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MAR 2 6 2009

L-PI-09-045
EA-08-349

U S Nuclear Regulatory Commission
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Washington, DC 20555-0001

Prairie Island Nuclear Generating Plant Units 1 and 2
Dockets 50-282 and 50-306
License Nos. DPR-42 and DPR-60

Response to Questions from "Meeting Summary for Regulatory Conference with Northern States Power – Minnesota" held on March 17, 2009 (EA-08-349)

References: 1) Letter from the Nuclear Regulatory Commission to Northern States Power – Minnesota, "Prairie Island Nuclear Generating Plant, Unit 1 and 2 NRC Inspection Report 05000282/2008009; 05000306/2008009 Preliminary Yellow Finding", dated February 10, 2009 (ADAMS Accession Number ML090410466).

2) Letter from the Nuclear Regulatory Commission to Northern States Power – Minnesota, "Meeting Summary for Regulatory Conference with Northern States Power – Minnesota (EA-08-349)", dated March 20, 2009 (ADAMS Accession Number ML090790543).

By Reference 1, the Nuclear Regulatory Commission (NRC) informed Northern States Power – Minnesota (NSPM) of a preliminary yellow finding.

In a regulatory conference with the NRC on March 17, 2009, NSPM met with the NRC to discuss this finding. Reference 2 provides a meeting summary which includes four additional questions the NRC raised at the regulatory conference. The attached enclosure submits NSPM's response to those questions.

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IE01
NRR

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

Michael D. Wadley

Michael D. Wadley
Site Vice President, Prairie Island Nuclear Generating Plant
Northern States Power Company - Minnesota

Enclosure

cc: Administrator, Region III, USNRC
Project Manager, Prairie Island Nuclear Generating Plant, USNRC
Resident Inspector, Prairie Island Nuclear Generating Plant, USNRC

ENCLOSURE

NORTHERN STATE POWER – MINNESOTA'S (NSPM) RESPONSE TO QUESTIONS ARISING OUT OF THE 2009 RADIOACTIVE MATERIAL TRANSPORTATION EVENT, REGULATORY CONFERENCE HOSTED BY NRC REGION III.

In preparing responses to the following questions, NSPM collaborated with several contract consultants as provided in Attachment 1 to this enclosure. In addition, Attachment 2 provides a discussion of the calculations used to support the answer to question 1.

Question 1: Were correction factors used for the 800 mR/hr RO-2 (ion chamber) measurement? If not, what correction factors would be appropriate for measurements in a non-uniform radiation field based on the ANSI standard and RO2 (ion chamber) technical manual? (The results should be provided in terms of radiation levels instead of effective dose equivalent).

No correction factors (CF) were used in any of the measurements performed at either the Prairie Island Nuclear Generating Plant (PINGP) or at the Westinghouse Waltz Mill facility.

American National Standards Institute (ANSI) N323A-1997, Radiation Protection Instrumentation Test and Calibration states that:

> If dose or dose equivalent rate instruments are used under conditions that do not uniformly irradiate the detector volume (close to a source or in a beam), the instrument response may vary significantly with source geometry, source energy, detector geometry, and detector distance. Correction factors should be determined and documented for the use of instruments under such conditions.

The RO-2 technical manual provides correction factors for temperature and altitude differences. The maximum correction factor for the RO-2, based on calibrated conditions versus outdoor conditions on the day of the survey would be 0.97 (assuming 65 degrees F for the calibration temperature and 50 degrees F when the survey was performed and interpolating a value from Table 2.2).

National Council on Radiation Protection and Measurements (NCRP) Report No. 112 provides two methods for calculating correction factors for the case where cylindrical and spherical detectors are in close proximity to point sources. One of these methods was derived within the NCRP report and the other is referenced from Langril and Boyer (1984). An analysis of these factors is summarized in Attachment 2 to this enclosure.

From the two methods provided in Attachment 2, the most conservative geometry CF for the RO-2 for response to a point source in close contact (0.1 inch from the outside of the container to the source) to the detector is 1.097. This results in a corrected dose rate of 878 mR/hr.

This CF coupled with a temperature CF of 0.97 and taking into account temperature conditions apparent at the time of the survey would yield a final value (0.97*1.097*800 mR/hr) of 851 mR/hr.

Question 2: What corrective actions or controls are in place to ensure that radioactive contamination is "essentially uniformly distributed" on the material and equipment that is being shipped as surface contaminated object (SCO) II?

The most significant corrective action and control changes that will ensure proper shipments are:

1. The revision to Radiation Protection Implementing Procedure (RPIP) 1122, Discrete Radioactive Particle Program, Revision 15, requires the use of audible capable instrumentation to detect fixed discrete particles which would be missed by normal smear surveys. This would allow for detection and removal of particles not detected by previous survey methods which would ensure meeting the rules regarding SCO II shipments.

2. Increased supervisory oversight is now required when discrete particles are suspected of being on components being prepared for shipment.

3. Incorporation of a risk evaluation matrix that increases supervisor approval levels with higher risk shipment activities has been implemented.

4. Procedures now require Radioactive Waste Shipping Coordinator oversight of risk significant shipment preparations during packaging and loading materials and/or wastes.

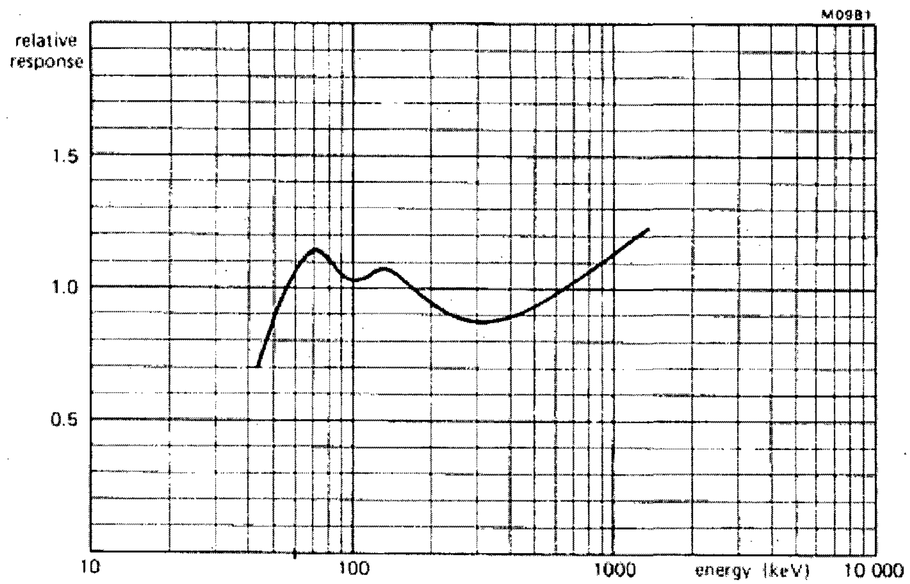
These corrective actions and controls, taken as a whole, ensure that contamination is distributed throughout the material and equipment that is being shipped as a surface contaminated object (SCO). This is in accordance with SCO II as defined in NUREG-1608, Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects.

Question 3: What is the basis for considering the energy compensated Telepole (Geiger-Mueller) measurement inaccurate, given that vendor information and test data demonstrate that the instrument is linear in its response to Co-60 energies in the activity range of interest?

Energy Response of the Merlin Gerin (MG) Telepole Geiger-Mueller (G-M) Tube:

The MG Telepole G-M tube technical manual states that the instrument energy response is +/- 20% at 70 keV to 1.1 MeV relative to Cs-137. In follow up correspondence with Radiological Engineers at Merlin Gerin Instruments, it was confirmed that the low-range G-M tube is the active detector for readings below 2500 mR/h due to a modification in place for a major portion of Telepoles deployed in the industry, including those in use at PINGP. Testing of the low-range tube at independent laboratories resulted in an over response to Co-60 photon energies of 26%. A proprietary vendor document contains detailed data demonstrating the over-response. This information is available for review at PINGP. These data are similarly represented by the energy response curve supplied by Merlin Gerin (see Figure 1) for the low-range G-M tube in independent testing.

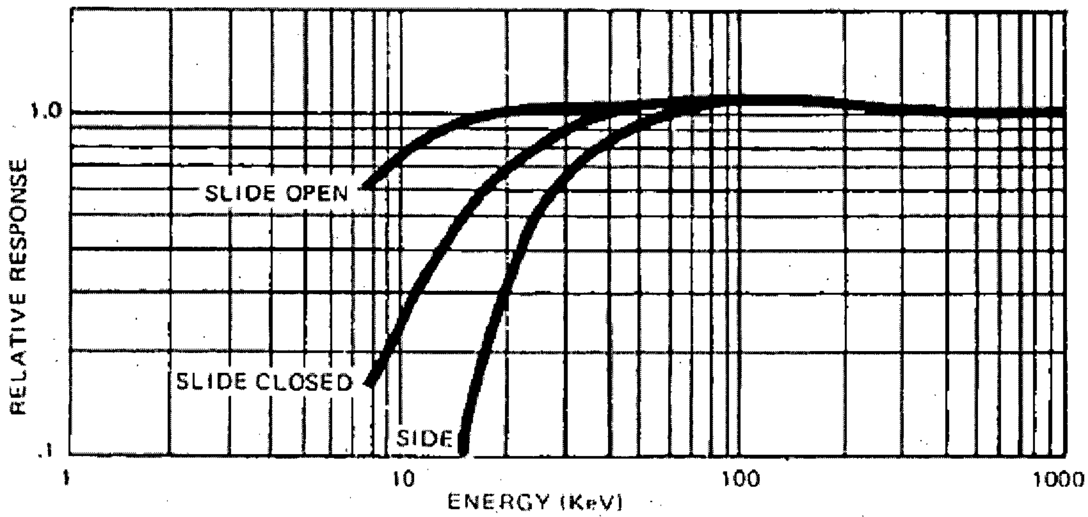
Figure 1: Typical Energy Response Relative to Cs-137 (Telepole)



Energy Response of the Eberline RO-2 Ion Chamber:

The Eberline RO-2 ion chamber technical manual states that the instrument energy response is +/- 15% from 12 keV to more than 1.3 MeV. From the energy response curve that is included in the manual (see Figure 2), the RO-2 relative response is essentially 1.0 from 70 keV to 1 MeV. Meter response data recorded by Pacific Northwest Laboratory when testing the RO-2 to Co-60 showed a relative response of 0.95 to 0.99 at the Co-60 energies.

Figure 2: Nominal Photon Energy Response (RO-2)



Summary

Based on the reported energy response of the RO-2 and Telepole instruments, the RO-2 will respond very near a one-to-one ratio (0.99 window closed) at Co-60 photon energies when calibrated to Cs-137, while the Telepole will significantly over-respond (+26%) at those same energies. Based on this information, NSPM concludes that the Telepole exhibits a notably non-linear response as it appreciably over-responds to the Co-60 photon field, thereby providing a less accurate measurement of the radiation field when compared to the RO-2 ion chamber's uniform response.

Question 4: Supply any Instructor or College Professor data that relates to an adverse impact on Telepole (Geiger-Mueller) from an energy scatter effect when measuring radiation levels on the surface of the package.

General Considerations:

Other than information provided in the response to question 3, documented data specific to effects of scattered photons on the Telepole (GM) instrument were not found.

To expand on this topic, Dave Meddich (PhD, CHP) and Eric Darois (MS, CHP) were contacted to investigate the principals associated with this question. Their input follows:

> The Bragg-Gray principle states that for a gas-filled detector, the dose deposited on the wall of the detector is proportional to the energy deposited per unit mass of the gas cavity provided that: 1) the charged particles crossing the gas chamber deposit a small fraction of their energy, and 2) the field is relatively uniform (in this case as corrected by the calculations in Attachment 2 of this enclosure). In the case of an ionization chamber, the measured current is directly proportional to energy deposition in the chamber. Therefore, the current is directly proportional to the dose to the wall of the chamber. Conversely, in all G-M detectors, any ionization event within the detector causes a complete discharge and is then recorded as a pulse, or count. The calibration of a G-M detector to gamma radiation represents a mathematical relationship between the measured count rate and the known radiation field radiation levels. Therefore, at the fundamental level, an ionization chamber meets the basic conditions of the Bragg-Gray principle where the GM detector is an approximation dependent on the calibration conditions.
>
> G-M tubes are typically constructed of high Z (non-tissue equivalent) materials and can be operated either as compensated or uncompensated. Uncompensated GM tube count rates will either respond evenly, over-respond, or under-respond to photon energies other than the energy to which they are calibrated. This means that with different photon energies, at the same dose rate, the actual count rate will be the same, higher, or lower than at the calibrated energy. Energy compensation corrects this to some extent so that the indicated count rate will be somewhat flattened over a broader range of photon energies; however, as observed in [Figure 1: Typical Energy Response Relative to Cs-137 (Telepole)], the response is still quite inconsistent. While energy compensation allows for a more acceptable count rate response over a broader range of photon energies, it does not correlate to the exposure or dose delivered based on energy of the incoming photons. Consequently, significant energy dependence is still present in compensated G-M tubes and the fundamental relationship to energy deposited described by the Bragg-Gray principle is still not achieved.

> Photons of differing energies deposit dose to tissue at different rates with photons of low energy more likely to deposit all of their energy in a high Z absorber through photoelectric absorption. The cross section for photoelectric absorption approximately varies as a function of Z^4 and E^{-3}. An ion chamber, because it is more tissue equivalent and because it measures the sum of the ionizations created (an energy dependant activity), provides a more accurate indication of the energy deposited in the detector and, hence, tissue. An energy compensated G-M tube, while being somewhat linear with respect to the number of events over a broad energy spectrum, is constructed from high Z materials and also does not differentiate the dose consequence of the event, i.e., every event in a G-M tube is counted as a "full pulse" regardless of incoming photon energy. Since photon energy spectrums constantly vary depending on the distance from source and any shield materials attenuating the photon field, the response of a G-M tube that "fires" a response in the chamber regardless of the energy that entered it, introduces inaccuracy to the measurement.
>
> The ion chamber, on the other hand, is still accounting for true energy deposited in these degraded beams since the output of the detection circuit is proportional to the photon energies entering the chamber. This proportionality to energy deposition is also directly related to biological dose to tissue. Hence, the ion chamber will be the more accurate measure of the dose rate at any point in space from a degraded or pure field of radiation. For these reasons the ion chamber provides a more accurate measure of dose rates across a broad energy spectrum than a G-M tube.

In addition, the following excerpt was provided by industry expert George Chabot (PhD, CHP) in a letter dated March 24, 2009:

> Since workers must use available and appropriate instruments to evaluate dose rates at package surfaces for testing compliance with regulations, the choice of a well-accepted and reliable instrument, such as the Eberline RO-2 ionization chamber, I believe is consistent with intentions and regulatory policy. For purposes of making measurements consistent with regulatory specifications and sensible with respect to practical implementation by licensees, such an instrument choice seems entirely valid. I would hope that regulatory bodies would agree with this opinion.

ATTACHMENT 1

LETTER FROM RADIATION SAFETY AND CONTROL SERVICES

2 pages follow

L09-025

March 25, 2009

Scott Nelson, Corporate RPM
Xcel Nuclear
Prairie Island Nuclear Power Plant
Red Wing, MN

Re: Technical Review and Calculations of Radiological Shipping Criteria in Support of Xcel Energy's AR#1557726

Dear Mr. Nelson

As you know, RSCS was contracted to provide technical review and calculations in support of a radiological survey that was performed of a shipment of radioactive material that arrived at the Westinghouse Waltz Mill Facility in October 2008 from the Prairie Island nuclear plant. The survey results showed that the DOT shipping criteria was exceeded for a small area on the bottom of the container. This exceedence was determined by the XCEL Energy staff to be due to material that moved during shipment causing a discrete particle of Co-60 to be dislodged to a location near the bottom of the container.

As a follow-up to this event, the NRC had issued a proposed violation to XCEL Energy based on the survey results. During the past few months, correspondence between NRC and XCEL had occurred with a final set of four questions being issued from NRC to XCEL on 03/26/2009. The RSCS team reviewed and provided calculational support by its internal staff of Certified Health Physicists and by contracted support. The Table below provides a summary of the support provided by our team.

Please contact me if you need any clarification of this support.

Eric L. Darois, CHP
Executive Director

Radiation Safety & Control Services, Inc.
91 Portsmouth Avenue • Stratham, NH 03885-2468
1-800-525-8339 • (603) 778-2871 • Fax (603) 778-6879 • www.radsafety.com

Question #	Support Personnel	Type of Support
All	Eric L. Darois, MS, CHP	Editorial Comments, Text Review.
	George Chabot, Ph.D., CHP	Review
	Frederick P. Straccia, CHP	Review
	James P. Tarzia, MS, CHP	Review
1	Eric L. Darois, MS, CHP	Provided Primary Response, CF Calculations
	Clayton French, Ph.D., CHP	MathCad® Calculations, Review
3	Dave Meddich, Ph.D, CHP	Provided Primary Response
4	Dave Meddich, Ph.D, CHP	Provided Primary Response
	Eric L. Darois, MS, CHP	Provided Primary Response

ATTACHMENT 2

DISCUSSION TO QUESTION 1

Discussion to Question 1:

While numerous documents discuss possible correction factors for non-uniform fields when a detector is calibrated in a uniform field, there is not a consistent or uniform standard for application across the broad spectrum of instruments available. One document identified from Pacific Northwest National Laboratories provides a case for correction factors for an RO-20 Ion Chamber (very similar to an RO-2). On careful review, the methodology proposed in that document is not considered applicable to our situation. That model evaluates disc sources of varying sizes (down to 0.5 inches) whereas this situation deals with a discrete particle with an extremely small diameter. Mathematical extrapolation using that model would predict unreasonably large correction factors. For instance, in Prairie Island Nuclear Generating Plant's (PINGP) example, a simple power curve fit of data presented (using a Microsoft Excel X,Y scatter plot function) would yield a contact surface dose rate of ~9,900 R/hr for a 0.01", 2 mCi Co^{60} particle.

National Council on Radiation Protection and Measurements (NCRP) Report 112 Method:

Section 2.5.3 of NCRP Report No. 112 provides for point source correction factors that relate the average gamma fluence over a detector volume to that of the fluence at the detector's geometric center for various combinations of detector diameter (D) to source distance (L), and detector height (H) to L for irradiation of both the flat surface and curved surfaces of a cylinder. The values listed in Table 2.1 of NCRP Report No. 112 do not represent the range of values represented by the current case. However, Appendix E of NCRP Report No. 112 provides the calculation methods used to determine these factors. In all three geometric cases provided, the solution requires numerical integration.

In the case of PINGP, the internal dimensions of the RO-2 detector were needed as input variables to this calculation. The vendor's manual for this instrument provides the detector's diameter (7.62 cm) and volume (208 cm^3). However, these values represent the outside diameter of the chamber and the free-air volume of the detector's interior respectively. In order to calculate the corrections using the method provided in NCRP Report No. 112, the internal geometric dimensions of the detector are needed. Therefore, these values were measured for an RO-2 resulting in the values provided in Table 1: RO-2 Physical Parameters below:

Table 1: RO-2 Physical Parameters

Parameter	Vendor Values	Internal Measured Values
Diameter, cm	7.62	7.27
Radius, cm	N/A	3.63
Height, cm	N/A	5.14
Geometric Volume, cm^3	Not Provided	213.4
Volume of Internal Electrode and Supports	N/A	6.66
Net Air Volume, cm^3	208	206.7

As shown in Table 1, the net air volume (based on the measured dimensions) differ by only 1.3 cm^3 or 0.6%, however, the geometric volume (213.4 cm^3) is used in the calculations that follow.

The geometry correction factor (CF) was then calculated by numerical integration using Geometry 1 (for the case of radiation incident on flat surface of cylinder) and Geometry 2 (for the case of radiation incident on the curved surface of the cylinder) from NCRP 112 Appendix E using MathCad® (version 13). The corrected RO-2 reading, R_c is determined from the measured value, R, as:

$$R_c = R \times CF$$

Equation 1

Where:

$$CF = \phi_L / \overline{\phi}$$

Equation 2

And: ϕ_L is the photon flux at the detector's center (distance L to the source) given as:

$$\phi_L = \frac{S}{4\pi L^2} \text{, and}$$

Equation 3

$\overline{\phi}$ is the average photon flux over the detector volume for Geometry 1, as:

$$\overline{\phi} = \frac{S/4\pi}{\pi R^2 H} \int_0^{2\pi} d\theta \int_0^R dr \int_{-H/2}^{H/2} dh \frac{r}{r^2 + (L-h)^2} \text{, and}$$

Equation 4

$\bar{\phi}$ is the average photon flux over the detector volume for Geometry 2, as:

$$\bar{\phi} = \frac{S/4\pi}{\pi R^2 H} \int_0^{2\pi} d\theta \int_0^R dr \int_{-H/2}^{H/2} dh \frac{r}{h^2 + L^2 + r^2 - 2Lr\cos\theta}$$

Where: S is the source strength, s^{-1},
R is the detector radius,
H is the detector height, and
L is the distance from the source to the detector center.

By substitution, the CF can be re-written as:

Geometry 1

$$CF = \frac{\pi R^2 H}{L^2 \int_0^{2\pi} d\theta \int_0^R dr \int_{-H/2}^{H/2} dh \frac{r}{r^2 + (L-h)^2}}$$

Equation 5

Geometry 2

$$CF = \frac{\pi R^2 H}{L^2 \int_0^{2\pi} d\theta \int_0^R dr \int_{-H/2}^{H/2} dh \frac{r}{h^2 + L^2 + r^2 - 2Lr\cos\theta}}$$

Equation 6

For Geometry 1, a conservative distance of 0.1 in (.254 cm) was applied for the distance of the source to the surface of the container and the value of L is calculated as the distance from the surface to the detector centerline (3.59 cm) added to the source to surface distance (.254 cm), or 3.844 cm. These values, along with the detector dimensions in Table 1 and Equation 5 were solved using MathCad® (version 13) resulting in a CF of 1.096. Appling this value to the RO-2 measured value of 800 mR/hr yields a corrected dose equivalent of 877 mR/hr.

For Geometry 2, a conservative distance of zero was applied for the distance of the source to the surface of the container and the value of L is calculated half of the measured width of the RO-2 survey meter, or 4.706 cm. These values, along with the detector dimensions in Table 1 and Equation 6 were solved using MathCad® (version 13) resulting in a CF of 0.824. Applying this value to the RO-2 measured value of 800 mR/hr yields a corrected dose equivalent of 659 mR/hr.

Langrill and Boyer Method:

Section 4.3.3 of NCRP Report No. 112 provides for a method to calculate a correction factor E for a point source positioned at distance z_0 along the central axis of a cylindrical detector as:

$$E=\frac{V}{\pi z_o^2}\left[(z_o+H)\ln\left(1+\frac{R^2}{(Z_0+H)^2}\right)-(z_0-H)\ln\left(1+\frac{R^2}{(Z_0-H)^2}\right)+2R\left[\tan^{-1}\left(\frac{z_0+H}{R}\right)-\tan^{-1}\left(\frac{z_0-H}{R}\right)\right]\right]^{-1}$$

Equation 7

Where: V is the detector volume,
z_0 is the distance from the detector center to the source (same as L in Equation 5),
R is the detector radius, and,
H is one-half of the detector height.

Using this expression for the same input values as above, the correction factor for the current case is 1.097 and corroborates the previous value above.