February 7, 2003

MEMORANDUM TO: Larry W. Camper, Chief
DCB/DWM/NMSS

FROM: Lawrence E. Kokajko, Acting Chief ***/RA/***
EPAB/DWM/NMSS

SUBJECT: REVIEW AND APPROVAL OF PROPOSED DCGLs FOR KERR McGEE TECHNICAL CENTER (TAR 8096)

The Performance Assessment Section (EPAB) has reviewed the Licensee's proposed DCGLs for the Kerr McGee Technical Center. This review was complicated by the Licensee's use of ICRP-72 dosimetry instead of the default ICRP-30 dosimetry on which most decommissioning and other licensing actions at NRC are based. Although NRC regulations do not require the use of ICRP-30 dosimetry, ICRP-72 allows the determination of age-specific doses to the critical group or groups. The Licensee's calculations were restricted to adults only. The NRC staff supplemented the Licensee's determination of DCGLs by calculating doses for children using ICRP-72. We concluded that the Licensee's DCGL's were generally protective of all age groups, as detailed in the attached report. Please contact Dr. Richard Codell with any questions.

Docket Number: 40-8006
License Number: SUB-986

Attachment: DCGLs Report Review

CONTACT: Richard B. Codell, EPAB/DWM
(301) 415-8167

(EPAB-TAR-30)

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NRC Staff Final Review of Proposed Derived Concentration Guideline Levels for the
Kerr-McGee Technical Center, Oklahoma City, OK
TAR 8096 (EPAB-TAR-30)

I. Introduction

A. Background of Initial Review

The Nuclear Regulatory Commission (NRC) staff has reviewed previously the Decommissioning Plan for the Kerr-McGee Technical Center (KMTC) in Oklahoma City, OK (Memo from L.W. Camper to Dwight Chamberlain, December 17, 2001). We concurred in the licensee's conclusions with the following exceptions:

- Use of ICRP 72 dose factors for ingestion along with Federal Guidance Report 11/ICRP 30 dose factors for inhalation.

- Use of an air turnover rate of 10/hour for indoor DCGLs.

The Commission has recommended that use of ICRP-72 in licensing and decommissioning should be handled on a case-by-case basis.

Kerr-McGee responded to NRC's request for additional information in a report and memo to Blair Spitzberg, Chief of the Fuel Cycle Decommissioning Branch, Region IV, on March 6, 2002. Upon further review, the NRC staff had additional concerns with the DCGL analyses; in particular:

- The licensee used a conversion factor of 2.03 to account for the number of beta plus internal conversion electrons per disintegration. This effectively increased DCGL's by a factor of 2.03. The staff did not feel that it was appropriate to include this factor directly in the DCGLs. This is more correctly an issue concerning instrument calibration.

- The licensee did not justify the choice of the inhalation absorption class (slow, medium, fast) for ICRP-72.

- The licensee did not consider the six age classes in ICRP-72, but chose the adult as the average member of the critical group.

There were several exchanges with representatives of Kerr-McGee to resolve these differences. On September 25, 2002, the NRC staff met with Kerr-McGee representatives at NRC headquarters. Based on the conversations in this meeting, the Licensee agreed to provide an amended assessment of DCGLs for the Decommissioning Plan directly to the staff.

II Licensee's Revised Input

The Licensee submitted a report to Blair Spitzberg dated October 16, 2002, "Clarification and Modifications to KMCLLC Techncial Center Derived Concentration Guideline Levels and Decommissioning Plan". In this report, they discussed four areas:

- Justification for the use of ICRP 72 inhalation absorption classes.
- Justification of the proposed removal fraction for surfaces.
- Justification for weighting factors for external exposure.
- Justification of the adult as the average member of the critical group.

A. Licensee's Justification for use of ICRP 72 Inhalation absorption classes

The NRC staff voiced its concern that inhalation absorption classes should be justified, or the most conservative class should be chosen for the dose assessments. The licensee elected the latter approach, choosing the most restrictive ICRP 72 absorption classes for indoor building DCGLs. The staff accepts this approach.

B. Licensee's Justification of the proposed removable fraction

The licensee presented data on the removable fraction for contaminated surfaces based on surface swipes and the ratio between fixed plus removable beta surveys and beta smear surveys. The highest removable fraction found in their survey was about 10 percent, and the minimum was zero. The average removable fraction deduced from these measurements was 0.007. Although the staff recognized that measurement of this parameter is difficult and uncertain, the staff has no basis for questioning the licensee's results. The staff accepts these results for use in the calculations.

C. Licensee's Justification for use of weighting factors for external exposure

The licensee presented information that the differences in the ICRP 26/30 and ICRP 60/72 factors would be minor ---not likely to exceed about 10 percent--- and would only affect the portion of the doses from external radiation. The licensee claims that the differences are small in comparison to other uncertainties in the dose modeling. While the staff believes that the licensee's point is valid, we took an alternative approach to adjusting the radiation exposure to children, which will be covered below.

D. Licensee's Justification of the Adult as the average member of the critical group

The licensee states that the Technical Center is the primary laboratory for research for the Chemical Division and will remain so for the foreseeable future. The laboratory employs approximately 85 people, who work primarily on titanium dioxide and electric batteries, and does not deal directly with radioactive substances. Only adults will be employed, and the presence of younger individuals will be only on an occasional basis, for short periods of time. The grounds of the site were formerly used for occasional outdoor sports by youth teams, but such use is no longer allowed. The licensee argues that Kerr-McGee is not ignoring other age groups, but after deliberate consideration has decided that the adult was the likely age group for evaluating the site. Further, they argue that NRC guidance does not demand that the maximally exposed

group has to be chosen for the purposes of dose assessments or that a "worst case" analysis has to be performed; only that the licensee has to consider expected exposure to the group that is most likely to use the facility.

One scenario the licensee considered is the reversion of the laboratory sometime in the future to another use involving children. They argue that modification of areas of the laboratory where radioactive materials were used or stored would require significant new construction materials that would reduce the potential for exposure.

E. Other factors in the analysis

The licensee originally proposed that an air exchange rate of 10 changes/hour was suitable for their situation because the space would be devoted largely to laboratories. Staff commented that this was at the upper end of the recommended range from NUREG/CR-6755. In response, the licensee reduced the air exchange rate to 1.52 changes/hour for conservatism.

III. Staff's analysis of use of adult as average member of critical group

The staff lacks specific guidance on the use of ICRP-72 dosimetry in its regulations, and especially the exposure of children. Since this license termination is unconditional, the staff feels it is prudent to at least present results of calculations involving ICRP-72 dosimetry and exposure to children, and to compare to the doses calculated from the standard ICRP-30 dosimetry normally used. The staff conducted some alternative analyses to determine how protective of children would be the use of the adult as the average member of the critical group. This analysis consisted of a set of deterministic and probabilistic runs using the RESRAD (Yu, 1994) and RESRAD-BUILD (Yu, 2000) codes, comparing instantaneous doses for an adult versus children, both using ICRP-72 dose factors for the respective age categories. These calculations were performed mainly to highlight differences in doses among the age groups rather than to calculate DCGLs. Most of the runs were probabilistic, using ranges from NUREG/CR-6755 (Biwer, 2002). However, in most cases usage factors for inhalation and ingestion were kept at fixed values for each age category to simplify the interpretation of age-dependent results. For the probabilistic results, only mean dose values were reported.

A. Dose Factors from ICRP-72

Ingestion and inhalation dose factors are presented in Table 1 for ICRP-72. The inhalation dose factors represent the worst-case absorption for each age category. Currently, RESRAD Version 6.23 allows the definition of a new dose factor library, and the ICRP-72 values were manually added for these cases. RESRAD-BUILD version 3.1 does not have the same provision, and the file NUCDCF.DAT had to be manually edited to include the new dose factors.

B. Usage Factors for Adults and Children

Usage factors were compiled from several sources, and compared to the licensee's values for adults. Table 2 shows the ratios of usage factors for inhaled air, ingested water, food calories and cow's milk, derived from FRG-13 (Eckerman, 1999). This table assumes that an adult is the average of a 20-year old male and female user, and gives the ratio of usages for average members of each age group to the adult user. Ratios from Table 2 are then used to generate

age-specific inputs for outdoor soil and groundwater DCGLs. Somewhat different set of references for inhalation was used for the indoor surface DCGL's, because inhalation rates are likely to be lower for indoor activities. For indoor surface DCGLs, staff used breathing rates directly from EPA (1997), averaged for males and females. All of the derived usage factors for RESRAD and RESRAD-BUILD calculations are given in Table 3.

Although it would have been possible to calculate a dose for the 3-month age category, its meaning and usefulness to the present analysis were questionable. Children so young are likely to be carried in arms, receive only a milk diet, and generally would not be exposed by way of ingestion from hand-to-mouth as would older children. For this reason, only doses from one year old children and older are reported.

C. Correction factors for direct radiation

Neither RESRAD nor RESRAD-BUILD allow modification to dose weighting factors for direct radiation. Therefore, direct radiation doses to children were adjusted using NCRP Report 129 (NCRP, 1999), which suggests that children will receive from 10 to 30 percent higher doses than for typical adults, with a larger ratio for low-energy gamma, beta and x-ray emitters. The direct exposure doses to all children was therefore increased by 30 percent.

D. Soil and groundwater DCGLs

We conducted a set of deterministic and probabilistic RESRAD runs comparing dose levels and soil cleanup levels for the three radionuclide series. These calculations differ from those of the licensee in two important respects, namely (1) They were calculated for all age categories greater than or equal to one year using age-specific dose conversion factors from ICRP-72, (2)They used age-specific usage factors, and (3) they used worst-case inhalation absorption factors from ICRP-72 (the staff did not ask the licensee to repeat soil calculations with worst-case inhalation absorption factors).

Soil DCGLs

The licensee and staff results are in reasonable agreement:

Uranium series - The staff calculated a soil DCGL for uranium series isotopes U-238, U-235 and U-234 plus progeny using the resident farmer scenario. The staff's probabilistic and deterministic results for the adult were 210 and 205 pCi uranium per gram, respectively, compared to the licensee's value of 228 pCi uranium per gram.

Th-232 and progeny - The staff calculated the soil DCGL for Th-232, Th-228 and Ra-228 and progeny to be 6.4 and 6.2 pCi thorium per gram for the probabilistic and deterministic runs, respectively. This compares to the licensee's DCGL of 5.3 pCi thorium per gram.

Th-230 and progeny - The staff calculated the soil DCGL for Th-230, Ra-226 and progeny to be 3.73 and 3.43 pCi thorium per gram for the probabilistic and deterministic cases, respectively. This compares to the licensee's DCGL of 3.5 pCi thorium per gram.

Age-dependent doses - Table 4 shows the relative doses for five of the six age classes stipulated in ICRP-72. Assumptions about age-specific usage factors are shown in Table 3.

Contaminated Soil in Uranium Pit

Results for the uranium pit show reasonable agreement between the staff's and licensee's calculated DCGLs for the adult resident farmer. The staff's deterministic DCGL was 136 pCi uranium per gram, compared to the licensee's result of 165 pCi uranium per gram. The relative doses for all age category are summarized in Table 5. The largest dose reported was for the 15-yr old age category, due mainly to Ra-226.

E. Dose from exposure to contaminated surfaces in buildings

Calculated DCGLs for contaminated building surfaces show good agreement between the staff and licensee:

Uranium series - The staff calculated a deterministic surface DCGL for uranium series isotopes U-238, U-235, U-234 plus progeny of 146,200 DPM/100 cm^2 compared to the licensee's value of 177,300 DPM/100 cm^2.

Th-232 and progeny - The staff calculated a deterministic surface DCGL for Th-232, Th-228, Ra-228 and progeny to be 11,100 DPM/100 cm^2 compared to the licensee's value of 12,500 DPM/100 cm^2.

Th-230 and progeny - The staff calculated a deterministic surface DCGL for Th-230, Ra-226 and progeny to be 16,100 DPM/100 cm^2 compared to the licensee's value of 12,500 DPM/100 cm^2. Doses to the five age categories are given in Table 6 for indoor exposure from contaminated surfaces, and compared to results from the standard dosimetry of RESRAD-BUILD. Doses for children are up to a factor of about 2.5 larger than the adult.

F. Protectiveness of Adult Dose Applied to Children

The question of whether the choice of the adult as the average member of the critical group is protective of children has been considered in formulating other NRC regulations, particularly 10CFR63 for the proposed Yucca Mountain high-level waste repository. In response to questions asked during the rule-making period, NRC responded that:

> '...The purpose of the public dose limit is to limit the lifetime risk from radiation to a member of the general public. The conversion factor used to equate dose into risk is based on data from various populations exposed to very high doses of radiation such as the atomic bomb survivors, and these populations contained individuals of all ages. Therefore, variation of the sensitivity to radiation with age and gender is built into the standards which are based on a lifetime exposure. A lifetime exposure includes all stages of life from birth to old age..." (FR 2001).

Several other reasons can be cited to support the notion that the use of the adult as the average member of the critical group is appropriate:

- The concept of an “average member of the critical group” recognizes that the there will be a range of individuals in that group, some more affected by radiation and some less. If children are more affected by some of the radionuclides by factors of less than 3, it could be argued that they are still members of the critical group, just not the average member.

- The facility is being used as a laboratory by adults, and no children would be expected to be stay in the building or grounds other than for short visits.

- Should the facility convert to some other use in the future that would allow significant use by children (e.g., a day care center), it would probably involve renovation, including replacement, painting, sealing or renewal of walls, ceilings, and floors.

- The dose a person receives in a single year contributes to an overall risk over their lifetime. risk to a person is proportional to the cumulative dose he or she received since birth. In the Statement of Consideration for the License Termination Rule, risks were estimated assuming a 30-year lifetime exposure “...from contaminated sites based on the assumption that it is unlikely that an individual will continue to live or work in the same area for more than 30 years”(FR, 1997). Applying this same philosophy of a 30-year accumulation of risk, it is possible to demonstrate the difference in assuming that the exposed person is always an adult, versus assuming age-based doses in each category.

  For the purposes of this demonstration we make the following simplifying assumptions:

– The site has been cleaned-up precisely to the DCGLs for soil, groundwater and building surfaces.

– The person gets an equal dose from the soil, groundwater and building-surface pathways.

– The person gets an equal dose from each of the three radionuclide groups; i.e., U-238 through U-234, Th-232 and progeny, and U-230 and progeny.

– Children in the first year (i.e., 0 to 1 year) receive the same dose as the one-year old child.

Integrating the dose rates for the age categories from zero to 30 years and comparing it to the doses received to an adult in the same period results in an increased risk of about 28 percent. This increase in risk would be smaller if a 50 or 70 year period for accumulating risk had been used (17 percent and 12 percent, respectively). The modest increase in integrated risk to children demonstrates that there is only a small effect of ignoring age-related dose in setting the DCGLs.

G. Comparison of ICRP-72 Dosimetry and Standard Approach

The RESRAD and RESRAD-BUILD results were compared for the adult age group only, using the ICRP-72 dosimetry and the default ICRP-30 dosimetry. Table 7 shows the comparisons. All runs were deterministic, although probabilistic runs for RESRAD gave similar results. The higher allowed DCGLs calculated by the licensee reflect the lower dose factors of ICRP-72.

IV Conclusions and recommendations

The staff agrees with the licensee that the adult is the average member of the critical group for this site, and is generally protective of all age groups likely to use the site. Furthermore, scenarios for which the site occupants would be different than the chosen scenario would be less likely, and therefore could receive a lower weight than the main scenario when risk is considered.

The licensee proposes to assume that the contaminant is entirely the most restrictive one, Th-232, in their final status survey, unless they encounter values higher than the DCGL. In that circumstance, they will determine the relative contribution from the residual contamination of each radionuclide, combined into a single dose value with the unit rule. The staff considers this approach to be reasonable and concurs in its use.

In consideration of all factors discussed above, the staff recommends approval of the DCGLs for the licensee's Decommissioning Plan, as shown in Table 8.

V References

Biwer, B.M., and others, "Technical basis for calculating radiological dose for building occupancy scenario using probabilistic RESRAD-BUILD 3.0 code", Environmental Assessment Division, Argonne National Laboratory, NUREG/CR-6755, U.S. Nuclear Regulatory Commission, February 2002.

Eckerman, K., R. Leggett, C. Nelson, J. Puskin, A. Richardson, "Cancer Risk Coefficients for Environmental Exposure to Radionuclides", Environmental Protection Agency, Office of Radiation and Indoor Air, September 1999

EPA 1997, EPA/600/P-95/002 a, b&c, National Center for Environmental Assessment, Office of Research and Development, Environmental Protection Agency, August 1997, also reproduced as Table A-11 in "Technical Basis for Calculating Radiation Doses for the Building Occupancy Scenario using the Probabilistic RESRAD-BUILD 3.0 Code", Argonne National Laboratories, NUREG/CR-6755, February 2002.

FR 1997, Radiological Criteria for License Termination, IV. Summary of Public Comments, Responses to Comments, and Changes from Proposed Rule, A.2.2.1, page 39061, Federal Register, Vol 62, no 139, Rules and Regulations, July 21, 1997

FR 2001, Rules and Regulations, pages 55752-55753, Federal Register, Vol 66, No. 213, November 2, 2001

NCRP 1999, “Recommended Screening Limits for Contaminated Surface Soils and Review of Factors Relevant to Site-Specific Studies”, NCRP Report 129, National Council for Radiation Protection and Measurements, Bethesda MD, January 29, 1999

Yu, C. , and others, “RESRAD-BUILD: A computer model for analyzing the radiological doses resulting from the remediation and occupancy of buildings contaminated with radioactive material”, ANL/EAD/LD-3, Environmental Assessment Division, Argonne National Laboratory, November 1994.

Yu, C. and others, “Users manual for RESRAD Version 6", ANL/EAD-4, Environmental Assessment Division, Argonne National Laboratory, July 2001.

Table 1 - Dose factors, Sv/Bq from ICRP72, Most Conservative Inhalation Absorption Class

Nuclide	3mo	3mo	1yr	1yr	5yr	5yr	10yr	10yr	15yr	15yr	adult	adult
	Ingest	Inhale	Ingest	Inhale	Ingest	Inhale	Ingest	Inhale	Ingest	Inhale	Ingest	Inhale
Pb210	8.4e-6	1.8e-5	3.6e-6	1.8e-5	2.2e-6	1.1e-5	1.9e-6	7.2e-6	1.9e-6	5.9e-6	6.9e-7	5.6e-6
Ra226	4.7e-6	3.4e-5	9.6e-7	2.9e-5	6.2e-7	1.9e-5	8.0e-7	1.2e-5	1.5e-6	1.0e-5	2.8e-7	9.5e-6
Ac227	3.3e-5	1.7e-3	3.1e-6	1.6e-3	2.2e-6	1.0e-3	1.5e-6	7.2e-4	1.2e-6	5.6e-4	1.1e-6	5.5e-4
Th228	3.7e-6	1.8e-4	3.7e-7	1.5e-4	2.2e-7	8.3e-5	1.4e-7	5.5e-5	9.4e-8	4.7e-5	7.2e-8	4.0e-5
Th230	4.1e-6	2.1e-4	4.1e-7	2.0e-4	3.1e-7	1.4e-4	2.4e-7	1.1e-4	2.2e-7	9.9e-5	2.1e-7	1.0e-4
Th232	4.6e-6	2.3e-4	4.5e-7	2.2e-4	3.5e-7	1.6e-4	2.9e-7	1.3e-4	2.5e-7	1.2e-4	2.3e-7	1.1e-4
Pa231	1.3e-5	2.2e-4	1.3e-6	2.3e-4	1.1e-6	1.9e-4	9.2e-7	1.5e-4	8.0e-7	1.5e-4	7.1e-7	1.4e-4
U234	3.7e-7	3.3e-5	1.3e-7	2.9e-5	8.8e-8	1.9e-5	7.4e-8	1.2e-5	7.4e-8	1.0e-5	4.9e-8	8.4e-6
U235	3.5e-7	3.0e-5	1.3e-7	2.6e-5	8.5e-8	1.7e-5	7.1e-8	1.1e-5	7.0e-8	9.2e-6	4.7e-8	8.5e-6
U238	3.4e-7	2.9e-5	1.2e-7	2.5e-5	8.0e-8	1.6e-5	6.8e-8	1.0e-5	6.7e-8	8.7e-6	4.5e-8	8.0e-6

Table 2 - Usage Factor Ratios from FGR13, Table 3.1 (Eckerman, 1999)

Age group	Air Ratio	Water Ratio	Food Calories	Cow's Milk
Adult	1	1	1	1
15 yr	0.895	0.856	0.873	1.32
10 yr	0.765	0.729	0.738	1.38
5 yr	0.44	0.551	0.815	1.24
1 yr	0.26	0.233	0.316	1.07
0 yr	0.145	0.201	0.194	1.04

Table 3 - Usage Factors for Age Groups 1 year to Adult

Usage	1 year	5 year	10 year	15 year	Adult
Breathing Rate, Farm m^3/yr	2180	3700	6430	7520	8400
Breathing Rate, Indoor m^3/yr	2154	3249	4928	5146	4836
Exposure Duration, Yr	69	65	60	55	50
Fruits and Vegetables, Kg/yr	52.5	102	123	145	166
Leafy Vegitables, Kg/yr	3.5	6.8	8.1	9.6	11
Milk, Liters/yr	107	124	138	132	100
Meat and Poultry, kg/yr	19.9	38.7	46.5	55	63
Fish, Kg/yr	1.7	3.3	4	4.7	5.4
Other seafood, Kg/yr	0.28	0.55	0.66	0.79	0.9
Outdoor soil ingest, gr/yr	66.6	66.6	66.6	18.25	18.25
Drinking Water, liters/yr	170	402	532	625	730
Indoor ingest, m^2/yr	0.011	0.011	0.011	0.00011	0.00011

Other fixed factors for RESRAD-BUILD analysis of indoor surfaces:

Time for release = 365 days
Release fraction 0.007
6 sources
250 total days per year
Fraction inside = 0.685
Room height = 3 M
Room area = 36 M^2

Deposition velocity = 3.9×10^{-4} M/s
Resuspension rate = 6.26×10^{-8} /s
No direct ingestion
Removable fraction 0.007
Removal time = 365 days
Fraction released to air = 0.1

Table 4 - Age Related Doses for Soil

Age Category	U series and Progeny- mrem/pCi U	Ratio to Adult	Th-232, Th228 and Ra-228, mrem/pCi Th	Ratio to Adult	Th-230, and progeny mrem/pCi Th	Ratio to Adult
Adult	0.06262	1	3.097	1	4.518	1
15 yr old	0.0787	1.26	3.98	1.29	6.44	1.43
10 yr old	0.0958	1.53	4.02	1.3	6.52	1.44
5 yr old	0.101	1.61	4.02	1.3	6.7	1.43
1 yr old	0.111	1.77	4.02	1.3	6.7	1.48

Table 5 - Age Related Doses for Groundwater Contamination At Uranium Pit

Age Category	Dose mrem/pCi	Ratio to Adult Dose
Adult	0.1839	1
15 yr old	0.2791	1.52
10 yr old	0.219	1.19
5 yr old	0.1942	1.06
1 yr old	0.1258	0.684

Table 6 - Summary of RESRAD-BUILD Results

Age Class	U Series - mrem/pCi U	Ratio to adult	Th-232 mrem/pCi Th	Ratio to adult	Th230 mrem/pCi Th	Ratio to adult
Adult	1.71E-4	1	2.25E-3	1	1.55E-3	1
15 yr	2.17E-4	1.27	2.91E-3	1.29	1.86E-3	1.2
10 yr	3.5E-4	2.05	3.59E-3	1.6	3.6E-3	2.32
5 yr	3.92E-4	2.29	3.77E-3	1.68	3.85E-3	2.48
1 yr	4.15E-4	2.43	3.48E-3	1.55	3.67E-3	2.37

Table 7 - Comparison of Doses from ICRP-72 Dosimetry and ICRP-30 Dosimetry for Soils and Surfaces

Radionuclide Group	Ratio ICRP-30 results to ICRP-72 results - RESRAD soil	Ratio ICRP-30 results to ICRP-72 results RESRAD-BUILD surfaces
Uranium Series	2.31	2.73
Th-232 Series	1.04	0.97
Th-230 Series	1.2	1.8

Table 8 - Licensee's DCGLs for Soil and Surfaces

Radionuclide and Situation	DCGL Value
Uranium Series - Soil	228 pCi U/gram
Th-232 Series - Soil	5.3 pCi Th/gram
Th-230 Series - Soil	3.5 pCi Th/gram
Uranium Series - Indoor Surfaces	166,300 DPM/100 cm^2
Th-232 Series - Indoor Surfaces	12,500 DPM/100 cm^2
Th-230 Series - Indoor Surfaces	16,300 DPM/100 cm^2
Uranium Series - Soil in Test Pit	165 pCi U/gram