Lessons Learned from Issues Affecting Radiation Monitors- White Paper

Purpose

This white paper provides a summary of issues associated with plant radiation monitors that are relied upon to implement a site emergency plan, along with lessons learned and recommendations to prevent their occurrence. The issues were documented in notices of violations given to licensees over the past 10 years by the U.S. Nuclear Regulatory Commission (NRC) and are associated with challenges to the calibration, maintenance, and use of radiation monitors.

Background

In response to the Three Mile Island (TMI) accident in 1979, the NRC published NUREG-0737, "Clarification of TMI Action Plan Requirements," in 1980 (NUREG-0737). This NUREG contains requirements related to radiation monitoring and underscores the importance of the relationship between a properly maintained Radiation Monitoring System (RMS) and a site's Emergency Action Level (EAL) thresholds, dose assessment capabilities, and Protective Action Recommendation (PAR) decision-making scheme. A site emergency classification scheme has thresholds based on both operational and radiological indications, including effluent radiation monitor readings. Radiological effluent EALs are included in a scheme to provide a basis for classifying events and conditions that cannot be readily or appropriately classified based on plant conditions alone. The inclusion of both plant condition and radiological effluent EALs more fully addresses the spectrum of possible accident events and conditions.

In 2015, the NRC issued Information Notice (IN) 2013-13 Revision 1, "Deficiencies with Effluent Radiation Monitoring System Instrumentation," (ML14253A270) which identified 11 RMS-related issues dating back to 2007. This IN discusses operating experience with effluent monitoring systems and clarifies that the scope of a Maintenance Rule[1] monitoring program includes only those RMS components relied upon to mitigate accidents or transients or are used in plant emergency operating procedures (EOPs). RMS components outside those bounds are not covered by the Maintenance Rule; however, they may support implementation of other license-related requirements (e.g., functions described in a site emergency plan) and should therefore be considered of equal importance. Since the issuance of that document, there have been an additional 15 RMS-related events significant enough to warrant an NRC finding including seven since 2020.

Due to the relatively high number of findings related to RMSs and an increased inspection interest from the NRC, EPRI conducted an analysis of the events since 2013 to identify the technical issues or insights that may warrant additional guidance to improve industry performance in this area. While the data used in the analysis for this white paper comes from nuclear power plants in the U.S., it should be noted

[1] These are site programs required by 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants." (10-CFR-50.65)

that most plants outside the U.S. also use radiation monitoring data to support accident assessment and emergency response functions.

Expertise

Proper maintenance of a site RMS is a multi-disciplinary responsibility involving personnel from radiation protection/health physics, maintenance, instrumentation and controls (I&C), chemistry, engineering, and emergency preparedness (EP). Recognizing this fact, EPRI established an industry working committee consisting of individuals with expertise in these areas to help define project steps, conduct the analysis, and identify lessons learned and recommendations. Additionally, since the topic of this white paper involves regulatory and industry performance, EPRI collaborated with both the Nuclear Energy Institute (NEI) and the Institute of Nuclear Power Operations (INPO) to ensure alignment on the identified issues and recommendations.

Approach

Summaries of each event were prepared, and event categories were defined. The industry working committee and knowledgeable representatives from EPRI, NEI and INPO then reviewed each event to identify:

- the appropriate event category,
- causal and common factors,
- lessons learned, and
- recommendations to prevent occurrence.

The summaries, lessons learned, and recommendations for each event can be found in the Event Summaries section at the end of this paper. For the deepest insight, it is recommended that the reader review both the summaries and the individual inspection reports.

Insights

An aggregate review of the separate events and input from industry working committee members indicate that three causal factors contributed to most of the findings. These factors are:

- The ties between the RMS and emergency plan processes are not well understood.
- The ownership of the site RMS is not clearly defined.
- The site staff's knowledge of, and expertise with, their RMS has declined over time.

Radiation Monitors and Emergency Plan Processes

A common theme in many of the events reviewed in this paper is that site personnel had an incomplete understanding of how the site RMS is foundational to the performance of the EP functions of emergency classification, dose assessment, and development of protective action recommendations.

Ownership of Radiation Monitoring Systems

For a given site, the fundamental question of who owns a site RMS may not have a clear answer. This challenge arises because no one group has responsibility for all the functions necessary to design, install, maintain, calibrate, and use the system. In some cases, ownership is not defined, and in other cases

ownership has been reassigned multiple times. Many groups such as Radiation Protection, Chemistry, Engineering, I&C, or Emergency Preparedness play a role in the maintenance, calibration, and use of the RMS, and could be assigned ownership. Regardless of which group is assigned ownership, they must recognize that the system supports compliance with NRC requirements in multiple areas, including emergency operating procedures, radiation protection, radiochemistry, effluent releases, and emergency preparedness. Ownership of the system includes the responsibility to understand and protect the system design functions and basis. It also includes ensuring proper calibration, maintenance and troubleshooting methodologies. Some sites utilize a multidisciplinary group for oversight of the RMS that includes all stakeholders to ensure the above responsibilities are appropriately addressed.

The event reviews also identified two management/supervisory level contributing factors that relate to ownership:

- There was inadequate oversight of activities affecting the site RMS or use of RMS data. It appeared that site leadership and management did not give enough attention to the "health" of the RMS or its components because of the greater focus and higher priorities placed on the maintenance of other plant systems.
- Insufficient resources were made available to properly maintain the RMS (e.g., missing or degraded equipment was tolerated, system engineering support was not provided, proper basis documentation was not maintained).

Knowledge and Expertise

Most sites have lost personnel such as RMS engineers, radiological engineers, HP/RP staff, and I&C technicians who had extensive experience with the design and maintenance of the RMS. These were individuals who may have been at the site for multiple decades, sometimes since plant startup, and knew the history of the RMS and important details about maintenance and calibration activities such as reproducible geometries, traceable sources, proper dose conversion factors, etc. Because of their deep knowledge they also understood that RMS capabilities and functionality supported compliance with the requirements of various site programs like operations, radiation protection, chemistry, and emergency preparedness. This allowed them to provide robust technical, independent, and cross-discipline reviews of engineering and maintenance activities affecting the RMS.

In addition to the loss of experience there is also a loss of knowledge related to the location, retrievability, and need to reference basis documentation from vendors, manufacturers, and others. Updates to vendor documents may not be well tracked or readily known or available. Vendor guidance also needs to be validated. Whether vendor guidance is available or missing, the design basis of the RMS needs to be maintained.

As site organizations have evolved, there are typically no longer specific individuals designated to support the RMS; this impedes the development of a new cadre of plant staff with knowledge and experience levels similar to their predecessors. To complicate the issue, many sites have classified the RMS to be a "low importance" system and no longer provide dedicated engineering support to the RMS. Further, the application of operating experience, participation in industry user's groups, and peer assessments has declined. Over time, the absence of such a cadre can lead to inadequacies in areas such as:

- technical, independent, and cross-discipline reviews

- work planning
- independent work or post-work verification and validation
- procedures
- training
- equipment and tools
- database controls
- performance of maintenance and calibration activities
- regulatory compliance

It was noted that causal and contributing factors were often present in combinations which resulted in an issue not being self-identified or not being corrected in a timely and effective manner after initial recognition.

Recommendations

General Recommendations

From the above discussion, general recommendations include:

- Designate an owner of the RMS and define the roles and responsibilities of the groups that use and maintain the system.
- Identify the knowledge and skills needed to perform system maintenance and calibration activities and provide appropriate training and coaching/mentoring to workers.
- Include in training and coaching/mentoring opportunities a discussion of the reliance of site programs (e.g., performance of emergency plan functions) on the capabilities and functionality of the RMS. The goal is to cultivate an appreciation of the interrelationship between RMS operation and the requirements in various site programs, processes, and procedures.

A site should also ensure that up-to-date procedures, equipment, spare parts, and tools are available to workers. In particular, it is important that missing or obsolete equipment and tools be addressed in a timely manner. It is likely that direct support from the manufacturer to address missing or obsolete parts will be required. Similar expert support will likely be necessary if the original manufacturer is no longer available.

Specific Recommendations

In addition to the general recommendations provided above, the following specific recommendations were identified through an analysis of the individual events. It is recommended that the Event Summaries be reviewed for a deeper understanding of the specifics behind these recommendations.

Independent and Cross-Discipline Reviews

There are many types of activities and changes that could affect a site RMS or the use of RMS data. These include:

- New procedures or procedure changes
- Design changes
- Calculations including models used to convert monitor response (e.g., exposure or count rate, R/hr or c/min) to activity concentration, (e.g., µCi/cm^{3}or Bq/m^3)

- Database changes
- Review of maintenance and calibration records
- Software changes (e.g., changes to a dose assessment model, URI interfaces)
- Calibration frequency changes

From the examination of the events listed in this white paper, it is apparent that robust, independent, and cross-discipline reviews are essential to ensuring that activities or changes do not impact the availability, accuracy, or proper use of RMS data. While reviews can vary in scope and depth depending on the topic, the rigor of any given review process should be commensurate with the potential consequences of an error. This is particularly true for activities and changes that affect RMS capabilities and data supporting implementation of the EP functions of emergency classification, dose assessment, and protective action recommendations. These EP functions are associated with the NRC's "risk-significant planning standards" as defined by the NRC Inspection Manual Chapter 0609 Appendix B, 'Emergency Preparedness Significance Determination Process", Section 5.10 (ML15128A462) because of their important role in emergency plan implementation and protection of the public. The majority of greater-than-green findings issued by the NRC under the EP cornerstone were for issues associated with a risk-significant planning standard. Robust review processes are a critical barrier for preventing an activity or change that challenges the performance of EP functions. A robust review process must include a diversity of expertise that adequately covers the change being made.

It is important that independent and cross-discipline reviews are performed by Subject Matter Experts (SMEs), as appropriate to the nature of the proposed activity or change. For example, these could be SMEs knowledgeable in radiation detector design and installation, geometry source term modeling, EAL and PAR scheme development, offsite dose assessment software, etc. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered. With respect to new or changed dose assessment software, the program should be subjected to a functional testing and validation process before implementation and consistent with requirements in the site's quality assurance program.

RMS Database Configuration Control

The RMS database requires a rigorous change control process. One way to accomplish this is to utilize a high-level procedure to categorize and define the change processes for various database parameters. To ensure database changes are made when needed, all documents controlling work on the RMS, such as procedures, engineering design changes, and maintenance work orders, should point to the high-level procedure governing the database change control process. Another option is to prevent exiting calibration procedures until the database is updated for the changes that were required. The error trap to address is to ensure that the work management process requires that the most up to date values are entered into the system before the work management process can be exited.

Vendor Guidance

Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed

vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS. In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

Detector Replacements

The steps to perform a detector replacement should be included in appropriate work procedures (e.g., the routine calibration procedures for each model detector). In the detector replacement process where Engineering Units Conversion Factors (ECFs) require alteration, the associated procedure should point to the appropriate steps in the database change control process. This is to ensure that the correct ECFs are maintained until the next detector replacement. ECF changes may also require the reconciliation of calibration transfer source acceptance criteria. When these revised transfer source calculations are performed for solid state detectors and some area monitors (e.g., GM and ion chambers) compare the originally installed detector ECF and the transfer source response(s) (or replacement source dedication), to determine the correction ratio (new ECF/original ECF) for the decay correction of the source response(s). Failure to use the data from the original detector and transfer source response(s) (or replacement source dedication) in the process will propagate uncertainties in the calculated transfer source acceptance criteria. Source replacements involve similar concerns.

Transfer Source Positioning

Proper RMS calibration procedures and processes must maintain a reproducible geometry traceable to the primary calibration. Ensure all transfer (or secondary) calibrations of radiation monitors are performed using reproducible geometries, preferably using source jigs that ensure consistent reproducible geometries.

Source Jigs

Clearly established controls for source jigs should be established. When possible, the original source jig should be maintained. All source jigs should be labeled and tracked appropriately for each detector type. Ensure source jigs are sufficiently described in the calibration procedure(s). It is strongly recommended that the procedure(s) include pictures or figures depicting setup and positioning. The basis for the reproducible geometry should be properly documented and maintained with the applicable primary and associated transfer calibration documentation. If the site does not have the original source jig and a new jig must be designed, it is important that the new design provides the same geometry, fit, form and function as the source jig used when the transfer response data for a particular source was first obtained.

Primary/Transfer Calibration Documentation

Calibrations are typically performed utilizing radioactive sources that are traceable to National Institute of Standards and Technology (NIST) standards. Source certificates identifying such traceability should be maintained and easily retrievable. All transfer (or secondary) calibration data must be traceable to the

initial transfer source response obtained when the primary calibration was performed, or otherwise qualified, i.e., a technical basis for transfer source(s) replacement. This technical basis becomes the reference for the transfer calibration mean response(s) using the replacement source going forward. Documentation of the primary calibration and transfer source response(s) following the primary calibration (or replacement source dedication) must be available and should be referenced in the routine calibration procedure. When the initial transfer source requires replacement, and the existing transfer source response(s) does not have sufficient pedigree, i.e., a replacement transfer source is not available in the same geometry (fit, form and function), a new primary calibration is required to dedicate a new transfer source(s).

Transfer Source Decay

Transfer (or secondary) source decay correction calculations should include the half-life of the transfer calibration isotope to a sufficient number of significant digits. Failure to use a sufficiently granular half-life value can propagate significant error over the life of the source. For example, using 30 years as the half-life of ^{137}Cs versus 30.17 years will introduce an ~15% error in the decayed values after 30 years of operation which is equivalent to many site's calibration acceptance criteria bounds. Similarly, the minimization of propagated errors in transfer source decay calculations should always use initial (or initial replacement) transfer source mean response value as the initial response value to be decayed. Use of the last transfer calibration response for determining the current desired transfer calibration bounds, continually propagates additional errors because of rounding and the fluctuation of both radioactive decay and background.

Implementation of Design Change Operating Procedure(s)

Plant design changes should clearly identify affected equipment that provides inputs for, or interfaces supporting, emergency classification assessments, dose assessments, and PAR decision-making. The design change package should also specify required compensatory measures and list the new or revised procedures needed to operate the new or modified equipment. Procedures required for post-installation operation should be prepared in advance and issued concurrent with declaring design operability.

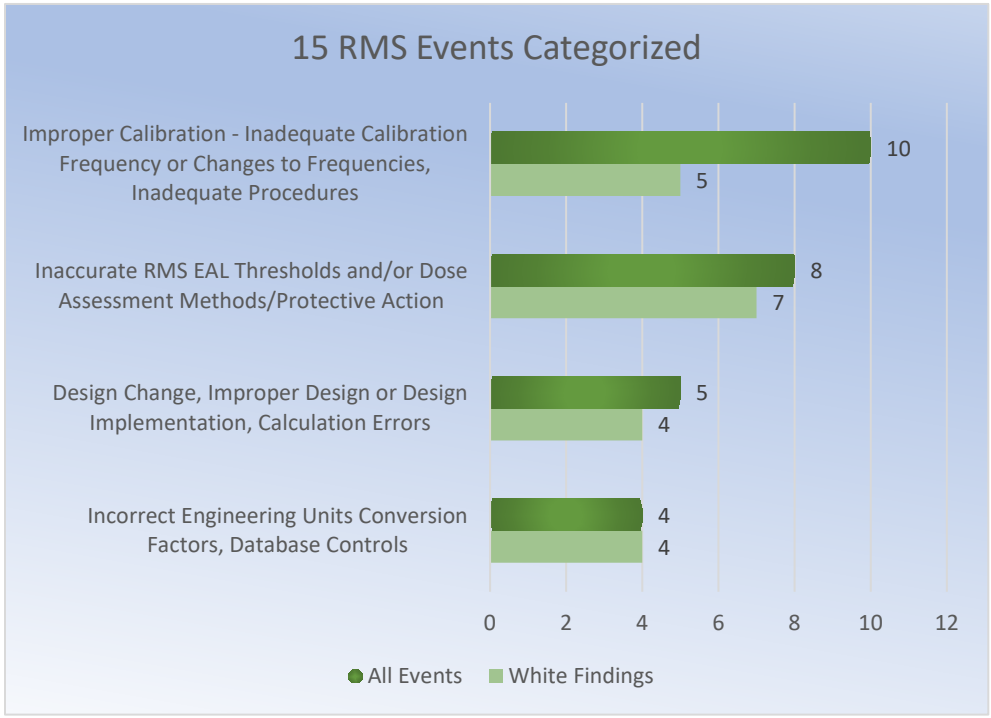
Radiation Monitor Placement, Detector/Process Response Conversion Factor(s) and Shielding

Design and placement of radiation monitors should include an evaluation of background impacts and the need for shielding. For adjacent-to-line process monitors, ensure that a qualified SME is engaged in the design to: 1) identify the most suitable location and position of the detector, 2) create the model for determining the exposure rate to activity concentration conversion factor, and 3) specify the shielding type and thickness. A good example of an exposure rate to activity concentration calculation is converting the response of a PWR main steam line monitor from mR/hr to a release rate in µCi/s from a primary to secondary tube leak. Appropriate independent and cross-discipline reviews must be performed that consider the risk commensurate with the potential consequences of errors.

Analysis

To begin the analysis, a search of the NRC ADAMS database was conducted to identify regulatory findings in the U.S. related to radiation monitors over the past decade. This search found 15 RMS related events. Four event cause categories were defined, and each event was placed in one or more categories as appropriate to its cause (most events spanned more than one category). A summary of the event cause categorization results is depicted in Figure 1.

Figure 1: Categorized RMS Events



This assessment shows that issues involving improper calibrations or errors affecting EAL thresholds, dose assessment, and/or protective action recommendations were the primary factors in the majority of the cited violations. Design issues and calculational errors are also cited in many of the violations.

Each event was then evaluated to identify causal factors. An aggregate review of the events and technical judgment were used to identify 13 different potential causal factors. Each event was then evaluated against these causal factors, and as expected, multiple causal factors were identified for each one. Table 1 summarizes the outcome of this analysis.

Table 1: Causal Factor Analysis

ID	Topic(s)	Inadequate Knowledge or Expertise	Inadequate Procedures/ Frequency Change Guidance	Inadequate Vendor Guidance	Inadequate Design or Design Implementation/Calculations	Inadequate Database Controls	Inadequate Independent Verification/Review Rigor	Inadequate Cross-Discipline or Stakeholder Review/Input	Inadequate/Untimely Corrective Actions	Inadequate Calibration Method/Tools	Inadequate Reproduceable Calibration Geometry	Human Performance	Missed Opportunities	Overall System/Software Ownership
2023 A	2, 3	X	X	X		X	X	X		X			X	X
2023 B	3	X	X					X		X			X	
2022 A	1, 2, 3	X	X	X		X	X	X		X			X	X
2022 B	1, 2, 3	X	X	X		X	X	X				X	X	X
2022 C	3	X	X				X	X		X			X	X
2022 D	3		X											
2020 A	1, 2, 3	X	X	X			X	X		X	X		X	
2019 A	1, 4	X			X		X	X				X		X
2018 A	1, 3, 4		X		X		X	X						X
2017 A	3		X				X	X				X		
2017 B	1, 4	X			X		X	X	X			X	X	X
2017C & 2015A	3	X		X			X	X	X	X	X		X	X
2014 A	1, 4				X		X	X				X	X	
2014 B	1, 4				X		X	X				X	X	
Totals		9	9	5	5	3	12	13	2	6	2	6	10	8
	1	Inaccurate RMS EAL Thresholds and/or Dose Assessment Methods/Protective Action Recommendations												
	2	Incorrect Engineering Units Conversion Factors/Database Controls												
	3	Failure to Properly Calibrate (Includes Insufficient Calibration Frequencies 10CFR20.1501(c)), Inadequate Procedures												
	4	Design and/or Calculation Errors												

In this analysis, inadequate cross-discipline review, inadequate independent verification, inadequate knowledge or expertise, inadequate procedures, missed opportunities, and ownership stand out as the most common contributing factors.

Thirteen events identified Inadequate Cross-Discipline or Stakeholder Review/Input as a contributing causal factor. Examples of these include:

- Changing calibration frequencies without engaging an RMS SME.
- An engineering calculation that did not include a review by a health physicist

Twelve events identified Inadequate Independent Verification/Review Rigor as a contributing causal factor. Examples of these include:

- Procedures containing typographic errors in critical values
- Calculations containing errors that should normally be caught with a proper independent verification

Ten events identified Missed Opportunities as a contributing causal factor. Examples of these include:

- Failure to implement corrective actions in a timely manner
- Failure of preparers and checkers to recognize the technical risk associated with calculations supporting emergency preparedness and utilize sufficient rigor

Nine events identified Inadequate Knowledge/Expertise as a contributing causal factor. Examples of these include:

- Transfer calibration attempts not in a fixed and repeatable geometry
- Failure to identify when Engineering Unit Conversion Factors (ECF) changes are required following detector replacement in digital radiation monitor systems.
- Configuration of an adjacent-to-line RMS detector in the plant without background collimation

Nine events identified Inadequate Procedures as a contributing causal factor. Examples of these include:

- Not directly referencing the initial transfer calibration criteria which should be directly in the procedure and easily retrieved by document number
- Procedures containing errors in proper transfer calibration methodologies
- Failure to incorporate vendor guidance into a transfer calibration procedure

Eight events identified Overall System/Software Ownership as a contributing causal factor. Examples of these include:

- An evaluation was completed during a preventative maintenance ownership group meeting that improperly changed the calibration frequencies of over 50 radiation monitors without involving any other stakeholders
- Multiple instances of relevant stakeholders not being engaged when evaluating changes to the RMS

Next Steps

This project is planned to assess radiation monitor issues in two phases. The first phase, documented in this white paper, summarizes the issues from the past 10 years and provides the associated lessons learned, casual factors, and prevention recommendations. The second phase will delve more deeply into the technical requirements associated with maintaining a healthy RMS and proper utilization of outputs utilized as inputs to EAL Thresholds, dose assessment and protective action recommendations.

Event Summaries

As noted above, a search of the NRC ADAMS database was conducted to identify regulatory findings in the U.S. related to radiation monitors over the past decade. This search found a number of White findings, Green findings, Green non-cited violations, and one closed Unresolved Issue. Summaries of these findings, violations, and issues are presented below in reverse chronological order (from most recent to oldest), and are intended to provide a brief, high-level description of the event, an assessment of the most significant lessons learned, and recommendations to prevent occurrence.

Links to the documents in ADAMS are provided for readers who wish to see more detail on one or more of the events. Depending upon the event method of discovery, and the administrative processes applied, not all event summaries will necessarily depict the same correspondence sequence.

2023A: White Finding, Failure to Maintain a Standard Emergency Classification and Dose Assessment Scheme Due to Incorrect/Inadequate RMS Conversion Factors and Calibration Methods

EA-23-071 Final Finding: ML23201A132

This White Finding of low to moderate safety significance identified a failure to maintain a standard emergency classification scheme as required because the Main Plant Exhaust Primary, Main Plant Exhaust Secondary, Fuel Building Ventilation Primary, the Radwaste Building Vent Primary, and the Liquid Radwaste Effluent radiation monitors had errors related to the calibration of RMS causing them to read lower values than they should, resulting in emergency action levels (EAL) up to the General Emergency level to be ineffective. The finding involved errors in database controls and calibration procedures for radiation monitoring systems which introduced the potential to improperly classify radiological emergencies up to a General Emergency. These errors were introduced as part of a detector replacement process. In addition, the licensee failed to use adequate methods, systems, and equipment for assessing and monitoring actual and potential offsite dose consequences of a radiological emergency as required because those same errors (excluding the Liquid Radwaste Effluent Monitor since it is not used for dose assessment) would result in inaccurate dose assessments for a radiological release through the main plant exhaust, fuel building, and radwaste building paths.

Licensee Response: ML23257A251

Lessons Learned:

Procedures and/or methods can introduce errors into the calibration of RMS monitors used for determining EAL thresholds and offsite dose assessment. Replacement of detectors may require update of the ECFs. The change process should direct review and update of the ECF for detector replacements.

Recommendations:

RMS Database Configuration Control

The RMS database requires a rigorous change control process. One way to accomplish this is to utilize a high-level procedure to categorize and define the change processes for various database parameters. To ensure database changes are made when needed, all documents controlling work on the RMS, such as procedures, engineering design changes, and maintenance work orders, should point to the high-level procedure governing the database change control process. Another option is to prevent exiting calibration procedures until the database is updated for the changes that were required. The error trap to address is to ensure that the work management process requires that the most up to date values are entered into the system before the work management process can be exited.

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Detector Replacements

The steps to perform a detector replacement should be included in appropriate work procedures (e.g., the routine calibration procedures for each model detector). In the detector replacement process where Engineering Units Conversion Factors (ECFs) require alteration, the associated procedure should point to the appropriate steps in the database change control process. This is to ensure that the correct ECFs are maintained until the next detector replacement. ECF changes may also require the reconciliation of calibration transfer source acceptance criteria. When these revised transfer source calculations are performed for solid state detectors and some area monitors (e.g., GM and ion chambers) compare the originally installed detector ECF and the transfer source response(s) (or replacement source dedication), to determine the correction ratio (new ECF/original ECF) for the decay correction of the source response(s). Failure to use the data from the original detector and transfer source response(s) (or replacement source dedication) in the process will propagate uncertainties in the calculated transfer source acceptance criteria. Source replacements involve similar concerns.

Vendor Guidance

Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS.

In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2023B: Green Finding, Failure to Calibrate Primary Drywell and Containment High Range Area Radiation Monitors

EA-23-019 Final Finding: ML23201A252

This Green Finding of low to moderate safety significance identified apparent calibration failures for the drywell and containment high range area radiation monitors. The licensee failed to perform a calibration in accordance with NRC requirements and then failed to declare these radiation monitors inoperable in accordance with their technical specification requirements and perform the associated limiting condition for operation (LCO) action. Inoperable radiation monitors would be unable to perform their intended function for Emergency Preparedness actions.

Based on review of documents related to the licensee's radiation monitoring instrumentation program, the inspectors identified apparent documented failures of selected radiation monitoring instruments associated with the 'sensitivity' parameters. Upon further review, inspectors determined that all four of the licensee's accident high range radiation monitors failed to be within the 'sensitivity' tolerance specified in the procedure during their last two calibration cycles. The licensee had added the sensitivity parameter check to the calibration procedure as a corrective action associated with a 2017 violation. The preliminary evaluation of this finding was white. By presenting additional information at a regulatory conference, the licensee was able to demonstrate that the monitors were indeed within the +/-20% source exposure criteria for the last two calibration cycles. The determination of a sensitivity parameter using a point source on the lowest decade was removed from the procedure as it was well intentioned but misapplied.

The procedure was corrected to use the source exposure tolerances (+/- 20%) as specified in the vendor manual. Additional procedural instructions were added to use the plant's Safety Parameter Display

System (SPDS) as the readout location because of the higher resolution compared to the analog logarithmic display. The sensitivity parameter check on the lowest decade was deleted in favor of using the single transfer source exposure rate tolerance on the lowest decade, combined with the current injection verification (electronic calibration) already performed on each decade consistent with NUREG 0737 and HPPOS-001 ML103420044 guidance for high range containment area monitors.

A contributing factor was related to verifying the correct transfer source exposure rate for the desired mean response. This was resolved after obtaining the initial vendor transfer source dedication certificate depicting traceability to the primary calibration.

EA-23-019 Licensee NOV Response: ML23240A395
EA-23-019 Regulatory Information Conference: ML23193A841
EA-23-019 Inspection Report and Preliminary Finding: ML23122A163

Lessons Learned:

Procedures should reflect vendor guidance and provide specifics from where responses are obtained. A point source measured dose rate cannot be compared to the free air sensitivity of the detector when obtained on a calibration range because the point source cannot uniformly irradiate the full volume of the detector. Transfer (or secondary source) response must be obtained from a vendor certificate or other primary calibration document that depicts the transfer source traceability to the primary calibration.

Recommendations:

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Vendor Guidance

Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS. In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

Primary/Transfer Calibration Documentation

Calibrations are typically performed utilizing radioactive sources that are traceable to National Institute of Standards and Technology (NIST) standards. Source certificates identifying such traceability should be maintained and easily retrievable. All transfer (or secondary) calibration data must be traceable to the initial transfer source response obtained when the primary calibration was performed, or otherwise qualified, i.e., a technical basis for transfer source(s) replacement. This technical basis becomes the reference for the transfer calibration mean response(s) using the replacement source going forward. Documentation of the primary calibration and transfer source response(s) following the primary calibration (or replacement source dedication) must be available and should be referenced in the routine calibration procedure. When the initial transfer source requires replacement, and the existing transfer source response(s) does not have sufficient pedigree, i.e., a replacement transfer source is not available in the same geometry (fit, form and function), a new primary calibration is required to dedicate a new transfer source(s).

Transfer Source Decay

Transfer (or secondary) source decay correction calculations should include the half-life of the transfer calibration isotope to a sufficient number of significant digits. Failure to use a sufficiently granular half-life value can propagate significant error over the life of the source. For example, using 30 years as the half-life of ^{137}Cs versus 30.17 years will introduce an ~15% error in the decayed values after 30 years of operation which is equivalent to many site's calibration acceptance criteria bounds. Similarly, the minimization of propagated errors in transfer source decay calculations should always use initial (or initial replacement) transfer source mean response value, as the initial response value to be decayed. Use of the last transfer calibration response for determining the current desired transfer calibration bounds, continually propagates additional errors because of rounding and the fluctuation of both radioactive decay and background.

Calibration Documentation Review

Documentation of calibration activities performed on RMS components should be subject to independent and cross-discipline reviews, with these reviews described in procedures. These reviews should focus on identifying errors in both the calibration data and the calibration processes/methods.

Independent/Cross-Discipline Review

RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME

All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2022 A: White Finding, Use of Incorrect Calibration Methods and Engineering Units Conversion Factors in the Calibration of Radiation Monitors Resulting in the Failure to Maintain Accurate EAL Thresholds and Dose Assessment Methods

EA-22-033 Final Finding ML22241A143

This White Finding of low to moderate safety significance involved errors associated with the improper decay correction of the calibration source(s). An evaluation determined that the mid and high range channels would have read between 69 to 76 percent higher than actual. This resulted in the licensee's failure to maintain a standard emergency classification scheme because the main condenser wide range gas monitor (WRGM) mid and high range detectors had output errors that could result in an over-classification up to a General Emergency, resulting in unnecessary public protective actions. Also, the licensee was cited with failure to use adequate methods, systems, and equipment for assessing and monitoring actual and potential offsite consequences of a radiological emergency because those same errors would result in inaccurate dose assessments for a radiological release through the main condenser exhaust path between January 1, 2011, to February 4, 2022. The NRC considers adequate dose assessments essential to ensuring licensees can make accurate protective action recommendations to state and local officials.

EA-22-033 Licensee NOV Response: ML22285A214
EA-22-033 Regulatory Information Conference: ML22217A007
EA-22-033 Inspection Report and Preliminary Finding: ML22159A275

Lessons Learned:

Several detector technologies require energy calibrations following replacement to determine future reference count-rates. These reference count-rates will be used to evaluate the replacement detector's response when exposed to the calibration source during future surveillances. Methods used to determine the reference values include deriving the values by calculation or using a multi-channel analyzer (MCA). The MCA provides the user with the ability to calculate a replacement detector's count-rate response to the calibration source's photo-peak.

Derivation of the replacement detector reference count-rates can also be calculated in lieu of using an MCA. The reference count-rate can be calculated through decay-correction and accounting for the difference between the old and new detector sensitivities. Nevertheless, it is still important to also verify that the discriminator is set fully below an 80 keV peak using an MCA or a low energy source such as ^{241}Am 60keV, ^{109}Cd 88 keV or both.

However, when deriving the replacement detector reference count-rates for the Condenser WRGM, the licensee failed to decay-correct the original response correctly. In response to the incorrect reference count-rates, adjustments were made such that the Condenser WRGM mid and high range channels would have read between 69 to 76 percent higher than actual.

The initial investigation also revealed that incorrect engineering conversion factors were installed in channels of the plant stack and fuel handling building WRGM.

Engineering units conversion factors (ECF) convert the detector count rate to concentration. Some detectors have detector specific values. The failure to use the correct conversion factor with an individual detector would make the monitor channel read higher or lower than what it should read. Maintenance procedures for detector calibrations must outline the specific steps required if a detector requires replacement following an attempted calibration. Whether the detector replacement occurs under the same calibration procedure or a different work document, the routine calibration procedure is an appropriate place to capture the knowledge associated with ECF changes for replacement detectors, when applicable. This will ensure that the required knowledge is transferred to the new work document and not solely dependent on the knowledge of the personnel preparing (or implementing) the work document. Alternatively, procedures for each model of detector change-out could be developed to inform a detector replacement work document. In this instance, the knowledge of the need to change ECFs for certain replacement detectors was not adequately communicated to site maintenance/planning/engineering personnel.

Administrative processes must be sufficient to manage and control database parameters. Database parameters are generally associated with one of three processes; 1) administrative, that may be frequently changed by procedure, e.g., setpoints, 2) maintenance, e.g., ECF of a replacement detector, and 3) design, e.g., the type of monitor and the number of channels. A database control procedure requires management of all three change processes (administrative, maintenance and design) and a defined master database that is updated with changes. Work processes must point to the master database for the most current ECF. Automatic uploading of individual monitor databases should not be relied upon unless it is verified that the outstanding database changes for the monitor are indeed reconciled with the operating database. A routine PM to reconcile these outstanding changes and perform a database compare between the operating and master databases will ensure that the electronic master database remains current.

Recommendations:

Transfer Source Decay

Transfer (or secondary) source decay correction calculations should include the half-life of the transfer calibration isotope to a sufficient number of significant digits. Failure to use a sufficiently granular half-life value can propagate significant error over the life of the source. For example, using 30 years as the half-life of ^{137}Cs versus 30.17 years will introduce an ~15% error in the decayed values after 30 years of operation which is equivalent to many site's calibration acceptance criteria bounds. Similarly, the minimization of propagated errors in transfer source decay calculations should always use initial (or initial replacement) transfer source mean response value, as the initial response value to be decayed. Use of the last transfer calibration response for determining the current desired transfer calibration bounds, continually propagates additional errors because of rounding and the fluctuation of both radioactive decay and background.

RMS Database Configuration Control

The RMS database requires a rigorous change control process. One way to accomplish this is to utilize a high-level procedure to categorize and define the change processes for various database parameters. To ensure database changes are made when needed, all documents controlling work on the RMS, such as

procedures, engineering design changes, and maintenance work orders, should point to the high-level procedure governing the database change control process. Another option is to prevent exiting calibration procedures until the database is updated for the changes that were required. The error trap to address is to ensure that the work management process requires that the most up to date values are entered into the system before the work management process can be exited.

Detector Replacements

The steps to perform a detector replacement should be included in appropriate work procedures (e.g., the routine calibration procedures for each model detector). In the detector replacement process where Engineering Units Conversion Factors (ECFs) require alteration, the associated procedure should point to the appropriate steps in the database change control process. This is to ensure that the correct ECFs are maintained until the next detector replacement. ECF changes may also require the reconciliation of calibration transfer source acceptance criteria. When these revised transfer source calculations are performed for solid state detectors and some area monitors (e.g., GM and ion chambers) compare the originally installed detector ECF and the transfer source response(s) (or replacement source dedication), to determine the correction ratio (new ECF/original ECF) for the decay correction of the source response(s). Failure to use the data from the original detector and transfer source response(s) (or replacement source dedication) in the process will propagate uncertainties in the calculated transfer source acceptance criteria. Source replacements involve similar concerns.

Vendor Guidance

Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS. In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Calibration Documentation Review

Documentation of calibration activities performed on RMS components should be subject to

independent and cross-discipline reviews, with these reviews described in procedures. These reviews should focus on identifying errors in both the calibration data and the calibration processes/methods.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2022 B: White Finding, Errors Associated with Conversion Factors Used in the Calibration of the Plant Stack Wide Range Gas Monitor Resulting in the Failure to Maintain Accurate Dose Assessment Methods

EA-22-119 Final Finding: ML23025A384

This White Finding of low to moderate safety significance involved a failure to maintain the reliable and accurate indications on the Plant Stack wide range gas monitor (WRGM), High Range Detector. This resulted in the potential to produce inaccurate dose assessments from June 6 to September 9, 2022. On September 8, 2022, the licensee identified that engineering conversion factors for the Plant Stack WRGM had been in error since June 6, 2022. The radiation monitors in the WRGM are inputs to the radiological dose assessment modeling software used in emergency response. The licensee evaluated the issues in an extent of condition review and root cause evaluation and determined that the errors were introduced when an incorrect version of the correction factors database was used to upload the values after maintenance was completed on the WRGM on June 6, 2022. The impact of the error was the affected high range detector would read 30.5 percent lower than it was supposed to. The normal calibration range is plus or minus 10 percent. For emergency plan event classification, the high-range detector would not be used for classifying EALs AU1.1, AA1.1, AS1.1 and AG1.1 (classification is addressed with the mid-range detector, which was not affected by the error). However, the high range detector is used for dose assessment. The error would result in Plant Stack release dose assessments for radiological releases being lower than expected by approximately 30.5 percent and could impact assessment of protective action recommendations for the public at distances of 5 and 10 miles from the site boundary.

The issue resulted from a failure to update a controlled copy of the WRGM conversion factors based on recent calibration activities. Between February 2-4, 2022, the Plant Stack WRGM high-range detector was re-calibrated as part of an ongoing corrective action effort. As part of this, the engineering

conversion factors in question were corrected to reflect the sensitivity values from detector replacement in June 2005. Updates to the Radiation Monitoring System (RMS) control room database manual, which would have captured the updated conversion factor and other information from the calibration for future use, did not occur. Following troubleshooting and repair activities on the Plant Stack WRGM low-range detector on June 6, 2022, a different channel from the high range detector, the conversion factors for all of the detectors were reloaded with RMS database values that did not reflect the changes made between February 2-4, 2022. Work control and information update processes did not provide for use of the most current and accurate database values to ensure WRGM correct function.

A Cross-Cutting Aspect for H.5 - Work Management was identified where the licensee's work management process did not ensure that accurate, up to date information was used appropriately to return equipment in maintenance to full functionality. The process allowed use of an incorrect copy of the engineering conversion factor database during equipment restoration, thus degrading their capability to meet their emergency preparedness function.

EA-22-119 Licensee NOV Response: ML23051A002
EA-22-119 Inspection Report and Preliminary Finding: ML22348A272

Lessons Learned:

Engineering units conversion factors (ECF) convert the detector count rate to concentration. Some detectors have detector specific values. The failure to use the correct conversion factor with an individual detector would make the monitor channel read higher or lower than what it should read. Maintenance procedures for detector calibrations must outline the specific steps required if a detector requires replacement following an attempted calibration. Whether the detector replacement occurs under the same calibration procedure or a different work document, the routine calibration procedure is an appropriate place to capture the knowledge associated with ECF changes for replacement detectors, when applicable. This will ensure that the required knowledge is transferred to the new work document and not solely dependent on the knowledge of the personnel preparing (or implementing) the work document. Alternatively, procedures for each model of detector change-out could be developed to inform a detector replacement work document. In this instance, the knowledge of the need to change ECFs for certain replacement detectors was not adequately communicated to site maintenance/planning/engineering personnel.

Administrative processes must be sufficient to manage and control database parameters. Database parameters are generally associated with one of three processes; 1) administrative, that may be frequently changed by procedure, e.g., setpoints, 2) maintenance, e.g., ECF of a replacement detector, and 3) design, e.g., the type of monitor and the number of channels. A database control procedure requires management of all three change processes (administrative, maintenance and design) and a defined master database that is updated with changes. Work processes must point to the master database for the most current ECF. Automatic uploading of individual monitor databases should not be relied upon unless it is verified that the outstanding database changes for the monitor are indeed reconciled with the operating database. A routine PM to reconcile these outstanding changes and perform a database compare between the operating and master databases will ensure that the electronic master database remains current.

Recommendations:

Vendor Guidance

Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS. In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

RMS Database Configuration Control

The RMS database requires a rigorous change control process. One way to accomplish this is to utilize a high-level procedure to categorize and define the change processes for various database parameters. To ensure database changes are made when needed, all documents controlling work on the RMS, such as procedures, engineering design changes, and maintenance work orders, should point to the high-level procedure governing the database change control process. Another option is to prevent exiting calibration procedures until the database is updated for the changes that were required. The error trap to address is to ensure that the work management process requires that the most up to date values are entered into the system before the work management process can be exited.

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Independent/Cross-Discipline Review

RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME

All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2022 C: Green NCV Open/Closed, Calibration Frequencies Extended Without Proper Screening

Inspection Report 05000482/2022003: ML22294A090

This Green non-cited violation identified a failure to periodically calibrate radiation monitoring equipment used to perform dose rate and effluent measurements. During a review of calibration records, inspectors identified a total of 51 radiation monitors which had not been periodically calibrated since 2019.

Specifically, on December 7, 2020, a change evaluation was completed during a preventative maintenance ownership group meeting which resulted in 35 Area Radiation Monitors (ARMs) being removed from a routine preventative maintenance and/or calibration schedule and were placed in a run-to- maintenance operating mode. "Run-to-maintenance" is not a frequency; it is a maintenance strategy. In addition, 16 process and effluent radiation monitors were moved to a three-year calibration frequency. The change was approved by the preventative maintenance ownership group without the involvement of impacted stakeholders (radiation protection organization, emergency planning, or licensing). In addition, the ownership group did not recognize these radiation monitors were used to provide radiological surveys and information as defined in 10 CFR Part 20 (10 CFR 20), meet the requirements of the discharge concentration limits of 10 CFR Part 20 and the as low as is reasonably achievable (ALARA) dose objective of 10 CFR Part 50, Appendix I (10 CFR 50 App I), and support operator decision making and emergency response. Further, a technical justification to support the mode or frequency change was not documented.

This NCV included a cross-cutting aspect H.4 - Teamwork: Individuals and work groups communicate and coordinate their activities within and across organizational boundaries to ensure nuclear safety is maintained. Specifically, impacted stakeholders (radiation protection, emergency planning, and licensing) were not included on decisions that negatively affected the preventative maintenance, calibration commitments, and regulatory requirements for installed radiation monitors.

In addition, the inspectors reviewed a listing of condition reports for deficiencies identified for the table 11.5-1 liquid and airborne process and effluent monitors and table 12.3-2 ARMs since July 2019. All 16 process and effluent radiation monitors and 8 ARMs were identified with some form of calibration, source check, material/component, or other performance deficiency during this time period. The inspectors were not able to identify how the licensee used or considered the documented issues regarding each monitor in the decision to modify its preventative maintenance and/or calibration frequency.

Lessons Learned:

It is acceptable to extend and possibly even run to maintenance some radiation monitors depending upon the failure mechanisms, however, a technical basis for the change must be documented for each monitor and all stakeholders need to be involved in the decision process. Technical bases for changing calibration frequencies must include a review of the monitor deficiencies and failures from condition reports and corrective maintenance activities.

Recommendations:

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Calibration Frequency Changes and Application of Frequency Grace Period Tolerance

When a change to the calibration frequency of an RMS component is being proposed, it should include a technical basis and be reviewed by all stakeholders (e.g., chemistry, EP, etc.) for acceptability. Changes to calibration frequencies must address Final Safety Analysis Report (FSAR) specified frequencies, Offsite Dose Calculation Manual (ODCM) requirements, license commitments including considerations for 10 CFR Part 20.1501 (10 CFR 20.1501), site programmatic requirements, and the monitor/channel maintenance history. Quantitative assessments should be performed and documented that supports calibration at the new frequency. Qualitative assessments (e.g., extensions based simply on Preventative Maintenance [PM] feedback codes) are often inadequate in the view of regulators. Considerations for other programmatic ties and the program stakeholder(s), must be engaged, e.g., effluents, monitors scoped in the Maintenance Rule, etc. Further guidance on calibration frequency changes may be found in "Area and Process Radiation Monitoring System Guide—Revision 3". EPRI, Palo Alto, CA: 2017. 3002010580. The basis for calibration frequency intervals must also consider the application of any frequency grace period to ensure that the intent of the frequency interval is not compromised.

Independent/Cross-Discipline Review

RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME

All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2022 D: Green NCV Open/Close, Failure to Periodically Calibrate Radiation Monitors within their Specified Frequency as Required by 10 CFR 20.1501(c)

Inspection Report 05000445/2022004 AND 05000446/2022004: ML23025A098

This Green non-cited violation identified a failure to periodically calibrate radiation monitoring equipment used to perform dose rate and effluent measurements. This monitoring equipment included effluent, process, area, and emergency plan related radiation monitors. The inspectors identified that required calibrations for 11 radiation monitors exceeded the specified frequency and the grace period

as established by the licensee's Preventive Maintenance (PM) program. Per the licensee PM program procedure, "PMs which are required by License Basis Documents coded as "TU" should be performed within the specified time interval of PM frequency plus 25% of the PM frequency (Grace Period)." The licensee failed to ensure that 11 radiation monitors were calibrated within their established calibration/PM frequency, plus 25%, in accordance with the site's PM program procedure.

Lessons Learned:

10 CFR 20.1501 (c) is being used as the basis for violations due to it defining the need to perform periodic calibrations on radiation monitors. The regulation does not define required frequencies for the calibrations to be performed. License basis documents or site programs that implement 10 CFR 20.1501(c) required maintenance activities may specify the frequencies and grace periods. Inspections verify that the required maintenance activities are being performed per the licensees' processes.

Most sites have a statement within their Technical Specifications Bases, SR 3.0.2, wherein "the specified Frequency for each SR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met." It is an industry standard to apply this same 25% grace period to those maintenance tasks controlled by the PM program. In this instance, the violation is associated with what is deemed the improper application of the grace period due to not performing the calibrations within the sites PM program requirements.

Note: The topic of calibration due dates and the impact of grace periods related to performance of preventative maintenance on non-tech spec items is expected to be explored more thoroughly in phase 2 of this work.

Recommendations:

Calibration Frequency Changes and Application of Frequency Grace Period Tolerance

When a change to the calibration frequency of an RMS component is being proposed, it should include a technical basis and be reviewed by all stakeholders (e.g., chemistry, EP, etc.) for acceptability. Changes to calibration frequencies must address Final Safety Analysis Report (FSAR) specified frequencies, Offsite Dose Calculation Manual (ODCM) requirements, license commitments including considerations for 10 CFR Part 20.1501, site programmatic requirements, and the monitor/channel maintenance history. Quantitative assessments should be performed and documented that supports calibration at the new frequency. Qualitative assessments (e.g., extensions based simply on Preventative Maintenance [PM] feedback codes) are often inadequate in the view of regulators. Considerations for other programmatic ties and the program stakeholder(s), must be engaged, e.g., effluents, monitors scoped in the Maintenance Rule, etc. Further guidance on calibration frequency changes may be found in "Area and Process Radiation Monitoring System Guide—Revision 3". EPRI, Palo Alto, CA: 2017. 3002010580. The basis for calibration frequency intervals must also consider the application of any frequency grace period to ensure that the intent of the frequency interval is not compromised.

2020 A: White Finding, Failure to Use a Reproducible Source to Detector Geometry to Calibrate Containment Post LOCA Monitors

EA-19-112 Final Finding: ML20091L428

This White Finding of low to moderate safety significance involved failure to adequately calibrate the containment high range area radiation monitors and was also found to be a violation of Technical Specifications. Technical Specification (TS) 3.3.3 requires the licensee to perform periodic channel calibrations for post-accident monitoring equipment, including containment high-range area radiation monitors. Section 1.1 of the TS states that "A channel calibration shall be the adjustment, as necessary, of the channel so that it responds within the required range and required accuracy to known inputs." Specifically, the source-to-detector geometry used for isotopic calibrations was not fixed and reproducible.

Contrary to the above, from each unit's initial plant startup until September 30, 2019, the licensee failed to periodically calibrate containment high-range area radiation monitors so that they responded within the required accuracy to known inputs. This resulted in main control room indications that were biased high and would have resulted in overly conservative Emergency Action Level (EAL) declarations during certain accident scenarios.

Inspectors identified a potential error in the calibration process used to perform transfer calibrations because of a failure to create a reproduceable source-to-detector geometry. The concept was flawed by attempts to characterize the transfer source using a small traceable ion chamber and then attempting to achieve that dose rate at the same distance from the much larger post-LOCA detector where the transfer source cannot irradiate the full volume of the post-LOCA detector. This method resulted in detector over responses calculated between 46% and 128%. Several spare detectors were uniformly irradiated on a calibration range using a NIST traceable ion chamber as a standard and then proper transfer source response data was obtained for the portable irradiator for use in a reproduceable contact geometry going forward.

EA-19-112 Licensee Response: ML20121A302
EA-19-112 Licensee Pre-Decisional Response: ML20031E882
EA-19-112 Inspection Report and Preliminary Finding: ML19361A059

Lessons Learned:

The primary calibration of an area monitor is performed using known and traceable uniform radiation fields that can irradiate the entire volume of the detector on multiple scales. The transfer (or secondary) source that will be dedicated as traceable to the primary calibration is then measured in a fixed and reproduceable geometry with the calibrated detector. Subsequent transfer calibrations are then performed using the same fixed and reproducible geometry to obtain a measurement. These routine transfer measurements must fall within a prescribed tolerance of the decay corrected mean response, that was obtained for the same source, when it was measured at the primary calibration. Transfer calibration irradiators use highly collimated point sources that are not capable of producing a uniform field, that can be characterized in any meaningful way, at such close distances. Rather the relationship between the transfer source and the uniform field of the primary calibration is just relative. In these

area monitor transfer calibrations, the transfer source is often not capable of irradiating the full volume of the detector uniformly. If one reproduces the same geometry of the transfer source obtained following primary calibration, one will obtain the same relative reading from the transfer source when corrected for decay.

Recommendations:

Transfer Source Positioning

Proper RMS calibration procedures and processes must maintain a reproducible geometry traceable to the primary calibration. Ensure all transfer (or secondary) calibrations of radiation monitors are performed using reproducible geometries, preferably using source jigs that ensure consistent reproducible geometries.

Source Jigs

Clearly established controls for source jigs should be established. When possible, the original source jig should be maintained. All source jigs should be labeled and tracked appropriately for each detector type. Ensure source jigs are sufficiently described in the calibration procedure(s). It is strongly recommended that the procedure(s) include pictures or figures depicting setup and positioning. The basis for the reproducible geometry should be properly documented and maintained with the applicable primary and associated transfer calibration documentation. If the site does not have the original source jig and a new jig must be designed, it is important that the new design provides the same geometry, fit, form and function as the source jig used when the transfer response data for a particular source was first obtained.

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Vendor Guidance

Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS. In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

Primary/Transfer Calibration Documentation
Calibrations are typically performed utilizing radioactive sources that are traceable to National Institute of Standards and Technology (NIST) standards. Source certificates identifying such traceability should be maintained and easily retrievable. All transfer (or secondary) calibration data must be traceable to the initial transfer source response obtained when the primary calibration was performed, or otherwise qualified, i.e., a technical basis for transfer source(s) replacement. This technical basis becomes the reference for the transfer calibration mean response(s) using the replacement source going forward. Documentation of the primary calibration and transfer source response(s) following the primary calibration (or replacement source dedication) must be available and should be referenced in the routine calibration procedure. When the initial transfer source requires replacement, and the existing transfer source response(s) does not have sufficient pedigree, i.e., a replacement transfer source is not available in the same geometry (fit, form and function), a new primary calibration is required to dedicate a new transfer source(s).

Transfer Source Decay
Transfer (or secondary) source decay correction calculations should include the half-life of the transfer calibration isotope to a sufficient number of significant digits. Failure to use a sufficiently granular half-life value can propagate significant error over the life of the source. For example, using 30 years as the half-life of ^{137}Cs versus 30.17 years will introduce an ~15% error in the decayed values after 30 years of operation which is equivalent to many site's calibration acceptance criteria bounds. Similarly, the minimization of propagated errors in transfer source decay calculations should always use initial (or initial replacement) transfer source mean response value, as the initial response value to be decayed. Use of the last transfer calibration response for determining the current desired transfer calibration bounds, continually propagates additional errors because of rounding and the fluctuation of both radioactive decay and background.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2019 A: White Finding, Exposure Rate to Activity Conversion Factor Errors (Introduced at Start Up) Associated with Some Effluent Monitors Adversely Impacted EAL Threshold Values and Dose Assessment Capabilities

EA-18-182 Final Finding: ML19105B198

This White Finding of low to moderate safety significance identified that from each unit's initial plant startup until September 17, 2018, the licensee failed to maintain the effectiveness of their emergency plan and a standard emergency classification scheme which included facility effluent parameters. Specifically, calculation errors for the Main Steam Line Monitors and Condenser Vacuum Exhaust monitors exposure rate to activity conversion factors resulted in significantly non-conservative effluent Emergency Action Level (EAL) threshold values for the abnormal radiation EAL matrix RU1 notification of unusual event (NOUE), RA1 alert, RS1 site area emergency, and RG1 general emergency for conditions associated with failed fuel and steam generator tube rupture events. These same incorrect conversion factors also resulted in non-conservative dose assessment results for the affected monitor pathways.

These radiation monitors were being relied upon to continuously assess the impact of the release of radioactive materials, provide criteria for determining the need for notification and participation of local and State agencies, and provide for technically accurate dose assessments associated with failed fuel and steam generator tube rupture accidents using the affected monitor indications. The calculation errors adversely impacted the EAL threshold values and dose assessment capabilities as the incorrect exposure rate to activity conversion factors for these effluent monitors also propagated into the dose assessment methodology.

The licensee had been conducting a design change impact review for implementation of NEI 99-01, Revision 6, "Development of Emergency Action Levels for Non-Passive Reactors" (ML12326A805), when the errors were discovered. The licensee determined that a multitude of calculation errors over time contributed to the EAL radiation monitor threshold values being incorrect. These errors, existed for both units from initial plant startup until September 17, 2018, when the licensee corrected the errors.

The licensee performed a root cause of the calculation errors that identified the failure of preparers and checkers to recognize the technical risk associated with calculations supporting emergency preparedness. EP technical products are inherently higher risk because conservativism cannot be used in the same manner as in other technical products.

EA-18-182 Licensee Pre-Decisional Response: ML19080A178
EA-18-182 Inspection Report 05000390/2019501 AND 050003912019501 and Preliminary Finding: ML19053A547

Lessons Learned:

Calculational error introduced prior to initial plant start-up adversely impacted how the RMS data was used to determine EAL threshold values and dose assessment capabilities. This error was identified during a design change impact review for implementation of NEI 99-01, Revision 6, "Development of Emergency Action Levels for Non-Passive Reactors". Calculation preparers and checkers must recognize the technical risk associated with documentation prepared in support of emergency preparedness and EALs.

Recommendations:

Calculation Review

Calculations associated with RMS response conversion factors (e.g., $\mu Ci/cm^3$ mR^{-1} h^{-1}) and the use of radiation monitor readings in EALs, dose assessment models, and PAR decision-making schemes should

be subject to a rigorous review process. These EP functions are considered "risk significant" by the NRC and experience has indicated that greater-than-green findings can result if appropriate independent and cross-discipline reviews are not performed.

Software V&V
New dose assessment software, or changes to existing software, should be subject to a robust functional testing and validation process. Dose assessment is considered a "risk significant" EP function by the NRC and experience has indicated that greater-than-green findings can result if appropriate testing and validation are not performed.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2018 A: URI Closed, Replacement Station Vent Monitor Interface with Dose Projection Software Uncertain

Inspection Report 05000346/2017501 ML18045A076

The licensee replaced the accident range station vent monitors in 2014. The replacement monitors were manufactured by a different company than the original monitors, had different detection capabilities, different system calibration, and different computer hardware to convert detector output into usable information. The licensee could not immediately provide specifics regarding the interface between the new accident range monitors and the program used during accident conditions for providing dose projections and the resulting protective action recommendations. Specifically, the licensee could not demonstrate how the new accident range monitors accounted for the potentially rapidly changing mixture of radioactive gases during the early phase of a postulated accident.

Closure Basis: The licensee provided details regarding how the dose assessment computer program would use the output from vent stack radiation monitor to calculate dose projections and develop protective action recommendations during postulated accident scenarios. Additionally, the licensee developed a graph to describe how the radiation monitor, calibrated to ^{133}Xe, would respond over time to the various radionuclides that would be present in the source term during postulated accidents. The inspectors determined that the time dependent instrument response factor for the radiation monitor would provide results that would be sufficiently representative of the actual discharge and would permit a realistic assessment of projected offsite doses to the population. This would be true for a range of accident conditions from a relatively low source term associated from a fuel gap release through a

reactor core melt scenario. Consequently, the inspectors did not identify a performance deficiency and this issue is closed.

Lessons Learned:

When replacing radiation monitors it is important to clearly understand and document the interface between the new radiation monitor and any dose assessment software. The impacts of these interfaces should be identified early in the design change process so that any adverse impacts are addressed before the new monitor is placed in service. Procedures should be developed in advance of and issued concurrently with monitor operability.

Recommendations:

Design Review

Proposed changes to radiation monitors and display systems, EAL thresholds, the dose assessment process, and the PAR decision-making scheme should be subject to a rigorous review process. Emergency classification, dose assessment, and PARs are considered "risk significant" EP functions by the NRC and performance deficiencies in these areas can result in greater-than-green findings. Appropriate independent and cross-discipline reviews should be determined with this regulatory risk in mind.

Implementation of Design Change Operating Procedure(s)

Plant design changes should clearly identify affected equipment that provides inputs for, or interfaces supporting, emergency classification assessments, dose assessments, and PAR decision-making. The design change package should also specify required compensatory measures and list the new or revised procedures needed to operate the new or modified equipment. Procedures required for post-installation operation should be prepared in advance and issued concurrent with declaring design operability.

Independent/Cross-Discipline Review

RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME

All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2017 A: White Finding, Transposition of EAL Threshold Values in Emergency Classification Procedures

EA-17-014 Final Finding: ML17115A077

This White Finding of low to moderate safety significance identified the failure to maintain the effectiveness of an emergency plan and have a standardized emergency action level (EAL) scheme in use based on facility system and effluent parameters. Specifically, the emergency classifications in the

abnormal radiation EAL matrix for a General Emergency and Site Area Emergency contained effluent radiation monitor threshold values that were forty-two times different than the correct values. The finding involved the emergency classification scheme for the Radiological Effluent EALs RG1 (General Emergency) and RS1 (Site Area Emergency), which contained radiation monitor threshold values that were significantly different than analyzed due to an administrative error involving the transposition of the threshold values in the classification procedures.

EA-17-014 Final Licensee Response: ML17143A300
EA-17-014 Licensee Pre-Decisional Response: ML17075A476
EA-17-014 Inspection Report 05000424/2017503 and 05000425/2017503, and Preliminary Finding: ML17040A346

Lessons Learned:

Human performance error would have been caught with adequate independent and/or cross-discipline review.

Recommendations:

Procedure(s) and Procedure Changes

Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Independent/Cross-Discipline Review

RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME

All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2017 B: White Finding, Failure to Shield Adjacent-to-Line RM Detector from Post Accident Background Alters RMS Effluent Detector Reading, Yields Premature EALs and PARs

EA-17-012 Final Finding: ML17132A263

This White Finding of low to moderate safety significance identified a failure to maintain the ability to accurately declare an Emergency Action Level (EAL) Classification RG-1.1, General Emergency, and to develop and issue accurate protective action recommendations during the implementation of the site's

Emergency Plan in response to a rapidly progressing accident due to the failure to accurately analyze the effect of increasing background radiation on the site's Standby Gas Treatment System (SGTS) accident range radiation monitor (AXM) indications. As configured without a background evaluation, the AXM would provide indications reflecting a higher radioactive release than present. The AXM indications are used as the licensee's basis for determining EAL classification and development of PARs.

While the original design introduced the configuration error, the licensee missed more than one opportunity to self-identify the issue and correct it. Specifically, when the licensee performed the design reconstitution project in 1996, the licensee's staff identified a discrepancy between the configuration of the monitor and its description in the FSAR, which included the description of a background suppression feature that was not installed. The staff chose to revise the FSAR instead of correcting the issue with the monitor. More recently, NRC inspectors identified the issue to the licensee's staff, and the staff initially evaluated the monitor, based on the radiological conditions expected during normal operating conditions, which demonstrated an ongoing deficiency with the licensee's understanding of the emergency preparedness implications and considerations.

EA-17-012 Licensee Pre-Decisional Response: ML17094A745
EA-17-012 Inspection Report and Preliminary Finding: ML17055C090

Lessons Learned:

Radiation monitors used in the plant for measuring activity from a process stream must utilize adequate shielding and collimation to properly quantify the process stream in the presence of increased background from other sources in the vicinity (including accident conditions). Similarly, models designed to convert monitor response (R/hr or cpm) to a release must ensure that the collimated view of the process is used in the model. Additional knowledge on behalf of the designers and modelers of the effects of monitor placement and impacts from elevated background levels from other sources in the facility were not considered in the original design and were not identified during subsequent modifications.

Opportunities were missed to identify the adverse impact of excessive background on response during postulated accident conditions. Normally, process monitors in the plant that are adjacent-to-line utilize a shielded collimator to reduce the adverse impact of excessive backgrounds.

Recommendations:

Design Review

Proposed changes to radiation monitors and display systems, EAL thresholds, the dose assessment process, and the PAR decision-making scheme should be subject to a rigorous review process. Emergency classification, dose assessment, and PARs are considered "risk significant" EP functions by the NRC and performance deficiencies in these areas can result in greater-than-green findings. Appropriate independent and cross-discipline reviews should be determined with this regulatory risk in mind.

Radiation Monitor Placement, Detector/Process Response Conversion Factor(s) and Shielding

Design and placement of radiation monitors should include an evaluation of background impacts and the need for shielding. For adjacent-to-line process monitors, ensure that a qualified SME is engaged in the design to: 1) identify the most suitable location and position of the detector, 2) create the model for determining the exposure rate to activity concentration conversion factor, and 3) specify the shielding type and thickness. A good example of an exposure rate to activity concentration calculation is

converting the response of a PWR main steam line monitor from mR/hr to a release rate in µCi/s from a primary to secondary tube leak. Appropriate independent and cross-discipline reviews must be performed that consider the risk commensurate with the potential consequences of errors.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2015 A: Green NCV, 2017 C: Green Finding Cited/Closed, Failure to Use a Reproducible Source to Detector Geometry to Calibrate Main Steam Line Radiation Monitors and Containment/Drywall High Range Radiation Monitors

Inspection Report (2019 Green Closed) ML19038A437
Notice of Final Violation (2017 Green SDP) ML17235B265

In 2015 a Green non-cited violation of very low safety significance was identified for the licensee's failure to properly calibrate the main steam line radiation monitors and the containment/drywell high range radiation monitors.

Subsequently in 2017 a cited Green finding was identified for the failure to properly calibrate installed radiation monitors using industry accepted calibration methods and tolerances. This violation was originally entered into the licensee's corrective action program in March 2015, however, in 2017, inspectors determined that subsequent to 2015, the licensee failed to implement corrective actions to properly calibrate the instruments. Specifically, the main steam line, containment high range, and drywell high range radiation monitors have not been properly calibrated since at least January 2012. This violation was originally entered into the licensee's corrective action program in March 2015. However, in 2017, inspectors determined that the licensee failed to implement appropriate corrective actions to properly calibrate the instruments.

Based on their review of the current revisions of the applicable procedures, corrective action documents, and calibration data, the inspectors determined that the licensee had not corrected the calibration method from the previous non-cited violation. The licensee procedures did not address the required reproducible source-to-detector geometry, or the characterization of the calibration sources

used. After further review, the regulator closed this cited Green Finding during a subsequent 2019 inspection.

NRC Response to Licensee ML18038B584
Licensee Response to RFI: ML17362A041
NRC RFI: ML17304A956
Licensee Response: ML17269A031
Inspection Report (2015 Green NCV): ML15127A549

Lessons Learned:

Area monitor detectors such as the main steam line and drywell atmosphere monitors in this event must be calibrated in a repeatable geometry using sources dedicated to the primary calibration. Traceability of a new or different sources can only be obtained through the vendor or by irradiating the same type of detector to known uniform exposure rate fields in a calibration range, and then obtaining the transfer source mean response. Irradiating a detector to known uniform exposure rate fields and obtaining new transfer source response value(s) is essentially performing a new primary calibration.

Point transfer source positioning is critical at close distances. Vendor transfer calibration sources with vendor positioning jigs and vendor acceptance criteria must be used exclusively. Transfer sources cannot be adequately calibrated using other primary standard ion chambers or condenser R meters because the two detector dimensions are different. The transfer source measurements cannot be used to validate or infer ion chamber sensitivity (A/R/h) to a uniform field of exposure because the transfer source cannot fully irradiate the volume of the detector gas space the same way that the type test and primary calibration did.

The notice of violation (NOV) was a result of ineffective corrective actions resulting in a repeat issue.

Proper calibration of radiation monitors often involves multidisciplinary expertise. Failure to include both health physics and maintenance expertise led to this deficiency.

Support of obsolete equipment creates additional challenges to meet the requirements of maintaining proper procedures and processes to maintain the RMS.

Recommendations:

Transfer Source Positioning
Proper RMS calibration procedures and processes must maintain a reproducible geometry traceable to the primary calibration. Ensure all transfer (or secondary) calibrations of radiation monitors are performed using reproducible geometries, preferably using source jigs that ensure consistent reproducible geometries.

Procedure(s) and Procedure Changes
Procedures and procedure changes associated with RMS maintenance and calibration, radiological EALs thresholds, dose assessment inputs, and PAR decision-making must employ sufficient technical rigor that fully reflects the risk associated with the end use. Change reviews require diversity of expertise that adequately covers the change being made.

Vendor Guidance
Ensure that procedures and/or methods used for RMS calibrations adequately incorporate vendor

guidance where applicable, e.g., acceptance criteria, transfer source positioning, and mean response. Vendor documentation of primary calibrations were typically supplied to the licensee in the form of a calibration report for each particular model detector and geometry. Vendor dedication of originally supplied transfer source responses were typically communicated to the licensee within completed vendor procedures. The version of these completed vendor transfer calibration procedures may no longer be current, however the data contained within them remains valid. It is these completed vendor transfer calibration procedures that provide the documentation of the traceability of a given transfer source to the primary calibration. Some vendors may no longer be in business or no longer support RMS. In some instances, current vendors may maintain updated versions of the original transfer calibration procedures that provide valuable updated transfer calibration guidance. In other instances, a vendor procedure may or may not exist (e.g., any need to modify conversion factors or transfer source acceptance criteria when replacing detectors). The process of changing a detector and adjusting conversion factor and/or transfer source responses may exist in a vendor procedure or it may only be in vendor knowledge space and has never been communicated to industry in any formal documentation.

Primary/Transfer Calibration Documentation

Calibrations are typically performed utilizing radioactive sources that are traceable to National Institute of Standards and Technology (NIST) standards. Source certificates identifying such traceability should be maintained and easily retrievable. All transfer (or secondary) calibration data must be traceable to the initial transfer source response obtained when the primary calibration was performed, or otherwise qualified, i.e., a technical basis for transfer source(s) replacement. This technical basis becomes the reference for the transfer calibration mean response(s) using the replacement source going forward. Documentation of the primary calibration and transfer source response(s) following the primary calibration (or replacement source dedication) must be available and should be referenced in the routine calibration procedure. When the initial transfer source requires replacement, and the existing transfer source response(s) does not have sufficient pedigree, i.e., a replacement transfer source is not available in the same geometry (fit, form and function), a new primary calibration is required to dedicate a new transfer source(s).

Transfer Source Decay

Transfer (or secondary) source decay correction calculations should include the half-life of the transfer calibration isotope to a sufficient number of significant digits. Failure to use a sufficiently granular half-life value can propagate significant error over the life of the source. For example, using 30 years as the half-life of ^{137}Cs versus 30.17 years will introduce an ~15% error in the decayed values after 30 years of operation which is equivalent to many site's calibration acceptance criteria bounds. Similarly, the minimization of propagated errors in transfer source decay calculations should always use initial (or initial replacement) transfer source mean response value, as the initial response value to be decayed. Use of the last transfer calibration response for determining the current desired transfer calibration bounds, continually propagates additional errors because of rounding and the fluctuation of both radioactive decay and background.

Calibration Documentation Review

Documentation of calibration activities performed on RMS components should be subject to independent and cross-discipline reviews, with these reviews described in procedures. These reviews should focus on identifying errors in both the calibration data and the calibration processes/methods.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

2014 A: White Finding, Incorrect Calculation of RMS Response for Fission Product Barrier Integrity EAL Matrix Results in Incorrect Effluent EAL Threshold Values

EA-14-100 Final Finding: ML14297A547

This White Finding of low to moderate safety significance identified the incorporation of incorrect RMS Main Steam Line Radiation Monitor (MSLRM) response to released radioactivity threshold values into its emergency action levels (EALs) for the replacement main steam line monitors. Specifically, during the replacement of the Unit 2 main steam line radiation monitors, staff inaccurately calculated the associated EALs effluent threshold values for the Alert, Site Area Emergency, and General Emergency classifications. These thresholds were subsequently incorporated into Table R-1, " Effluent Monitor Classification Threshold" of the EALs. This calculation error could have resulted in an over-classification of an event, an unnecessary protective action recommendation, and could have caused offsite response organizations to implement unnecessary protective actions for the public. The licensee determined that the cause of this event was that site leadership did not manage risk commensurate to the potential consequences associated with an inaccurate EAL revision. Specifically, management did not manage the change with the appropriate amount of technical rigor. This violation was associated with the EAL threshold values associated with the fission product barrier EAL matrix. There is no indication from the event documentation that this incorrect calculation impacted the MSLRM response for dose assessment.

Lessons Learned:
Erroneous calculation resulted in incorrect EAL effluent threshold values for MSLRMs that could have resulted in over-classification of an event and unnecessary protective actions based on the fission product barrier EAL matrix. Technical review processes associated with RMS inputs to EAL thresholds require a thorough independent verification of all calculations. All calculations that impact RMS inputs to EAL thresholds should require multidisciplinary reviews with appropriate technical expertise.

Recommendations:
Calculation Review
Calculations associated with RMS response conversion factors (e.g., $\mu Ci/cm^3$ mR^{-1} h^{-1}) and the use of radiation monitor readings in EALs, dose assessment models, and PAR decision-making schemes should

be subject to a rigorous review process. These EP functions are considered "risk significant" by the NRC and experience has indicated that greater-than-green findings can result if appropriate independent and cross-discipline reviews are not performed.

Independent/Cross-Discipline Review
RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME
All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

EA-14-100 Licensee Pre-Decisional Response: ML14252A229
EA-14-100 Inspection Report and Preliminary Finding: ML14219A624

2014 B: White Finding, Incorrect Units Conversion of RMS Response to Abnormal Radiological EAL Matrix Results in Incorrect Effluent EAL Threshold Values

EA-14-112 Inspection Report with Final Finding: ML14216A482, ML14218A669

This White Finding of low to moderate safety significance identified a failure to maintain a standard emergency classification scheme, which included facility effluent parameters, in that effluent parameter classification threshold values for the abnormal radiological EAL matrix RG1 (General Emergency) and RS1 (Site Area Emergency) were significantly non-conservative:

In March 2005, a corporate engineering calculation was developed to estimate dose rates as a function of radiological releases correlated to radiation monitor values. The calculation provided radiation monitor threshold values for General Emergency (i.e., exceeding 1000 mrem TEDE/5000 mrem thyroid CDE beyond the site boundary) and Site Area Emergency (i.e., exceeding 100 mR TEDE/500 mrem thyroid CDE beyond the site boundary). The calculation was a manual calculation using a spreadsheet program; however, a unit conversion (Sieverts/second to mrem/hour) was made incorrectly and not detected during the review process. The error resulted in threshold values sixty times greater than appropriate. In 2005, the licensee submitted a license amendment request to the NRC to change their EAL scheme. The request included EAL threshold values for RG1 and RS1 which were based on the errant calculation. The NRC approved the amendment, and the licensee implemented the EAL scheme and the non-conservative threshold values were contained in the associated implementing procedure. There is no indication from the event documentation that this incorrect calculation impacted the effluent monitor response models used for dose assessment.

The calculation error was discovered during a fleet extent of condition review conducted by the licensee. The violation was determined to meet the criteria for enforcement discretion as an old design issue.

Lessons Learned:

Erroneous calculation caused by human performance error in units conversion resulted in incorrect EAL effluent monitor threshold values for the abnormal radiological EAL matrix. The EAL effluent monitor threshold values could have resulted in over-classification of an event and unnecessary protective actions based on the abnormal radiological EAL matrix RG1 (General Emergency) and RS1 (Site Area Emergency). Technical review processes associated with RMS inputs to EAL thresholds require a thorough independent verification of all calculations. All calculations that impact RMS inputs to EAL thresholds should require multidisciplinary reviews with appropriate technical expertise.

Recommendations:

Calculation Review

Calculations associated with RMS response conversion factors (e.g., $\mu Ci/cm^3$ mR^{-1} h^{-1}) and the use of radiation monitor readings in EALs, dose assessment models, and PAR decision-making schemes should be subject to a rigorous review process. These EP functions are considered "risk significant" by the NRC and experience has indicated that greater-than-green findings can result if appropriate independent and cross-discipline reviews are not performed.

Independent/Cross-Discipline Review

RMS procedures, procedure changes, design changes, calculations, inputs to offsite dose assessment, and routine calibration documentation all require an appropriate independent and/or cross-discipline review(s) that fully reflects the risk associated with the end use.

Technical Expertise/SME

All independent and/or cross-discipline reviews should employ Subject Matter Experts (SMEs) in radiation detection/monitoring, geometry source term modeling, EALs and PARs, offsite dose assessment, etc., as applicable. Where internal SMEs are not available, the use of outside industry peers or consultants with appropriate expertise should be considered.

Acronyms/Abbreviations

µCi/cm^3 mR^{-1} h^{-1}	Microcuries per cubic centimeter per milliroentgen per hour
µCi/cm^3	Microcuries per cubic centimeter
µCi/s	Microcuries per second
AA1	The first Alert emergency Initiating Condition in Recognition Category A – "Abnormal Radiation Levels / Radiological Effluent"
ADAMS	Agencywide Documents Access and Management System - official recordkeeping system, through which the NRC provides access to collections of publicly available documents
AG1	The first General Emergency Initiating Condition in Recognition Category A – "Abnormal Radiation Levels / Radiological Effluent"
ALARA	As low as reasonably achievable
A/R/h	Amps per Roentgen per hour (detector current/exposure field)
ARM	Area Radiation Monitors
AS1	The first Site Area Emergency Initiating Condition in Recognition Category A – "Abnormal Radiation Levels / Radiological Effluent"
AU1	The first Unusual Event emergency Initiating Condition in Recognition Category A – "Abnormal Radiation Levels / Radiological Effluent"
AXM	Accident Range Radiation Monitor
Bq/m^3	Becquerels per cubic meter
c/min	Counts per minute
CFR	Code of Federal Regulations
cpm	Counts per minute
e.g.	For example
EAL	Emergency Action Level
ECF	Engineering Units Conversion Factor
EOP	Emergency Operating Procedures
EP	Emergency Preparedness
FSAR	Final Safety Analysis Report

GM	Geiger Mueller
HP	Health Physics
HPPOS	NRC Health Physics Position Papers
I&C	Instrumentation and Controls
i.e.	That is or in other words
IN	Information Notice
INPO	Institute of Nuclear Power Operations
keV	Kilo electron volt
LCO	Limiting Condition of Operation
LOCA	Loss of Coolant Accident
MCA	Multi Channel Analyzer
MSLRM	Main Steam Line Radiation Monitor
NCV	Non-cited Violation
NEI	Nuclear Energy Institute
NIST	National Institute of Standards and Technology
NOUE	Notification of an Unusual Event
NOV	Notice of Violation
NRC	Nuclear Regulatory Commission
NUREG	NRC Reports or brochures on regulatory decisions, results of research, results of incident investigations, and other technical and administrative information
ODCM	Offsite Dose Calculation Manual
PAR	Protective Action Recommendation
PM	Preventive Maintenance
PWR	Pressurized Water Reactor
R/hr	Roentgen per hour
RG1	General Emergency
RMS	Radiation Monitoring System
RP	Radiation Protection
RS1	Site Area Emergency

RU1	Unusual Event
SGTS	Standby Gas Treatment System
SME	Subject Matter Expert
SPDS	Safety Parameter Display System
SR	Surveillance Requirement
TMI	Three Mile Island
TS	Technical Specifications
URI	Unresolved Issue
U.S.	United States
WRGM	Wide Range Gas Monitor

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