	Model Characteristics					
Model	**Simplicity**	**Efficiency**	**Validation**	**Conservative Bias**	**Community Acceptance**	**Ease of Implementation**
OpenFOAM	3	3	1	2	1	3
QUIC	3	2	1	2	2	3
ARCON96	1	1	2	2	1	1
AERMOD	1	1	1	2	1	2

Based on these rankings, QUIC, AERMOD, and ARCON96 and were selected for comparison with MACCS

Test Cases

Two weather conditions

- 4 m/s, neutrally-stable (D stability class) – typical condition
- 2 m/s, stable (F stability class) – reduced dispersion condition

Three building configurations (HxWxL)

- 20m x 100m x 20m (5:1 W:H) – extreme width to height ratio
- 20m x 40m x 20m (2:1 W:H) – typical building size
- No building (point source) – evaluate differences for elevated releases with no building

Two power levels (heat content)

- 0 MW – without buoyancy
- 5 MW – with buoyancy

Weather/Energy Content	Building HxWxL (m)		
	20x100x20	20x40x20	None
4 m/s, D stability, 0 MW	Case01	Case05	Case09
2 m/s, F stability, 0 MW	Case02	Case06	Case10
4 m/s, D stability, 5 MW	Case03	Case07	Case11
2 m/s, F stability, 5 MW	Case04	Case08	Case12

Code Trends

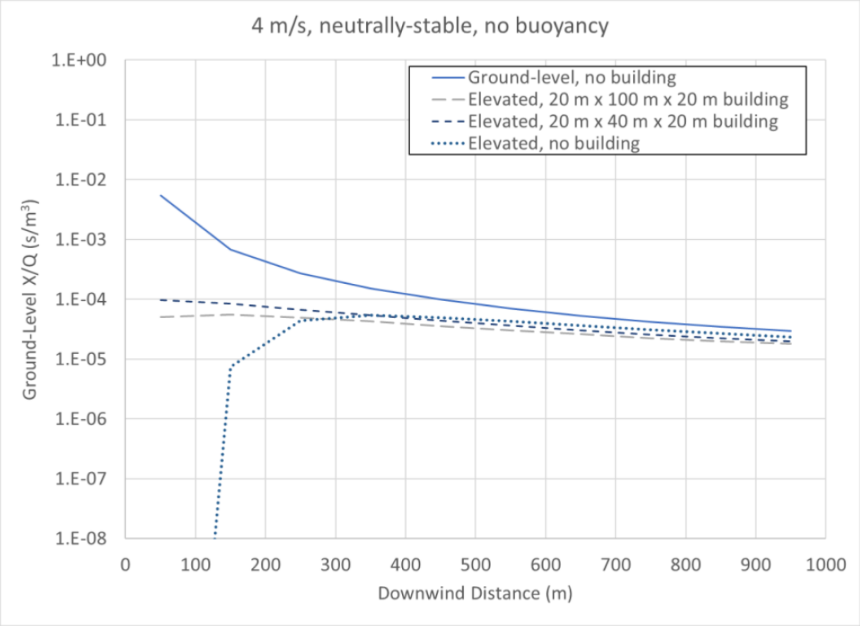
MACCS Results

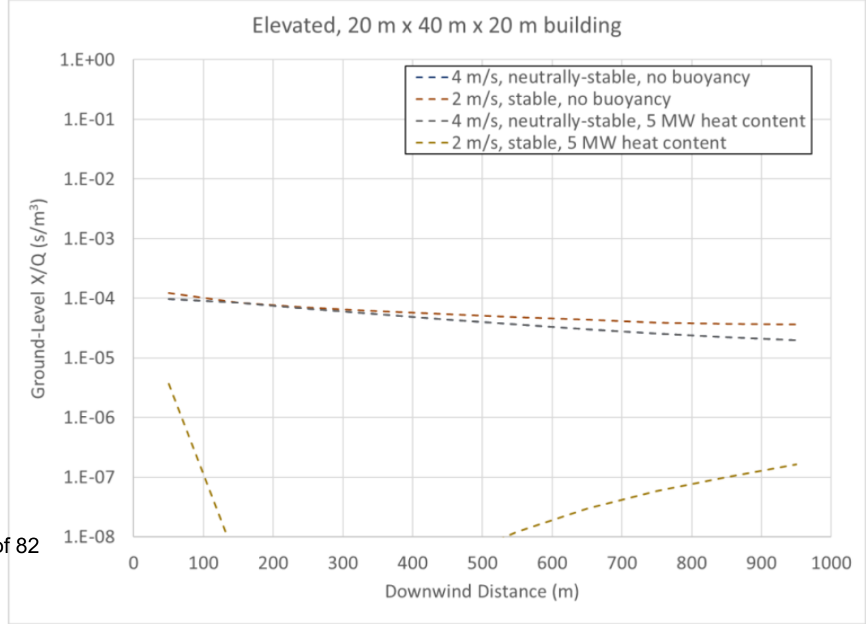
Building and **elevation** effects greatly **diminished** at 800 m **downwind**

Building significantly **increases dispersion** at short distances

Dilution for **stable** conditions generally **higher** than the corresponding dilution for **neutrally-stable** conditions

Buoyant plumes that escape building wake produce significantly **lower dilution values** due to fast plume rise compared with dispersion



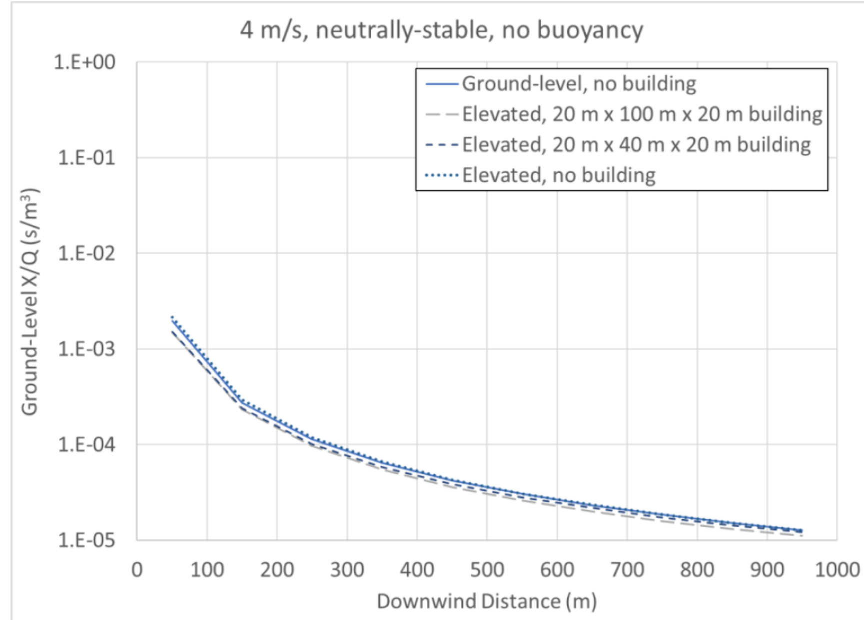


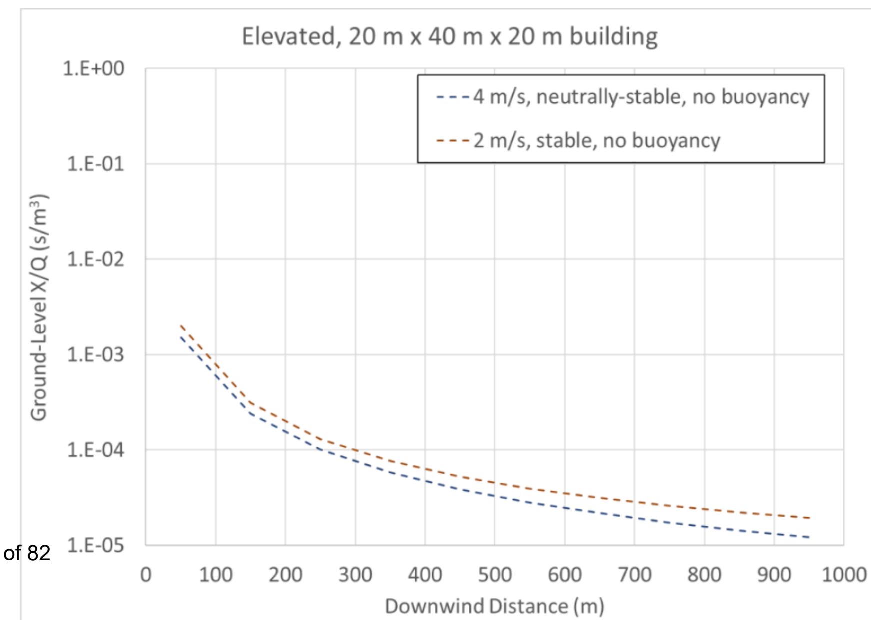
ARCON96 Results

Minimal change due to inclusion of **building** or **elevated** release within 1 km

Dilution for **stable** conditions generally **higher** than the corresponding dilution for **neutrally-stable** conditions

No plume rise model implemented; buoyant cases were not modeled





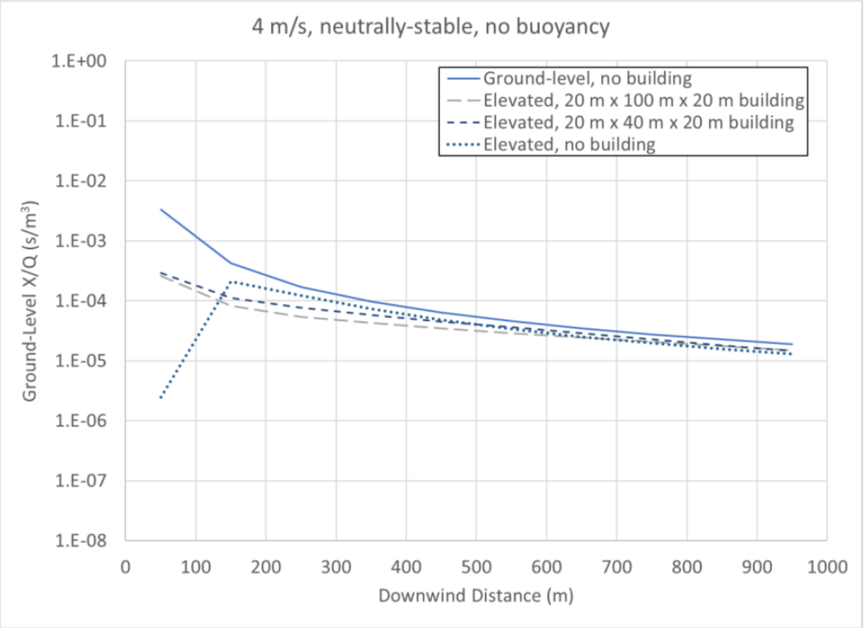
AERMOD Results

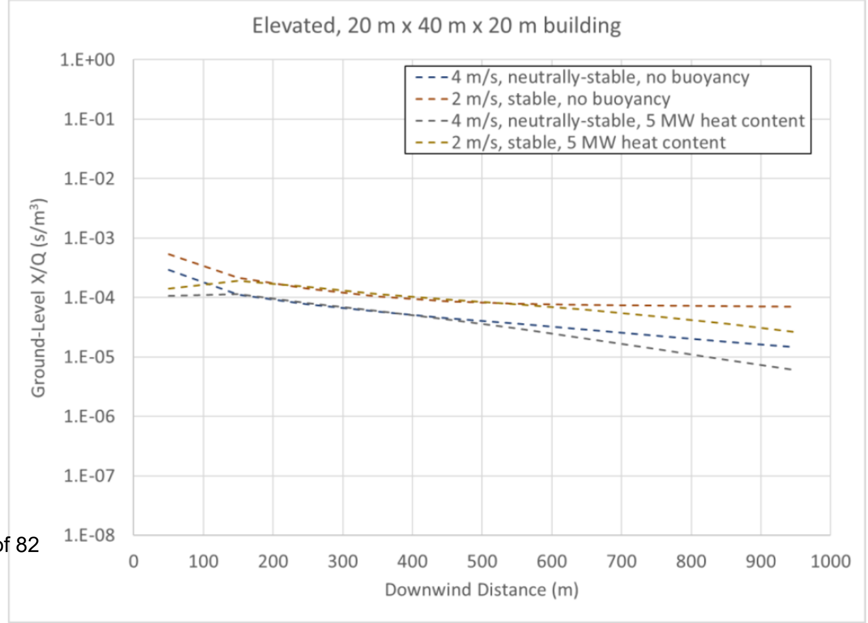
Building and **elevation** effects greatly **diminished** at 500 m **downwind**

Building significantly **increases dispersion** at short distances

Dilution for **stable** conditions generally **higher** than the corresponding dilution for **neutrally-stable** conditions

Minor differences due to **buoyancy**





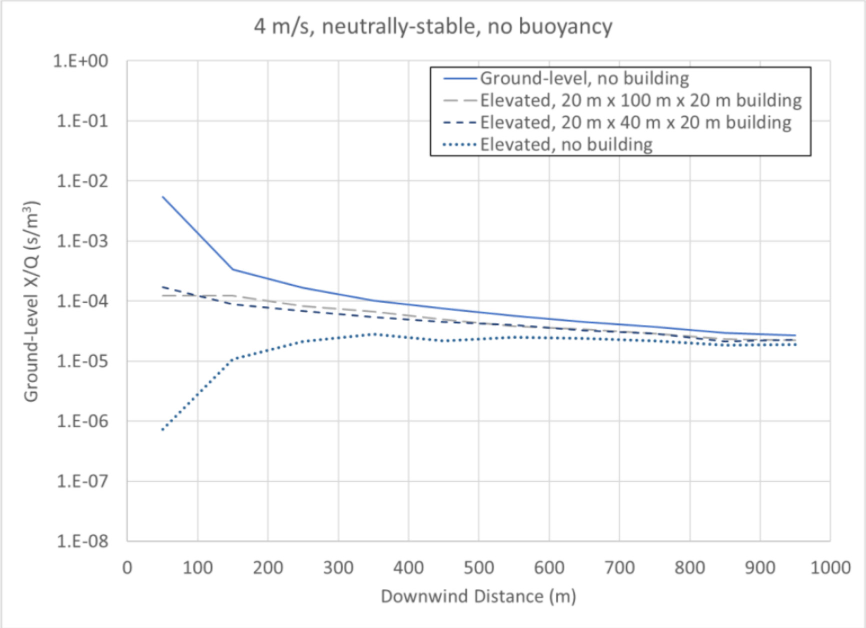
QUIC Results (1/2)

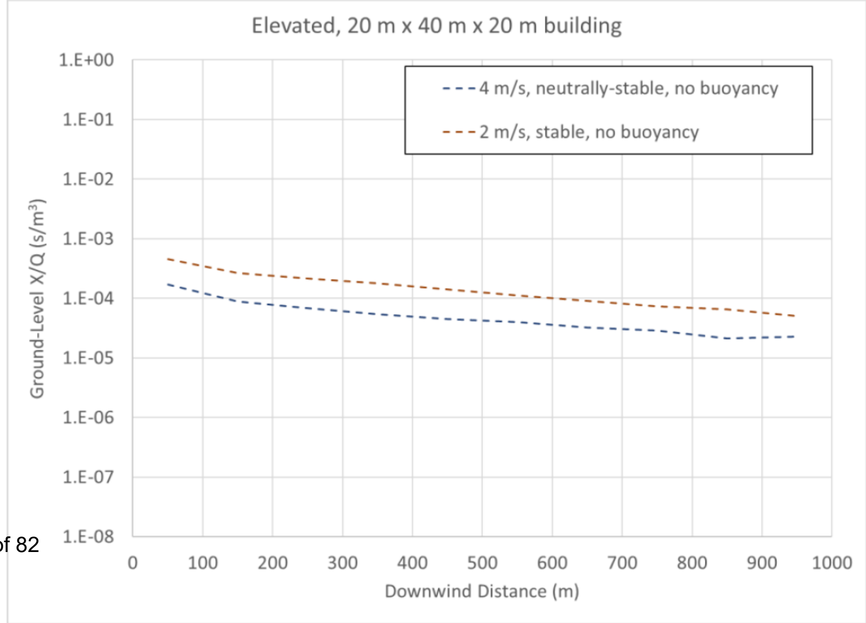
Building and **elevation** effects greatly **diminished** at 1 km **downwind**

Building significantly **increases dispersion** at short distances

Dilution for **stable** conditions generally **higher** than the corresponding dilution for **neutrally-stable** conditions

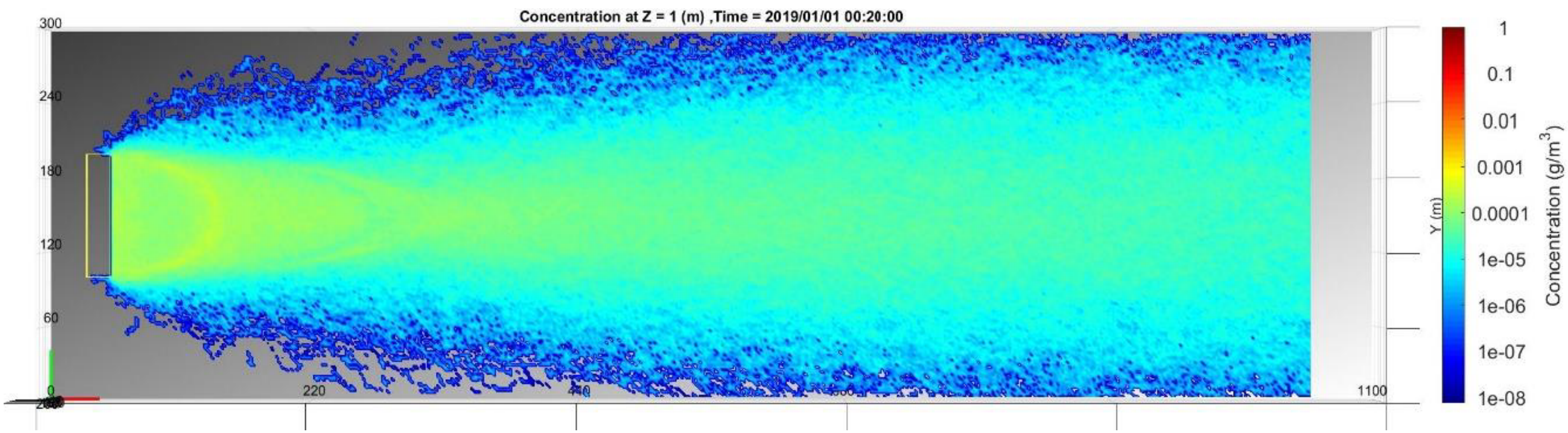
No straightforward way to implement buoyancy; buoyant cases were not modeled

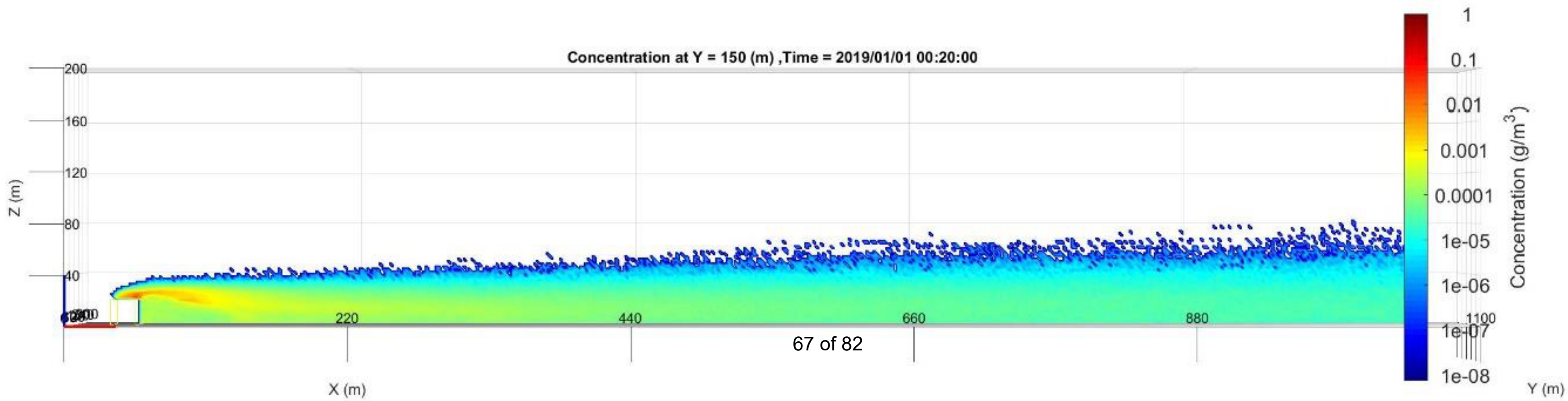




QUIC Results (2/2)

Horizontal and vertical slices for a 4 m/s, neutrally-stable weather condition with a non-buoyant, elevated release from a 20 m x 100 m x 20 m building (Case 01)





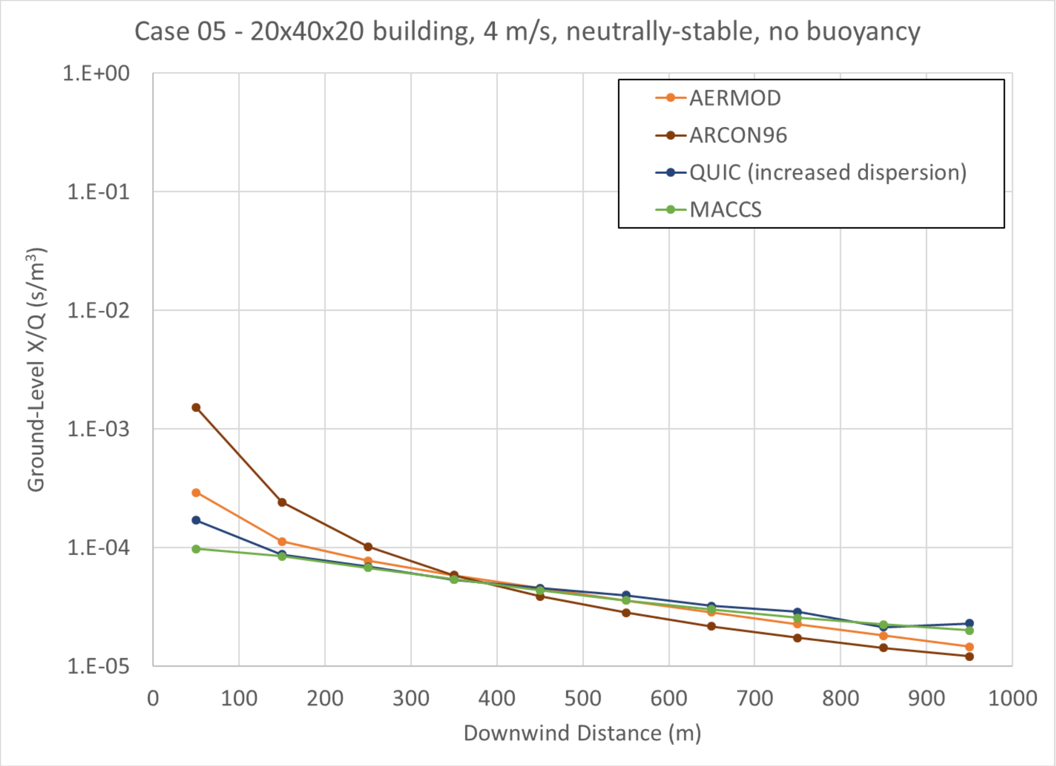
Code Comparisons

Comparison Results

At 50 m, order from **highest to lowest dilution** is ARCON96, AERMOD, QUIC, MACCS

Order changes with distance

- ARCON96 shifts from highest to lowest
- AERMOD shifts from 2nd highest to 2nd lowest
- Relative order between QUIC and MACCS is consistent



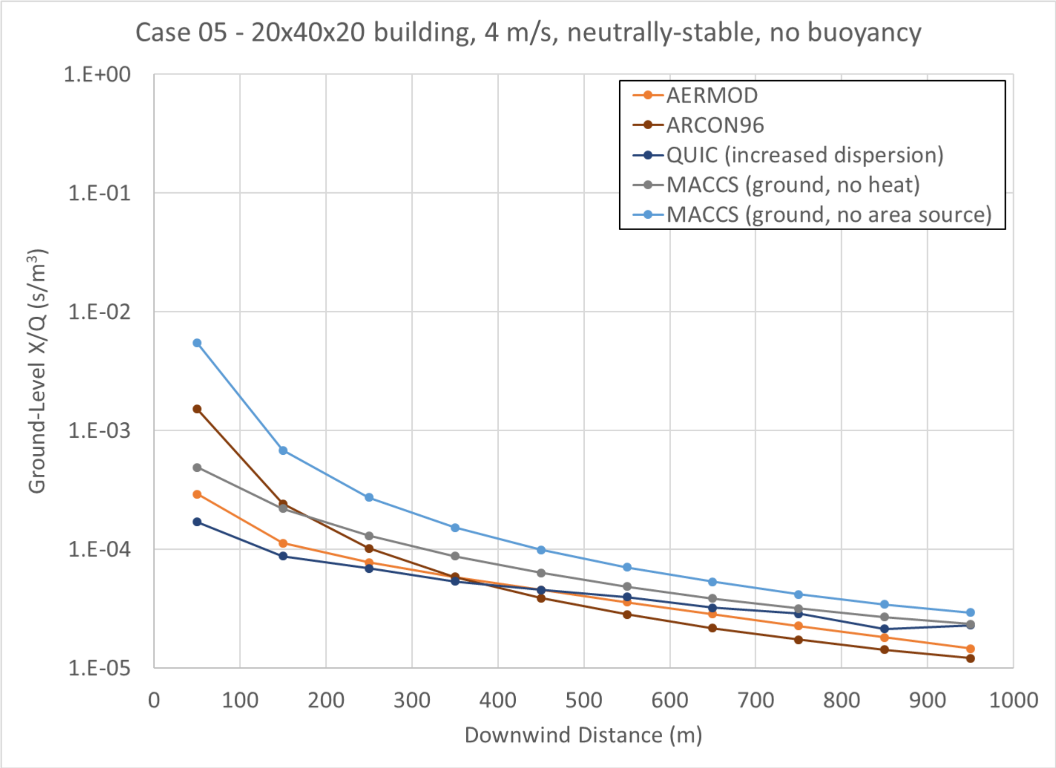
Potential Modifications to MACCS Input

1. Specify a **ground-level release**, instead of a release at the height of the building
   - **ARCON96** model showed **little dependence on elevation** of release
   - **Wake-induced building downwash** observed in QUIC output
   - **Regulatory Guide 1.145** discusses releases less than 2.5 times building height should be modeled as **ground-level releases**
2. Specify **no buoyancy** (plume trapped in building wake)
   - **AERMOD** model showed **little dependence on buoyancy**
3. If **additional conservatism** needed or desired, model as a **point source**
   - **ARCON96** model showed **little dependence on building** size
   - **DOE** approach used for **collocated workers**
   - If point source **too bounding**, use an **intermediate building** wake size

Updated Comparison Results

MACCS input **modified** to reflect a ground-level (1), non-buoyant (2) release (grey) **bounds AERMOD and QUIC** up to 1 km and **ARCON96** from 200 m up to 1 km

MACCS input **modified** to reflect a ground-level (1), non-buoyant (2), point-source (3) release (light blue) **bounds all three** up to 1 km



Wrap up

Summary (1/3)

ARCON96, AERMOD, and QUIC selected for **comparison** with **MACCS** based on initial evaluation

Test cases developed to give a **broad range** of conditions, **not** to be **exhaustive**

- Two weather conditions
- Three building configurations
- Two buoyancy variations

Summary (2/3)

MACCS calculations configured with **point-source, ground-level, nonbuoyant plumes** provide conservative nearfield results that **bound** the centerline, ground-level air concentrations from **ARCON96, AERMOD, and QUIC** .

MACCS calculations with **ground-level, nonbuoyant plumes** that include the effects of the building wake (area source) provide nearfield results that **bound** the results from **AERMOD and QUIC** and the results from **ARCON96 at distances >200 m**

If using a **point-source** is **too conservative** and it is desired to bound the results from all three codes, another **alternative** is to use area source parameters in MACCS that are less than the standard values, i.e., an area source **intermediate** between the standard recommendation and a point source.

Summary (3/3)

MACCS can be used at distances significantly shorter than 500 m downwind (50 – 200 m) from a containment or reactor building

However, the MACCS user needs to **select** the MACCS input **parameters appropriately** to generate results that are adequately conservative for a specific application

A **conservative nearfield result** may be obtained using the **following MACCS parameter choices**:

- The parameterization of Eimutis and Konicek for the dispersion model.
- The plume meander model based on Regulatory Guide 1.145. This model is selected by setting the value of the MACCS parameter MNDMOD to NEW.
- The release modeled as a point-source, ground-level, nonbuoyant plume.

Additional information available from final technical report (Clayton D.J and N.E. Bixler, "Assessment of the MACCS Code Applicability for Nearfield Consequence Analysis" Sandia National Laboratories, Albuquerque, NM, February 2020, ADAMS Accession Number ML20059M032)

Overview of the Oak Ridge National Laboratory Report on Preparing and Reviewing a Non-Power Liquid Fueled Molten Salt Reactor License Application

William B. Kennedy
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Non-Power Production and Utilization Facility Licensing Branch
Division of Advanced Reactors and Non-Power Production and Utilization Facilities
U.S. Nuclear Regulatory Commission

Background

- In response to the Nuclear Energy Innovation and Modernization Act, the NRC staff identified an opportunity to enhance its readiness to license non-power reactors that will use liquid fueled molten salt reactor (MSR) technology
- Under contract with NRC, Oak Ridge National Laboratory developed a report titled, "Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application"

Overview of the Report

- An information resource for stakeholders interested in licensing of non-power MSRs
- Based on NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors”
- Focuses on the technical information needed to apply NUREG-1537 to a non-power MSR license application

Overview of the Report

- Covers topics including:
  - Siting
  - Design of structures, systems, and components
  - Reactor description
  - Reactor cooling systems
  - Engineered safety features
  - Instrumentation and control systems
  - Auxiliary systems
  - Radiation protection and waste management
  - Accident analysis
  - Technical specifications

Future Plans

- The NRC staff is considering endorsing the report for use by potential non-power MSR applicants by January 2021
- Subsequently, the NRC staff will consider incorporating appropriate information from the report in an existing NRC guidance document, such as the next revision of NUREG-1537, a process that would include a formal public comment period
- Any feedback is welcome

How to Get the Report

- Available on the NRC's Agencywide Documents Access and Management System (ADAMS) at Accession No. ML20219A771
- Posted on the NRC's public website on the advanced reactors page at https://www.nrc.gov/reactors/new-reactors/advanced.html under the heading, "Advanced Reactor Reference Materials"
- Contact me at william.kennedy@nrc.gov

Future Meeting Planning and Open Discussion

2020 Tentative Schedule for Periodic Stakeholder Meetings
October 22 (TICAP, ARCAP)
November 5