Disposal of Bruce Power's Mixed Liquid Wastes – 11460

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ABSTRACT

In 2009, Bruce Power contracted with Kinectrics for the disposal of its accumulated mixed liquid waste (MLW) inventory. The waste consists of solvent, PCB (Poly Chlorinated Biphenyls) and non-PCB contaminated oils and aqueous waste drums. The radioactivity in the wastes is principally due to cobalt-60, cesium-137 and tritium.

Historically, MLW drums originating from Canadian utilities were shipped to a licensed US facility for destruction via incineration. This option is relatively expensive considering the significant logistics and destruction costs involved. In addition, restrictions on importation of non-US PCB containing wastes also apply. Because of this, Kinectrics proposed a wholly Canadian option for the disposal of the MLW.

Disposal of Bruce Power's MLW was conceived to be carried out in three phases.

Phase 1: Develop an overall plan for disposal of the accumulated wastes,
Phase 2: Dispose the PCB oil waste drums (highest priority), and
Phase 3: Dispose all other waste drums

A description of the key activities undertaken in Phases 1 and 2 are described in this paper. This work sets the stage for the future management of Bruce Power's MLW based exclusively or largely on disposal within Canada. All key technical, regulatory and logistical issues pertaining to the receipt, handling, processing and shipment of the wastes were addressed. Equipment was installed for basic processing of the incoming wastes. Based on Pathways methodology, it was shown that the wastes can be shipped to unlicensed facilities within Canada without exceeding the 10 µSv per annum exposure to the critical individual. Despite this and for compliance with ALARA, wastes containing relatively elevated levels of radioactivity will be solidified and shipped for storage as radioactive waste.

1.0 INTRODUCTION AND BACKGROUND

Bruce Power recently contracted with Kinectrics for the disposal of its accumulated mixed liquid waste (MLW) inventory. As shown in Table I, the drums fall into three categories: aqueous, oils and solvent wastes. The solvents consist of Varsol and petroleum based distillates[1], aliphatic hydrocarbons[2] and aromatic (benzene, toluene and xylene) based hydrocarbons[3]. The oils consist of lubes [4] and oily water

[1] Ontario Ministry of Environment (MOE) Waste Class 213
[2] MOE Waste Class 212
[3] MOE Waste Class 211
[4] MOE Waste Class 252

emulsions[5]; five of the oil drums are also contaminated with Poly Chlorinated Biphenyls (PCBs). The radioactivity in all the wastes is principally due to cobalt-60, cesium-137 and tritium.

Table I. Distribution of Accumulated Mixed Liquid Wastes

Type of Mixed Waste	Number of Drums
Solvents	51
Oil	5
Aqueous	8
PCB Contaminated Oil	5
Total	69

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Disposal of Bruce Power's MLW was conceived to be carried out in three phases as follows:

Phase 1: Develop an overall plan for disposal of the accumulated wastes,
Phase 2: Dispose the PCB oil waste drums (highest priority), and
Phase 3: Dispose all other waste drums

Key activities undertaken in Phases 1 and 2 included the following:

- Sample waste drums and develop additional characterization data as required,
- Assess characterization data and identify preliminary disposal options,
- Perform Pathways Analyses to support conditional clearance of selected waste drums,
- Obtain approvals from Ontario Ministry of Environment (MOE) to receive and process waste drums,
- Perform laboratory assessment of treatment and solidification options for each drum, and
- Develop an overall waste disposal plan.

A description of these activities is presented in this paper.

2.0. CHARACTERIZATION OF MIXED LIQUID WASTE

2.1. Inventory and Visual Characteristics

The inventory of liquid waste in the various MLW drums, developed based on the use of Coliwasa samplers, is as follows:

- < 100 liters 9 drums
- 100-150 liters 10 drums
- > 150 liters 50 drums

Of the 5 PCB contaminated oil drums, one drum contains essentially 100% oil while the rest have an

[5] MOE Waste Class 253

associated aqueous phase ranging from 10 to 50 % of the total waste volume. Of the 5 non-PCB oil drums, one contains mostly aqueous waste.

Of the 51 solvent designated drums,

- 21 drums contain over 99% solvent while 7 drums contain over 95% aqueous waste,
- 12 drums contain two phases both of which are solvents, and
- 9 drums contain a top solvent phase and a bottom aqueous phase comprising 30-90% of the waste volume; one drum contained the two phases in reverse order.

Most of the MLW drums had visible suspended solids and/or sediments. All aqueous waste drums contain a minor (< 2 %) second phase (liquid and/or solid).

Color of the waste generally ranged from clear to black with majority of the waste drums being brown/black/red.

2.2. Physico-Chemical Characteristics of Mixed Liquid Waste

- Flash points of the oils MLW were high and ranged between 90 and190^{0}C. Flash points of solvent MLW varied in the range 41-110^{0}C, with the majority (~80%) exceeding 60^{0}C. Overall, the data indicate limited flammability concerns for most of the MLW drums.

- The oil phase PCB content of the PCB contaminated oils ranged between 99 and 9300 ppm; the corresponding aqueous phase generally contained less than 50 ppm PCBs. Other MLW generally contained less than 2 ppm PCBs.

- pH of the MLW varied between 3.5 and 11.3

- Pb concentrations were generally higher than those of other toxic elements, namely, As, Be, Cr, Cd and Hg. Concentrations of Ag, Te, Sb and Se were lower than 2.3 ppm; those of other elements including B, Ba, Na, Ni, P and S varied widely in the range 0.001-300,000 ppm.

2.3. Radiochemical Characteristics of Mixed Liquid Waste

Typically, gamma spectrometry was performed on the entire 2 phase (where applicable) sample. Because tritium preferentially partitions into the aqueous phase[6], only the latter was generally analyzed for it. For selected samples, both gamma spectrometry and tritium analysis of the individual phases present were performed to assist in development of process options.

Measured radiochemical characteristics indicated Co-60, Cs-134 and Cs-137 to be the principal gamma emitting radionuclides present in the MLW. Tritium was present in all samples. Compared with it, the levels of C-14 present were generally significantly lower. Table II presents an overview of the results.

[6] Preferential partitioning of tritium into the aqueous phase is generally expected when its concentration is relatively low. When present at elevated concentrations, tritium is expected with aging to be increasingly incorporated into the associated organic phase.

Table II. Summary of Mixed Liquid Waste Radiochemical Characteristics

Type of MLW	Total Drums	H-3 Activity (nCi/Kg)			(β,γ) Activity (nCi/Kg)		
		Min.	Max.	LM*	Min.	Max.	LM*
PCB Oil	5	127	17,000	1470	0.09	4.2	0.42
Non-PCB Oil	5	20	1,490,000	7365	0.52	139.2	4.6
Aqueous	8	2270	344,000	15560	0.09	24.2	1.3
Solvent	51	<0.2	330,000,000	425	0.04	3110	1.0

* LM indicates Log or Geometric Mean.

Based on the analysed sample characterization data, Table III indicates the number of drums of each type of waste which potentially meet Bruce Power's free release criteria, namely, 2.7 nCi/Kg (β, γ) and 2000 nCi/Kg H-3 activity. Some of these drums upon recounting using the barrel monitor at Bruce Power, however, failed to meet the free release criterion for (β, γ) activity. It is likely that the failed drums contain significant sediments which were not drawn into the Coliwasa tube used for sampling and subsequent characterization. The last column in Table III shows the final drum inventory requiring disposal.

Table III. Drums Potentially Meeting Free Release Criteria and Final Drum Inventory Requiring Disposal

Type of MLW	Initial Drum Inventory Requiring Disposal	Number of Drums Potentially Meeting Free Release Criteria	Final Drum Inventory Requiring Disposal
PCB Oil	5	1	4
Non-PCB Oil	5	1	3
Aqueous	8	0	8
Solvent	51	28	36
All	69	30	51

3.0 OVERALL APPROACH FOR DISPOSAL OF MIXED LIQUID WASTES

Based on an assessment of the preliminary waste characterization data, Kinectrics developed an overall approach for treatment and final disposal of the MLW. This consisted of the following:

- ***Conditional Clearance***

Currently, free or unconditional release limits for tritium and (β, γ) activity at Bruce Power are 2000 nCi/kg and 2.7 nCi/kg, respectively. Generally, one or both of these limits are exceeded in the MLW. However, wastes with limited activity exceedances can potentially still be conditionally cleared through the application of Pathways Analysis [1]. This is the main underpinning of the proposed disposal plan. Canadian Nuclear Safety Commission (CNSC) regulatory document R-85 requires that an application for conditional release of radioactive waste to unlicensed facilities be based on an assessment of the associated dose impacts to workers and members of the general public [2]. Based on Pathways Analysis, qualifying solvent, aqueous and non-PCB oil waste drums can potentially be shipped to Clean Harbors' incineration facility in Sarnia, Ontario while PCB-contaminated oil drums can be shipped to Aevitas facility at Ayr, Ontario for subsequent transportation to and incineration at the Swan Hills incineration facility in Alberta.

- ***Waste Processing and ALARA***

Consistent with CNSC's regulatory guide on ALARA [3], wastes in general will undergo simple processing to reduce the radioactivity present prior to being shipped to unlicensed facilities. This will be performed even though the Pathways Analyses may support conditional clearance of the unprocessed wastes. Separation of the aqueous phase associated with most oil and solvent wastes is expected to significantly lower the tritium content of the remaining wastes while filtration is expected to significantly lower (β, γ) activity.

- ***Solidification***

Wastes containing relatively elevated tritium and/or (β, γ) activity will be solidified. Solidified wastes will be shipped back to Bruce Power for eventual transfer and storage at the Western Waste Management Facility (WWMF) operated by Ontario Power Generation (OPG).

- ***Maximizing Usage of Existing Drums***

In order to minimize secondary waste generation, appropriate steps will be undertaken to maximize usage of existing drums. Note that the waste drums have an integral top (with two openings) and cannot readily be used for waste solidification. All waste drums will be transported in over-packs to Kinectrics. Several of these drums will be reused for shipments of conditionally cleared wastes to Aevitas or Clean Harbors.

4.0 REGULATORY APPROVALS AND ISSUES

This section presents a summary of various regulatory approvals and issues that were addressed during the course of the present work.

4.1. Approval from Ontario Ministry of the Environment (MOE)

Kinectrics' radioactive laboratory hitherto was not approved for treating bulk quantities of wastes along with any associated emissions. Accordingly, Kinectrics submitted two applications to the MOE which have subsequently been approved [4, 5].

- Application for a Provisional Certificate of Approval for a Waste Disposal Site , and
- Application for Approval (Air & Noise)

The Approval for Waste Disposal Site permits Kinectrics to receive up to 200 drums of wastes per year, treat the wastes appropriately, and dispose the treated wastes. The maximum number of liquid waste drums allowed to be on-site at any time is limited to ten. All air emissions will be appropriately scrubbed prior to release.

4.2. Conditional Clearance of Wastes

Pathways Analysis was carried out to establish the conditional clearance limits for disposal of a) PCB waste via incineration at Swan Hills Treatment Facility in Alberta and b) non PCB waste via incineration at Clean Harbors' incinerator in Corunna, Ontario. Results from these analyses were submitted to CNSC for their review and concurrence.

4.3. Shipment of PCB Contaminated Oils

The PCB contaminated wastes contain activity levels below Exempt or Excepted levels and hence have to be transported from Bruce Power to Kinectrics as Class 9 (not as Class 7; they do not require placarding) under a MOE waste manifest (hazardous waste under Regulation 347) and MOE Director's Instructions (Regulation 362). Shipment of out-bound conditionally cleared wastes from Kinectrics will be carried out directly by the disposal vendors and will require a MOE waste manifest; PCB contaminated wastes will be shipped under Aevitas' blanket Director's Instruction.

5.0 PATHWAYS ANALYSIS

Pathways Analysis was performed to establish the conditional clearance limits for disposal of the MLW via incineration. For conditional clearance of the wastes, the activity present in the shipped wastes should not result in an effective individual (workers or members of the general public) dose greater than 10 µSv per year. The Pathways Analysis performed involved the following steps:

- Establish waste processing and final disposal path for each type of waste,
- Gather input information for dose calculations and outline assumptions used, if any.
- Estimate dose associated with transportation of waste,
- Estimate dose associated with disposal of waste.

Transportation dose calculations were performed using MicroShield® [6]. The input information used for the calculations includes waste gamma activity, source - receptor distance and extent of shielding. The radiation dose to workers and the public during incineration were calculated using a modified Gaussian plume model to evaluate the time-integrated concentration at downwind distances from 100 m to 100 km from the release. Required inputs for these calculations included the total activity released during incineration, duration of release, mean wind speed, receptor distance from point of release, type of land and precipitation rate.

5.1. Conditional Clearance of PCB Contaminated Wastes - Results from Pathways Analysis

The disposal scheme for PCB contaminated wastes is shown in Figure 1 below.

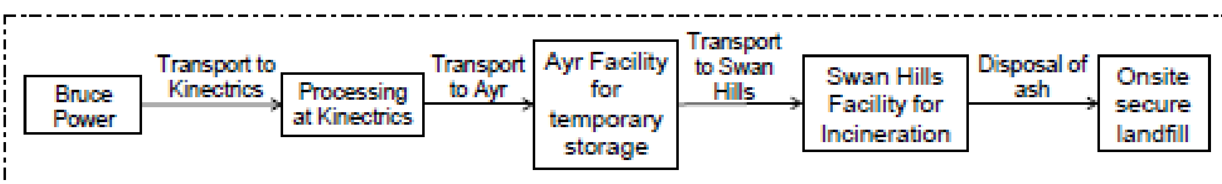

Fig.1. PCB waste disposal path

Wastes are initially transported from Bruce Power to Kinectrics to separate the aqueous phase from the oil phase. Because the aqueous phase has less than 50 ppm PCB, only the oil phase needs to be sent for incineration at Swan Hills. Further, the preferential partitioning of tritium into the aqueous phase significantly reduces the amount of tritium shipped to Swan Hills along with the waste. The PCB contaminated oil phase will be transported first to Aevitas' facility in Ayr for temporary short-term storage, pending transfer to the Swan Hills Treatment Centre. The ash produced from incineration at

Swan Hills will be disposed of in a secure landfill located on-site. Finally, the separated aqueous phase will be solidified and shipped for storage at OPG's Western Waste Management Facility.

Results from the Pathways Analysis showed that:

- The overall dose received from transportation, incineration and disposal of the PCB waste residues is substantially lower than 10 µSv/yr and, therefore, supports the proposed conditional clearance of the waste.

- The conditional clearance levels for the dominant radionuclides present in the waste were estimated to be $9.6x10^5$ Bq Co-60, $1.4x10^6$ Bq Cs-134, $4.2x10^6$ Bq Cs-137 and $1.6x10^{12}$ Bq H-3.

- Dose Conversion Factors for Co-60, Cs-134, Cs-137, and H-3 were estimated to be $1.1x10^{-11}$, $7.1x10^{-12}$, $2.4x10^{-12}$ and $6.3x10^{-18}$ Sv/Bq, respectively. These values can be generally used to assess the feasibility of conditionally clearing other similar wastes provided key parameters such as the mode of transportation, routing of the wastes etc. remain unchanged.

5.2. Conditional Clearance of non-PCB Contaminated Wastes - Results from Pathways Analysis

The disposal scheme for non-PCB mixed radioactive liquid waste is shown in Figure 2.

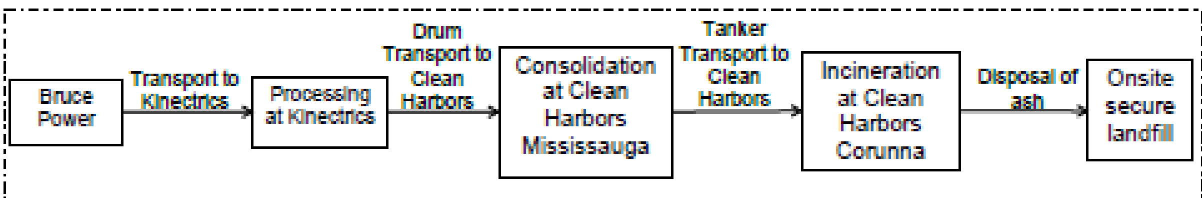

Fig.2. Disposal path for non-PCB mixed radioactive liquid waste

Wastes are initially transported from Bruce Power to Kinectrics for processing to reduce the levels of tritium and beta/gamma emitters present; the processed wastes are then sent to the Clean Harbors facility in Mississauga for consolidation and fuel blending. Each shipment will contain a maximum of ten 200 L MLW drums. Waste drums received at the Mississauga facility will be consolidated with other non-radioactive hazardous waste, thus resulting in dilution of the activity. The bulk consolidated wastes will be transported to Clean Harbors in Corunna, Ontario for incineration and final disposal. Any combustion residue will be stabilized and disposed of on-site in a secure landfill.

A Pathways Analysis was conducted considering the disposal of 64 drums of non-PCB MLW. Dose calculations for drum transport were based on a compilation of the maximum specific activity for each observed radionuclide in the waste. Dose calculations during transport in a tanker were based on the activity contained in 10 drums diluted over the volume (approximately 27,000 L) of the tanker. Doses to the public and workers during incineration of the wastes were calculated based on the release of all the activity contained in 10 drums. Results of the pathways analysis show that:

- Overall, the estimated dose from transportation and disposal of the waste is about 1.75 µSv, a factor of about 6 lower than the yearly allowed dose of 10 µSv and therefore supports the proposed conditional clearance of the waste.

- The estimated conditional clearance levels for the dominant radionuclides present in each waste shipment were $4.1x10^7$ Bq Co-60, $1.8x10^8$ Bq Cs-137, $2.2x10^8$ Bq Sb-125 and $1.3x10^{15}$ Bq H-3.

- Dose Conversion Factors for Co-60, Cs-137, Sb-125 and H-3 were estimated to be $2.4x10^{-13}$, $5.6x10^{-14}$, $4.6x10^{-14}$ and $7.8x10^{-21}$ Sv/Bq, respectively, These values can be generally used to assess the feasibility of conditionally clearing other similar wastes provided key parameters such as the mode of transportation, routing of the wastes etc. remain unchanged.

6.0 PROCESSING OPTIONS – A FEASABILITY ASSESSMENT

Although results from the Pathways Analysis indicated the feasibility of directly shipping the wastes to unlicensed facilities for disposal, ALARA considerations dictated the need for simple processing to reduce the levels of radioactivity present in the shipped wastes. As well, development of solidification options will provide an alternative route for disposal of some of the wastes which contain relatively higher levels of radioactivity, thus avoiding their shipment to unlicensed facilities.

Bench scale investigations were carried out to assess the feasibility of processing options, such as phase separation, particulate filtration, use of solid sorbents and waste solidification, in order to assemble a 'tool kit' which could be applied if and when required. Some of these investigations were of a scoping nature while others were more detailed. Selected results obtained are described below.

6.1. Phase Separation

Intuitively, tritium is expected to preferentially partition into the aqueous phase and PCBs into the oil phase, offering the potential for improved management of the separated phases. Table IV presents characterization data for the individual phases of the PCB contaminated wastes. They indicate the following:

- In the absence of phase separation, both tritium and (β, γ) activities in the waste significantly exceeded the reference criteria, 2,000 nCi/kg for tritium and 2.7 nCi/kg for (β, γ) activity.

- However, following phase separation, both tritium as well as (β, γ) concentrations in the separated oil phase would clearly meet the reference criteria. Thus, shipment of the separated oil phase would significantly reduce the levels of radioactivity that would be shipped to Aevitas.

- The separated aqueous phase in all cases would have a PCB concentration lower than 50 ppm and thus could be classified as non-PCB waste.

The above results clearly indicate the possibility of using phase separation to meet ALARA requirements. If required, the separated non-PCB aqueous phase could potentially be solidified and shipped to OPG.

Table IV. Characteristics of Individual Phases of PCB Contaminated MLW

Drum ID	Aqueous Phase (%)	PCB Concentration (ppm)			Tritium Concentration (nCi/kg)		Total (β, γ) Concentration (nCi/kg)	
		Oil	Interface	Aqueous	Aqueous	Oil	Oil	Total
08-LO-065	50	1140	1720	18	7620	140	0.09	0.09
03-LOR-009	15	200	26	<2	17,000	613	0.34	4.2
10309	10	1950	183	2	7,300	503	0.09	0.17
10311	10	99	71	20	3,450	127	0.09	0.3

6.2. Solidification

OPG accepts solidified radioactive waste provided its PCB concentration is less than 50 ppm. It has pre-approved the use of selected binders. Proof of satisfactory solidification must be provided for acceptance of the solidified waste by OPG.

Accordingly, five solidification agents (modified natural clays) from Fluid Tech Inc., namely, Petroset II, Petroset, Petroset H, Aquaset H and Aquaset II were chosen for bench scale testing. Petroset H and Aquaset H also contain a cement additive that generally results in a hard waste form; the other waste forms typically have a putty-like consistency. Immobilization of wastes occurs through the action of complex bonding mechanisms and ion exchange reactions resulting in the formation of a homogeneous solidified waste form. Petroset II, is an organophilic solidifier which will solidify non-aqueous liquids, such as oils and other hydrocarbons; it will not, however, solidify aqueous liquids. On the other hand, Aquaset II, Aquaset H, Petroset and Petroset H are suitable for solidifying aqueous liquids. Aquaset II is reported to be useful for solidification of aqueous solutions with extremely high dissolved solids (such as neutralized acids and bases) and water soluble or miscible organic liquids. In general, because MLW contains both aqueous and organic phases, a combination of two solidification agents, to respectively address both phases is required. Petroset II must be added first to aqueous wastes in order to solidify any small amount of oils/solvents present. The general procedure for solidification involves the following steps:

- Transfer the homogenized raw waste into a solidification container followed by further mixing,
- Adjust pH to the desired range of 5-11, if required.
- While continuing to mix, slowly pour the calculated amount of solidification agent (s) into the drum followed by addition, if required, of a polar activator such as methanol or iso-propanol[7], and
- Verify completion of solidification by visual inspection over a curing time of 1-7 d.

A series of tests were carried out to evaluate the solidification of various MLW streams using the Fluidtech agents described above. The key findings were:

- Petroset, Petroset II and Petroset-H showed good solidification behavior at loadings of 0.36-0.72 kg/liter waste (3-6 lbs/gallon). Aquaset II was only effective at the higher loading of 6 lbs/gallon. Petroset H waste forms were harder compared to those prepared using Petroset/Petroset II.
- In general, the Fluidtech agents were able to successfully solidify a range of MLW yielding a relatively homogeneous, non-slumping, hard solidified waste form with no free liquid.
- Solidification resulted in a 6-33 % increase in volume.
- If required, Aquaset may be added on top of the solidified waste to absorb any condensed water in drum scale applications.

Test results were submitted to OPG for pre-approval of the solidified wastes.

[7] When using Petroset-II in combination with Aquaset, Aquaset-H, Petroset or Petroset-H, the materials are added in the sequence: (i) Waste, (ii) Petroset II, (iii) Petroset or Petroset-H or Aquaset or Aquaset-H and (iv) Alcohol activator (required only for organics).

7.0 OVERALL STRATEGY FOR TREATMENT AND DISPOSAL OF MLW

Based on the foregoing, the overall strategy for disposing the MLW drum is outlined below:

- Drums that meet the free release criteria, i.e. (β, γ) < 2.7 nCi/Kg (100 Bq/kg) and H-3 < 2000 nCi/Kg) will be directly disposed by Bruce Power as liquid industrial or hazardous waste, thus significantly reducing overall disposal costs. Although several drums as listed in Table III met these criteria based on sample characterization results, further assessment using a barrel monitor at Bruce Power indicated that 12 of these drums still failed to meet the free clearance criteria. It is likely that these drums contain significant sediments which were not drawn into the Coliwasa tube used for sampling and subsequent characterization.

- Excluding the drums which met the free release criteria, all other wastes, in general, will first be filtered to reduce (β, γ) activity and then undergo phase separation if applicable. Filtration is expected to significantly reduce (β, γ) activity when particulates or sediments are present; tritium activity may also be reduced to some extent as a result of filtration. Phase separation is expected to significantly reduce the complexity of disposal by beneficially partitioning key contaminants between the phases; however, the additional effort involved may not be justifiable when one of the phases is dominant.

- Although all the wastes in principal qualify for disposal via incineration as established using Pathways Analyses, the criteria 2.7 < (β, γ) < 27 nCi/Kg and 2000 < H-3 < 20,000 nCi/Kg (i.e. 10 times the free clearance limits) were adopted to determine if the wastes should be disposed via the incineration route or be solidified and disposed via OPG. Thus, if (β, γ) > 27 nCi/Kg and H-3 > 20,000 nCi/Kg, the waste was deemed, from ALARA perspective, to be more appropriately disposed via solidification.

8.0 EQUIPMENT FOR PROCESSING MLW

Filtration and Phase Separation

A skid was designed and built for drum scale filtration and phase separation of MLW (see Figure 3). Its key features are:

- The filtration unit consists of a filter housing equipped with a bag microfilter which can be easily removed and replaced. Pressure gauges on the housing permit the pressure differential across the filter to be monitored. A pressure release valve ensures the safe operation of the system.

- A conical bottom tank equipped with level gauges to provide a visual assessment of the heights of the individual phases and the total volume in the tank.

- A conical bottom tank equipped with level gauges to provide a visual assessment of the heights of the individual phases and the total volume in the tank.

- A weighing station and a sight glass located at the bottom of the tank to permit quantitative phase separation[8] of the MLW transferred from a drum into the tank.

[8] A Coliwasa sampler will be used to collect a representative sample of waste from a drum before its contents are transferred into the tank. This will be used to estimate the weights of the individual phases in the drum and to control the amount of the bottom phase transferred into an empty drum placed under the tank drain.

- An air powered diaphragm pump capable of running dry to minimize liquid retention in spent filter bags.

- Ramps with rollers to facilitate handling and positioning of drums and a spill tray,

- A spray ball located within the tank to permit flushing and cleaning of tank internals including level gauges using a degreasing solution.

- Control of fugitive emissions during transfer of solvents into the tank using an activated carbon based scrubber system.

- Registered with the TSSA (design pressure 60 psi).

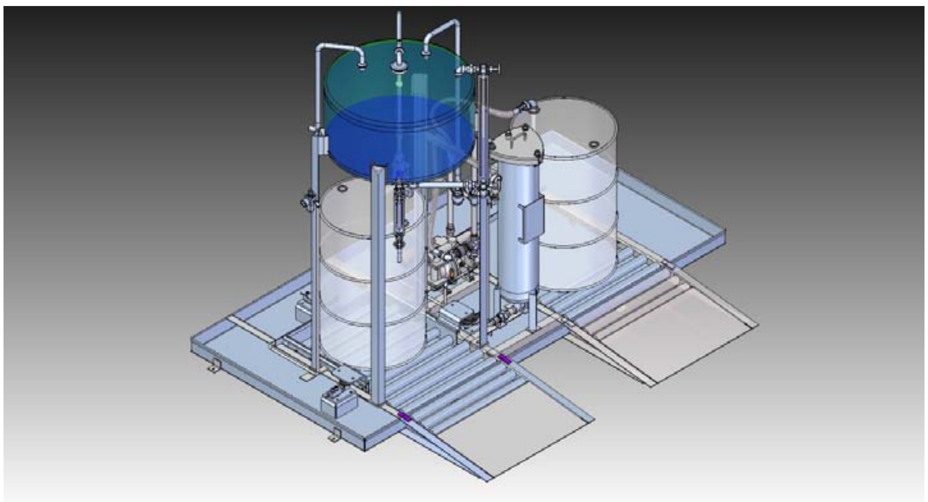

Fig.3. Skid built for filtration and phase separation of MLW

Solidification

Solidification of the MLW will be done using a hydraulically operated, variable speed in-drum mixer. Its key features are:

- The system including valves, piping, instrumentation and controls is skid mounted.

- The power mixing equipment includes an impeller and motor (typically ≥3 HP). The impeller is driven by a directly coupled low speed high torque hydraulic motor.

- The mixer is equipped with hydraulic controls for varying impeller speed and direction, and also for raising/lowering it.

- The skid is equipped with a manual steel drum clamp device to prevent drum rotation.

Scrubbing Emissions

During operation of the Filtration/Phase Separation skid, emissions will arise from the displacement of air out of the headspace within drums and the phase separation tank. Without a scrubber system, solvent and water vapor emissions containing low levels of tritium and C-14 will be directly vented into the environment. To minimize emissions into the environment, a dual bed granulated activated carbon (GAC) based scrubber will be used to scrub out air emissions. Exhaust from the processing skid will be channeled into the scrubber system and then released into the fumehood.

Figure 4 shows a mobile dual bed scrubber system previously developed to remove tritium and C-14 from air streams which was adapted for the present application. It features the following major components: a)two replaceable sorbent tanks, (b) mass flow controller, (c) dry gas meter, (d) a HEPA particulate filter, (e) 3-way electric solenoid, (f) a high flow rate vacuum pump, (g) interconnecting plumbing (fittings, piping/hosing and valves) and (h) a mobile steel platform. An electric vacuum pump is used to draw exhaust air through the unit. View ports are present on each vessel.

Assessment of end-of-service life of the sorbent beds will primarily be made by periodic sampling of the air vented through the unit followed by analysis for total organic carbon (TOC). The mass flow controller and the volume totalizing dry gas meter are used to confirm the presence of air flow and to totalize the air drawn through the unit as a secondary means for determining end-of-service life of the scrubber medium

Fig.4. Dual bed air scrubbing system

9.0 CONCLUDING REMARKS

This work sets the stage for the future management of Bruce Power's mixed liquid wastes exclusively or largely based on disposal within Canada. All key technical, regulatory and logistical issues pertaining to the receipt, handling, processing and shipment of the wastes have been addressed. Kinectrics has the required MOE approvals for processing wastes within its Radioactive Facility. Equipment has been installed for basic processing of incoming wastes. Processing is designed to simplify disposal of wastes which typically exist as dual phases with tritium enriched in the aqueous phase, (β, γ) activity significantly associated with particulates and PCBs (when present) associated largely with the organic phase. Based on the Pathways methodology, it was shown that the wastes can be shipped to Clean Harbors and Aevitas without exceeding the 10 μSv per annum exposure to the critical individual. Despite this and for compliance with ALARA, aqueous wastes, including the separated aqueous phase from dual phase wastes, which contain relatively elevated levels of radioactivity will be solidified and shipped for storage and eventual disposal at the WWMF.

Based on the assessment carried out in this study, 18 fewer drums need to be disposed. A significant portion of this, namely 17, was achieved because the wastes were shown to meet Bruce Power's unconditional release limits for both tritium and (β, γ) activity; these drums can be directly shipped for disposal as hazardous wastes. The first batch of wastes consisting of the PCB contaminated oil wastes was received at Kinectrics at the end of November 2010. Thereafter, the other wastes will be processed and disposed of at an approximate throughput of 10 drums per month.

Profile of the disposed wastes is expected to be as shown in Table V where the exact number of drums shipped to Clean Harbors and OPG will depend on the extent of activity reduction achieved during waste processing. Because of the expected volume increase (up to 50%) upon solidification, the number of solidified waste drums may exceed those shown. In addition, one drum of solidified filter waste bags will also be produced as secondary waste.

Table V. Profile of Wastes Shipped for Disposal

Type of Mixed Waste	Processed Wastes	Shipment Destination
Solvent	Filtered Wastes	Clean Harbors (max. 31 drums)
	Filtered/Separated Wastes	Clean Harbors (max. 2 drums)
	Solidified Wastes	OPG (max. 3 drum)
Oil	Filtered Wastes	Clean Harbors (max. 3 drums)
	Solidified Wastes	OPG (max. 2 drums)
Aqueous	Filtered Wastes	Clean Harbors (max. 8 drums)
	Solidified Wastes	OPG (max. 2 drums)
PCB Contaminated Oil	Filtered/Separated Wastes	Aevitas (4 drums)
	Solidified Wastes	OPG (1 drum)

Existing drums will be re-used to the extent possible for shipment of processed wastes. However, if wastes are shipped to OPG as shown above, up to 8 of the original waste drums at a minimum will not be utilizable because a different type of drum (open top) is needed for solidifying wastes. Heels may require to be solidified prior to shipment of the empty drums to OPG.

10.0 REFERENCES

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