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NRC Update

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Radiological Effluents and Environmental Workshop
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Topics

1. Regulatory Guide Updates

– RG 1.21 ~ Routine Effluent Monitoring

– RG 4.13 ~ Environmental Dosimetry

– RG 4.25 ~ Groundwater Discharges

2. Decommissioning Planning Rule

3. Accident- Monitoring Instrumentation

4. Instrument Calibrations

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RG 1.21

Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste

- Significant changes to RG 1.21
  - Updating long-term, annual average χ/Q and D/Q values
  - Environmental monitoring for iodine (I) -131 in drinking water
  - ODCM - making changes to effluent and environmental programs
  - Incorporates Regulatory Issue Summary 2008-03, “Return/Reuse of Previously Discharged Radioactive Effluents
  - Calibration of accident-range radiation monitors

χ/Q and D/Q values

- Long-term annual-average χ/Q and D/Q should be based on 5 or more years of meteorological data
- χ/Q and D/Q values should be reevaluated periodically (e.g., every 3–5 years).
- If χ/Q and D/Q values are substantially nonconservative (e.g., higher by 20–30 percent or more), revise χ/Q and D/Q values used in dose assessment

Environmental Monitoring
I -131 in Drinking Water

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- Perform a prospective dose evaluation to determine if the likely dose from I-131 in drinking water is > 1 mrem/yr
- If dose is > 1 mrem/yr, perform I-131 sampling & analysis using an LLD of 1 pCi/L
- If dose is < 1 mrem/yr, perform I-131 sampling and analysis using an LLD of 15 pCi/L

Offsite Dose Calculation Manual (ODCM)

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- ODCMs need to be kept current
- Plant changes affecting ODCMs:
  - Plant operating status (operating or decommissioning)
  - Principal radionuclides (e.g., failed fuel or decommissioning status – noble gas and iodine have been eliminated)
  - Installation of new or out-of-service radwaste processing equipment
- Technical Specifications establish change process for ODCMs (not 10 CFR 50.59)

C-14 Dose Assessment

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- C-14 is likely a principal radionuclide in operating reactors
- C-14 is not a principal radionuclide for air dose calculations
- C-14 source term and dose assessment
  - Scaling factors can be based on power generation
  - NUREG-0016 GALE computer codes
  - NCRP-81's C-14 report
  - PWRs release ~ 6 curies, (~ 4.6 mrem max dose)
  - BWRs release ~ 9 curies, (~4.7 mrem max dose)
- Appendix I ingestion doses include iodines, tritium and particulate nuclides

Environmental Dosimetry for Direct Radiation Dose Assessment

- RG 4.13, Rev. 2, "*Environmental Dosimetry – Performance Specifications, Testing, And Data Analysis*" was revised in June 2019
- RG 4.13 provides an NRC-approved method of determining facility-related dose (FRD) from direct radiation
- NRC endorsed ANSI/HPS N13.37, *"Environmental Dosimetry – Performance Specifications, Testing, And Data Analysis"*
- RG 4.13 methods can be used in the demonstration of compliance with 10 CFR 20.1302 surveys and EPA's 40 CFR 190's dose limit of 25 mrem/year

Direct Radiation Data Analysis Method Using Environmental Dosimetry

- At each location, using historical data, determine the baseline background dose rate and the baseline standard deviation (**σ**)
- Then, perform a 2-step quarterly data analysis process:
  - At each location, determine if there is there a detectable increase **greater than 3σ?** (a yes/no question)
  - If **> 3σ,** determine the facility-related dose (FRD)
    - Subtract current quarterly reading from baseline background dose rate
    - Do not subtract the **> 3σ value**
- Environmental dosimetry systems can measure FRD dose at: ~ 5 mrem/quarter, and ~ 10 mrem/year

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Compliance with EPA dose limit

- EPA dose limit required by 10 CFR 20.1301(e) is 25 mrem/yr whole body and any organ (except thyroid)
- C-14 is a dominant source of organ dose (bone)
  - maximum organ dose in 2020 was 4.6 mrem
  - Total organ dose = effluent dose plus direct radiation dose
    - For example, total dose = 4.7 mrem + <10 mrem <14.70 mrem
    - < 14.70 mrem is less than the 25 mrem EPA 40 CFR 190 limit

Return/Reuse of Previously Discharged Radioactive Effluents

- Regulatory Issue Summary (RIS) 2008-03 (ML072120368)
- RIS 2008-03 states radioactive material with less than exempt concentrations that is properly released in gaseous or liquid effluent is not considered licensed material (does not apply to solids)
- The unlicensed material can be used and returned to the environment without being considered a new radioactive material effluent release
- Licensees are responsible for evaluating any new exposure on-site or off-site exposure pathways > 10% of total effluent dose (per RG 1.109)

List of Leaks and Spills (L&S)

- NRC publishes a list of L&S on the NRC web site

  http://www.nrc.gov/reactors/operating/ops-experience/tritium/sites-grndwtr-contam.html

- 55 - currently licensed and operating nuclear sites

- 38 of those sites historically have had L&S of H-3 ≥ 20,000 pCi/L reported

- 7 sites currently have residual radioactive ground water with H-3 ≥ 20,000 pCi/L

Leaks and Spill Remediation

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- SRM-SECY-13-108, "*Remediation of Residual Radioactivity During Operations*"
- Evaluate feasibility of prompt remediation
- However, prompt remediation is not a requirement

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OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE

March 2017
Revision 0

Technical Lead
Thomas Nicholson

REGULATORY GUIDE 4.25

(Draft was issued as DG-4025, dated December 2015)

ASSESSMENT OF ABNORMAL RADIONUCLIDE DISCHARGES IN GROUND WATER TO THE UNRESTRICTED AREA AT NUCLEAR POWER PLANT SITES

RG 4.25
Groundwater Discharges

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- RG 4.25 – guidance on calculating “on-site” groundwater discharges to “off-site” groundwater

- Groundwater discharge to “off-site” areas is not a calculation of plant releases into the “on-site” subsurface groundwater

Reporting Abnormal Discharges (leaks and spills)

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- RG 1.21, Section 9.5 Supplemental Information
  - Provides guidance on abnormal releases from plant equipment into onsite groundwater
  - Reporting thresholds include:
    - Voluntary reports under NEI 07-07, "*Industry Groundwater Protection Initiative - Final Guidance Document, Rev. 1*"
    - Abnormal discharges to the unrestricted area
- Information submitted should include:
    - Date, duration, volume, etc.
    - Doses to public

On-site Discharges into On-site Ponds

- Some licensees dispose of liquid effluents to on-site ponds as though releases were to the “unrestricted area” (10 CFR 50.36a)
- Most on-site ponds leak into on-site groundwater (GW)
- **There is an important footnote in RG 4.25 that provides an exclusion for reporting leakage from on-site ponds into GW if previously accounted for**
  - Leakage from bottom of lake or pond to groundwater does not need to be reported (again)
- However, the potential dose (through a new groundwater pathway) must be assessed **if** the off-site dose from leakage from onsite ponds is greater than 10% of all pathways combined per RG 1.109
- RG 1.109, “*Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR part 50, Appendix I*”

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Decommissioning Planning Rule* (DPR)

- Licensees are required to plan for decommissioning during operations

- The DPR as revised in 2012 made changes to 10 CFR 20.1501(a) to include performing radiological surveys in the subsurface (i.e., ground water)

*76 FR (2012) pp. 35512 – see NRC website at https://www.nrc.gov/reading-rm/doc-collections/fedreg/notices/

- 10 CFR 20.1406(c) - Licensees shall minimize residual radioactivity (contamination), including subsurface (ground water)

10 CFR 20.1501
Radiological Surveys and Monitoring

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- Related documents:
  - NEI 07-07, "*Industry Groundwater Protection Initiative - Final Guidance Document, Rev. 1*"
  - NEI *08-08, "Generic FSAR Template Guidance for Life Cycle Minimization of Contamination"*
  - *NEI 09-14, "Guideline For The Management Of Underground Piping And Tank Integrity "*

Decommissioning Programs

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- Groundwater monitoring may need to be increased in support of license termination
- Licensees must maintain and update 10 CFR 50.75(g) record keeping files to include leaks and spills
- Decommissioning-related RGs
  - RG 4.22, "*Decommissioning Planning During Operations*"
  - RG 1.185, "*Standard Format and Content for Post-Shutdown Decommissioning Activities Report*"
  - NUREG-1757, "*Consolidated Decommissioning Guidance*"
  - Draft Revision of NUREG-1757 for public comment

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Accident Monitoring Instrumentation

- RG 1.21, Rev. 1 "*Measuring, Evaluating, and Reporting Radioactive Material In Liquid and Gaseous Effluents And Solid Waste*" summarizes previously issued NRC requirements and guidance in:
  - NUREG-0737, "*Clarification of TMI Action Plan Requirements*" (ML051400209)
  - HPPOS-001, "*Guidance on Calibration and Surveillance to meet Item II.F.1, Additional Accident-Monitoring Instrumentation*"

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Accident Monitoring Instrumentation (Cont'd)

- NUREG-0737, "*Clarification of TMI Action Plan Requirements*" (ML051400209)
- Item II.F.1 is "*Additional Accident-Monitoring Instrumentation"* requiring:
  - **Noble gas effluent monitoring (Item II.F.1-1)**
  - **Iodine and particulate sampling and analysis (Item II.F.1-2)**
  - **Containment high range radiation monitoring (II.F.1-3)**
- Specifications for radiation monitoring equipment are provided in Tables II.F.1-1, II.F.1-2, and II.F.1-3

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Accident-Range Radiation Monitors

- Three different instrument criteria to discuss:
  - **Instrument "design" criteria**
  - **Instrument "calibration" criteria**
  - **Instrument "measurement" criteria**

Three Different Criteria

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- Design criteria:

- RG 1.97, "*Instrumentation For Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During And Following an Accident*," establishes a "design" accuracy criteria of a factor of 2

- Note: These are "design" accuracy criteria, not "calibration criteria"

Accuracy Criteria

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- NUREG-0737, Rev. 1, "*Clarification of TMI Action Plan Requirements"* states that the accuracy requirement is that "**accuracy is sufficient to perform intended function"**
- ANSI N320-1979, "*Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation*" provides an accuracy criteria of ± 40% at the 95% confidence level
- IEEE-497, "*Accident Monitoring Instrumentation for Nuclear Power Generating Stations" specifies* accuracy within ± 50%

"Measurement" criteria NUREG-0737

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- Item II.F.1 "*Additional Accident-Monitoring Instrumentation*"
  - Effluent monitors should be able to measure fresh noble gas mixtures (0 – 10 days) within overall system accuracy factor of 2
  - Containment High Range Monitors (CHRMs) should be able to measure within factor of 2

Design, Calibration & Measurement Criteria

- "Design criteria" is prescribed in RG 1.97 within a factor of 2 (not the calibration accuracy)
- "Calibration criteria" is prescribed in NUREG-0737 as "**sufficiently accurate to perform the intended function**"
  - ANSI N320-1978 says (calibration) accuracy should be ± 40%
  - IEEE-397 – (calibration) accuracy should be ± 50%
- "Measurement criteria" is prescribed in NUREG-0737 as per RG 1.97 (i.e., within a factor of 2)

Health Physics Positions (HPPOS) Calibration of Accident-Range Radiation Monitors

- HPPOS-001 is a summary of the NRC guidance on meeting Item II.F.1 calibration and surveillance criteria
- https://www.nrc.gov/about-nrc/radiation/protects-you/hppos/hppos001.html

Proposed Guidance for Calibration and Surveillance Requirements to Meet Item II.F.1 of NUREG-0737

HPPOS-001 PDR-9111210074

See the memorandum from D. G. Eisenhut to Regional Administrators dated August 16, 1982.

- The memo from D. G. Eisenhut (NRR) to Regional Administrators contains detailed calibration guidance and is located in ADAMS at Accession Number ML103420044

NUREG-0737 Item II.F.1-1 Noble Gas Effluent Monitoring

- Ion chamber, GM detector, scintillator or CdTe(Cl) solid-state detector output is in mR/hr or cpm
- Manufacturer provides energy response characterization from low (~81 keV) to high (~3 MeV) gamma energy
- Manufacturer provides instrument response factor (efficiency factors) for Xe-133 (and Kr-85 for scintillators and CdTe(Cl) detectors)
- $- \frac{uCi/cc}{mR/hr}$ or $\frac{\frac{uCi}{cc}}{cpm}$ $(Xe-133 \text{ or } Kr-85)$

NUREG-0737 Item II.F.1-1 Noble Gas Effluent Monitoring

- Licensees perform periodic calibration “checks” with a solid source to ensure proper operation
- Licensees should account for time-dependent, changing radionuclide mix

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NUREG-0737 Item II.F.1-2 Iodine and Particulate Monitoring

- Real-time iodine and particulate monitoring is not practical
- Licensees must develop procedures for collection and analysis of samples
- Note: Iodine releases can be calculated based on partitioning (scaling) factors to noble gas (RG 1.21)

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Item II.F.1-3
Containment High Range Monitors (CHRMs)

- High Range measurement is up to 10 million R/hr
- Output used in estimating containment conditions and assessing Core Damage
- Manufacturer provides the instrument response factor; e.g., ion chamber is ~ 1E-11 $\frac{amps}{R/hr}$
- Licensees perform a periodic solid source calibration check in the 1 – 10 R/hr range
- Perform electronic calibration above 10 R/hr

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Instrument Calibrations

Accident Range Effluent Monitors Initial Vendor Calibrations

- Vendors perform initial calibrations:
  - Perform dose-rate linearity check
  - Determine the detector's energy response characteristics
  - Determine the instrument response factor for a standard gas (Xe-133 or Kr-85)
  - (µCi/cc) / (cpm) or (µCi/cc) / (mR/hr)
  - Vendors also build a field calibrator with a Cs-137 source for licensee's use for in-plant calibration checks
  - Vendors provide a calibration check source value (~ 7 R/hr)

In-plant Calibration Checks

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- I&C / RP / Chem conduct a one-point radiological calibration check
- Licensees decay correct the check source value
- I&C conduct an electronic calibration check for all scales above first decade
- Instrument adjustments are normally NOT made based on the radiological calibration check

Instrument Response Factors (Noble gas monitoring)

- Historically, noble gas monitoring instruments are GM detectors, ion chambers, plastic scintillators, or CdTe(Cl) solid-state detectors
- GM and ion chambers are typically calibrated to Xe-133; i.e., to low energy, 81 keV photons with low yield (~36%)
- Plastic scintillators and solid-state detectors are calibrated to Xe-133 (gamma) and Kr-85 (beta)
- Energy response curves are provided in the vendor calibration summary report

Instrument Response Factors (noble gas monitoring) (Cont'd)

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- Detector output is a count rate or a dose rate
- Output is converted to a Xe-133 concentration, µCi/cc
- Concentration (µCi/cc) times flow rate (cubic feet per sec) = release rate (µCi/sec)
- µCi/cc x flow rate = release rate (µCi/sec) of Xe-133

Challenge
(noble gas monitoring)

- Gaseous effluent is not just Xe-133
- Gaseous effluent is a mix of noble gases, and is very energy dependent and time dependent
- Generally, short-lived noble gas nuclides have higher energy gammas than long-lived nuclides
- Detector efficiency is higher for high energy gammas
- A time-dependent instrument response factor for a mix of noble gases is needed

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Accident Source Term: 13 Noble Gases

6 Kryptons

- 1. Kr-83m
- 2. Kr-85m
- 3. Kr-85
- 4. Kr-87
- 5. Kr-88
- 6. Kr-89

7 Xenons

7. Xe-131m
8. Xe-133m
9. Xe-133
10. Xe-135m
11. Xe-135
12. Xe-137
13. Xe-138

There are ~ **60 different gamma energies and gamma yields** from 13 noble gas nuclides to consider

60 Gamma Energies

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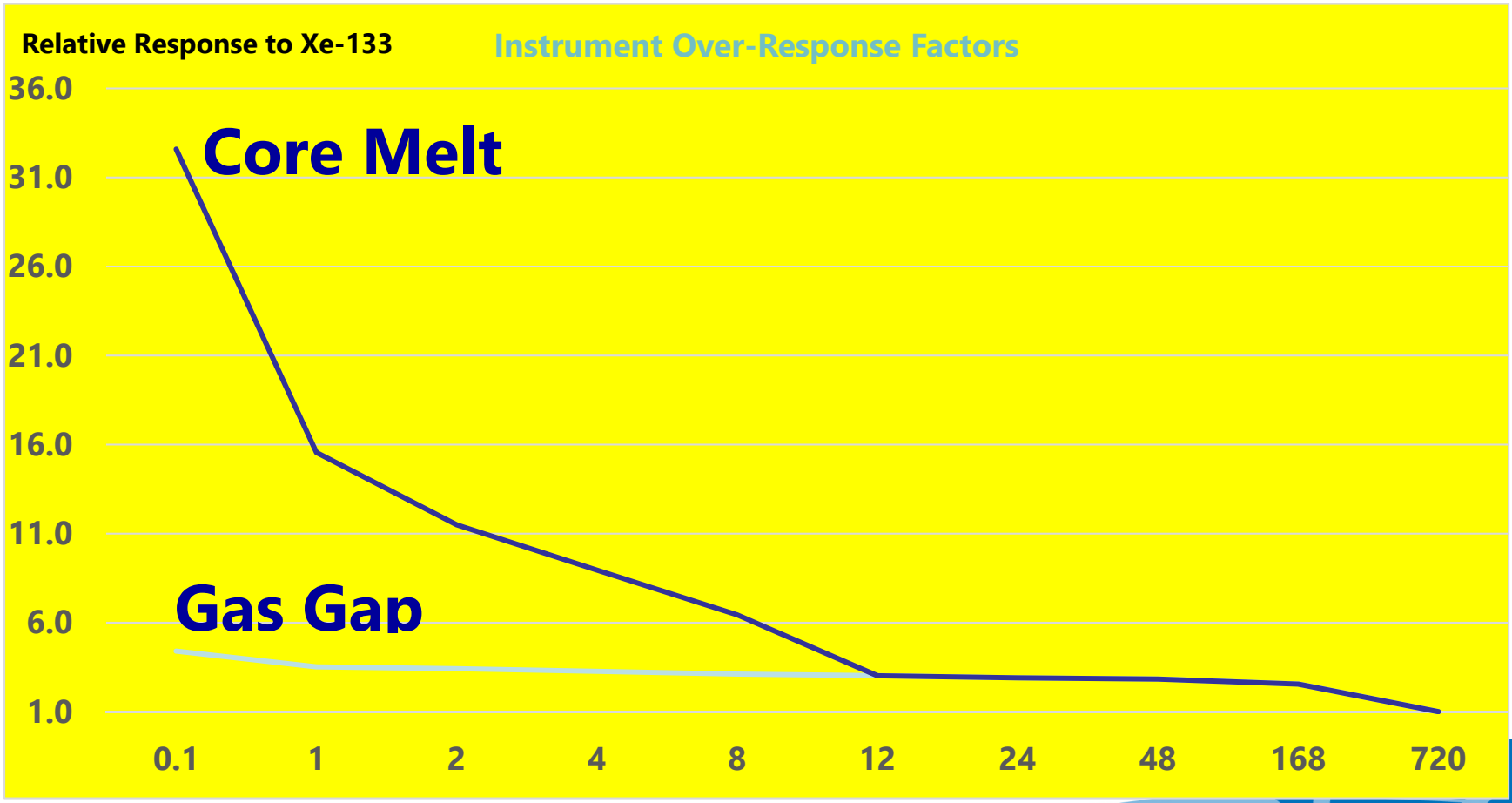
Nuclide	Half Life (hours)	gamma energy keV
Kr-83m	1.9	9
Kr-85m	4.5	150
	4.5	305
Kr-85	94,000	514
Kr-87	1.3	403
	1.3	674
	1.3	845
	1.3	1,175
	1.3	1,740
	1.3	2,010

	Half Life	keV
Kr-88	2.8	166
	2.8	196
	2.8	362
	2.8	835
	2.8	986
	2.8	1,000
	2.8	1,140
	2.8	1,180
	2.8	1,530

	Half Life	keV
Kr-89	0.053	197
	0.053	221
	0.053	345
	0.053	369
	0.053	411
	0.053	498
	0.053	586
	0.053	696
	0.053	738
	0.053	776
	0.053	836
	0.053	867
	0.053	904
	0.053	1,108
	0.053	1,117
	0.053	1,274
	0.053	1,324
	0.053	1,473
	0.053	1,501
	0.053	1,532
	0.053	1,694
	0.053	1,903

	Half Life	keV
	0.053	1,903
Xe-131m	288	164
Xe-133m	55	223
Xe-133	127	81
Xe-135m	0.25	527
Xe-135	9.2	250
	9.2	608
Xe-137	0.065	455
	0.065	1,491
Xe-138	0.3	153
	0.3	242
	0.3	258
	0.3	396
	0.3	401
	0.3	434
	0.3	1,114
	0.3	1,768
	0.3	1,851
	0.3	2,005
	0.3	2,016

GM Instrument Response Factors (based on calibration to Xe-133)



Plant Staff Responsibilities

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- Plant staff should know:
  - which department is in charge
  - what equipment is installed
  - how equipment works (vendor manuals and calibrations)
  - how calibration checks are performed
  - the basis for instrument response factors
  - how monitor output interfaces with dose assessment codes

NRC presentation at REEW in 2018

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Accident-Range Gaseous Effluent Monitoring Calibration and Time-Dependent Instrument Response Factors

ADAMS ML18171A035

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Iodine and Particulate (I&P) Monitoring

- NUREG-0737, Item II.F.1-2 (ML051400209)
- Real-time iodine and particulate monitoring is not required
- However, licensees should have procedures for sample collection and analysis of hot samples
- Real-time dose assessment can be performed using scaling factors to noble gas

Containment High Range Monitors (CHRMs)

- CHRMs measurements are used in Emergency Action Levels (EALs) and for core damage assessment
- Core damage assessment methods are in NUREG-1940, "*Radiological Assessment System for Consequence Analysis (RASCAL)*" section 1.2.8 and NUREG-1940, Supplement 1, Section 2.6
- Licensee staff perform a one-point radiological calibration check below 10 R/hr
- Licensee staff perform an electronic calibration check for each decade above 10 R/hr

NRC staff training CHRMs

- NRC gave training to NRC inspection staff on CHRMs in 2021

- Training material is publicly available at ML21327A271

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Questions & Discussion

Acronyms

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ARERR	Annual Radioactive Effluent Release Report
CHRM	Containment High Range Monitor
FRD	Facility-Related Dose
GALE	Gaseous and Liquid Effluents
GW	Ground Water
GM	Geiger-Mueller
GPI	Groundwater Protection Initiative
LLD	Lower Limit of Detection
ODCM	Offsite Dose Calculation Manual
RASCAL	Radiological Assessment System for Consequence Analysis
RG	Regulatory Guide
TS	Technical Specifications