HIGH FLUX ISOTOPE REACTOR (HFIR) COOLING TOWER DEMOLITON WASTE MANAGEMENT

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ABSTRACT

This paper describes the results of a joint initiative between Oak Ridge National Laboratory, operated by UT-Battelle, and Bechtel Jacobs Company, LLC (BJC) to characterize, package, transport, treat, and dispose of demolition waste from the High Flux Isotope Reactor (HFIR), Cooling Tower. The demolition and removal of waste from the site was the first critical step in the planned HFIR beryllium reflector replacement outage scheduled. The outage was scheduled to last a maximum of six months. Demolition and removal of the waste was critical because a new tower was to be constructed over the old concrete water basin. A detailed sampling and analysis plan was developed to characterize the hazardous and radiological consituents of the components of the Cooling Tower. Analyses were performed for Resource Conservation and Recovery Act (RCRA) heavy metals and semi-volatile constituents as defined by 40 CFR 261 and radiological parameters including gross alpha, gross beta, gross gamma, alpha-emitting isotopes and beta-emitting isotopes. Analysis of metals and semi-volatile constituents indicated no exceedances of regulatory limits. Analysis of radionuclides identified uranium and thorium and associated daughters. In addition ^{60}Co, ^{99}Tc, ^{226}Rm, and ^{228}Rm were identified. Most of the tower materials were determined to be low level radioactive waste. A small quantity was determined not to be radioactive, or could be decontaminated. The tower was dismantled October 2000 to January 2001 using a detailed step-by-step process to aid waste segregation and container loading. The volume of waste as packaged for treatment was approximately 1982 cubic meters (70,000 cubic feet). This volume was comprised of plastic (~47%), wood (~38%) and asbestos transite (~14%). The remaining ~1% consisted of the fire protection piping (contaminated with lead-based paint) and incidental metal from conduit, nails and braces/supports, and sludge from the basin. The waste, except for the asbestos, was volume reduced via a private contract mechanism established by BJC. After volume reduction, the waste was packaged for rail shipment. This large waste management project successfully met cost and schedule goals.

INTRODUCTION

The High Flux Isotope Reactor (HFIR), located in Melton Valley at the Oak Ridge National Laboratory (ORNL), is operated by UT-Battelle for the U.S. Department of Energy (DOE). Associated with the operation of HFIR is building 7902, HFIR Cooling Tower. The characterization, demolition and packaging of the HFIR Cooling Tower was directed by UT-Battelle teamed with Bechtel Jacobs Company LLC who facilitated waste treament and final disposition.

Facility Description

Construction of HFIR and the associated cooling tower began in 1961 and reached design power of 100 Megawatt (MW) in September 1966. The HFIR produces transuranium isotopes for research, industrial and medical applications and a variety of materials irradiation tests and experiments. The HFIR cooling system design utilizes two cooling loops. The primary cooling loop utilizes four heat exchangers to cool water having passed through the reactor core. The secondary cooling loop removes heat from the exchangers and transfers it to the atmosphere by passing water through an induced draft-cooling tower. The old cooling tower was roughly 120 ft by 68 ft and was 45 ft high. The superstructure was primarily constructed of redwood fastened by bolts, nails and metal hardware. The cooling tower was covered with transite siding on four sides. Large electric powered fans drew air through each of eight tower cells. Tower cells were filled with plastic grating which provided a large surface area for heat transfer. Potable water was used to initially charge the cooling loop, and was periodically used to make up volume losses during operation. The water was introduced to the tower via four riser pipes.

Waste Stream Description

The waste from the tower demolition comprised of three primary waste materials: plastic (~47%), wood (~38%) and asbestos transite (~14%). The remaining ~1% consisted of the fire protection piping (contaminated with lead-based paint) and incidental metal from conduit, nails and braces/supports. Tables I and II identify the non-radiologically contaminated and the radiologically contaminated materials resulting from the tower's demolition. Also included are material-specific volume estimates of the tower components.

Table I. Non-radiologically Contaminated Items/Waste*

Waste Stream	Waste Type	Volume, m^3 (ft^3)	Disposition
New fiberglass plenums (8) unbolted curved panels	clean fiberglass		Landfill
Fan motors (8) on rails (oil drained)	clean metal	20 (720)	Landfill
Fan blade sets (8)	clean fiberglass	20 (720)	Landfill
Fan Gear Boxes (8) (oil drained)	clean metal	2 (64)	Landfill
Piping 3 new risers	clean metal	13 (471 - 150 ft of 24 in. pipe)	Landfill
TOTAL		***86 (3055 ft^3)***	

* UT Battellle Radiation Protection responsible for survey and green tag.

Table II. Radiologically Contaminated Items/Waste*

Waste Stream	Waste Type	Volume, m^3 (ft^3)	Disposition
Transite siding 3 ft x5 ft*	Asbestos fibers in concrete	77 (2700)	SLLW
Fire protection piping riser	Mixed Waste metal with lead paint	2 (78.5 @ 100 ft – 6 in pipe)	Mixed Waste
Electrical conduit	Construction debris	.5 (15 @ 300 ft - 3 in pipe)	SLLW
Drift eliminators	Construction debris	153 (5400)	SLLW
Motor Control Centers K&N	Construction debris with asbestos wire removed (pkg with siding)	9 (320 – wire 5 ft^3)	SLLW
Piping – 1 old riser and horizontal sections	Scrap metal	18 (628) (200 ft of 24 in pipe)	SLLW
Sludge (basin residue)	Sludge	2.5 (90)	SLLW
Wood plank deck	Construction debris	23 (810)	SLLW
Wood partition walls	Construction debris	34 (1188)	SLLW
Plastic fill	Construction debris	260 (9180)	SLLW
Wood supports – 4 ft x 4 ft	Construction debris	153 (5400)	SLLW
TOTAL		***732 (25,810)***	

* UT Battelle Radiation Protection responsible for survey and yellow tag.

WASTE CHARACTERIZATION

Sampling was performed on the tower and the sludge in the concrete basin to determine the presence of radiological and/or hazardous contamination. The sampling was executed prior to demolition of the tower. Several considerations were used to set the scope of the sampling program:

- Although there was no expectation that hazardous waste constituents existed in the waste material or the building components, each of the tower components was sampled: transite, fire protection piping, wood plank decking, wood partition walls, wood supports and plastic fill material. Each of these components was assumed to be homogenous, i.e., all wood components were from similar sources and have similar characteristics, etc.
- Proper Cooling Tower operation requires that cooling water from the reactor building be passed through a stream of air in order that heat in the water be transferred to the air. It was assumed that the cooling water diffused through the Cooling Tower and had come in contact with each of the Cooling Tower components listed above.
- Random sampling was performed to determine breadth of contamination and quantify accordingly.
- Stratified random sampling approach was used dependent on the relative volume of waste generated by the demolition of the tower. A 95% confidence interval was utilized to set the number of samples collected.
- A total of 40 samples, two duplicate samples and one equipment rinsate sample was collected from Cooling Tower components.

Analysis of metals and semi-volatile consituents per RCRA criteria indicated no exceedances above regulatory limits.

Analysis of radionuclides (see Table III) identified uranium and thorium and associated daughters. In addition cobalt-60, technetium-99, radium-226 and radium-228 were found to be present. The evaluation of the data used the following steps:

- Rank order all data from greatest magnitude to none detected;
- Select of median reported activity (pCi/g) by nuclide;
- Calculate of estimated total activity present by waste volume using mass of material in waste container;
- Report of activity per container on Waste Item Descriptions subsequent to container actual weight determination scales.

Note that the use of the median data to characterize waste was selected because of the wide variability of contamination across the tower media. Non-uniformity and low level of activity have historically made the tower a radiological buffer area and not a contamination area. Sampling personnel, after climbing all throughout the tower to access the areas identified by the plan, frisked free of radiological contamination.

The applicable BJC Envirocare Waste Disposal Profiles and the waste characterization data were used to determine acceptability of the waste for disposal at Envirocare of Utah. This information set a path for disposal which included Radioactive Scrap Metal, Construction Debris, Sludge, and Asbestos.

COOLING TOWER DEMOLITION

The tower was dismantled using several steps to aid waste segregation prior to disposition:

- Initial demolition began with removal of the non-radiologically contaminated material (fiberglass stacks/plenums (8), fan motors (8), fan blade sets (8), fan gear boxes (8), piping risers (3)). This material/equipment was transported to a temporary staging radiological buffer area. There health physics technicians performed complete surveys and tagged items accordingly to facilitate final disposition, e.g. sale via surplus equipment or landfill disposal.
- Second, removal of the old fire protection riser was completed. The principal waste handling/disposition concern was suspect lead-based paint coating. Subsequent analyses of the paint mass and lead fraction versus the mass pipe facilitated scrap metal low level waste disposal.
- Third, removal of the asbestos transite siding from all four sides of the tower was performed. This asbestos waste was wrapped in plastic and then placed into large intermodal containers (6 feet x 6 feet x 14 feet).
- Fourth was the removal of sludge from the tower basin. The sludge had a high solids concentration prohibiting pumping. Therefore, manual shoveling on to a conveyor was used with subsequent transfer to 55 gallon drums.
- Last, a large crane equipped with a clam shell performed the demolition of the remaining tower wood, plastic and incidental metal conduit. This waste which comprises the bulk of the tower waste volume was placed in sea-land containers (no liner required - 8 feet x 8 feet x 20 feet) for transport to the offsite commercial treatment facility. The volume as transported from the demolition site was approximately 70,000 cubic feet. The after treatment volume was approximately 20,000 cubic feet.

Table III. HFIR Cooling Tower Sampling Results - Positive/2 sigma results only

Sample	Radiological Contaminants, pCi/g											Percent
Number	**Th-228**	**Th-232**	**U-234**	**U-235**	**U-236**	**U-238**	**Cs-137**	**Co-60**	**Tc-99**	**Ra-226**	**Ra-228**	**U-235***
1	0.558	0.0565	8.23	0.691	0.0511	5.94	**1.56**	8.57	16.2	**9.16**	**19.4**	**1.78**
2	0.491	0.047	6.44	0.257	0.0499	4.86	**0.46**	8.44	16.1			**0.816**
3	0.437	0.0459	6.42	0.208	**0.043**	4.02		5.24	14.6			**0.798**
4	0.429	0.0419	6.25	0.187	**0.039**	3.79		4.79	14.6			**0.761**
5	0.403	**0.0412**	4.58	**0.134**	0.0306	3.28		4.42	14.3			**0.631**
6	**0.388**	0.0388	4.46	**0.132**	0.0302	3.01		4.33	13.3			**0.677**
7	**0.385**	0.0381	4.1	0.0969		3		4.11	12.2			**0.5**
8	0.383	0.0363	3.96	0.0725		2.87		3.4	12.1			**0.391**
9	0.267	0.0305	3.32	0.0725		2.82		3.13	11.8			**0.398**
10	0.244		2.53	0.0611		2.61		2.81	**11.7**			**0.363**
11	0.201		2.39			1.86		2.32	10.8			
12	0.162		**2.39**			**1.86**		**2.31**	9.73			
13			2.08			**1.69**		1.12	5.59			
14			2.03			1.4		1.01	5.36			
15			1.78			1.38		0.936	5.35			
16			1.65			1.35		0.922	3.52			
17			1.48			1.09		0.91	3.11			
18			1.46			0.991		0.822	2.15			
19			1.46			0.978		0.724	1.39			
20			1.02			0.747		0.533				
21			0.28			0.656		0.501				
22			0.14			0.259		0.367				
23			0.105			0.113		0.309				
24						0.056						
Avg	**0.3865**			**0.133**	**0.041**	**1.775**	**1.01**					

*Percent enrichment calculated using data in row

WASTE DISPOSITION

Sea land containers (8 feet x 8 feet x 20 feet) were staged in the lay down area for the tower demolition contractor to use as the dismantling/demolition occured. As the containers were filled with demolition waste, they were temporarily stored at the laydown area adjacent to the HFIR until offsite movement to the nearby offsite treatment facility could occur. Radiation surveys of the containers were performed prior to off site shipment. Sludge was placed into 55-gallon drums for transport to the treatment facility. Asbestos transite was packaged for direct shipment to disposal.

BJC utilized their contract with Duratek, Inc. to provide containers transport the containerized wasteto their facility for treatment, package the treated waste, and transport the treated waste to Envirocare of Utah for disposal by rail. The DOE National Low Level Waste Disposal Contract with Envirocare was used as the contractual mechanism for disposal.

LESSONS LEARNED

The Management and Integration (M&I) contract for waste disposition requires intensive communication between members of different companies. UT-Battelle placed one contract for both the demolition of the old cooling tower and construction of a new cooling tower. This one contract utilized a single prime contractor with direct cost/schedule responsibility for two subcontractors. Waste characterization and documentation of the demolished cooling tower was the responsibility of UT-Battelle. Waste treatment and disposal planning and contracting was performed by BJC. Duratek Inc. performed waste treatment under contract to BJC. Weskem, Inc performed final waste documentation and recordkeeping.