NRC Update
NEI Radiation Protection Forum

Steve Garry, CHP

Sr. Health Physicist
Office of Nuclear Reactor Regulation
Division of Risk Assessment
U.S. Nuclear Regulatory Commission

August 2, 2022
(ML22208A284)

RG 1.21 - Accident-Range Gaseous Effluent Monitoring

- RG 1.21 summarizes previously issued NRC requirements and guidance in:
  - NUREG-0578 (July 1979) ~ TMI Short Term Items
  - NUREG-0660 ~ TMI Action Plan Requirements
  - 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”
  - NRR Letter to Regional Administrators, (August 16, 1982) “Proposed Guidance for Calibration and Surveillance…”

Accident-Range
Gaseous Effluent Monitoring

- NUREG-0737, TMI Action Plan Requirements
- 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 in Tables II.F.1-1, II.F.1-2, and II.F.1-3

Containment High Range Monitors (CHRM)

- CHRM 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

RG 1.21 Accident-Range Gaseous Effluent Monitoring

- RG 1.21 summarizes previously issued NRC requirements and guidance in:
  - NUREG-0660 ~ TMI Action Plan
  - 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”

Accident-Range
Gaseous Effluent Monitoring

- NUREG-0737, 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 in Tables II.F.1-1, II.F.1-2, and II.F.1-3

Accident-Range Radiation Monitors

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

Three different criteria:

- Design criteria:
  - RG 1.97 establishes a factor of 2 for "design criteria," not a "calibration criteria"
- Calibration criteria:
  - NUREG-0737 – **sufficient to perform intended function**
  - ANSI N320-1979 and IEEE-497 – generally ± 40% – ± 50%
- Measurement criteria:
  - Effluent monitors should be able to measure fresh noble gas mixtures (0 – 10 days) within overall system accuracy factor of 2
  - CHRMs should be able to measure within factor of 2

Calibration of Accident-Range Radiation Monitoring Equipment

- Health Physics Position (HPPOS-001) is a summary of the NRC guidance on meeting NUREG-0737, Item II.F.1 calibration and surveillance criteria is in 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

- Actual guidance is in a letter from NRR to NRC Regional Administrators (ML103420044)

See the memorandum from D. G. Eisenhut to Regional Administrators

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

- GM detector, scintillator or CdTe(Cl) detector output is in cpm or mR/hr
- Manufacturer provides energy response characterization from low to high gamma energy (~81 keV to 3 MeV)
- Manufacturer provides instrument response factor (efficiency factors) for Xe-133 (and Kr-85 for scintillators and CdTe(Cl) detectors)
- Licensees perform periodic calibration checks with a solid source

$$- \frac{uCi/cc}{mR/hr} \; or \; \frac{\frac{uCi}{cc}}{cpm} (Xe - 133 \; or \; Kr - 85)$$

- Licensees perform periodic calibration checks with a solid source to ensure proper operation

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

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

NUREG-0737 Item II.F.1-3
Containment High Range Monitor (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

In-plant calibration checks

- Instrument and Control (I&C) technicians do a one-point radiological calibration check in the first scale/decade
- I&C do an electrical calibration checks for higher scales/decades
- HP only provides radiological support (RWP, pre-job briefings, and job coverage)
- “Instrument response factors” (efficiency factors) are normally NOT adjusted

Instrument Response Factors (Efficiency Factors)

- Noble gas monitoring instruments are GM detectors, plastic scintillators, and CdTe(Cl) solid-state detectors, typically ~2 mm x 2 mm x 5 mm size
- Each solid-state detector has its own counting efficiency – (Monticello, Waterford examples)
- 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)

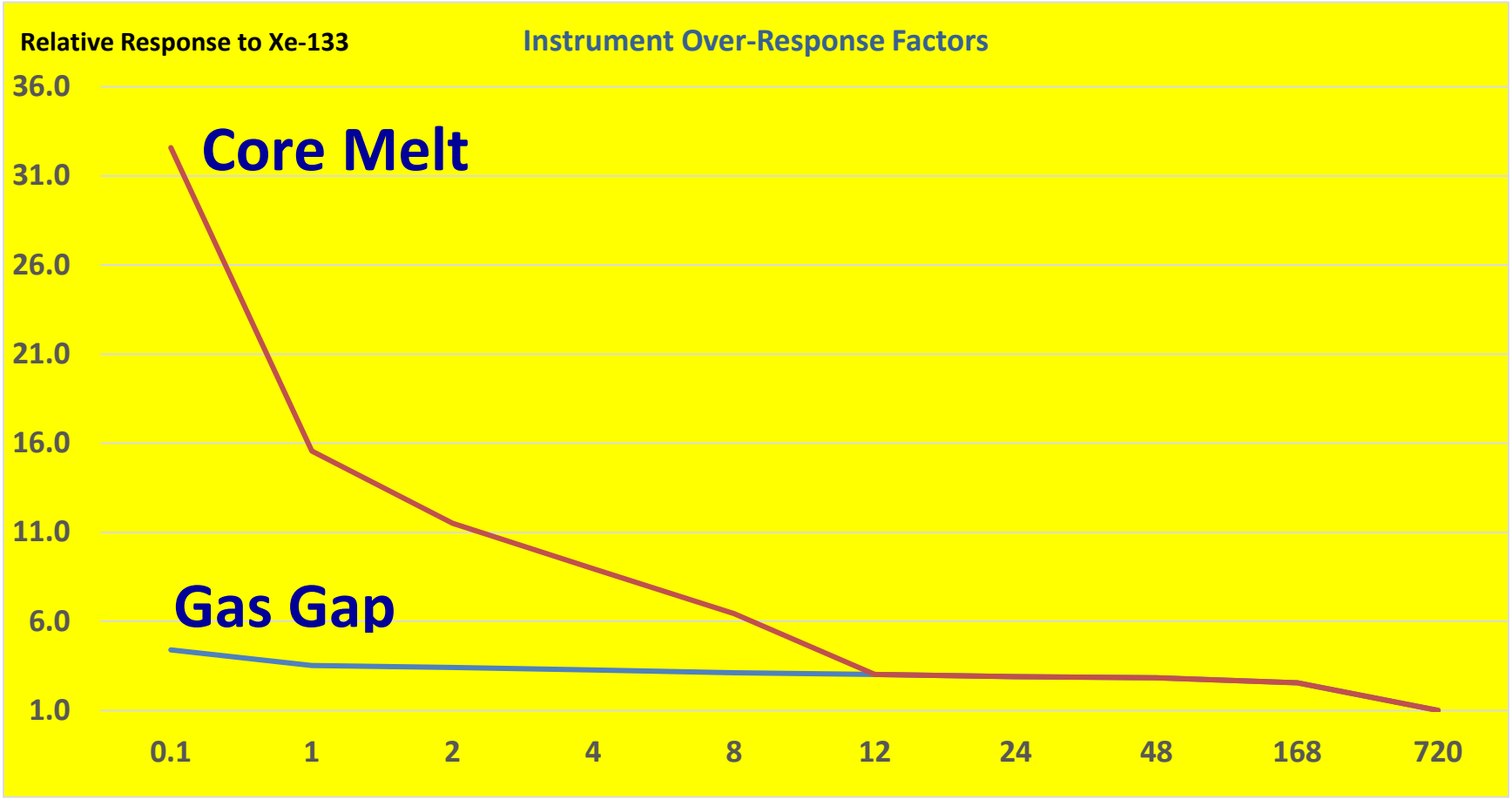
Instrument Response Factors
(Efficiency Factors for effluent monitors)

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

Radionuclide Mix

- Gaseous effluent is not just Xe-133
- Gaseous effluent is a **mix** of noble gases, and is very time dependent
- Generally, short-lived noble gas nuclides have higher energy gammas than long-lived nuclides
- Efficiency factors are 10 – 30 times higher for high energy gammas
- A time-dependent efficiency factor (instrument response factor) is needed

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



Potential Errors in Use of Efficiency Factors (instrument response factors)

- Licensees use wrong calibration geometry
- Licensees may use wrong efficiency factors
  - Assume 1 efficiency factor fits all detectors
  - Replace detectors and do not update efficiency factors (particularly General Atomics CdTe(Cl) solid state detectors
  - Apply Xe-133 efficiency factor to the radionuclide mix

Plant staff responsibilities

- Plant staff:
  - Some plants have lost their rad-engineering expertise
  - I&C does calibrations without knowledge of radiological response characteristics

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

2018 REEW Presentation - Effluent Monitoring

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

ADAMS ML18171A035

Steve Garry, CHP

Sr. Health Physicist

Office of Nuclear Reactor Regulation

U.S. Nuclear Regulatory Commission

Radiological Effluents and Environmental Workshop
June 27, 2018

New Orleans, LA

Iodine and Particulate (I&P) Monitoring

- NUREG-0737, TMI Action Plan Requirements, 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 (CHRM)

- CHRM 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 developed, provided, and recorded training on CHRMs calibration in 2021

- Training slides are publicly available at ML21327A271

Plant staff responsibilities

- Plant staff:
  - Some plants have lost their rad-engineering expertise
  - Instrument and Control (I&C) staff may be doing calibrations without knowledge of radiological response characteristics
- Plant staff should know:
  - what equipment is installed
  - which department is in charge
  - how equipment works (vendor manuals and calibrations)
  - how calibration checks are performed
  - the basis for efficiency factors and detector specific factors
  - how monitor output interfaces with dose assessment codes

Questions & Discussion