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High Burnup Topical Report - Radiological Dose and Content

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Radiological Dose Introduction

Calculation Basis

Source Term

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Source Term

Source Term

Source Term - Example

Non-LOCA

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Non-LOCA

Release Fractions

Reg Guide 1.183, Rev. 0

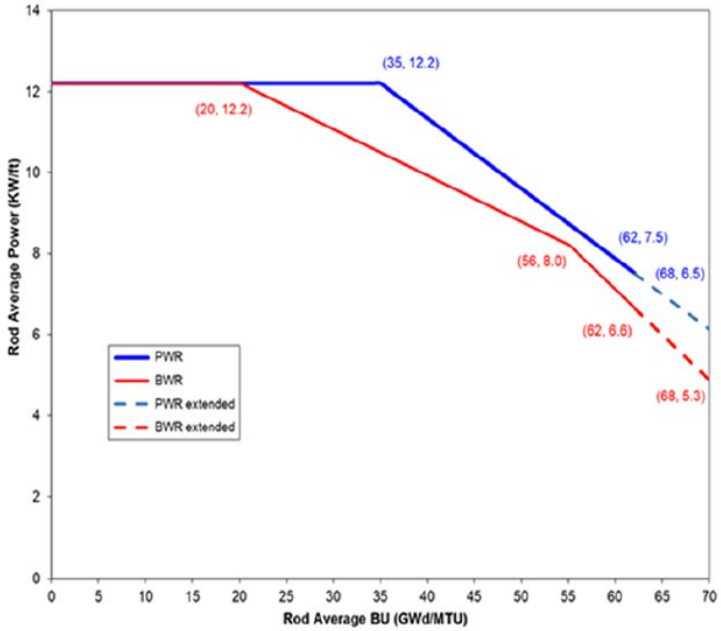
Table 3[11]

Non-LOCA Fraction of Fission Product Inventory in Gap

Group	Fraction
I-131	0.08
Kr-85	0.10
Other Noble Gases	0.05
Other Halogens	0.05
Alkali Metals	0.12

[11] The release fractions listed here have been determined to be acceptable for use with currently approved LWR fuel with a peak burnup up to 62,000 MWD/MTU provided that the maximum linear heat generation rate does not exceed 6.3 kw/ft peak rod average power for burnups exceeding 54 GWD/MTU. As an alternative, fission gas release calculations performed using NRC-approved methodologies may be considered on a case-by-case basis. To be acceptable, these calculations must use a projected power history that will bound the limiting projected plant-specific power history for the specific fuel load. For the BWR rod drop accident and the PWR rod ejection accident, the gap fractions are assumed to be 10% for iodines and noble gases.

Proposed Reg Guide 1.183, Rev. 1



Approach

High Burnup Impact on non-LOCA FGR

Primary Coolant Activity

Application to Non-LOCA Source Term – Steady-State Conditions

Steady-State FGR Fractions for High Burnup Fuel

Process for AFM Non-LOCA FGR Fractions

AFM Non-LOCA FGR Fraction Calculation

Benchmarking Process for FGRANS5.4

Examples of AFM Power Histories & Averaged Axial Shapes

Summary of Preliminary AFM 95/95 R/B Results

LOCA (MHA)

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“LOCA” Dose

10 CFR 50.67

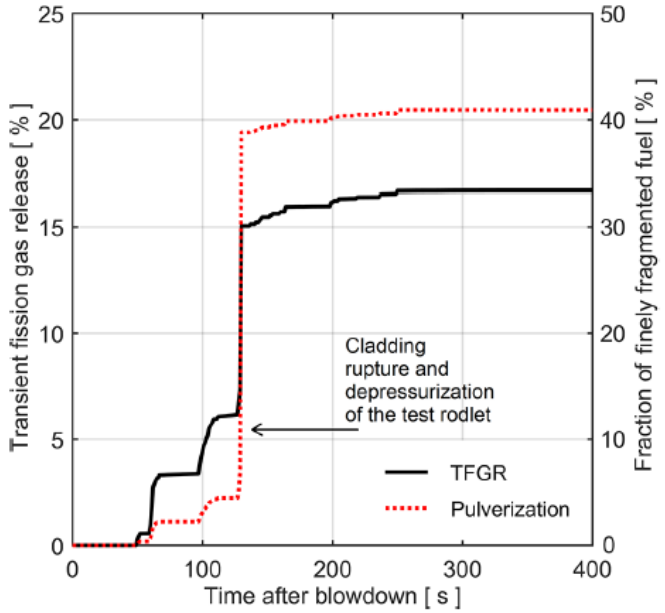
The fission product release assumed for these calculations should be based upon a **major accident**, hypothesized for purposes of design analyses or postulated from considerations of possible accidental events, that would result in **potential hazards not exceeded by those from any accident considered credible**. Such accidents have generally been assumed to result in **substantial meltdown** of the core with **subsequent release of appreciable quantities of fission products**.

- RG 1.183 defines “LOCA” as a double-ended cold leg guillotine rupture at full power operations with a 2 hour delay of ECCS

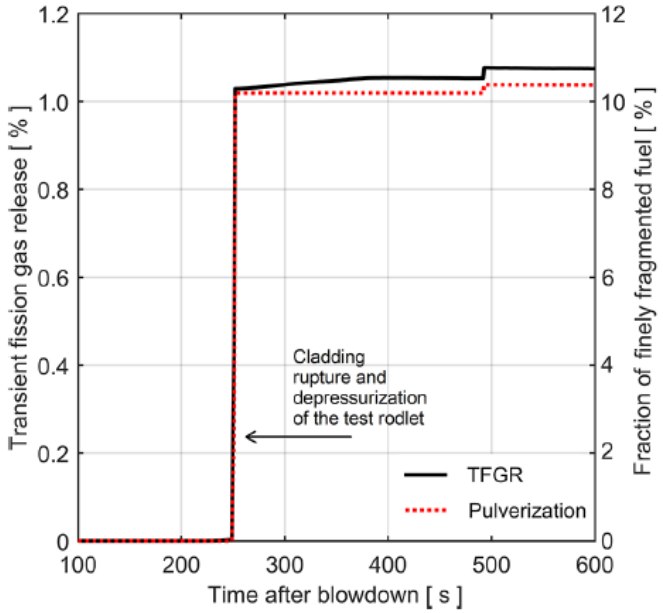
Example - LOCA Isotopic Releases

Example - LOCA Isotopic Releases

Halden LOCA tests IFA-650.9 and IFA-650.10 Transient Fission Gas Releases



90 GWd/MTU



61 GWd/MTU

LOCA FGR Fractions

Table 2
PWR Core Inventory Fraction Released Into Containment

Group	Gap Release Phase	Early In-vessel Phase	Total
Noble Gases	0.05	0.95	1.0
Halogens	0.05	0.35	0.4
Alkali Metals	0.05	0.25	0.3
Tellurium Metals	0.00	0.05	0.05
Ba, Sr	0.00	0.02	0.02
Noble Metals	0.00	0.0025	0.0025
Cerium Group	0.00	0.0005	0.0005
Lanthanides	0.00	0.0002	0.0002

Table 4
LOCA Release Phases

	PWRs		BWRs	
Phase	**Onset**	**Duration**	**Onset**	**Duration**
Gap Release	30 sec	0.5 hr	2 min	0.5 hr
Early In-Vessel	0.5 hr	1.3 hr	0.5 hr	1.5 hr

LOCA Dose

Demonstration “Realistic” Calculation

LOCA FFRD FGR Fractions

NUREG-1465

TABLE 2: NUREG-1465 CORE FISSION PRODUCT RELEASE FRACTIONS

Radionuclide Class	Gap Release	Early In-Vessel	Ex-Vessel	Late In-Vessel
Noble Gases	0.05	0.95	0	0
Halogens	0.05	0.35	0.25	0.1
Alkali Metals	0.05	0.25	0.35	0.1
Tellurium Group	0	0.05	0.25	0.005
Barium, Strontium	0	0.02	0.1	0
Noble Metals	0	0.0025	0.0025	0
Cerium group	0	0.0005	0.005	0
Lanthanides	0	0.0002	0.005	0

Proposed FFRD Release Fractions

LOCA Dose

[ ]

Realistic (Best Estimate) Results

Conclusions

Questions?

Topical Report Table of Contents

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Background – Advanced Codes and Methods

Neutronics	ARCADIA (ANP-10297P-A and S1P-A)
Thermal–Hydraulic	COBRA-FLX (ANP-10311P-A Revision 1)
CHF	GAIA CHF (ANP-10341P-A)
	ORFEO-HTP/HMP (ANP-10311P-A, S1P)
Non-LOCA	ARITA (ANP-10339P) and AREA (ANP-10338P-A)
SB LOCA	S-RELAP5 (EMF-2328P-A and S1P-A)
LB LOCA	S-RELAP5 (EMF-2103P-A Revision 3)
SB and LB LOCA	GALILEO in LOCA (ANP-10349P)
Fuel Performance Code	GALILEO (ANP-10323P-A Revision 1)
External Loads	ANP-10337PA and Supplement 1P
Fuel Design topical report	GAIA (ANP-10342P-A) with Q12 (ANP-10334P-A)
$M5_{Framatome}$	BAW-10227P Revision 2
Liftoff	BAW-10243P-A (statistical holddown)
Cladding Collapse	BAW-10084P-A Revision 3 (CROV)
Bow	XN-75-32P-A

Background – Building Blocks for Increased Burnup

ANP-10323P – New fuel performance code GALILEO

- Approved November 2020
- Peak rod average burnup of [ ]

BAW-10227P Revision 2 – $M5_{Framatome}$

- Requested approval date – [ ]
- Peak rod average burnup of [ ]

Table of Contents Overview

- Introduction and Summary
- Fuel Designs
- Neutronics (Arcadia)
  - Critical Experiment Comparison
  - Uncertainty Analysis Disposition
- Thermal Hydraulics
  - Applicability of CHF Correlation
  - Applicability of COBRA-FLX
  - Applicability of Fuel Rod Bow

Structure similar to Increased Enrichment Topical

Table of Contents Overview

- Mechanical
  - Applicability of Material Methodology
  - Applicability of Fuel Rod Thermal-Mechanical Methodology
  - Applicability of Fuel Design Methodology
  - Applicability of External Loads Methodology
  - Applicability of Statistical Hold Down Methodology
  - Applicability of Cladding Collapse Methodology
  - Applicability of Fuel Rod Bow Methodology

- Non-LOCA
  - Applicability of ARITA
  - Applicability of AREA

Table of Contents Overview

- LOCA METHODOLOGY
  - SBLOCA
  - RLBLOCA
  - LOCA Criteria

[ ]

Table of Contents Overview

Sample Problems

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Sample Problems

Questions?

Summary and Next Steps

Morris Byram

Summary

Radiological

Summary (cont.)

Increased Burnup Topical Content and Sample Problems

- Umbrella topical similar to Increased Enrichment topical – ANP-10353P

Next Steps

Acronyms

AFM – Advanced Fuel Management

ANS – American Nuclear Society

ANSI – American National Standards Institute

AOR – Analysis of Record

AREA – ARCADIA Rod Ejection Accident

AST – Alternate Source Term

CHF – Critical Heat Flux

EAB - Exclusion Area Boundary

ECCS – Emergency Core Cooling System

FFRD – Fuel Fragmentation, Relocation, and Dispersal

FPC – Fuel Performance Code

FSAR - Final Safety Analysis Report

LBLOCA – Large Break Loss of Coolant Accident

LB - Large Break

LOCA – Loss of Coolant Accident

LPZ - Low Population Zone

MCR - Main Control Room

NRC – U.S. Nuclear Regulatory Commission

PNNL – Pacific Northwest National Laboratory

PWR – Pressurized Water Reactor

RCS – Reactor Coolant system

RIA – Reactivity Insertion Accident

RLBLOCA – Realistic Large Break Loss of Coolant Accident

SB – Small Break

SBLOCA – Small Break Loss of Coolant Accident

SRP – Standard Review Plan

SS – Steady State

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