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The Impact of Carbon-14 on Limerick's Gaseous Effluent Dose Model

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From the 2009 RETS-REMP Workshop

- ✓ NRC is requiring that if Carbon-14 is a “Principal Radionuclide” at your site, then beginning in 2010, C-14 be must reported in the ARERR
- ✓ Report should include both curies and dose contributions from C-14
- ✓ Carbon-14 is **not** required to be measured
- ✓ May estimate the amount of C-14 released

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Is Carbon-14 a "Principal Radionuclide"?

- ✓ USNRC Regulatory Guide 1.21 Revision 2
  - Introduces the term "principal radionuclide"
  - A licensee may evaluate the list of principal radionuclides for use at a particular site
  - The principal radionuclides may be determined based on their relative contribution to (1) the public dose compared to the 10 CFR 50 Appendix I design objectives or (2) the amount of activity discharged compared to other site radionuclides released
  - Estimated that a BWR will release 9.5 curies per reactor per year.

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Is Carbon-14 a "Principal Radionuclide"?

- ✓ Limerick is a dual unit 3,458 MWt BWR

- ✓ Limerick's Gaseous Releases in 2009
  - 28.2 Ci of Noble Gas
  - 33.4 Ci of Tritium
  - 0.000049 Ci of Particulates
  - 0.000088 Ci of Iodines

  - 61.6 Ci Total

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Is Carbon-14 a "Principal Radionuclide"?

- ✓ 19 Ci of C-14 vs. 61.6 Ci from all other sources
- ✓ 19 Ci of C-14 would represents 23% of the radionuclides released from Limerick in 2009
- ✓ C-14 is a "Principal Radionuclide" based on curies released

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Limerick's ODCM Dose Model

- ✓ Simple model
- ✓ Assumes the pathways of milk (cow), inhalation, ground plane, meat (beef) and vegetation are located at site boundary
- ✓ Inhalation dose equation

$$D_I = 3.17E-8\left[\chi/Q\sum R_i Q_i\right]$$

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Limerick's ODCM Dose Model

- ✓ Vegetation, Meat and Cow Milk dose equation

$$D_{\mathrm{V,M,CM}} = 3.17E-8\left[\chi/Q\sum_{i=1}^{2} R_i Q_i + D/Q\sum_{i=3}^{n} R_i Q_i\right]$$

- ✓ C-14 dose is calculated using X/Q **not** D/Q

$$D_{\mathrm{V,M,CM}} = 3.17E-8\left[\chi/Q\sum_{i=1}^{2} R_i Q_i + D/Q\sum_{i=3}^{n} R_i Q_i\right]$$

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Limerick's ODCM Dose Model

- ✓ Uses conservative X/Q of 1.1E-5 sec/m^3
- ✓ 2009 NNG organ dose was = 3.68 E-02 mrem (teen thyroid)
  - 0.000049 Ci of Particulates
  - 0.000088 Ci of Iodines

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Carbon-14 Dose Contribution

- ✓ Using Limerick's simplified dose model
  - 19 Ci of C-14
  - X/Q of 1.1E-5 sec/m^3
  - Critical age group-organ = child-bone
  - Dose from:
    - Milk (cow) = **1.09E+01** mrem
    - Vegetation = **2.24E+01** mrem
    - Inhalation = **2.38E-01** mrem
    - Ground plane = **0.00E+00** mrem
    - Meat (beef) = **3.50E+00** mrem

    Total = **3.70E+01 mrem**

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Carbon-14 Dose Contribution

- ✓ 37 mrem = 9.25 mrem per quarter
- ✓ ODCM Limits (dual units):
  - 15 mrem - Quarter
  - 30 mrem - Annual
- ✓ The annual limit would be exceeded using conservative ODCM simplified dose model

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Changes to Limerick ODCM Dose Model

- ✓ Annual land-use census determines:
  - Nearest residence
  - Garden
  - Milk producing animal
- ✓ Annual land-use census does **not** determine the nearest meat location
- ✓ Modified census to include nearest meat (beef) location in each sector
- ✓ Meat (beef) to be included in future land-use censuses

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Changes to Limerick ODCM Dose Model

- ✓ Distance and direction information for those locations identified in the land-use census sent to Murray & Trettel, meteorological consultants
- ✓ M&T developed 5 Years of annual average X/Q and D/Q data for those receptors and for the ODCM default location (site boundary)
  - X/Q and D/Q determined by averaging the 5 data points (1 per year) and adding 2 standard deviation to the mean (maintain conservativism)

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Changes to Limerick ODCM Dose Model

- ✓ New site boundary X/Q = 1.37E-06 sec/m^3
- ✓ Almost a factor of 10 reduction
- ✓ Resulting dose to a child-bone calculated as 4.61 mrem
  - Milk (cow) = **1.36E+00** mrem
  - Vegetation = **2.79E+0**0 mrem
  - Inhalation = **2.96E-02** mrem
  - Ground Plane = **0.00E+00** mrem
  - Meat (beef) = **4.36E-01** mrem

  Total = **4.61E+00 mrem**
- ✓ Significant reduction, but still high

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New Receptor X/Q

New X/Q values for the following receptors:

- ✓ Nearest Residence
  - Inhalation
  - Ground Plane
- ✓ Vegetation
  - Inhalation
  - Ground Plane
  - Vegetation
- ✓ Meat
  - Meat (beef)
  - Inhalation
  - Ground Plane
- ✓ Milk
  - Cow Milk
  - Meat (assume a cow is butchered)
  - Inhalation
  - Ground Plane
  - Vegetation (assume farmer has a garden)

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Receptor X/Q Developed

- ✓ X/Q values for each receptor inputted into effluent dose model software
- ✓ Milk receptor has highest dose potential due to milk and vegetation pathways
  - X/Q = 6.810E-08 sec/m^3
- ✓ Dose from 19 curies of C-14
  - Child-Bone = 0.229 mrem (16,000% reduction)
- ✓ No impact on ODCM organ dose limits of 15 and 30 mrem

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Is Carbon-14 a "Principal Radionuclide"?

- ✓ 2009 = 0.037 mrem without C-14 (teen thyroid)
  0.00037 mrem to child bone
- ✓ C-14 dose would have increased total annual organ dose by 0.229 mrem
- ✓ Annual dose will increase 719% from C-14 releases
- ✓ C-14 is a "Principal Radionuclide" based on 10 CFR 50 Appendix I Design Objectives

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2010 ODCM Dose Model Changes

- ✓ Receptors with the highest X/Q, D/Q per pathway will have doses calculated
- ✓ North stack is the common offgas release point for both units (4.03E+09 cc/yr)
- ✓ A C-14 concentration of 4.71E-09 uCi/cc will be added monthly to the effluent dose program as a composite
- ✓ Calculated X/Q and D/Q values for the highest dose potential receptors will be added to the ODCM in the next revision

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Conclusions

- ✓ C-14 will significantly increase doses from gaseous effluents
- ✓ Based upon both curies released and dose contribution, carbon-14 is a “Principal Radionuclide”
- ✓ Carbon-14 needs to be reported in the Limerick's 2010 ARERR
- ✓ If not already done, then need to determine what impact C-14 has on your site’s gaseous effluent doses

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