Idaho National Engineering and Environmental Laboratory

INTEROFFICE MEMORANDUM

Date: November 22, 2002

To: V. L. Jacobson MS 3670 6-3763

From: R. R. Kimmitt RRK MS 6-3670 6-5158

Subject: REVISION 1 -TANK WM-182 CLEANING EFFECTIVENESS

References:
(a) DOE/ID-10802, Idaho Hazardous, *Waste Management Act/Resource Conservation and Recovery Act Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183*, November 2001
(b) DOE/ID-10777, *Idaho Nuclear Technology and Engineering Center Tank Farm Facility Residuals-Waste-Incidental-to-Reprocessing Determination Report*, July 30, 2001
(c) EDF-1920 Revision 4, *Validation of the Radionuclide Mass Balanced Used in the INTEC SBW WIR Determination Report*, August 29, 2002
(d) R. R. Kimmitt, letter to V. L. Jacobson, RKK-02-02, *Tank WM-182 Cleaning Effectiveness*, October 30, 2002

Throughout the summer of 2002, vessel WM-182 at INTEC was cleaned as part of a State-approved closure plan. Cleaning operations took place on six separate days. The primary goal of the cleaning process was to remove radioactivity and chemical contaminants from the tank. Even with the limits inherent in the cleaning methods, it is estimated that the 27,800 curies that remained in the tank WM-182 heel had been reduced through cleaning to about 1,800 curies (about 93% removal). Once the maximum practical amount of radioactivity had been removed (and pumped to nearby tank WM-187), the remaining contents would be grouted in place within WM-182. Mock-up tests have shown that the grouting process also moves much of the remaining liquids and solids to the ejector pump so they can be removed (reference a).

Background

By July 1999 WM-182 had been emptied to heel level by removing as much SBW as possible. Based upon the quantities of solids and liquids estimated from the in-tank video inspection, and from sampling results, the total WM-182 radionuclide content was estimated to be 14,000 curies in the solids and 13,800 curies in the liquid before cleaning began (decayed to June, 2002) (reference c).

Cleaning was accomplished by performing the following steps: (a) modifying the in-tank steam jet to lower it to within 1 inch of the tank floor, (b) washing with clean, high pressure water, and (c) pumping the slurry from the tank. Tank WM-182 was cleaned using a wash ball and directional spray nozzles to rinse and slurry the solids. The operations group used the steam jet to remove as many of the solids as practical.

As part of the documentation for a "Waste Incidental to Reprocessing" (WIR) determination from DOE, an initial prediction of the cleaning process performance was made. To do this, the cleaning process was modeled as a continuously stirred tank with clean water entering through spray nozzles and dirty water

leaving through the steam ejector (reference b). It was estimated that the bulk of the radioactivity could be removed by spraying about 75,000 gallons of clean water into the tank. In practice, it was not expected that stirred tank conditions could be maintained. The influent flow rate was about 75 gpm while the ejector could only pump about 50 gpm. The flow of wash water was periodically stopped to keep the fluid level from continuously rising and dampening the impact of the wash water streams. With a low fluid level, the maximum amount of mixing could be obtained from the wash water as it was sprayed into the tank. Complete mixing was also unlikely because of the tank configuration. The tank is 50 feet in diameter, and, during the cleaning process, the fluid level was kept between 1 and 6 inches. Complete mixing in a large shallow tank was expected to be difficult to achieve.

Actual WM-182 cleaning results showed that even with the limitations inherent in the cleaning methods, an estimated 93% of the total radioactivity in the tank was removed. This value is based on: (a) analyses of samples of the tank contents before cleaning, and (b) visual observations of the tank bottom and sides before, during, and after cleaning. The rate of removal of radioactivity showed an exponential decrease, as would be expected from a continuously stirred tank. The actual data from tank cleaning showed that nearly complete mixing was achieved, although there was a practical limit to the amount of solids removed. It is expected that a significant fraction of the remaining radioactivity will be removed early in the tank grouting process.

Data Collection

Radioactivity being pumped from tank WM-187 was monitored in the discharge piping in valve box C-2. The detector was an unshielded GM counter mounted near the pipe. Output from the counter was recorded at counts per minute at periodic time intervals. No measurement or estimate of detector efficiency is available. The count rate data were provided to project personnel in the form of charts. Figure 1 is an example.

No discharge volume flow rate data are available. It has been assumed that the ejector operated continuously at 50 gpm during each cleaning session. Flow was periodically interrupted to the wash ball and wash nozzles to prevent the tank fluid level from rising above the desired range.

Data Analysis

To determine how the radioactivity content of tank WM-182 was decreasing, it was necessary to estimate the activity concentration of material being pumped from the vessel. The count rate was typically noted at10-15 minute intervals. From these values and the assumed flow rate, a "concentration" term was calculated and plotted against cumulative volume of liquid pumped from the vessel. It was necessary to subtract a "background" level from the count rate information. Typically, background was assumed to be the starting count rate on each day of pumping operations. Table 1 and Figure 2 show the calculations and resulting curve.

Figure 1. Discharge Pipe Radiation Readings

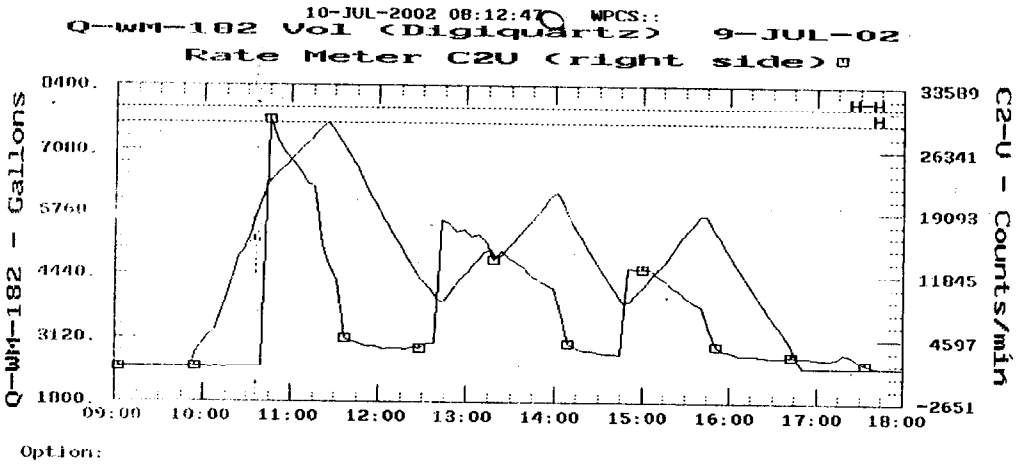


Table 1. Count Rate Calculations

Date	Hours	Minutes	Cumulative Gallons Pumped	Counts per Minute (adjusted for background)	CPM/Gallon
6/27/2002	16	20	0	-	N/A
	17	0	2000	-	-
	17	15	2750	8,232	11
	17	30	3500	5,051	7
	17	45	4250	3,750	5
	18	0	5000	3,326	4
	18	15	5750	16,185	22
	18	30	6500	21,969	29
	18	45	7250	13,293	18
	19	0	8000	723	1
	19	15	8750	-	-
7/9/2002	9	50	8750	-	N/A
	10	15	10000	8,698	7
	10	30	10750	15,221	20
	10	45	11500	28,267	38
	11	0	12250	23,919	32
	11	15	13000	20,874	28
	11	30	13750	11,451	15

Table 1. Count Rate Calculations (Continued)

Date	Hours	Minutes	Cumulative Gallons Pumped	Counts per Minute (adjusted for background)	CPM/Gallon
7/9/02	11	45	14500	3,623	5
	12	0	15250	2,900	4
	12	15	16000	2,610	3
	12	30	16750	3,190	4
	12	45	17500	17,396	23
	13	0	18250	16,361	22
	13	15	19000	14,496	19
	13	30	19750	13,046	17
	13	45	20500	11,161	15
	14	0	21250	9,713	13
	14	15	22000	2,900	4
	14	30	22750	2,175	3
	14	45	23500	2,030	3
	15	0	24250	11,596	15
	15	15	25000	10,438	14
	15	30	25750	8,118	11
	15	45	26500	4,928	7
	16	0	27250	1,885	3
	16	15	28000	1,595	2
	16	30	28750	1,450	2
	16	45	29500	1,305	2
7/22/2002	9	45	29500		
	10	0	30250	-	-
	10	15	31000	-	-
	11	15	34000	8,976.20	12
	11	30	34750	5,553.00	7
	11	45	35000	3,147.40	4
	12	0	36250	1,526.90	2
	12	15	37000	1,295.40	2
	12	30	37750	6,709.50	9
	12	45	38500	6,431.70	8
	13	15	40000	4,719.60	6
	13	30	40750	1,943.60	3
	13	45	41500	1,341.70	2
	14	0	42250	4,765.90	6
	14	15	43000	3,932.50	5
	14	30	43750	3,608.40	5
	14	45	44500	2,638.10	4

Table 1. Count Rate Calculations (Continued)

Date	Hours	Minutes	Cumulative Gallons Pumped	Counts per Minute (adjusted for background)	CPM/Gallon
7/22/2002	15	0	45250	1,295.40	2
	15	15	46000	2,452.90	3
	15	30	46750	3,008.50	4
	15	45	47500	1,388.00	2
	16	0	48250	972.30	1
	16	15	49000	833.40	1
	16	22	49350	787.10	2
8/15/02	10	25	49350		
	10	30	49600	-	-
	10	52	507000	840.00	1
	10	55	50850	3,640.00	24
	11	0	51100	3,240.00	13
	11	7	51450	2,540.00	7
	13	52	51450	-	-
	14	0	51850	4,440.00	11
	14	10	52350	5,340.00	11
	14	20	52850	4,380.00	9
	14	30	53350	3,880.00	8
	14	40	53850	3,060.00	6
	14	45	54100	2,880.00	12
8/21/02	13	35	54100	707.20	-
	13	45	54600	353.60	1
	13	55	55100	299.20	1
	14	5	55600	353.60	1
	14	15	56100	326.40	1
	14	25	56600	380.80	1
	14	35	57100	2,801.60	6
	14	45	57600	5,222.40	10
	14	55	38100	3,916.80	8
	15	0	58350	2,393.60	10
	15	10	58850	1,713.60	3
	15	20	59350	707.20	1
	15	30	59850	462.40	1
	15	40	60350	353.60	1
	15	50	60850	217.60	0
	16	0	31650	-	-

Table 1. Count Rate Calculations (Continued)

Date	Hours	Minutes	Cumulative Gallons Pumped	Counts per Minute (adjusted for background)	CPM/Gallon
8/26/2002	9	50	61350	-	-
	10	0	61850	1,478.40	3
	10	10	62350	963.20	2
	10	30	63350	1,747.20	2
	10	45	34100	828.80	1
	11	0	64850	560.00	1
	11	15	65600	470.40	1
	11	30	66350	2,732.80	4
	11	45	67100	3,382.40	5
	12	0	67850	1,792.00	2
	12	15	668600	716.80	1
	12	30	69350	604.80	1
	12	45	70100	582.40	1
	13	0	70850	179.20	0
	13	15	71600	67.20	0
	13	25	72100	44.81	0
9/4/02	12	40	72100	-	-
	12	45	72350	1,548.00	6
	13	0	73100	492.00	1
	13	15	73850	420.00	1
	13	30	74600	276.00	0
	13	45	75350	144.00	0
	14	0	76100	240.00	0
	14	15	76850	624.00	1
	14	30	77600	1,992.00	3
	14	45	78350	876.00	1
	15	0	79100	1,320.00	2
	15	15	79850	360.00	0
	15	30	80600	636.00	1
	15	45	81350	600.00	1
	16	0	82100	1,356.00	2
	16	15	82850	696.00	1
	16	30	83600	720.00	1
	16	45	84350	228.00	0
	17	0	85100	144.00	0
	17	15	85850	96.00	0

Table 1. Count Rate Calculations (Continued)

Date	Hours	Minutes	Cumulative Gallons Pumped	Counts per Minute (adjusted for background)	CPM/Gallon
9/9/02	10	15	85850	-	-
	10	30	86600	-	-
	10	45	87350	1,110.220	1
	11	0	88100	138.90	0
	11	15	88850	-	-
	11	30	89600	416.70	1
	11	45	90350	-	-
	12	0	91100	-	-
	12	15	91850	138.90	0
	12	30	95600	46.30	0
	12	45	93350	-	-
9/9/2002	13	0	94100	-	-
	13	15	94850	-	-
	13	30	95600	-	-
	13	45	96350	-	-
	14	0	97100	138.90	0
	14	15	97850	46.30	0
	14	30	98600	-	-

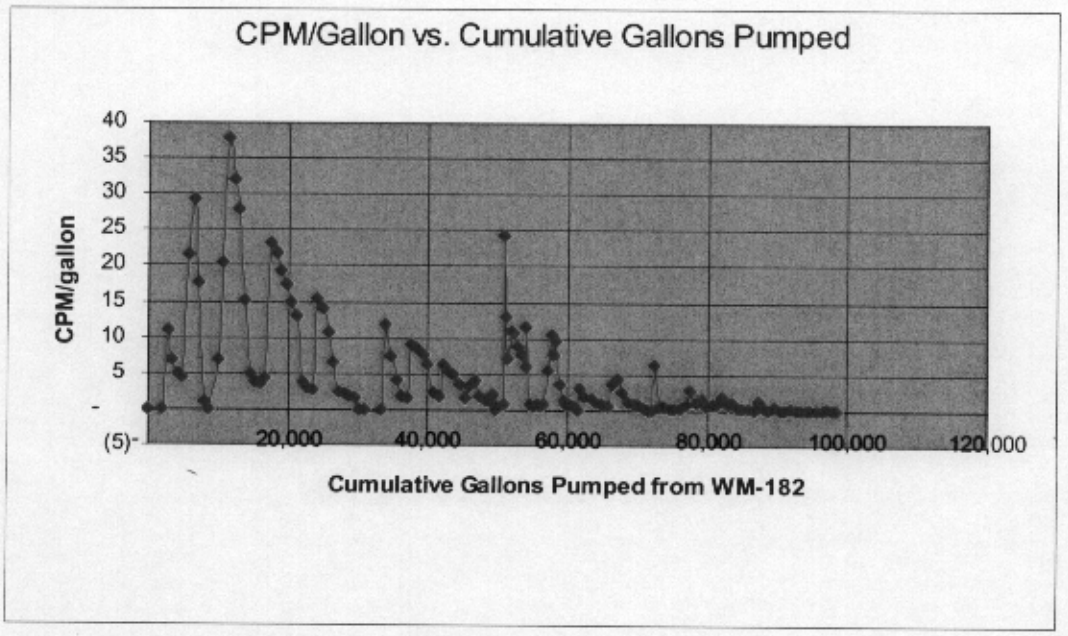
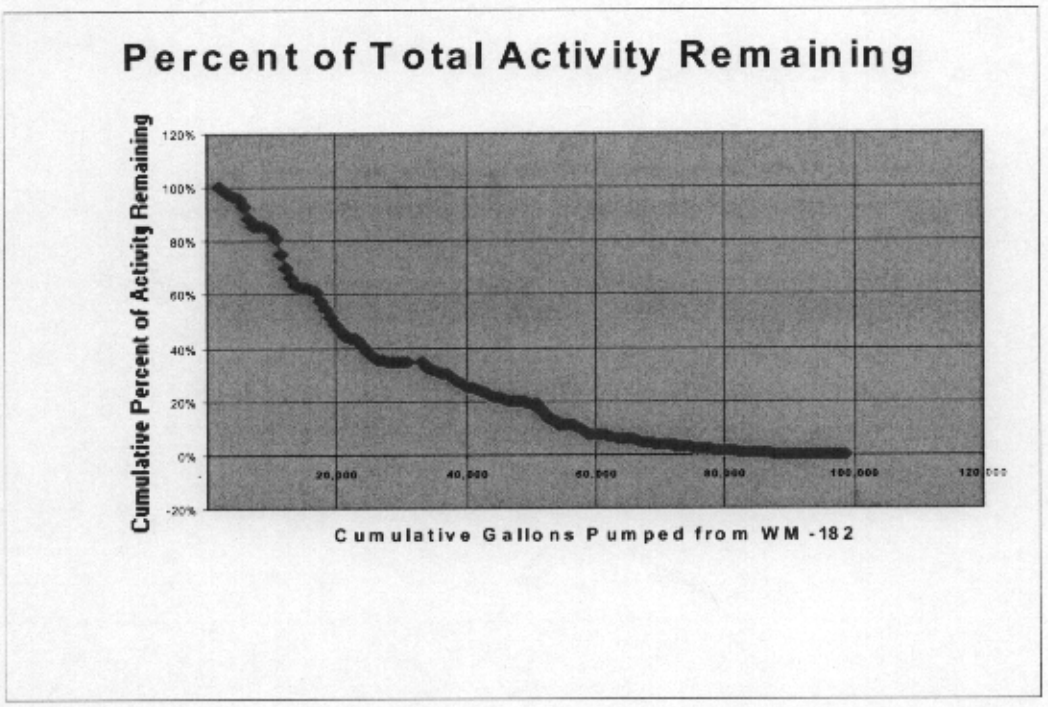


Figure 2. Activity Concentration Curve

This figure shows that there was initially a great deal of variability in the activity per unit volume of water pumped. Drops occurred when the wash water was shut off, and the suspended solids quickly settled to the bottom of the tank. The ejector could not efficiently pick up the settled solids. Once the wash water flow was restarted, the solids were re-suspended and pumped from the vessel. At first, only the wash ball was used, and it effectively stirred the solids. However, after 30,000 gallons had been pumped, this device became far less effective. At 50,000 gallons cumulative volume pumped, two directional nozzles were substituted for the wash ball. Solids removal efficiency increased immediately, but eventually tapered off again. By the time 98,000 gallons of water had been pumped, essentially no additional radioactivity was being removed with the wash water.

The total area under this curve represents the total amount of radioactivity removed from tank. The area was determined by numerical integration. So a general radioactivity reduction curve can be drawn. See Figure 3.

Figure 3. Reduction in Tank Radioactivity



The starting radioactivity content estimate is provided in EDF-1920 (reference c). The activity in the liquid is about 13,800 Curies (as of June 2002), and the activity in the solids is about 14,000 Curies (as of June 2002). This is based on sample data along with a video inspection showing about 6 inches of waste remaining in WM-182. That material consisted of about a 2-inch clear liquid layer on top of an estimated 4-inch sludge layer. The radionuclide content was expected to be the uniform throughout the liquid.

For the purpose of this evaluation, it has been assumed that the specific activity concentration in the solids does not change during washing. In other words, a gram of solids at the end of the washing process contained as much activity as a gram of solids at the beginning of the operation. On the other hand, the activity concentration in the liquid would be expected to decrease during cleaning because the contaminated water was blended with a relatively large volume of clean water. Figure 3 represents an exponential curve typical of a continuously stirred vessel, so the final activity associated with the water in the tank can be estimated as:

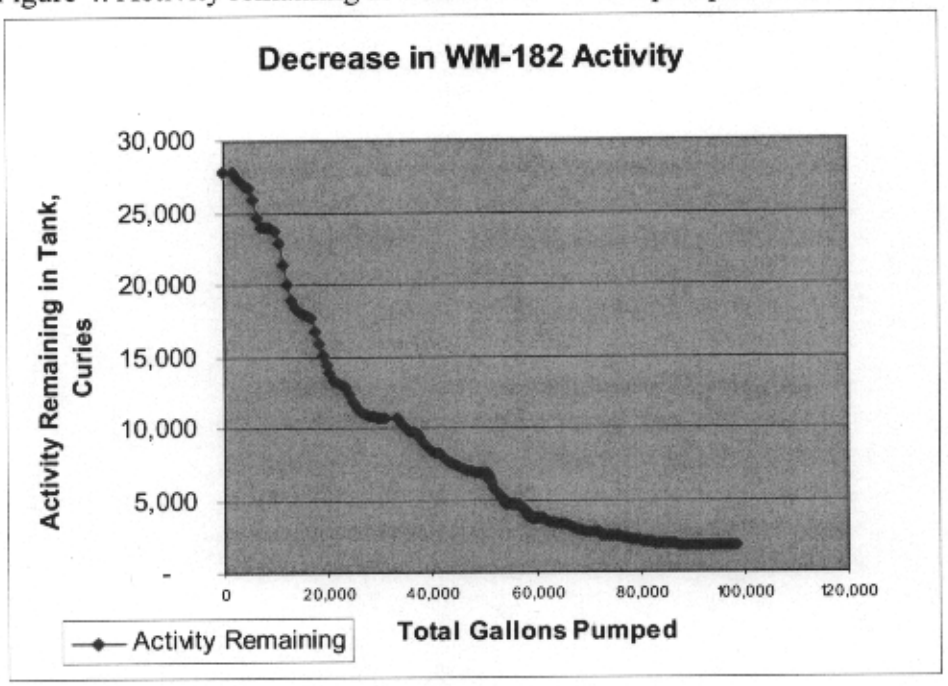
$$N = 15{,}000e^{-F/V}$$

Where: N = activity after F gallons of water have been pumped out
F = volume of water pumped out
V = nominal volume of water maintained in the tank = 7200 gal.

After 98,000 gallons of water had been pumped, the activity in the water phase should be less than 1 curie. In practice, since mixing was probably not complete, a final liquid activity value of 50 Curies has been assumed.

To estimate the activity associated with the solids, it was necessary to estimate the beginning and ending quantities of solids in the tank. Before cleaning started, samples and video tape inspections result in an estimate of 1,200 gallons (10,450 kg) of settled solids remaining, plus a small quantity of solids on the tank walls. This represents 4-inches of sludge comprised of about ¼ solids by volume. At the end of the cleaning operation, the tank walls were clean, and the sludge layer was about ½ inch total, with about ¼ of that being suspended solids. Since the solids volume decrease by 7/8, it is expected that the solids activity was also reduced by 7/8. The total solids activity remaining at the end of cleaning is estimated to be about 1,750 Curies. So the total remaining in the vessel after cleaning is about 1,800 Curies. This means that approximately 26,000 curies of activity were removed from tank WM-182 during the washing operation. Applying these beginning and ending points for total activity to Figure 3 gives the curve in Figure 4, which relates gallons pumped with estimated activity remaining in the tank.

Figure 4. Activity remaining as a function of water pumped from WM-182



sm

cc: S. W. Butterworth, MS 3670
K. Quigley, MS 3670
R. R. Kimmitt (RRK-03-02)

Uniform File Code: 8201
Disposition Authority: A17-31-d
Retention Schedule: Permanent. Cutoff at project close. Retain in CFL/SFL until no longer needed for reference, then transfer to record storage.