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7. Abstract

This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in tank 241-C-201. This report supports the requirements of Tri-Party Agreement Milestone M-44-08.

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Tank Characterization Report for Single-Shell Tank 241-C-201

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EXECUTIVE SUMMARY

This tank characterization report summarizes information on the historical uses, present status, and the sampling and analysis results of waste stored in the single-shell underground storage tank 241-C-201. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-08 (Ecology et al. 1994).

Tank 241-C-201 is located in the C-Tank Farm in the Hanford Site 200 East area. The tank went into service during 1947 and initially was used to store metal waste from the bismuth phosphate process. This waste subsequently was removed, and strontium semi-works waste was added beginning in the second quarter of 1955. In 1970, a large transfer of supernatant to tank 241-C-104 occurred, leaving approximately 4 kiloliters (1 kilogallons) of waste material in the tank. The tank was then removed from service in 1976 and classified as inactive in 1977. Tank 241-C-201 is said to presently contain approximately 8 kiloliters (2 kilogallons) of noncomplexed waste. Tank 241-C-201 was interim stabilized in March 1982, and intrusion prevention was completed in December 1982. The tank is classified as an assumed leaker. Currently, the tank is not on a watch list.

Tank 241-C-201 is described and its status summarized in Table ES-1. This report summarizes one recent auger sampling and analysis event that was performed to satisfy the requirements of the *Tank Safety Screening Data Quality Objectives* (Babad and Redus 1994). All requested analyses on the sludge material were performed. In addition to this event, one sampling and analysis event from 1978 is used to support this report's conclusions.

Results from the 1995 auger sampling and analysis event indicate that high levels of fuel are present in tank 241-C-201 (the fuel energy content results by differential scanning calorimetry were above 481 joules/gram on a dry weight basis). Further, the moisture level of the sludge is below the 17 percent safety-screening criteria (Babad and Redus 1994). Because the fuel energy content notification limit was exceeded, secondary analysis for total organic carbon was performed. It was found that the total organic carbon content in tank 241-C-201 was approximately 4.6 weight percent (on a dry weight basis), which exceeded the Operating Specification Document (OSD) safety criterion of 3 weight percent (WHC 1995). However, these results did not exceed the criterion of 5 weight percent stated in *Data Quality Objective to Support Resolution of the Organic Fuel Rich Tank Safety Issue* (Buckley 1995). Based on the OSD requirements, interim measures and controls are in place pending a final determination of watch list status by engineering personnel.

Tank waste heat production estimates were available from historical tank content estimate model predictions of heat producing radionuclides (cesium-137 and strontium-90) and tank temperature surveillance records. Based on these model predictions, the heat generated by the radioactivity in the tank is estimated to be 670 watts, which would categorize this tank as a low-heat producer. Insufficient analyses were performed on the 1995 auger samples to confirm this estimate, although the 1978 data supports this conclusion. The temperature of the tank has been consistently less than 21 °Celsius (69 °Fahrenheit) since 1992. This temperature reading represents the temperature in the vapor space, not the sludge waste. The total alpha activity levels in the sludge were measured in 1995 to be in

the range of 11.9 to 21.2 microcuries/gram, or about half of the criticality safety criterion (Babad and Redus 1994).

This report does not include any tank head-space vapor screening information as required by Babad and Redus (1994), nor does it contain the sufficient chemical, radiochemical, or physical data necessary to support successful pretreatment, retrieval, or disposal activities.

An estimate of the concentration and tank inventory for chemical and radiochemical components in the waste is summarized in Table ES-2. These estimates are based on the Hanford defined waste reference (Agnew 1994) and the revised historical tank content estimate information provided in Appendix A of this report, and represents information regarding both metal waste and strontium semi-works waste, the two waste types stored in tank 241-C-201.

Table ES-1. Description and Status of Tank 241-C-201.

Tank 241-C-201	
Tank description	
Type:	single-shell
Constructed:	1943-1944
In-service:	1947
Diameter:	6.1 m (20 ft)
Usable depth:	7.2 m (23 ft, 7 in)
Operating capacity:	208 kL (55 kgal)
Bottom shape:	dished
Ventilation:	passive
Tank status	
Total waste volume (April 1995):	approx. 8 kL (2 kgal)
Sludge volume (April 1995):	approx. 8 kL (2 kgal)
Supernatant volume (April 1995):	0 kL (0 kgal)
Manual tape surface level (range, past yr):	28 cm (11 in.) to 31 cm (12 in.)
Temperature (range, last three years):	15 °C (59 °F) to 21 °C (69 °F)
Integrity category:	assumed leaker
Watch list classification:	non-watch list
Sampling dates	
Auger sampling date:	April 1995
Sludge sampling date (type unknown):	1978
Service status	
Removed from service:	1976
Interim stabilized:	March 1982
Intrusion prevention completed:	December 1982

Table ES-2. Historically Estimated Concentrations for Analytes Present in Tank 241-C-201.

Single-Shell Tank 241-C-201			
Physical Properties			
Total Waste	1.03E+04 kg	(2.00E+00 kgal)	
Heat Load	0.67 kW	(5.01E+02 BTU/hr)	
Bulk Density	1.36 (g/cc)		
Water wt%	62.1		
TOC wt% C (wet)	0.850		
Chemical Constituents	mole/L	ppm	kg
Na^{+}	2.67E+00	4.52E+04	4.64E+02
Al^{3-}	0.00E+00	0.00E+00	0.00E+00
Fe^{3+} (total Fe)	002	7.25E+04	7.44E+02
Cr^{3+}	4.75E-03	1.82E+02	1.87E+00
Bi^{3+}	000	000	000
La^{3+}	0.000	0.000	0.00
Hg^{2-}	0.00	0.00	0.00
Zr (as $ZrO(OH)_2$)	000	000	000
Pb^{3+}	0.0	7000	71.8
Ni^{3+}	000	2446	2.51E+01
Sr^{2+}	0.000	0.000	0.00
Mn^{4-}	000	000	0.00E+00
Ca^{3+}	2.60E-02	7.67E+02	7.88E+00
K^{+}	3.49E-02	1.01E+03	1.03E+01
OH^{-}	8.62	1.08E+05	1.11E+03
NO_3^{-}	0.54	2.46E+04	2.53E+02
NO_2^{-}	0.01	3.65E+02	3.74E+00
CO_3^{2-}	0.451	2.00E+04	2.05E+02
PO_4^{3-}	0.200	1.40E+04	1.44E+02
SO_4^{2-}	0.107	7.61E+03	7.81E+01
Si (as SiO_2^{2-})	1.46E-03	030	3.10E-01
F^{-}	0.000	0.00E+00	0.00E+00
Cl^{-}	0.023	6.06E+02	6.22E+00
$C_6H_5O_7^{3-}$	1.79E-02	2.50E+03	2.56E+01
$EDTA^{4-}$	3.58E-02	7.61E+03	7.81E+01
$HEDTA^{3-}$	0.00E+00	0.00E+00	0.00E+00
glycolate	0.000	0.00E+00	0.00E+00
acetate	2.28E-01	9940	1.02E+02
oxalate	0.00E+00	0.00	0.00
DBP	0.00E+00	0.00E+00	0.00E+00
butanol	0.00E+00	000	0.00E+00
NH_3	0.000	3.75E-02	3.85E-04
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents			
Pu	0.0033 (μCi/L)		0.00057 (kg)
U	5.15E-01 (M)	9.0E+04 (μg/g)	9.27E+02 (kg)
Cs	0.001 (Ci/L)	000.47 (μCi/g)	4.80E+00 (Ci)
Sr	2.9E+00 (Ci/L)	2121.4 (μCi/g)	2.18E+04 (Ci)

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LIST OF TERMS

DQO	Data Quality Objectives
DSC	Differential Scanning Calorimetry
HDW	Hanford Defined Waste list
HTCE	Historical Tank Content Estimate
PUREX	Plutonium-Uranium Extraction
RPD	Relative Percent Difference
RSST	reactive system screening tool
TCP	Tank Characterization Plan
TGA	Thermogravimetric Analysis
TOC	Total Organic Carbon
WSTRS	Waste Status And Transaction Record Summary

1.0 INTRODUCTION

This tank characterization report is an overview of single-shell tank 241-C-201 and its waste contents. It provides estimated concentrations and inventories of the waste components based on background tank information which is supported by sampling and analysis data. This report describes the results of one recent sampling event that occurred in May 1995, in accordance with the requirements of the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994). In addition, this report uses historical analytical data from 1978 to strengthen its conclusions. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order,* Milestone M-44-08 (Ecology et al. 1994). For those unfamiliar with the Hanford Site tank farms, refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994) for an introduction to the history surrounding the generation, storage, and management, and information on sampling, analysis, and modeling activities that support the current waste characterization. A glossary of terminology can also be found in De Lorenzo (1994).

1.1 PURPOSE

This report summarizes the best available information about the use and contents of tank 241-C-201. This information primarily will be used to assess waste safety issues. In addition, this report will provide a reference point for future tank 241-C-201 sampling, analysis, and waste characterization activities.

1.2 SCOPE

The auger samples taken in 1995 supported completion of requirements in the *Tank Safety Screening Data Quality Objectives* (Babad and Redus 1994) and evaluation of decision criteria found therein. There were three primary analyses identified by Schreiber (1995a) that were performed on sludge samples. The analyses were fuel content and energetics by differential scanning calorimetry (DSC); percent moisture by thermogravimetric analysis (TGA); and total alpha activity to evaluate criticality concerns. Total organic carbon (TOC) analysis was also performed on the samples as a secondary analysis.

Because of the limited analysis set performed on the 1995 samples and because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994), the chemical and radiochemical concentrations for most components are estimated from the Historical Tank Content Estimate (HTCE; see Appendix A) and the Hanford Defined Waste: Chemical and Radionuclide Compositions (HDW) (Agnew 1994).

This report contains no information on vapor space sampling and analysis to determine the composition of the tank head space gases.

2.0 HISTORICAL TANK INFORMATION

This section describes tank 241-C-201 based on historical information. The first part of the section details the current condition of the tank, followed by discussions of the tank background, transfer history, and process sources that contributed to the tank waste. An estimate of the current contents based on the process history is presented. Events that may be related to tank safety issues, such as potentially hazardous tank contents (ferrocyanide, organics) or off-normal operating temperature are included in the discussion. The final part of the section details any surveillance data available for the tank. Solid- and liquid-level data are used to determine waste volume, tank integrity (leaks), and to provide clues about internal activity in the solid/crust layers of the tank (i.e., slurry growth from gas evolution with subsequent burping and collapse, or shrinkage resulting from drying). Temperature data are provided to evaluate the heat generating characteristics of the waste with respect to the predicted radionuclide inventory.

2.1 TANK STATUS

Tank 241-C-201 is presently a non-watch-list tank containing approximately 8 kL (2 kgal) of noncomplexed waste (Hanlon 1995). The partition of the waste is shown in Table 2-1.

The tank is identified as a low-heat-load tank, is passively ventilated, and is categorized as an assumed leaker. Tank 241-C-201 was interim stabilized in March 1982, and intrusion prevention was completed December 1982. Presently, the waste is predicted to be a mixture of metal waste from the bismuth phosphate process and strontium semi-works waste from the Plutonium-Uranium Extraction (PUREX) pilot plant study performed in the mid 1950's. Tank 241-C-201 is not in a cascade series but is connected to diversion boxes with tanks 241-C-202, 241-C-203, and 241-C-204.

Table 2-1. Summary Tank Contents Status.

Waste form	kL (kgal)
Total waste	7.6 (2)
Sludge	7.6 (2)
Saltcake	0 (0)
Supernatant	0 (0)
Drainable interstitial liquid	0 (0)
Drainable liquid remaining	0 (0)
Pumpable liquid remaining	0 (0)

2.2 TANK DESIGN AND BACKGROUND

The 241-C Tank Farm is a first-generation tank farm that was built between 1943 and 1944 and consists of twelve 2,010 kL (530 kgal) tanks and four 208 kL (55 kgal) tanks. These tanks were designed for non-boiling waste with a maximum fluid temperature of 104 °Celsius (C) [220 ° Fahrenheit (F)]. As with all first-generation tank farms, access to the tank is constricted, and monitoring and maintenance equipment is sparse. A typical 208 kL (55 Kgal) tank in C-Farm contains the following access ports: one below grade manhole; six risers, which range in size from 10 centimeters (cm) [4 inches (in.)] to 30 cm (12 in.) in diameter and provide surface level access to the underground tank; and four inlets and outlets. Tank 241-C-201 has only riser 7, which is 30 cm (12 in.) in diameter, available for sampling. Figure 2-1 illustrates the tank and the available risers. Figure 2-2 is a tank cross section showing the approximate waste level and a schematic of the tank equipment (Brevick 1994).

Tank 241-C-201 entered service in the fourth quarter of 1947. The single-shell tank is constructed of 30-cm- [1-foot- (ft)] thick reinforced concrete with a 6-mm (1/4-in.) milled carbon steel liner (ASTM A283 Grade C) on the bottom and sides and a 38-cm- (1.25-ft-) thick domed concrete top. These tanks have a 15-cm (6-in.) dished bottom with a 0.9-meter (m) (3-ft) radius knuckle and a 5.7-m (18-ft, 8-in.) operating depth. The bottom center elevation of tank 241-C-201 is 185 m (607 ft). The four smaller 200 series tanks of the C-Tank farm are not cascaded but are joined together with piping at the same elevation to allow the waste volumes to equalize within the tanks. All are connected by inlets to a diversion box. The tanks are set on a reinforced concrete foundation. Each tank was covered with approximately 2.2 m (7.25 ft) of overburden (refer to Figure 2-2).

The surface level was last monitored in July 1995 through riser 5 with a manual tape. A list of tank 241-C-201 risers showing size and use is provided in Table 2-2. A plan view that depicts the riser configuration and relative location is shown as Figure 2-1. This constitutes all installed equipment for tank 241-C-201.

2.3 PROCESS KNOWLEDGE

These sections present the transfer history of tank 241-C-201. Section 2.3.1 and Table 2-3 present the major transfers involving tank 241-C-201 along with a narrative describing the transfers.

Figure 2-1. Tank 241-C-201 Riser Location.

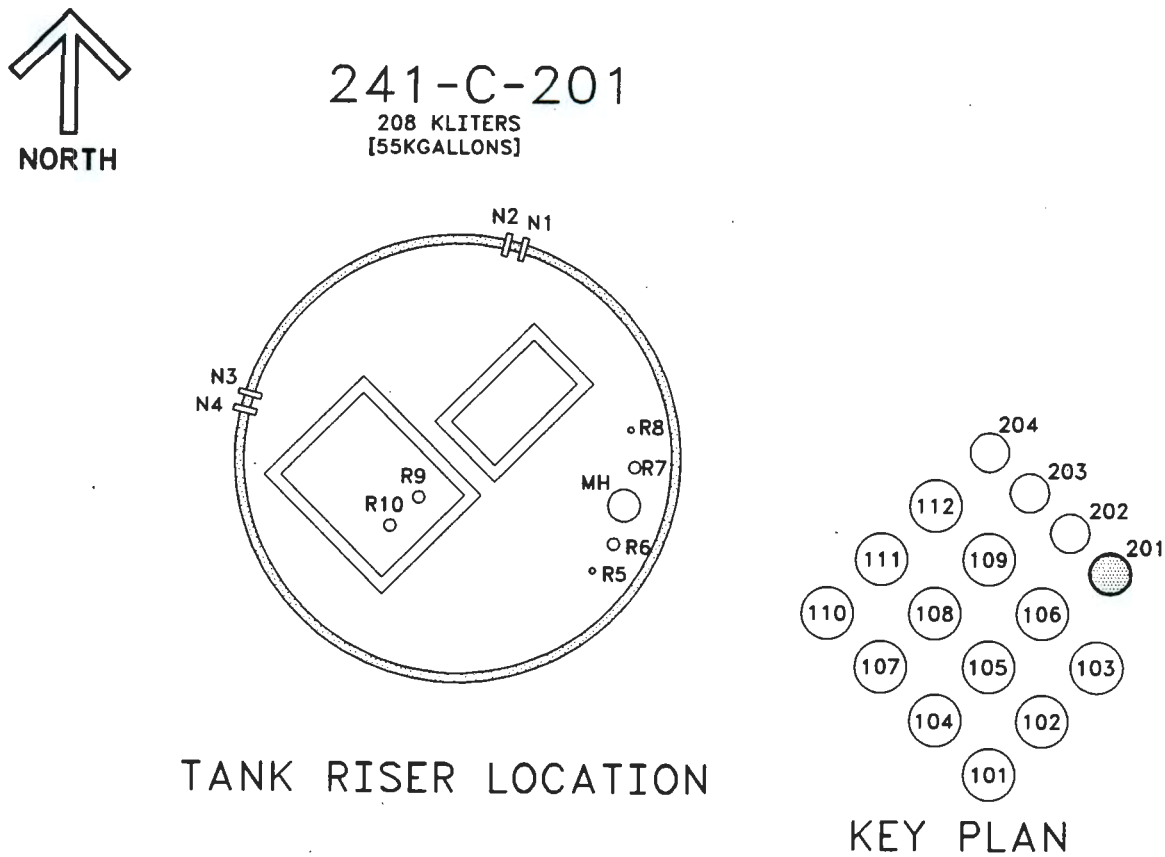


Figure 2-2. Basic Design of Tank 241-C-201.

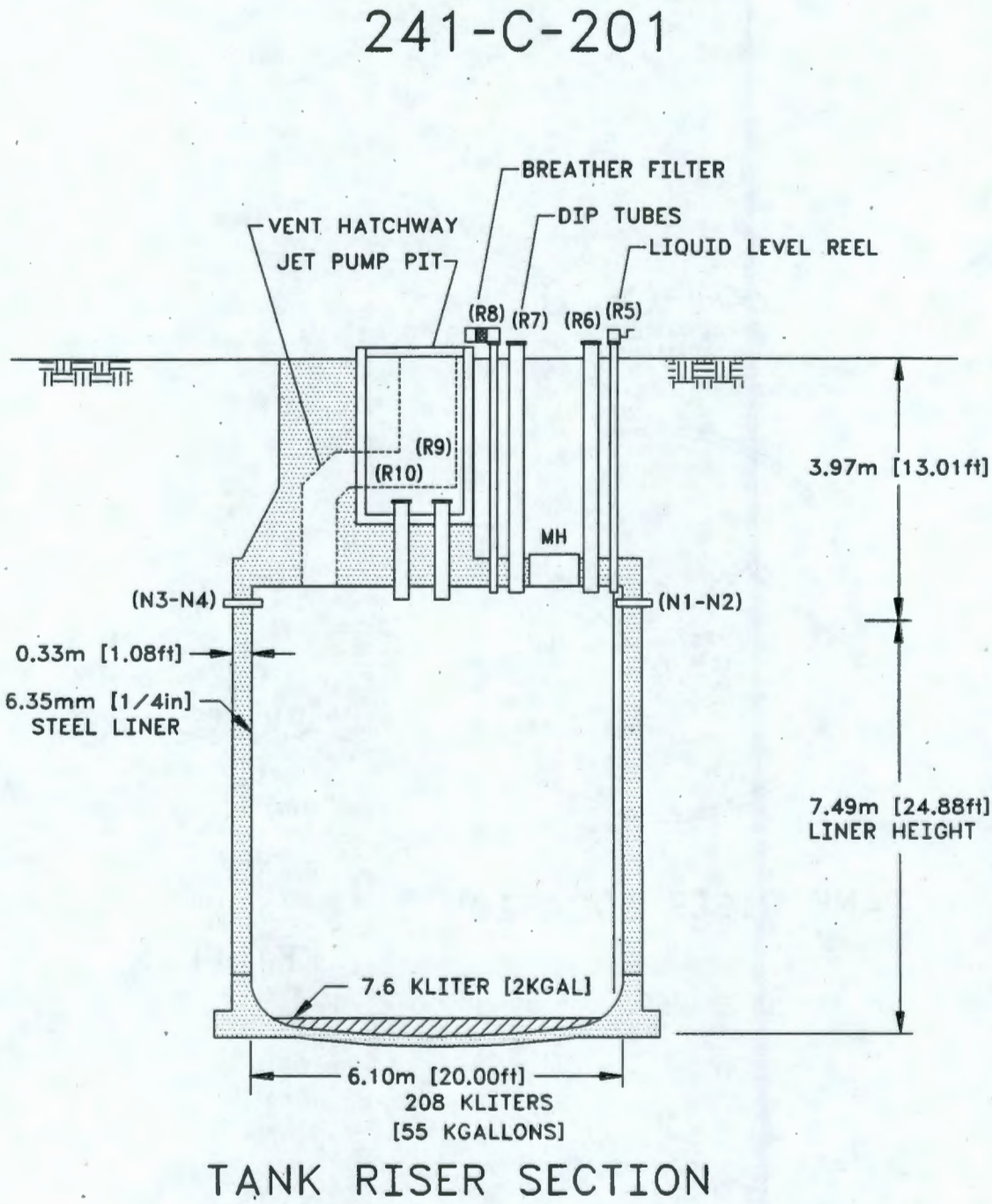


Table 2-2. Tank 241-C-201 Risers.

No.	Dia. (in.)	Description and comments
MH	42	Manhole tank access (below grade)
R5	4	Liquid level reel/manual tape
R6	12	Thermocouple Tree
R7	12	Observation port **(1995 auger sample location)**
R8	4	Breather filter
R9	12	Sludge jet access, WC (pit)
R10	12	Sluicing access, WC (pit)

Notes:

MH = manhole
Obsv = observation
WC = weather covered

2.3.1 Waste Transfer History

Tank 241-C-201 received no waste until 1947. According to Agnew and Brown (1994), 833 kiloliters (kL) [220 kilogallons (kgal)] of metal waste initially was added to tank 241-C-201 from an unknown source during the fourth quarter of 1947. This transfer data is questionable because tank 241-C-201 has an operating capacity of 208 kL (55 kgal). It is suspected that this large volume of metal waste was transferred directly from the bismuth phosphate plant (B Plant) through the master diversion box in C-Farm (see Figure 2-3). This master diversion box was connected to the piping system which allowed waste to flow into the four 200 series C-Farm tanks in such a way that the waste volumes equilibrated (see Section 2.2). Therefore, it is suspected that this major transfer of metal waste involved all four of the 200 series C-Farm tanks and not only tank 241-C-201. This hypothesis is substantiated by additional information in Agnew and Brown (1994), which alludes to cascading between the four tanks during the time that the metal waste transfer was occurring. Since these tanks are not directly connected in a cascade, it is surmised that the above scenario is credible and that the waste was sent to all four tanks via the master diversion box. A second hypothesis is that the metal waste was added through the secondary diversion box (see Figure 2-3). However, waste entering this diversion box was routed through tanks 241-C-109 and 241-C-112, neither of which are purported to have received metal waste. After the metal waste transfer was completed in November 1947, tank 241-C-201 was declared full.

During the fourth quarter of 1953, supernatant from tank 241-C-201 was transferred to tank 241-C-106, and the remaining sludge was transferred to tank 241-C-204 during the

first quarter of 1954 (Agnew and Brown 1994). The tank was declared empty in March 1954. Both Agnew and Brown (1994) and Anderson (1990) show that, during 1955, there were transfers of strontium semi-works waste, also known as hot semiworks waste, made to tank 241-C-201. Strontium semi-works waste was produced from the strontium extraction process after 1961, using a feed stream typically containing PUREX high-level acid waste. However, since the transfer into tank 241-C-201 occurred in 1955, it is suspected that this waste was generated during PUREX pilot plant studies conducted during the mid 1950s. During the second quarter of 1970, almost the entire contents of tank 241-C-201 were transferred to tank 241-C-104.

Tank 241-C-201 was removed from service in the first quarter of 1976 and was declared inactive in the fourth quarter of 1977. It was categorized as an assumed leaker [with a leak volume of 2,082 L (550 gal)] in 1987, and interim stabilization and intrusion prevention were completed in March and December 1982, respectively. Presently, the waste contained in tank 241-C-201 is classified as noncomplexed.

A synopsis of the major waste transferred through tank 241-C-201 is shown in Table 2-4.

2.3.2 Historical Estimation of Tank Contents

The following is an estimate of the contents of tank 241-C-201 based on historical transfer data. The historical data used for the estimate is Agnew and Brown (1994) and the HDW list (Agnew 1994). Agnew and Brown (1994) is a compilation of available waste transfer and volume status data. Agnew (1994) provides the assumed typical compositions for 50 separate waste types. In some cases the available data is incomplete, reducing the usability of the transfer data and the modeling results derived from it. The tank layer model takes the data from Agnew and Brown (1994), models the waste deposition processes and using additional data from the HDW list (which may introduce more error), generates an estimate of the tank contents; therefore, these model predictions can only be considered an estimate that requires further evaluation using analytical data.

Based on the information provided in Appendix A, tank 241-C-201 contains two types of waste: metal waste and strontium semi-works waste. Two waste layers are expected in the tank with volumes of approximately 4 kL (1 kgal) each. Metal waste is estimated to contain large amounts of sodium, uranium, carbonate, phosphate, sulfate, and hydroxide. Strontium-90 and cesium-137 are probably also present. To further identify metal waste as such, the following constituents will be totally or relatively absent from the waste. These constituents include, but are not limited to, aluminum, bismuth, nickel, lead, and TOC. Strontium semi-works waste is predicted to have substantial amounts of sodium, sulfate, lead, TOC, and a relatively high strontium-90 content, despite being produced from a strontium recovery process. Table 2-5 shows an estimate of the expected waste constituents and their concentrations based on the pending HTCE revision for tank 241-C-201 (see Appendix A).

Table 2-3. Tank 241-C-201 Major Transfers.

Year: Qtr	Waste received by Tank 241-C-201			Waste transferred out of Tank 241-C-201			Waste amount in tank kL (kgal)
	Waste amount trans kL (kgal)	# of transfers	Waste type	# of transfers	X TF (waste type)	Waste amount kL (kgal)	
1947:4	833 (220)	3	MW	--	MW	[1]625 (165)	208 (55)
1953:4	--	--	--	1	C-106 (SU)	146 (39)	60 (16)
1954:1	--	--	--	1	C-204 (SL)	60 (16)	0
1955:2-1955:4	208 (55)	3	SSW	--	--	--	208 (55)
1970:2	--	--	--	1	C-104 (SU)	204 (54)	4 (1)
1993:2	--	--	--	--	--	--	8 (2)

Notes:

[1]Equilibration with other 200 series C-farm tanks via piping system. Tank full at 208 kL (55 Kgal).

MW = Metal Waste. Waste that originated from the extraction of plutonium using the $BiPO_4$ process. This type of waste contained 90% of the fission products, 1% of the plutonium and all of the uranium inherent in an irradiated fuel slug.

SSW = Strontium Semi-Works (also known as Hot Semiworks or HS) from the PUREX pilot plant study.

SU = Supernatant.

SL = Sludge.

Table 2-4. Synopsis of Major Waste Transferred.

Transfer type	Volume kL (kgal)
Addition of MW	833 (220) [1]
Addition of SSW	208 (55)
Transfer out of SU	-350 (-93)
Transfer out of SL	-60 (-16)

Notes:

[1] Suspected addition to master diversion box in C-farm corresponding to 208 kL (55 kgal) of metal waste being added to each of the 200 series C-farm tanks.

MW = Metal Waste. Waste that originated from the extraction of plutonium using the $BiPO_4$ process. This type of waste contained 90% of the fission products, 1% of the plutonium and all of the uranium inherent in an irradiated fuel slug.

SSW = Strontium Semi-Works (also known as Hot Semi-Works or HS) from the PUREX pilot plant study.

SU = Supernatant.

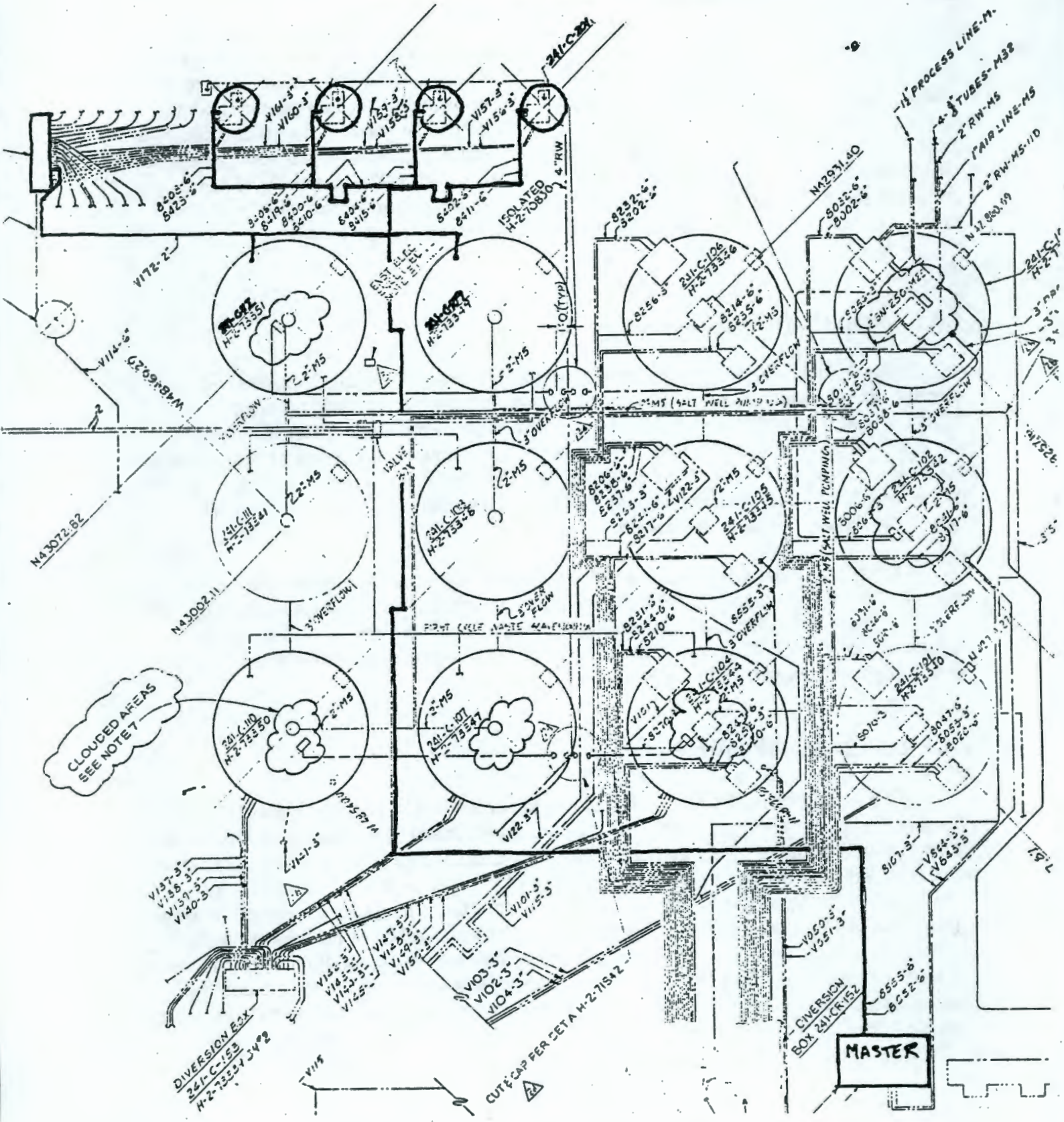
SL = Sludge.

2.4 SURVEILLANCE DATA

Tank 241-C-201 surveillance consists of liquid and solid surface-level measurements, vapor space temperature monitoring inside the tank, and leak-detection well (drywell) monitoring for radioactivity outside the tank. The surveillance data are significant because they provide the basis for determining tank integrity.

Liquid-level measurement can be an indicator of a major leak from a tank. Solid surface-level measurements provide an indication of physical changes and consistency of the solid layers of a tank. Drywells located around the perimeter of the tank are used to detect increased radioactivity resulting from a leak to the soil. Tank 241-C-201 does not have a liquid observation well or drywells.

Figure 2-3. C-Farm Schematic Drawing.



2.4.1 Surface Level Readings

The tank 241-C-201 surface level is monitored quarterly with a manual tape through riser 5. The liquid waste volume is determined by a photographic evaluation. The solid waste volume is determined by a photographic evaluation and a manual-tape surface-level gauge. The baseline for the tank is 43.8 cm (17.25 in.). The maximum allowable increase from the baseline is about 5 cm (2 in.). The criterion for a decrease is not applicable to this tank because there is no supernatant waste in tank 241-C-201. The surface level has remained steady for the past year, with the readings ranging from approximately 28 cm (11 in.) to 31 cm (12 in.). Figure 2-4 is a graph of the surface level history.

2.4.2 Internal Tank Temperatures

Tank 241-C-201 has a single thermocouple tree in riser 6 with 11 thermocouples to monitor the waste temperature. Elevations are available for all the thermocouples. Thermocouple 1 is at 40.5 cm (1.33 ft) from the bottom of the tank. Thermocouples 1 through 9 are evenly spaced 60 cm (2 ft) apart. Thermocouples 9 through 11 are spaced at 1.2 m (4 ft) apart. All of the 11 thermocouples have similar temperature readings. Review of the tank 241-C-201 level history indicates that, since 1974, all the probes have been measuring the vapor space temperature.

Tank 241-C-201 is scheduled to have temperature data taken semiannually in January and July. All thermocouples have four data points and similar readings that span from 1991 to 1993. Plots of the thermocouple readings for tank 241-C-201 are in the supporting documents for the HTCE (Brevick 1994). Figure 2-5 is a graphical representation of the weekly high vapor space temperature.

2.4.3 Tank 241-C-201 Photographs

Two photographs of tank 241-C-201 are presented in this section. Figure 2-6 is a photograph taken in 1984 and represents the tank approximately two years after stabilization and intrusion prevention. This photograph shows a dark, sludge surface with a considerable amount of moisture present. Figure 2-7 was taken two years afterward, in 1986. A comparison of the photographs show a remarkable difference; the latter photograph indicates a black and yellow sludge surface. The surface is dry and cracked in portions of the tank, and there is a black residue on the lower portion of the tank walls. Both photographs are of the same relative position of the tank. The temperature probe located in riser 6 and the manual tape located in riser 5 are visible at the top of the photographs. The rod-like object near the center of the photographs is not a piece of equipment, but is considered debris. These photographs substantiate the hypothesis that tank 241-C-201 leaked.

Table 2-5. HTCE Tank Inventory Estimate.

Single-Shell Tank 241-C-201			
Physical Properties			
Total Waste	1.03E+04 kg	(2.00E+00 kgal)	
Heat Load	0.67 kW	(5.01E+02 BTU/hr)	
Bulk Density	1.36 (g/cc)		
Water wt%	62.1		
TOC wt% C (wet)	0.850		
Chemical Constituents	mole/L	ppm	kg
Na^+	2.67E+00	4.52E+04	4.64E+02
Al^{3-}	0.00E+00	0.00E+00	0.00E+00
Fe^{3+} (total Fe)	002	7.25E+04	7.44E+02
Cr^{3+}	4.75E-03	1.82E+02	1.87E+00
Bi^{3+}	000	000	000
La^{3+}	0.000	0.000	0.00
Hg^{2-}	0.00	0.00	0.00
Zr (as $ZrO(OH)_2$)	000	000	000
Pb^{3+}	0.0	7000	71.8
Ni^{3+}	000	2446	2.51E+01
Sr^{2+}	0.000	0.000	0.00
Mn^{4-}	000	000	0.00E+00
Ca^{3+}	2.60E-02	7.67E+02	7.88E+00
K^+	3.49E-02	1.01E+03	1.03E+01
OH^-	8.62	1.08E+05	1.11E+03
NO_3^-	0.54	2.46E+04	2.53E+02
NO_2^-	0.01	3.65E+02	3.74E+00
CO_3^{2-}	0.451	2.00E+04	2.05E+02
PO_4^{3-}	0.200	1.40E+04	1.44E+02
SO_4^{2-}	0.107	7.61E+03	7.81E+01
Si (as SiO_2^{2-})	1.46E-03	030	3.10E-01
F^-	0.000	0.00E+00	0.00E+00
Cl^-	0.023	6.06E+02	6.22E+00
$C_6H_5O_7^{3-}$	1.79E-02	2.50E+03	2.56E+01
$EDTA^{4-}$	3.58E-02	7.61E+03	7.81E+01
$HEDTA^{3-}$	0.00E+00	0.00E+00	0.00E+00
glycolate	0.000	0.00E+00	0.00E+00
acetate	2.28E-01	9940	1.02E+02
oxalate	0.00E+00	0.00	0.00
DBP	0.00E+00	0.00E+00	0.00E+00
butanol	0.00E+00	000	0.00E+00
NH_3	0.000	3.75E-02	3.85E-04
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents			
Pu	0.0033 (μCi/L)		0.00057 (kg)
U	5.15E-01 (M)	9.0E+04 (μg/g)	9.27E+02 (kg)
Cs	0.001 (Ci/L)	000.47 (μCi/g)	4.80E+00 (Ci)
Sr	2.9E+00 (Ci/L)	2121.4 (μCi/g)	2.18E+04 (Ci)

Figure 2-4. Tank Level History.

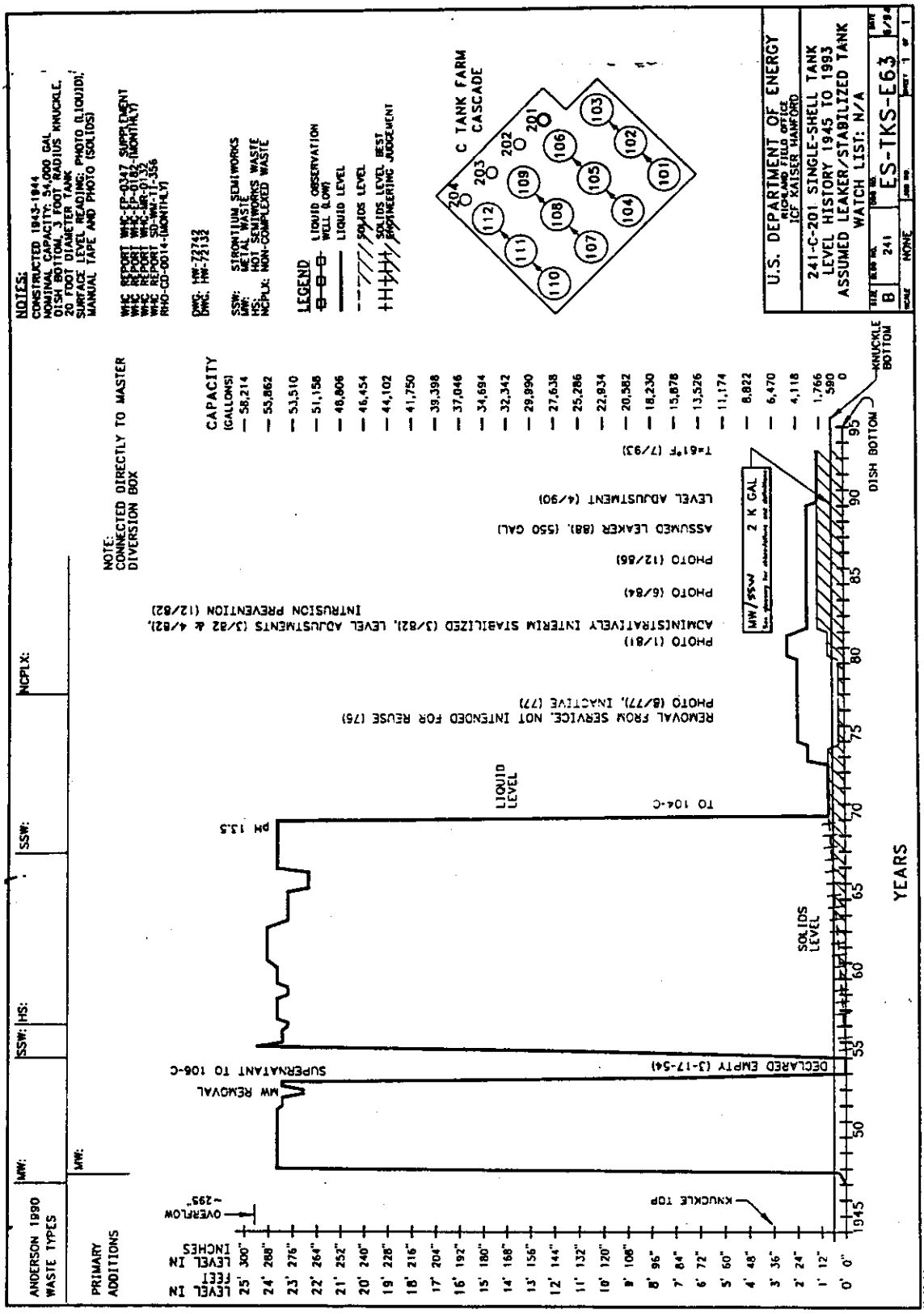


Figure 2-5. Tank 241-C-201 Weekly High Vapor Space Temperature Plot.

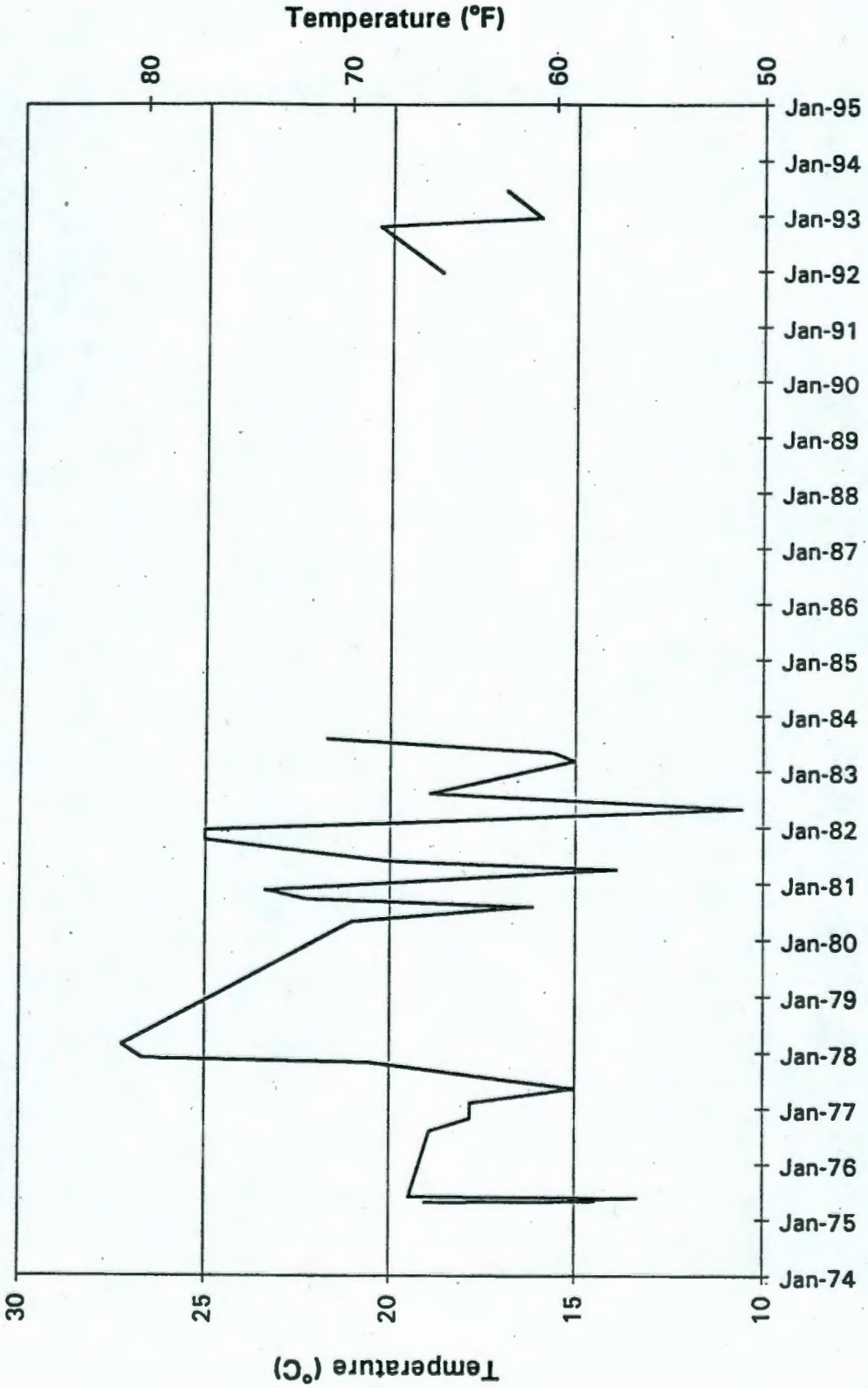


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Figure 2-6. 1984 Photograph of Tank 241-C-201.

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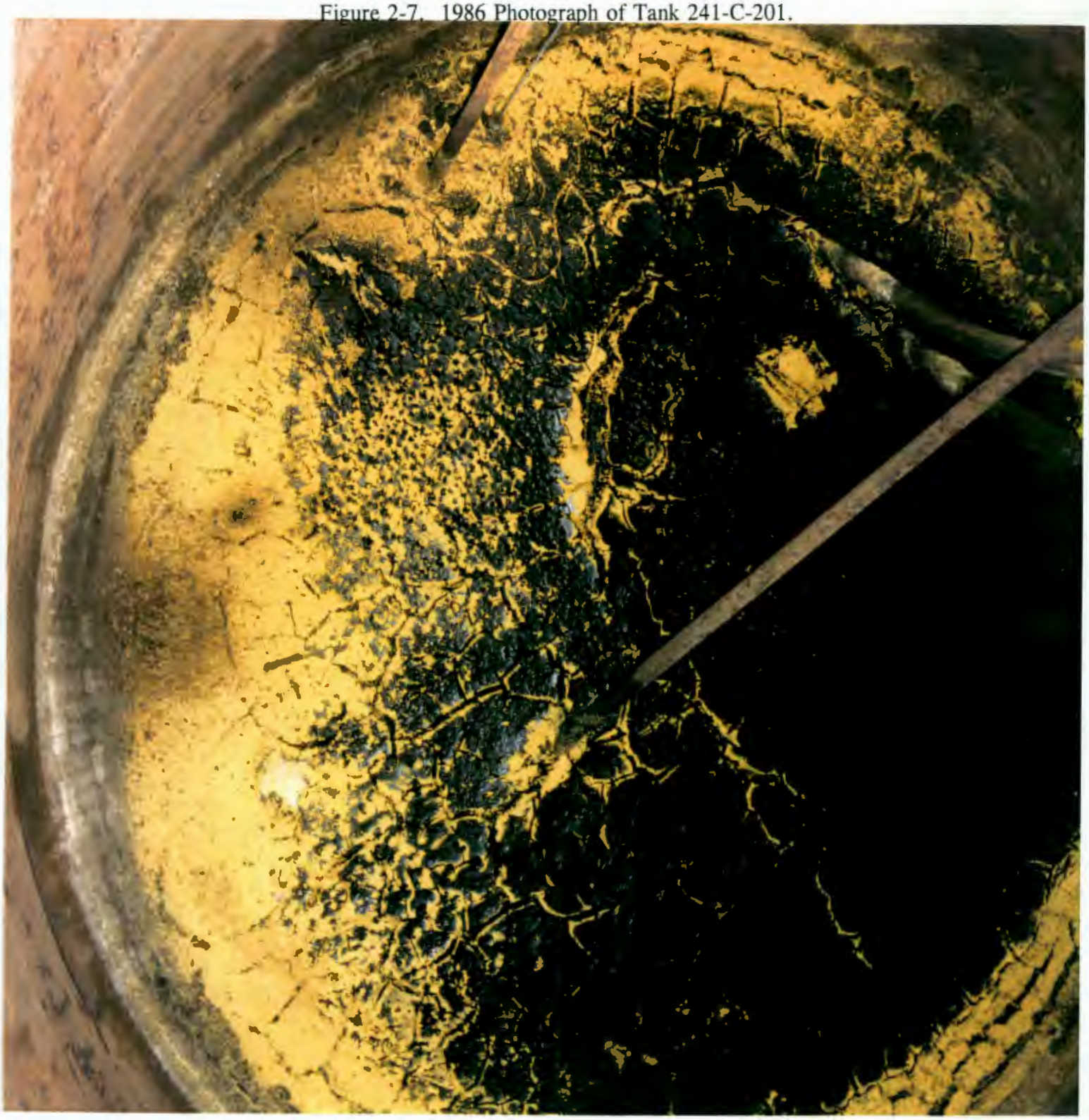
Figure 2-7. 1986 Photograph of Tank 241-C-201.



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3.0 TANK SAMPLING OVERVIEW

This section describes two sampling events from tank 241-C-201: a sampling event in 1978 and an auger sampling event in 1995. Section 3.1 describes the 1978 sampling event, and the data from this event are provided in Appendix B. A description of the two auger samples collected on May 3, 1995 for safety screening purposes is given in Sections 3.2, while the results are reported in Section 4.0 of this document. The 1995 sampling event followed the requirements of the Westinghouse Hanford Company *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994) and *Tank 241-C-201 Tank Characterization Plan* (TCP) (Schreiber 1995a). Sample handling and analytical results may be found in the *45-Day Safety Screen Results for Tank 241-C-201, Auger Samples 95-AUG-025 and 95-AUG-026* (Schreiber 1995b). A further description of sampling procedures may be found in De Lorenzo (1994).

3.1 DESCRIPTION OF SAMPLING EVENT (1978)

A description of the technique used to extract the 1978 sample from tank 241-C-201 was not available from the historical records. However, based on knowledge of sampling technology commonly used during that time, it was most likely acquired using a split-tube sampler. The sample appears to be a sludge sample analyzed for primary cations, anions, and radiological constituents (refer to Appendix B).

3.1.1 Sample Handling (1978)

The sample (3421) was black in color with the consistency of tar. No procedures or associated explanations for the sampling and analytical treatment are available (Horton 1978).

3.1.2 Sample Analysis (1978)

For the 1978 project, both a water and an acid digestion were performed prior to analysis of the sample. The post-digestion samples were then analyzed for major cations, anions, and radiological constituents, as well as such compounds as total organic carbon. Detailed analysis results are reported in Appendix B. It should be noted that because tank 241-C-201 was interim stabilized in 1982, the results from this early sampling and analysis event may not represent the tank's present contents with respect to percent moisture. However, the tank had been declared inactive prior to the sampling event, indicating that no waste transfers occurred after these 1978 results were obtained. Therefore, the data summarized in Appendix B may provide some insight into the current sludge content of the tank. Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology

et al. 1994), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

3.2 DESCRIPTION OF SAMPLING EVENT (1995)

On May 3, 1995, two auger samples were collected from riser 7 of tank 241-C-201 using 20-in. augers. Sample 95-AUG-025 was collected from the eastern coordinate and sample 95-AUG-026 was collected from the western coordinate of the riser. Auger sampling was used because approximately 13 in. of sludge material was expected. Although core sampling systems could have been used, the latter methods would have been more complicated and would not necessarily have added additional value. The 20-in. augers were expected to recover about 12 in. of waste material for sample 95-AUG-025 and 13 in. for sample 95-AUG-026. The dose rates through the drill strings were not recorded.

3.2.1 Sample Handling (1995)

The two auger samples were received at the Westinghouse Hanford Company 222-S Laboratory on May 4, 1995 and extruded on May 8, 1995. Table 3-1 summarizes the sampling data and describes the material collected on the augers. The recoveries for both auger samples were small and consisted of 3.7 and 12.09 grams (g) of solid material for samples 95-AUG-025 and 95-AUG-026, respectively. No drainable liquid was obtained. Color photographs of the auger samples were taken and are provided in Appendix D of this document. No discrete layers were noted in the samples, but yellow solids were intermixed throughout both samples. Descriptions of the sample material are provided in Table 3-1.

The samples were not divided into half segments as directed in the TCP. Because of the small amount of sample obtained from sample 95-AUG-025, all material was collected as one specimen, and no material was archived. Sample 95-AUG-026 also was collected as one specimen, but it was possible to archive material. Specimens removed from the augers were to be analyzed for energetics (fuel energy content), percent moisture, and total alpha activity as directed by the TCP (Schreiber 1995a). Subsampling information, sample identification, and completed analyses are presented in Table 3-2.

Table 3-1. Tank 241-C-201 Auger Sampling Summary.

Sample ID	Riser	Amount collected (g)	Description
95-AUG-025	7 (EC)	3.7	Sample material was very dry and powdery. Solids were gray to brown in color with some yellow colored solids intermixed. No sample material adhered to the auger and sample began to fall out as soon as the sleeve was removed from the auger.
95-AUG-026	7 (WC)	12.09	Sample material was very dry and powdery. Solids were brown and gray in color with some yellow solids mixed throughout. Powdery material began to fall out as soon as the sleeve was removed from the auger.

Notes:

EC = eastern coordinate
WC = western coordinate

Table 3-2. Tank 241-C-201 Sample Data Summary.

Sample ID	Core ID	Sample size	Preparation	Analyses
S95T000895	95-AUG-025	Whole	Direct	DSC, TGA, TOC
S95T000897	95-AUG-025	Whole	Fusion digestion	Total alpha
S95T000898	95-AUG-026	Whole	Direct	DSC, TGA, TOC
S95T000899	95-AUG-026	Whole	Fusion digestion	Total alpha

Notes:

DSC = differential scanning calorimetry
TGA = thermogravimetric analysis
TOC = total organic carbon

3.2.2 Sample Analysis (1995)

Following the requirements of the TCP (Schreiber 1995a), energetics by DSC, percent moisture by TGA, and total alpha activity analyses were completed on the samples as summarized in Section 3.2.1. TOC analysis was also performed on each auger sample because the DSC notification limit of 481 joules per gram (J/g) (dry weight basis) was exceeded. With concurrence from the Ferrocyanide and Organic Safety Program management, a decision was made not to run the secondary cyanide analysis as directed by the TCP. This decision was based on the existing knowledge of the tank fill history and the fact that very little waste material was obtained from the auger samples. Discussions regarding secondary energetics analysis by reactive system screening tool (RSST) adiabatic calorimetry are currently pending, and the results of this analysis shall be included in a revision to this tank characterization report.

As is typical, the DSC and TGA analyses for tank 241-C-201 waste were performed directly on 15- to 35-milligram (mg) specimens of the waste material. The total alpha activity specimens, however, had to be dissolved before analysis. This dissolution is accomplished by fusing a solid aliquot (0.2 to 0.5 g) of the waste material in potassium hydroxide and dissolving, or digesting, the resultant fluxed material in hydrochloric acid. Total alpha activity is then determined on a liquid aliquot of the dissolved waste material. The TOC secondary analysis used the persulfate oxidation method on a direct sample.

Laboratory control standards, spikes, blank analysis, and duplicate analysis quality control checks were applied to the TOC and total alpha activity analyses. Because spikes and blank analyses are not applicable to DSC and TGA methods, only laboratory control standards and duplicate analysis quality control checks were used for these analyses. An assessment of the quality control data from this analysis event is presented in Section 5.1.2.

All reported analyses were completed using approved laboratory procedures. No deviations from or modifications to the procedures were noted by the laboratory. Total alpha activity spike recoveries have typically been below the specified lower limit when solids are observed on the sample mount, as occurred during these analyses.

The preparation used for each analysis is shown in Table 3-2, and the laboratory's preparation and analytical procedures used for these analyses are presented in Appendix C.

4.0 ANALYTICAL RESULTS AND WASTE INVENTORY ESTIMATES

4.1 OVERVIEW

The May 1995 sampling and analysis event for tank 241-C-201 was done to evaluate the safety screening criteria defined in the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994). This data quality objective (DQO) requires analyses for energetics, percent moisture, total alpha activity, and flammability in order to rapidly classify tanks that contain high-level radioactive waste into specific safety categories. The safety screening analysis results reported in *45-Day Safety Screen Results for Tank 241-C-201, Auger Samples 95-AUG-025 and 95-AUG-026* (Schreiber 1995b) are summarized in Sections 4.2 and 4.3. Results from the 1978 sampling and analysis project will not be discussed in this section, but are provided in Appendix B.

Due to the limited amount of sample received and the fact that the 1995 auger samples were obtained from the same riser, no complete statistical analysis was performed. Therefore, no estimates of variability are given in this report.

4.2 DATA PRESENTATION - TOTAL ALPHA

Total alpha activity measurements were completed on homogenized material from both auger samples. Duplicate aliquots of each sample were fused, digested, and analyzed. The results of these analyses are summarized in Table 4-1. The *Average* column is the average of the primary sample and duplicate analyses. The *Mean* column is the average of the *Average* column values for the two auger samples or the overall average of the reported results.

Table 4-1. Tank 241-C-201 Analytical Data: Total Alpha Activity.

Sample number	Auger identification	Sample type	Result (μCi/g)	Average (μCi/g)	Mean (μCi/g)	Projected Inventory (Ci)
S95T000897	95-AUG-025	Primary	11.9	11.9	16.55	188 [1]
		Duplicate	12.0			
S95T000899	95-AUG-026	Primary	22.9	21.2		
		Duplicate	19.6			

Notes:

[1] Projected inventory calculated assuming a waste density of 1.5 g/mL.

μCi/g = microcuries per gram
Ci = curies

4.3 PHYSICAL MEASUREMENTS RESULTS

The tank 241-C-201 auger samples were analyzed in accordance with the previously mentioned DQO and TCP; density, percent solids, particle size, and rheology were neither requested nor performed. Weight percent moisture by TGA and energetic or fuel content by DSC are the only physical measurements required by the DQO. TGA provides an estimate of the weight percent water of the waste material and is used to interpret the DSC results. If the DSC results exceed the notification limit of 481 J/g dry weight basis, then TOC, cyanide, and energetic content by RSST adiabatic calorimetry analyses are to be completed on the sample material. As of this writing, only TOC analysis was completed on the samples. The rationale and decision to waive the secondary cyanide analyses is presented in Section 3.2.2, and the RSST adiabatic calorimetry test is pending. When this analysis is completed, the results will appear in a revision to this document. The results of the TGA and DSC analyses are summarized in Section 4.3.1.

4.3.1 DSC/TGA Results

TGA and DSC analyses were completed on homogenized material from both auger samples. After extrusion on May 8, 1995, specimens were collected and analyzed on May 12, 1995 and May 13, 1995. Both the TGA and DSC analyses were run in duplicate (runs 1 and 2). For more information regarding these analyses, refer to De Lorenzo (1994).

Three additional DSC runs were completed on samples S95T000895 and S95T000898 because of high relative percent difference (RPD) results. However, these additional runs produced even higher RPD results. These additional data are not presented in this report, although two of the additional runs are available in Schreiber (1995b). The remaining run is not included in either Schreiber (1995b) or this report because an instrument failure occurred during analysis and thus the results do not conform to requirements of the requesting program.

The results of the TGA analysis are provided in Table 4-2. The TGA recorded weight losses are relative to the original weight of the sample. Three of the four specimens analyzed by TGA show two distinct weight loss transitions. The first transition occurs between 40 °C and 160 °C and is associated with the free or interstitial water contained within the waste material. This weight loss represents the percent water in the specimen. The second transition occurs at 160 °C to 460 °C. Based on the DSC analysis, this second

weight loss is associated with an exothermic reaction between 180 °C and 400 °C and an endothermic reaction at 300 °C. The endothermic reaction at 300 °C may be caused by the melting of sodium nitrate, which occurs near this temperature. Some of this second weight loss probably represents the oxidation of organics in the specimen by sodium nitrate and subsequent loss of carbon dioxide, plus the dehydration of other chemical compounds contained in the waste material. The amount of weight loss observed in this second transition is much higher than has been observed in other tank waste matrices. The fourth specimen (S95T000898 duplicate) shows three weight-loss transitions. The first two transitions are in similar temperature ranges to the other three specimens and the third transition occurred between 420 °C and 460 °C. The corresponding DSC specimen (S95T000898) regarding this third transition indicates that an endothermic reaction may occur in this temperature range. Additional chemical and thermal analyses would be required to confirm these probable reactions. The TGA results for both samples and their duplicates violated (were below) the established notification limit of 17 weight-percent water.

Table 4-2. Tank 241-C-201 Analytical Data: Thermogravimetric Analysis.

Sample ID	Core ID	Run	Transition 1 %wt loss		Transition 2 %wt loss	
			Range (40 - 160 °C)	Mean %wt loss	Range (160 - 460 °C)	Mean %wt loss
S95T000895	95-AUG-025	1	10.69	10.18	16.91	15.96
		2	9.67		15.0	
S95T000898	95-AUG-026	1	11.46	11.0	15.89	14.33
		2	10.53		12.76	
S95T000898 duplicate shows a third transition with a 1.8% weight loss in the 420 to 460°C range.						

Notes:

Wt = weight

The results of the DSC analyses are provided in Table 4-3 and are based on both wet and dry weights of the samples. The endothermic values are based on the wet weight of the sample. For dry weight, the results are corrected using the weight percent water values determined by TGA analysis and are provided in parentheses in Table 4-3. The temperature range, temperature at maximum enthalpy change, and the magnitude of the enthalpy change in J/g are provided for each transition. Exothermic reactions are identified in the table by a negative sign for enthalpy and areas above the baseline on the scans. Runs 1 and 2 for

sample S95T000895 show three transition ranges; an endothermic reaction and an exothermic reaction followed by another endothermic reaction. Runs 1 and 2 for sample S95T000898 are similar in sequence to the sample S95T000895 runs, but show four transition ranges with endothermic reactions near 300 °C within the exothermic ranges. Sample S95T000895 runs also show endothermic regions, or dips in the exothermic area boundaries on their scans, near 300 °C within the exothermic reaction ranges. The first transition represents the endothermic reaction for the evaporation of the free or interstitial water in the sample. The endothermic reactions, or regions, within the exothermic reaction ranges probably represents the energy (or heat of crystallization) required to melt the sodium nitrate or other salts. TOC content of the samples exceeded the program notification limit of 30,000 μg C/g (see Section 4.3.2), and the exothermic transition area probably represents the decomposition of the organics in the samples and reaction with molten nitrate salts. The last endothermic reaction, beginning near 400 °C, probably represents the energy required to melt other salts. The onset for the exothermic reaction is from 115 °C to 180 °C. Of the exothermic reactions found for tank 241-C-201 (including reruns not presented in this report), all but two exceeded the program notification limit of 481 J/g (dry weight basis). Although not included in this report, the DSC scans are available in Schreiber (1995b).

Table 4-3. Tank 241-C-201 Analytical Data: Differential Scanning Calorimetry.

Run	Range °C	Peak °C	ΔH J/g	Range °C	Peak °C	ΔH J/g	Range °C	Peak °C	ΔH J/g	Range °C	Peak °C	ΔH J/g
Sample #: S95T000895 Sample ID: 95-AUG-025												
1	40-160	79.1	140.1	--	--	--	180-395	341.8	-546.6 (-609.0)	395-425	405.3	10.3
2	40-100	57.2	119.7	--	--	--	115-385	307.7	-615.6 (-685.0)	385-420	401.3	14.7
Sample #: S95T000898 Sample ID: 95-AUG-026												
1	40-170	83.0	200.6	175-295	289.7	-84.7	295-405	344.0	-254.5 (-381.0)[1]	405-460	437.5	19.1
2	40-110	77.0	88.8	180-295	289.5	-147.6	295-400	347.6	-254.8 (-452.0)[1]	--	--	--

Notes:

[1] Dry weight basis results calculated using results of both exotherms found for this run.
Negative sign denotes exothermic reaction.
Values in parentheses are based on dry weight of sample.
J/g = joules per gram
ΔH = change in enthalpy

4.3.2 TOC Results

Secondary analysis of the tank 241-C-201 auger samples for TOC was required because the program notification limit of 481 J/g (dry weight basis) for DSC analysis was exceeded. The auger samples were analyzed for TOC by the direct persulfate method. Duplicate runs were completed for TOC and results exceeded the OSD notification limit of 3 weight percent carbon [30,000 micrograms carbon per gram (μg C/g)], although the 5 weight percent limit specified in Buckley (1995) was not violated. The results of the TOC analyses are presented in Table 4-4. The *Average* column is the average of the duplicate analyses. The *Mean* column is the average of the *Average* column values, or the overall average of the reported results.

Table 4-4. Tank 241-C-201 Analytical Data: Total Organic Carbon.

Sample number	Auger identification	Sample type	Result (μg C/g)	Average (μg C/g)	Mean (μg C/g)	Projected inventory (kg)
S95T000895	95-AUG-025	Primary	37,700	39,900	41,650	473
		Duplicate	42,100			
S95T000898	95-AUG-026	Primary	45,700	43,400		
		Duplicate	41,000			

Notes:

Values given on wet weight basis. Dry weight basis results will be higher.
μg C/g = microgram carbon per gram
kg = kilogram

5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

This section compares current analytical results to historical information and programmatic requirements, as well as evaluating sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in its use.

5.1.1 Field/Laboratory Observations

During the handling of the 1995 samples, an observation was made that could impact the interpretation of the data. Although the safety screening DQO specifies that at least two risers be sampled, only one riser from tank 241-C-201 was available for sampling. Because of the small amount of solids in the tank, there was a suspicion that the material would be dry (percent moisture results of less than the notification limit of 17 weight percent). In order to help lessen the chance of receiving a false positive result, it was decided that two auger samples would still need to be obtained. Consequently, both auger samples were obtained from the same riser. Because little sample was recovered from the sampling event and the safety screening DQO requires only a limited analysis suite, it was not possible to sufficiently analyze the material to determine the effects, if any, of taking the samples approximately 10 in. apart in the same riser.

5.1.2 Quality Control Assessment of Analytical Data

The appropriate blanks, duplicates, spikes, and standards for quality control measures were performed on the 1995 auger sampling safety screening DQO analyses. The criteria established by the DQO and the TCP were ± 10 percent for the accuracy and precision of the data.

The control standard results and spiked sample results provide an estimate of the accuracy of the analysis. If a control standard or spike is above or below the accuracy criterion, then the analytical results may be biased high or low, respectively. All of the standards conducted on the analyses were in the acceptable range. Spikes were conducted only on the total alpha activity and TOC data, as they are not applicable to DSC and TGA methods. Both spikes conducted on the total alpha activity were outside the 90 to 110 percent recovery criterion, with values of 83.30 and 84.20 percent recovery. The poor recovery was attributed to the probable presence of solids on the sample mount. In addition, the spike recovery of the TOC data was slightly below the criterion. However, because of a lack of sample material, no reruns were performed.

Evaluation of analytical preparation blanks is only applicable to the total alpha activity and TOC analyses. For both analyses, preparation blanks were below the detection limits, indicating that contamination was not a problem.

Duplicate analyses were performed on each of the auger samples in order to provide an indication of the reproducibility for these analyses and also an indication of the sample homogeneity. Precision requirements are estimated by the RPD between the primary and duplicate samples. For the total alpha activity, TGA, and TOC analyses, the RPD results agree well and are within the 10 percent RPD criterion specified in the safety screening DQO, meaning the data reliability is not impacted seriously by the laboratory's analytical precision or sample heterogeneity. The DSC results, however, varied widely among the runs performed and resulted in higher RPD values, which could be caused by either insufficient homogenization or the small sample size used for the DSC method [typically 15 to 35 milligrams (mg)].

5.1.3 Data Consistency Checks

The small quantity of sample material recovered from tank-241-C-201 limited the ability to compare data trends between auger samples. If a greater amount of waste material had been recovered in auger samples 95-AUG-025 and 95-AUG-026, or additional samples had been obtained successfully, then further analyses of the consistency of the data would have been possible. The comparison of results from different sampling events is described in Section 5.4, and this comparison indicates the data consistency for this tank. Checks can be made between individual analytes when the same aliquot of sample is analyzed by two comparable methods. Two of these checks are made for the 1995 analysis results and are described in the following sections.

5.1.3.1 Comparison of DSC and TOC Analyses. This evaluation can be used to check the accounting of fuel (as organic carbon) and energy production because of an exothermic chemical reaction. The DSC data for the 1995 sampling event were:

Auger	Average Energy Produced as an Exotherm
95-AUG-025	-581.1 J/g of sample (wet basis), and
95-AUG-026	-370.8 J/g of sample (wet basis).

The TOC data for the 1995 sampling event were:

Auger	Average Concentration of Organic Carbon
95-AUG-025	0.0399 g of Carbon/g of sample (wet basis), and
95-AUG-026	0.0434 g of Carbon/g of sample (wet basis).

Therefore, the composition of organic carbon in the waste of tank 241-C-201 is approximately 0.04 g of carbon/g of sample (wet basis).

If the exotherm detected by the DSC analysis were produced exclusively from the oxidation of the organic carbon, knowing the form of the molecule(s) in which the organic carbon is contained would allow the exothermic heat of reaction to be calculated for that compound. For this evaluation a variety of organic compounds common to Hanford Site waste are presented in Table 5-1 along with their resultant heats of reaction or enthalpy (assuming complete reaction).

Based on the information summarized in Table 5-1, it may be speculated that Na_3HEDTA, Na_4EDTA, NaCitrate, NaAcetate, or NaGlycolate may be present in the tank. However, most of the compounds originally sent to storage in the waste tanks at the Hanford Site have aged and no longer exist in their original form. Further, most chemical reactions do not proceed to completion (approximately 50 percent of the theoretical energy production from a fuel is observed in experimental settings) (Scheele et al. 1995). Using this knowledge and the above data, the DSC and TOC data appear to be in agreement.

Table 5-1. Theoretical Energy from Oxidation of Organic Carbon.

Molecular form containing organic carbon				Energy that would be produced in tank 241-C-201 at 0.04 g C/g waste (J/g) (wet basis)
Compound	Molecular weight (g/mole)	C atoms/ molecule	Enthalpy (J/g)	
Na_3HEDTA	341	10	11,000	1250
Na_4EDTA	378	10	8,800	1080
NaCitrate	348	7	6,840	911
NaAcetate	82	2	7,940	1090
NaTBP	266	12	17,200	1,270
NaGlycolate	98	2	4,900	800
NaDBP	161	4	21,100	2280
NaOxalate	135	2	1,000	225

Notes:

g gram
J joules
C carbon

5.1.3.2 Comparison of TGA Data and Extrusion Photographs. When both auger samples were extruded in the laboratory hot cells, color photographs were taken of the sampled materials (see Appendix D). These photographs revealed no drainable liquid. The solids looked very dry and crumbly, and fell off the augers onto the sample tray after the sleeve was removed. The TGA results indicated that the tank 241-C-201 waste contained less than approximately 12 weight percent water. These data compare very favorably and substantiate one another quite well.

5.2 COMPARISON OF 1978 AND 1995 ANALYTICAL RESULTS

The analyses performed for both of these sampling and analysis projects were extremely limited, and the overlap between analyses is insufficient to make a comparison of these results. However, a comparison of the results of these analytical events to the analytes predicted by the transfer history of tank 241-C-201 is provided in Section 5.4.

5.3 TANK WASTE PROFILE

With the limited number of analyses performed for this analysis project, it is not possible to gain an understanding of the waste profile for tank 241-C-201.

5.4 COMPARISON OF ANALYTICAL AND TRANSFER HISTORY INFORMATION

Several observations and comparisons can be made with the available historical model results, past samples, and contemporary analytical data. Because the tank was emptied of metal waste early in its process history, and subsequent transfers indicated the presence of strontium semi-works waste, high beta activity and/or notable exotherms were not unexpected. Table 5-2 shows the principal analytes predicted from modeling of the waste in this tank (refer to Appendix A), the results from the 1978 sampling event, and the 1995 auger sample analytical results.

As revealed in Table 5-2, there is some agreement between the model results and the 1978 analytical results. The comparisons that can be made between the 1995 analytical results and the historical transfer information are quite limited. However, some assumptions about the physical behavior of the waste, to aid in interpretation of the historical analytical data, are necessary.

Table 5-2. Comparison of Analytes.

Analyte (μg/g unless indicated otherwise)	Historical Model	1978 analytical	1995 analytical
H_2O (%)	62.1%	68.0%	10.6%
Na	45,200	27,000	No analysis
Fe	72,500	62,000	No analysis
Pb	7,000	No analysis	No analysis
Ni	2446	8,000	No analysis
OH^-	108,000	5,000[1]	No analysis
NO_3^-	24,600	33,000	No analysis
NO_2^-	365	1,000	No analysis
CO_3^{-2}	20,000	20,000	No analysis
PO_4^{-3}	14,000	146,000	No analysis
SO_4^{-2}	7,610	below DL	No analysis
TOC	8,500	0.20 M	41,650
$C_6H_5O_7$	2,500	No analysis	No analysis
EDTA	7,610	No analysis	No analysis
Acetate	9,940	16,200[2]	No analysis
U	90,000	60	No analysis
Total Alpha (μCi/g)	No analysis	No analysis	16.55
Pu (μCi/g)	2.43E-06	3.54E-05	No analysis
Cs-137 (μCi/g)	0.47	7.66[3]	No analysis
Sr-90 (μCi/g)	2,121	40.8	No analysis

Note:

1978 data converted from percent to μg/g by multiplying by 1000.
[1] Water soluble portion only.
[2] Derived result from the 0.20-M TOC value reported.
[3] Water soluble and insoluble results combined.
DL = detection limit

The assumptions in this interpretation are the following:

- The tank was not completely emptied.
- Relatively small amounts of sludge can lose moisture.
- The tank is layered, with strontium semiworks waste on top of a metal waste heel.

This interpretation is a credible explanation of the differences observed between the historical estimates and the analytical data. However, this speculation should be used with caution due to a lack of measured variability or error in the data from the Table 5-2.

The waste sample appears to possess properties of both metal waste and strontium semiworks waste (although predominantly strontium semiworks waste), as predicted from the Los Alamos National Laboratory historical model. As time passed, the water content of the remaining waste was reduced by stabilization, leaking, and slow evaporation, which reconciles the high predicted water content and the 1978 water content with the measured 1995 water content. Iron, sodium, nitrate, and organic content correspond well to the tank 241-C-201 model estimates, although the phosphate and uranium values predicted by the model do not agree well with the 1978 analytical results. These observations suggest that sample heterogeneity may have biased the 1978 sample results. For instance, metal waste contains high concentrations of uranium, but very little uranium was present in the 1978 sample. It can be hypothesized that the metal waste was not observed because uranium compounds or particulates likely reside at the very bottom of the tank (and may not have been retrieved as part of the sample). Physical and chemical processes may have caused different waste compounds to segregate, with the uranium bearing materials settling first and other compounds, like phosphate, precipitating over them, where it was accessible to the sampling equipment. Because of the highly similar nature of the process histories of the 241-C 200 series tanks, the waste compositions and physical properties observed in tank 241-C-201 may be applicable to the other 241-C 200 series tanks.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

Tank 241-C-201 is currently classified as a non-watch list tank, and the 1995 auger sampling and analysis event was performed to meet the requirements of the safety screening DQO. Therefore, only the general safety program requirements can be assessed. Insufficient data exist to sufficiently evaluate operational, environmental, or process development programmatic requirements. This section will discuss only the 1995 auger sampling event, because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994).

5.5.1 Safety Evaluation

The safety screening DQO establishes decision criteria or notification limits for concentrations of analytes of concern. The decision criteria are used to determine if a tank has been appropriately categorized concerning safety issues, or if further investigation into the tank's safety is warranted. If results from the primary analyses exceed the decision criteria, the tank is classified "not safe," and further analyses are conducted to assure tank safety. The primary analytical requirements identified in the safety screening DQO are fuel energy content, percent moisture content, total alpha activity, and vapor flammability. Table 5-3 lists the applicable analytes, their notification limits, and the pertinent 1995 auger sampling analytical results.

Table 5-3. Safety Screening DQO Decision Variables and Criteria for Tank 241-C-201.

Safety issue	Primary decision variable	Decision criteria threshold	Analytical value
Ferrocyanide/ organic	Total fuel content	> 481 J/g (> 115 cal/g)[1]	381 - 685 J/g[1]
Organic	Percent moisture	< 17 wt %	10.18 - 11.0 wt%
Criticality	Total alpha analysis	> 41 μCi/g (> 1 g/L)[2]	16.6 μCi/g
Flammable gas	Flammable gas Concentration	NA	--
Organic	Total organic carbon	> 5 wt %[1]	4.65 wt %[3]

Notes:

[1]Dry weight basis. OSD specification is 3 wt %.
[2]Although the actual decision criterion listed in the DQO is 1 g/L, total-alpha activity is measured in μCi/g rather than g/L. To convert the notification limit for total-alpha activity to μCi/g, it was assumed that all alpha decay originates from ^{239}Pu. Using the HTCE estimate of the tank density of 1.5 g/mL, and using the specific activity of 0.0615 Ci/g for ^{239}Pu, the decision criterion may be converted to 41 μCi/g as shown:

$$(1\ g/L) \times (10^{-3}\ L/mL) \times (1/1.5\ mL/g) \times (0.0615\ Ci/g) \times (10^{6}\ \mu Ci/Ci) = 41\ \mu Ci/g$$

[3]Wet weight basis converted to dry weight basis using TGA value of 10.59 wt% (mean of auger results).

wt % weight percent
NA not applicable

The waste fuel energy value of tank 241-C-201 was determined using DSC analysis of the sample material. For both auger samples, results greater than the DQO limit of 481 J/g

(dry weight basis) were obtained [1], indicating that some fuel content is present in the waste material.

Large amounts of moisture reduce the potential for propagating exothermic reactions in the waste, and it has been found that sufficient moisture content can ensure that exothermic reactions will not occur, regardless of the fuel energy concentration (Meacham et al. 1995). The safety screening DQO has specified that a percent moisture content of above 17 weight percent is necessary for safe storage. However, results of the 1995 auger analysis event for tank 241-C-201 indicate a low moisture content in the waste material (see Table 4-2). This low moisture value, coupled with the high fuel energy results of tank 241-C-201 are sufficient to pose a potential safety hazard.

Because the DSC notification limit was exceeded in the tank 241-C-201 auger samples, TOC secondary analysis was performed in order to identify the source of the fuel. Both sample results exceeded the OSD notification limit of 3 weight percent (dry weight basis), suggesting that tank 241-C-201 may contain organic chemicals. This hypothesis is consistent with the tank fill history, which indicates that hot semiworks waste from the PUREX Pilot Plant study is present in the tank. However, it should be noted that the safety program limit of 5 weight percent, as stated in (Buckley 1995), was not exceeded. Because of its known fill history and the fact there was very little sample material obtained in the auger samples, cyanide analysis was not performed although it was required by the DQO.

Another factor in assessing the safety of the tank waste is the heat generation and temperature of the wastes. Heat is generated in the tanks primarily from radioactive decay. For the tank-241-C-201 auger samples, analyses for heat-generating radionuclides such as cesium-137 and strontium-90 were not performed. However, the historical inventory estimates include cesium and strontium at projected inventory levels of approximately 4.8 curies (Ci) and 2,180 Ci, respectively. At these estimated levels, the projected heat load from these radionuclides based on the information in Appendix A is 670 watts (a tank must have greater than 11.7 kilowatts of heat generating capacity to be classified as a high-heat load tank). In addition, the recorded tank temperature over the last three years has been relatively stable at or below 21 °C (70 °F), which further supports the designation of the tank as a low-heat-load tank.

The potential for criticality is assessed from either total alpha analysis or plutonium analysis. The safety screening criteria for criticality is 1 g/L. This is equivalent to 41 μCi plutonium-239/g of waste assuming the density of the settled sludge is 1.50 g/mL. The 1995 auger sample total alpha activity was between 11.9 and 21.2 μCi/g, which is approximately one half of the upper bound notification limit. The 1978 sample did not undergo a total alpha activity analysis, but analyses for plutonium and americium were

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1 For auger sample 95-AUG-026, the original sample and duplicate results did not exceed the notification limit of -481 J/g (see Table 4-3); however, the additional two runs performed due to high RPD values showed exotherms greater than the limit. Therefore, although this information was not used in the generation of this report due to even higher RPD values, it was considered of enough significance to warrant mention in this section.

performed. Based on these plutonium and americium results, a total alpha activity result can be calculated using the following equation:

$$Total\ \alpha\left(\frac{\mu Ci}{g}\right) = \left(\frac{g}{g}\ Pu\right) * \left(Activity\ Pu\ \frac{\mu Ci}{g}\right) + \left(\frac{g}{g}\ Am\right) * \left(Activity\ Am\ \frac{\mu Ci}{g}\right.$$

This calculation assumes that all the plutonium is in the form of plutonium-239, and that all the americium is found as americium-241. For the 1978 sample, a total alpha activity value of 2.4 μCi/g was calculated. As with the total alpha activity result found during the 1995 analysis event, this data supports the hypothesis that, from a criticality perspective, tank 241-C-201 may be declared safe.

The flammability of the gas in the headspace of a tank is another safety screening consideration. However, detailed analysis of the tank head space has not yet been conducted.

5.5.2 Operational Evaluation

Tank 241-C-201 was sampled to comply with the requirements of the safety screening DQO. These requirements do not include a complete list of the analyses required for a compatibility assessment. Further, interim stabilization and intrusion prevention were completed in 1982, so this tank is not being considered for any further stabilization or operational efforts.

5.5.3 Environmental Evaluation

Tank 241-C-201 waste was not characterized to designate the waste or for evaluation of any environmental compliance issues. It has been characterized to meet requirements dictating that the waste be safely stored and managed. No specific organic (volatile or semi-volatile) analyses have been performed on the tank; therefore, no environmental assessment of these compounds in the waste can be made. However, in general, tank waste matrices are highly caustic, radioactive, and have soluble nitrates associated with them. In turn, each of these characteristics has environmental impacts associated with them.

5.5.4 Process Development Evaluation

No specific characterization requirements for the waste in tank 241-C-201 have been identified for retrieval or disposal purposes; consequently, the waste in the tank has not been characterized per this need, which requires a complete list of metal cations and anions in addition to a full physical and rheological evaluation. Retrieval procedures, pumping requirements, and final waste-form determinations must await more complete analyses.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The sludge in tank 241-C-201 was sampled and analyzed in 1995. Very low sample recoveries and limited data from different risers and waste depths make it difficult to accurately determine the variability of the waste composition in the tank. However, the available historical and 1995 analytical information does show that the waste composition exceeds the safety criteria for percent water and energetics, demonstrating that significant fuel may be present in the tank. This conclusion is supported by the secondary TOC results, which exceeded the OSD safety criteria. Based on the OSD requirements, interim measures and controls are in place on tank 241-C-201 pending a final determination of watch list status by engineering personnel. Although the 3 weight percent OSD limit was exceeded, the 5 weight percent organic DQO limit (Buckley 1995) was not exceeded. Further secondary analyses, which include adiabatic calorimetry and heat capacity measurements, are currently being planned for the waste material. When these results are available, this tank characterization report will be revised.

The results of the auger sampling event do not address vapor flammability; therefore, the safety screening requirements are not fully met with respect to this tank. Because of the possible safety concerns cited above, it is recommended that tank 241-C-201 be considered for vapor sampling in the future.

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APPENDIX A

CONCENTRATION ESTIMATES FOR TANK 241-C-201 WASTE

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LosAlamos

Stephen F. Agnew
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Los Alamos National Laboratory
Los Alamos, New Mexico 87545

DATE: 17 Jul. 1995
IN REPLY REFER TO: CST-4:95-sfa198a

FAX: 505 667 0851
INTERNET: sfagnew@LANL.gov
TELEPHONE: 505 665 1764

To: Brett Simpson, WHC

Copies to: Chris Brevick, ICF Kaiser

Subject: Updated estimate for C-201

Dear Brett:

We have found that there were some missing transactions for the C-200 tanks that had a very serious affect on their contents, although there is only about ten kgal total waste amoung all these tanks. Evidently, there were some 200 kgal of waste from the Hot Semiworks or Strontium Semiworks that was placed into the C-Farm 200 series tanks in the late fifties. The Anderson-91 report clearly assigns all of these tanks to this waste type, even though no transaction volumes were reported. Our other records likewise show no transactions for this period although we have derived unknown transactions based on changes in tank level.

We therefore have derived the transaction volumes by assuming that all of the unknown transactions into these tanks during this time were due to additions of this waste type. Attached you will find an updated inventory calculation for C-201 to help you with your TCR for this tank.

The TLM analysis for this tank now shows one kgal each for MW and HS waste sludges. I also adjusted the HS waste type to reflect this new information and also found that the lead value for HS was too high. The HS waste type had shown a 0.034 M Pb in the feed, which resulted in a huge amount of Pb (1.6 M or 22 wt.%) in the sludge for this waste. I don't think that this is a reasonable value and so have arbitrarily reduced the lead by a factor of ten. Also, the Sr-90 inventory for this waste type was inconsistent with analytical information from C-112. I therefore adjusted the Sr-90 inventory in HS down to 0.5 MCi total, which is consistent with the 6 Ci/L value that was reported for surface samples from C-112 waste. Note that this is still evidently way more Sr-90 than is in C-201. The Pb amount derived from a report on six months of the semiworks operation in 1960 and seems much to large to be reasonable.

Since the TLM predicts a MW heel of one kgal, it is not surprizing that there is a high phosphate. The perplexing thing about the 1978 analytical results is how very high the phosphate, 15 wt.%. Pure $Na_3PO_4 \cdot 12H_2O$ is 25 wt.% PO_4, this suggests that the waste is around 60% of a phosphate salt, which seems rather unlikely. There is also a low U content, which is inconsistent with our assignment as a MW heel.

The very high TOC that you have now found in C-201 is more consistent with the HS waste, which is predicted to have a density of 1.3 g/cc, 61 wt.% water, and a TOC of 1.7 wt.%(wet). However, we also predict a very high concentration of Sr-90, 5.6 Ci/L, as well. This is much larger than that reported in the 1978 analysis (41 µCi/g vs. 2,121 µCi/g) for the composite. A useful comparison might be if you can determine what the dose reading at the segment was after it was brought to the surface. This amount of Sr-90 should result in 500-1,000 mR/hr. dose at the drill string.

This update is preliminary and subject to change in the final version. This new information will impact C-202,3, and 4 as well as C-109 (7 kgal HS) and C-112 (3 kgal HS), two other tanks with HS solids.

Sincerely,

Stephen F. Agnew

cc: CIC-2, CST-4

Single-Shell Tank 241-C-201			
TLM Solids Composite Inventory Estimate			
Physical Properties			
Total Supernatant Wa	1.03E+04 kg	(2.00E+00 kgal)	
Heat Load	0.67 kW	(5.01E+02 BTU/hr)	
Bulk Density*	1.36 (g/cc)		
Water wt%†	62.1		
TOC wt% C (wet)	0.850		
Chemical Constituents	mole/L	ppm	kg
Na^+	2.67E+00	4.52E+04	4.64E+02
Al^{3+}	0.00E+00	0.00E+00	0.00E+00
Fe^{3+} (total Fe)	002	7.25E+04	7.44E+02
Cr^{3+}	4.75E-03	1.82E+02	1.87E+00
Bi^{3+}	000	000	000
La^{3+}	0.000	0.000	0.00
Hg^{2+}	0.00	0.00	0.00
Zr (as $ZrO(OH)_2$)	000	000	000
Pb^{2+}	0.0	7000	71.8
Ni^{2+}	000	2446	2.51E+01
Sr^{2+}	0.000	0.000	0.00
Mn^{2+}	000	000	0.00E+00
Ca^{2+}	2.60E-02	7.67E+02	7.88E+00
K^+	3.49E-02	1.01E+03	1.03E+01
OH^-	8.62	1.08E+05	1.11E+03
NO_3^-	0.54	2.46E+04	2.53E+02
NO_2^-	0.01	3.65E+02	3.74E+00
CO_3^{2-}	0.451	2.00E+04	2.05E+02
PO_4^{3-}	0.200	1.40E+04	1.44E+02
SO_4^{2-}	0.107	7.61E+03	7.81E+01
Si (as SiO_4^{2-})	1.46E-03	030	3.10E-01
F^-	0.000	0.00E+00	0.00E+00
Cl^-	0.023	6.06E+02	6.22E+00
$C_6H_5O_7^{3-}$	1.79E-02	2.50E+03	2.56E+01
$EDTA^{4-}$	3.58E-02	7.61E+03	7.81E+01
$HEDTA^{3-}$	0.00E+00	0.00E+00	0.00E+00
glycolate*	0.000	0.00E+00	0.00E+00
acetate*	2.28E-01	9940	1.02E+02
oxalate^{2-}	0.00E+00	0.00	0.00
DBP	0.00E+00	0.00E+00	0.00E+00
butanol	0.00E+00	000	0.00E+00
NH_3	0.000	3.75E-02	3.85E-04
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents			
Pu	0.0033 (µCi/L)		0.00057 (kg)
U	5.15E-01 (M)	9.0E+04 (µg/g)	9.27E+02 (kg)
Cs	0.001 (Ci/L)	000.47 (µCi/g)	4.80E+00 (Ci)
Sr	2.9E+00 (Ci/L)	2121.4 (µCi/g)	2.18E+04 (Ci)

*Unknowns in tank solids inventory are assigned by Tank Layering Model (TLM).

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APPENDIX B

1978 ANALYTICAL RESULTS

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Waste Tank 241-C-201			
Analysis of Tank 241-C-201			
Sample 3421 December 4, 1978			
Physical Data			
	Water Soluble	Acid (Fusion)	
COMPONENT	LAB VALUE	LAB VALUE	LAB UNIT
Water solubility	8		%
Bulk density	1.16		g/cc
Percent water	68.0		%
Chemical Analysis			
Al*	0.06	0.1	%
Bi^{3+}	<0.03	<0.04	%
CO_3^{2-}	2.0		%
CrO_4^-	0.03		%
Cl^-	0.2		%
F^-	0.03	0.02	%
Fe*	0.006	6.2	%
Hg*	0.007		%
K^+	0.04		%
La^{3+}	0.01	0.06	%
Mn*	0.001		%
Ni^{2+}	NR	0.8	%
NO_2^-	0.1		%
NO_3^-	3.3	<0.5	%
Na^+	2.7		%
OH^-	0.5		%
PO_4^{3-}	0.2	14.6	%
SO_4^{2-}	<0.5	<0.7	%
$SiO_2$2-	<0.02	0.8	%
TOC	0.2		M
Radiological Analysis			
U*	6.41e-06	6.00e-05	g/g
Pu*	2.73e-07	3.48e-05	g/g
Am*	4.89e-11	6.43e-08	g/g
89+90 Sr^{2+}	0.020	40.8	uci/g
137Cs^+	4.36	3.3	uci/g
155 Eu*	NR		
*All Oxidation states			
NR--Analysis not requested			

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APPENDIX C

222-S LABORATORY ANALYTICAL AND PREPARATION PROCEDURES

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Table C-1. 222-S Preparation and Analytical Procedures.

Analysis	Instrument	Preparation procedure	Analytical procedure
Energetics by DSC	Mettler	NA	LA-514-113, Rev. B-1
%Water by TGA	Mettler	NA	LA-560-112, Rev. A-2
TOC	NA	NA	LA-342-100, Rev. A-0
Total alpha	NA	LA-549-141, Rev. C-3	LA-508-101, Rev. D-2

Notes:

DSC differential scanning calorimetry
NA Not Applicable
TGA thermogravimetric analysis

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APPENDIX D

TANK 241-C-201 AUGER EXTRUSION PHOTOGRAPHS

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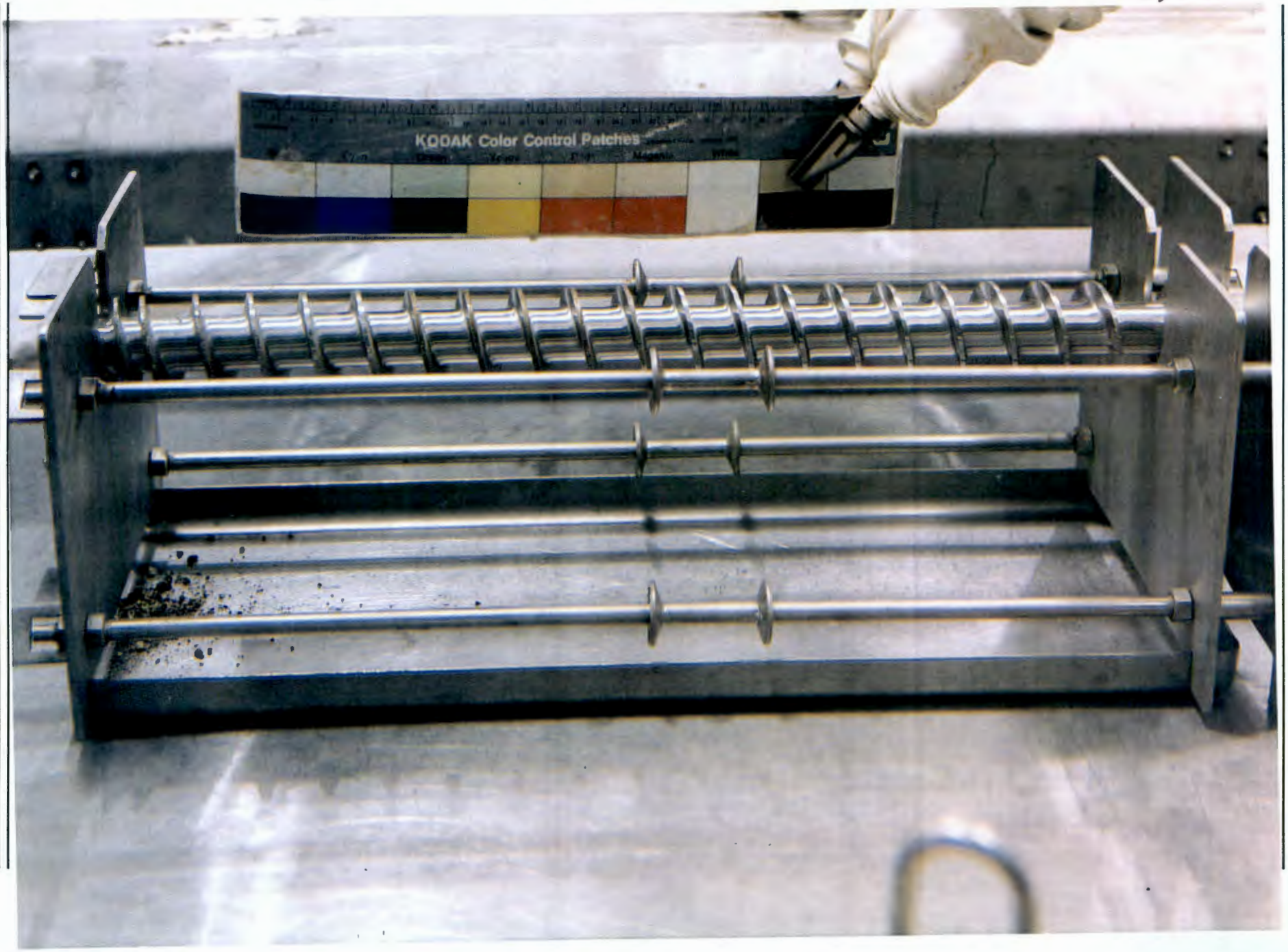
C-201 95-AUG-025 5/8/95



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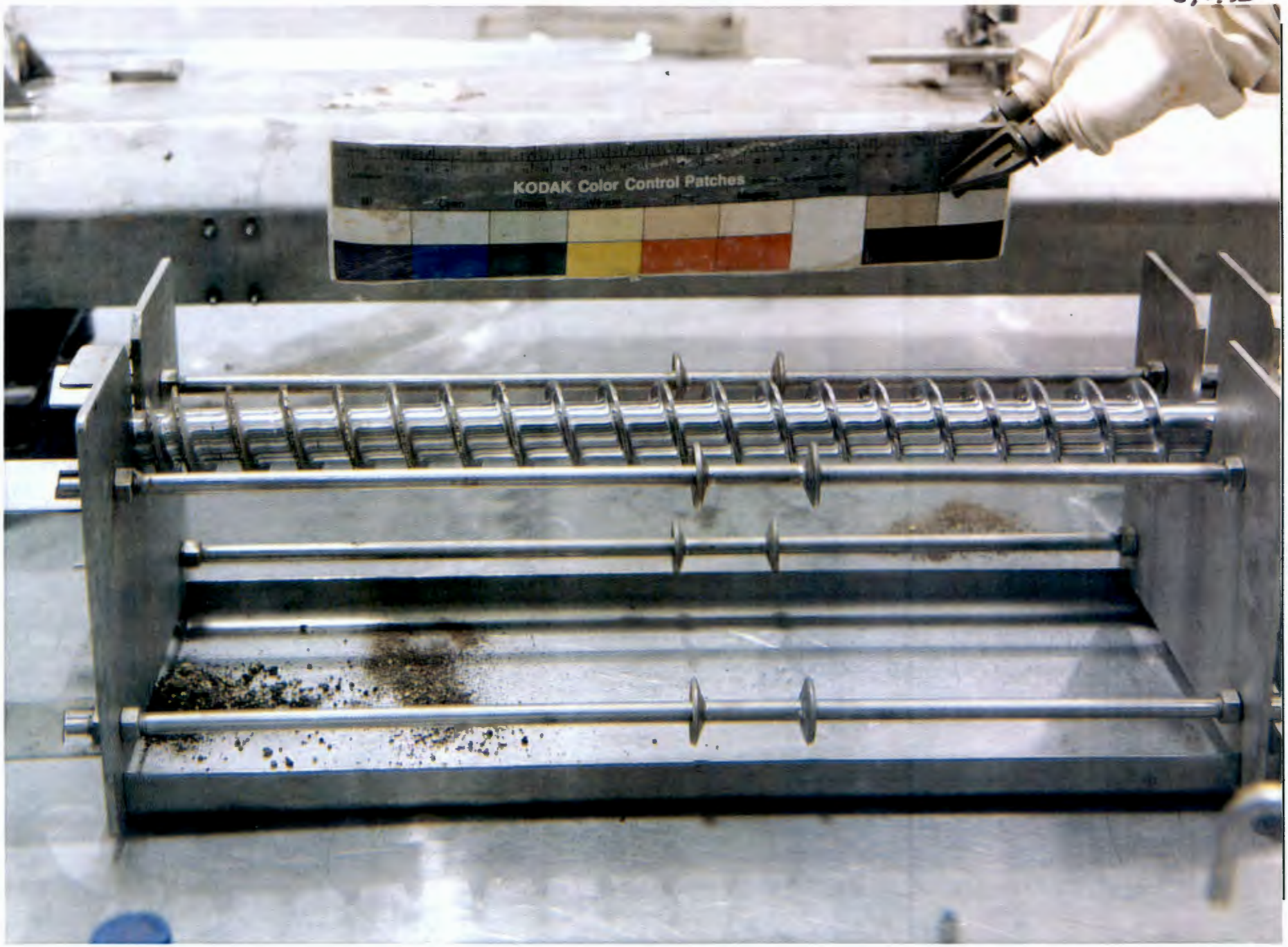

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