February 24, 2016

Larry Teahon, SHEQ Manager
Cameco Resources
Crow Butte Operation
86 Crow Butte Road
P.O. Box 169
Crawford, NE 69339-0169

SUBJECT: COMMENTS ON RESPONSE TO LICENSE CONDITION 11.10, BETA/GAMMA CONTAMINATION PROGRAM AND SURFACE CONTAMINATION DETECTION CAPABILITY, CROW BUTTE RESOURCES, INC., CRAWFORD, NEBRASKA, LICENSE NO. SUA-1534 (TAC NO. L00760)

Dear Mr. Teahon:

By letter dated December 19, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14364A196), Cameco Resources Crow Butte Operation (Cameco) submitted to the U.S. Nuclear Regulatory Commission (NRC) staff a response addressing License Condition 11.10 of SUA-1534 (ADAMS Accession No. ML13324A090). This license condition required Cameco to provide the NRC staff with information on its survey program for beta/gamma contamination and surface contamination detection capability for radiation survey instruments. During our technical review of this response, the NRC staff identified certain areas for which we are requesting additional clarification. The staff's comments are enclosed. These comments are organized according to the sections in Cameco's December 19, 2014, response. Please either respond to these comments or provide a schedule for submitting your responses within 30 days of receipt of this letter.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of ADAMS. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions, please contact me at 301-415-6443, or via email, at Ronald.Burrows@nrc.gov.

Sincerely,

/RA/

Ronald A. Burrows, Project Manager
Uranium Recovery Licensing Branch
Division of Decommissioning, Uranium Recovery,
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket No.: 040-8943
License No.: SUA-1534

Enclosure: Comments on Response to LC 11.10

cc: D. Miesbach, NDEQ
D. Pavlick, CBR

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cc: D. Miesbach, NDEQ
D. Pavlick, CBR

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ADAMS Accession No.: ML16050A513

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U.S. Nuclear Regulatory Commission
Comments on Response to License Condition 11.10
Cameco Resources Crow Butte Operation
for Source Material License SUA-1534

The purpose of the following comments are to provide the additional clarification and data that are necessary for the U.S. Nuclear Regulatory Commission (NRC) to review Cameco Resources Crow Butte Operation's (Cameco's, or the licensee) December 19, 2014, response to License Condition (LC) 11.10 (Cameco, 2014) of renewed license SUA-1534 (NRC, 2014a).

Background

By letter dated November 5, 2014 (NRC, 2014a), the U.S. Nuclear Regulatory Commission (NRC) staff renewed Crow Butte Resources, Inc.'s (CBR's or the licensee's) Source and Byproduct Materials License SUA-1534 (license) for the extraction and recovery of uranium source material at its Crow Butte In Situ Recovery (ISR) Project. License Condition (LC) 11.10 of the renewed license requires CBR to submit information on its contamination survey program for the NRC staff's written verification. Specifically, LC 11.10 requires the licensee to submit the following information:

> The licensee shall develop a survey program for beta/gamma contamination for personnel exiting from restricted areas, and beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F and submit the program to the NRC for review and written verification.
>
> The licensee shall provide for the NRC review and written verification the surface contamination detection capability (Minimum Detection Concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of dpm per 100 cm^2.

By letter dated December 19, 2014 (Cameco, 2014), the licensee submitted to the NRC staff a response to LC 11.10 (the submittal). The NRC staff comments below are organized according to the sections in the licensee's submittal.

Comments on Personnel Surveys:

Issue 1: Calculation of Minimum Detectable Concentration (MDC)

In its response the licensee stated:

"The Minimum Detectable Concentration (MDC) for scalar alpha and beta/gamma measurements using hand held probes will be determined based on the method in NUREG 1507, shown in equation (1)."

Enclosure

Where Equation (1) is presented as:

$$MDC\left(\frac{DPM}{100cm^2}\right) = \frac{3+3.29\sqrt{R_b\, t_g(1+\frac{t_g}{t_b})}}{\varepsilon_i t_g(\frac{SA}{100cm^2})}$$

where: R_b = the background count rate
t_g = the sample count time
t_b = the background count time
ε_i = the instrument efficiency
SA = probe surface area (cm^2)

Discussion

The NRC staff observes that the licensee's formula for the static MDC (Equation (1) above) is consistent with the form of the formula presented in Table 3.1 of NUREG-1507 (NRC, 1998) from the Strom & Stansbury reference, corrected for probe area. However, the efficiency term, ε, in the denominator of the licensee's Equation (1) above should be the counting, or total, efficiency, not the instrument efficiency. This was previously communicated to the licensee in NRC, 2014b.

NUREG-1507 (NRC, 1998) endorses the approach in the International Organization for Standardization standard ISO 7503-1, Evaluation of Surface Contamination – Part 1: Beta Emitters and Alpha Emitters (first edition), for calculating the counting, or total, efficiency. The counting efficiency is comprised of the instrument efficiency and the source efficiency. See the NRC staff discussion in Enclosure 1 of NRC, 2015b, under the heading *Counting efficiencies of Ludlum Model 3030 and 43-93*.

NRC Staff Comment 1

Please provide a methodology for calculating the static MDC that includes appropriate factors affecting the counting efficiency consistent with NUREG-1507 (NRC, 1998), or justification for an alternate methodology.

Issue 2: Determining Alpha and Beta Instrument Efficiencies

In its response the licensee stated:

"The typical beta/gamma efficiency for a 43-93 probe is 18 - 23 percent, therefore a value of 18 percent will be used in the nominal MDC calculations. For alpha efficiency, typical alpha detector efficiencies measured at site, which generally range from 13 - 22 percent, depending on the detector. A value of 13 percent has been assumed for the nominal calculations. The actual detector efficiency is determined for each probe on a routine basis, as per site procedures, using a natural uranium check source to ensure the efficiency is accurate and based on the applicable energy range for the contamination it is being used to measure."

In addition, the licensee stated the following regarding probe efficiencies for beta/gamma contamination:

"Note, these are nominal calculations, actual probe efficiencies may be used to determined limits for each detector and/or location."

Discussion

It is unclear to the NRC staff exactly how counting efficiencies will be determined for alpha and beta detectors.

As discussed in Issue 1 above, the MDC calculation should take the source efficiency into account in deriving the MDC. Moreover, consistent with NUREG-1507 (NRC, 1998) (see, for example, the discussion on page 5-14) and NUREG-1575, Supplement 1 (NRC, 2009), a weighted total efficiency should be calculated for the expected mixture of radionuclides to be evaluated. As a minimum, this should include aged yellowcake and pregnant lixiviant. See also NRC staff RAI No.3 in NRC, 2015a.

In addition, the NRC staff is uncertain of the pedigree of the source(s) being used to evaluate the efficiency of the detectors. While a radioactive standard that is traceable to National Institute of Standards and Technology (NIST), for example, would be suitable for calibration, a check source would not necessarily be appropriate (ANSI, 2013). See the discussion in Enclosure 1 of NRC, 2015b, under the heading *Calibration sources*.

NRC staff comment 2

Please provide the methodology for calculating radionuclide-weighted alpha and beta counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project. This should include, at a minimum, radionuclide mixtures for pregnant lixiviant and aged yellowcake.

As part of this description, please provide information on the radioactive source(s) used for determining the instrument efficiency of the alpha and beta detectors. This discussion should include information related to the physical size(s) of the source(s) in comparison to the active area of the probe(s) being calibrated and traceability (e.g., NIST) for the NRC staff to make a determination of consistency with applicable standards (e.g., ANSI, 2013).

Comments on Material & Equipment Surveys

Issue 3: MDC value for beta contamination on material and equipment

Discussion

As discussed above in Issues 1 and 2, the source efficiency and actual instrument efficiency will determine the MDC for beta emitting radionuclides.

NRC staff comment 3

After calculating radionuclide-weighted beta counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project, please demonstrate that the stated MDC values for beta contamination on material and equipment can be met.

Issue 4: MDC value for alpha contamination on material and equipment

In its response the licensee stated:

"For materials and equipment, Regulatory Guide 8.30 indicates the removable release limit is 1000 dpm/ 100 cm^2, the average total activity limit is 5000 dpm/ 100 cm^2 and the total maximum activity limit is 15,000 dpm/100 cm^2. Using the previously mentioned assumptions, if the background levels for beta/gamma reach 3450 counts in 5 minutes or 500 counts in 1 minute, this will result in MDCs of 745 dpm/100 cm^2 and 741 dpm/ 100 cm^2, respectively. If this background count rate is exceeded then smears will be required in order to release the equipment, as per existing site procedure, or the equipment will need to be moved to a lower background area for surveying. If contamination levels exceed 750 dpm/100 cm^2, an alpha smear will be required. Prior to leaving the restricted zone, the equipment must meet the alpha release limits outlined in Regulatory Guide 8.30."

Discussion

It is not clear to the NRC staff what MDC value the licensee is applying to alpha contamination for the release of material and equipment for unrestricted release. Regulatory Guide (RG) 8.30 (NRC, 2002) recommends that the value of the lower limit of detection be 500 dpm/ 100 cm^2.

NRC staff comment 4

Please provide the MDC value to be applied to alpha contamination for the release of material and equipment for unrestricted release.

In addition, after calculating radionuclide-weighted alpha counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project, please demonstrate that the stated MDC value for alpha contamination on material and equipment can be met.

Issue 5: Value for scan time, t_s, used in scan MDC formula

The licensee used Equation 6-2 from NUREG-1507 (NRC, 1998) to calculate the scan MDC for beta-gamma contamination. This is rewritten as Equation (2) in the licensee's December 19, 2014, submittal (Cameco, 2014) as follows:

$$Scan\ MDC\ \left(\frac{DPM}{100cm^2}\right) = \frac{d'\left(\frac{60}{t_s}\right)\sqrt{b\left(\frac{t_s}{60}\right)}}{\sqrt{p}\epsilon_i\epsilon_s\frac{Probe\ Area}{100\ cm^2}} \qquad (2)$$

Where: t_s = Scan time (sec)
d' = level of performance (Table 6.1 from NUREG 1507) (false negative portion =0.6, true positive = 0.95)
b_i = average number of bkg counts in interval (cpm)
p = surveyor efficiency; assumed 0.5
ϵ_i = instrument efficiency (18%)
ϵ_s = surface efficiency (0.5) from section 5 of NUREG 1507

In addition, the licensee stated:

"The planned scan rate is 1 cm/sec. With a 15 cm probe length, this scan rate equates to a scan time of 15 seconds."

Discussion

The NRC staff observes that the standard Ludlum Model 43-93 probe has a rectangular shape with a maximum active length of 14.48 cm, with the shorter active probe dimension being 6.93 cm (Ludlum, 2016). Using 14.48 cm instead of 15 cm would result in a slightly reduced scanning time if the maximum dimension was used for scanning consistently. Using the shorter active probe dimension would significantly decrease the scan time with a corresponding increase of the scan MDC. Although the licensee committed to recalculating the scan MDC if the scanning rate is changed, it is not clear to the NRC staff how the licensee will ensure that the maximum dimension is used consistently for scanning materials and equipment. This could be accomplished, for example, by procedures and training.

NRC staff comment 5

Please confirm that the actual active dimensions of the probe will be used for determining the scan MDC. In addition, please provide information on how the licensee will ensure that scans will be performed in a manner consistent with the calculated scan time used to calculate the scan MDC.

Issue 6: Description of level of performance, d', used in scan MDC formula

Refer to licensee's Equation (2) in Issue 5 above.

Discussion

Table 6.1 of NUREG-1507 (NRC, 1988) lists values for d' based on the accepted false positive proportion and true positive proportion. There appears to be a typographical error in the licensee's description of the value for d' that it chose, "false negative portion =0.6."

NRC staff comment 6

Please address typographical error in the description of d'.

Issue 7: Average number of background counts in interval, b_i.

Refer to licensee's Equation (2) in Issue 5 above.

Discussion

The licensee defines "b_i" in Equation (2). This definition is consistent with NUREG-1507 (NRC, 1998). However, the licensee use "b" (no subscript "i") in Equation (2), which is not defined.

NRC staff comment 7

Please provide a definition for "b" (no subscript "i") in Equation (2).

Issue 8: Efficiency values used in scan MDC formula

Refer to licensee's Equation (2) in Issue 5 above.

Discussion

As discussed above in Issues 1 and 2, the source efficiency and actual instrument efficiency calculated on a radionuclide-weighted basis will determine the MDC for beta emitting radionuclides.

In addition, using the licensee's assumed values, the NRC staff calculated a scan MDC of greater than 1000 dpm/ 100 cm^2.

NRC staff comment 8

After calculating radionuclide-weighted beta counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project, please demonstrate that the stated scan MDC value for beta contamination on material and equipment can be met.

Issue 9: Use of the scan MDC

Refer to the description of Issue 5 above.

Discussion

The scan MDC Equation 6-2 from NUREG-1507 is based on the premise that there are two stages of scanning (refer to p. 6-16 of NRC, 1998, and p. 6-39 of NRC, 2000): continuous monitoring and stationary sampling. The licensee has chosen a relatively high rate of false positives for the first stage in scanning. After detecting an increased number of counts during this first stage of scanning, the individual performing the scan should perform a stationary scan and compare the results to the background counting rate.

<u>NRC staff comment 9</u>

Please describe how the scan MDC will be utilized at the Crow Butte facility. Specifically, please address what actions will be required when individuals performing a scan detect an increased number of counts during the first stage of scanning and how these required actions will be maintained consistently among various individuals performing the scans, such as by written procedures and training.

Issue 10: No scan MDC calculation methodology proposed for alpha scans

Discussion:

In its September 4, 2014, e-mail to the licensee (NRC, 2014b), the NRC staff notified the licensee that the scan MDC formula presented in Equation 6-2 from NUREG-1507 (NRC, 1998) (see Issue 5 above) is not appropriate for alpha contamination. The licensee did not propose a methodology for calculating the scan MDC for alpha scans in its December 19, 2014, submittal (Cameco, 2014).

For alpha-emitting radionuclides, the scan MDC takes into account that the background response of most alpha detectors is very close to zero. At these low count rates, the probability of detecting alpha-emitting surface contamination is calculated using Poisson summation statistics. Equation 6-12 of NUREG-1575 describes the probability of observing a single count while passing the detector over a contaminated area (NRC, 2000). Abelquist (2014) defined the minimum alpha activity that can be detected by solving Equation 6-12 for “G”, resulting in:

$$Alpha\ scan\ MDC = \frac{\left[-\ln\left(1 - P(n \geq 1)\right)\right] * 60}{\varepsilon_i \varepsilon_s t}$$

Where P(n ≥1) is the probability of detecting a single count; ε_i is the instrument efficiency; ε_s is the surface efficiency; and t is the scan time (also referred to as residence time) in seconds.

For additional information see the discussion in NRC staff draft and final safety evaluations in NRC, 2015a, and NRC, 2015b, respectively.

NRC staff comment 10

If alpha scans will be used at the Crow Butte facility, please describe how the MDC will be calculated. In addition, after calculating radionuclide-weighted alpha counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project, please demonstrate that the stated scan MDC value for alpha contamination on material and equipment can be met.

Issue 11: Determining Alpha and Beta Instrument Efficiencies for the Ludlum Model 2929 counter or equivalent

Refer to the description of Issue 2 above for the calculation of MDC for stationary surveys.

Discussion

The NRC staff observes that there appears to be a typographical error on page 3 of 3 of Cameco, 2014, where Equation 3 (MDC) is labeled as Equation (1). The following equation is the subject of this issue:

$$MDC = \frac{3+3.29\sqrt{R_b\, t_g(1+\frac{t_g}{t_b})}}{\varepsilon_i t_g}$$

Where: R_b = the background count rate
t_g = the sample count time
t_b = the background count time
ε_i = the instrument efficiency

Similar to Issue 2 above, the MDC calculation should take the source efficiency into account in deriving the MDC. Moreover, consistent with NUREG-1507 (NRC, 1998) (see, for example, the discussion on page 5-14) and NUREG-1575, Supplement 1 (NRC, 2009), a weighted total efficiency should be calculated for the expected mixture of radionuclides to be evaluated. As a minimum, this should include aged yellowcake and pregnant lixiviant. See also NRC staff RAI No.3 in NRC, 2015a.

NRC staff comment 11

Please provide the methodology for calculating radionuclide-weighted alpha and beta counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project for the Ludlum Model 2929 counter or equivalent. This should include, at a minimum, radionuclide mixtures for pregnant lixiviant and aged yellowcake.

After calculating radionuclide-weighted alpha and beta counting efficiencies for the major radionuclide mixtures likely to be encountered at the Crow Butte Project, please demonstrate that the stated MDC values for alpha and beta contamination can be met for the Ludlum Model 2929 counter or equivalent.

General Comments

Issue 12: Source to detector distance

The distance between a source (i.e., area of contamination) and the detector may affect the instrument efficiency and, thus, MDC. (Refer to Section 4.2 of NRC, 1998, and p. 8 of NRC, 2015b)

Discussion

The NRC staff has endorsed (Refer to Section 4.2 of NRC, 1998) the recommendation that a detector's efficiency be determined at a source-to-detector distance that is similar to the expected detector-to-surface spacing in the field.

NRC staff comment 12

Please describe the source-to-detector distance used for determining detector efficiency and how various individuals performing surveys will maintain a detector-to-surface spacing that is similar to that distance.

References:

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