WM2017 Conference, March 5-9, 2017, Phoenix, Arizona, USA.

Technology Basis for Savannah River Tank Closure Cesium Removal Project - 17448

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ABSTRACT

Westinghouse is currently executing a contract, awarded in June 2016 from Savannah River Remediation LLC, to deliver a system capable of removing solids and up to 100,000 curies of Cesium-137 from tank 10H, located in the Savannah River "tank farm". Savannah River Remediation currently has the responsibility to perform work for the Savannah River Site Liquid Waste Operations Program at the Savannah River Site for the US government, represented by the US DOE under their Principal contract.

The scope of work covers the detailed design, procurement, fabrication, and delivery of the system to the Savannah River Site. It also includes the factory acceptance testing of the system, prior to delivery to site. Before leaving the site, Westinghouse will perform an evaluation of the system assembly and operations training for the incumbent operator.

The basis for the technology chosen to accomplish the solids and Cesium-137 removal is unique to the specific feed stream, but is based on well-known and successful technology, Toshiba SARRY water cleanup system. Toshiba is Westinghouse's parent company, allowing us to reach back and incorporate the lessons learned during the water cleanup at Fukushima Daiichi and the integration of various technologies. Another key to the technology basis was the ion exchange media selection. A number of possible ion exchange media for the cesium removal were considered with the final choice being inorganic CST resin. Several criteria were considered and compared, such as the radiation sensitivity of the CST and the cesium specific ion preference.

This paper will present the conceptual design of the modular system, noting the key benefits of specific components in the overall technology basis. Along with the design, a look at key technology improvements carried into the design through the Toshiba SARRY system will be incorporated. A first feedback on the implementation of the overall project will be provided. Since this system is a first-of-a-kind in this specific application, interesting lessons learned will be provided for future tank closure activities.

INTRODUCTION

The Tank Closure Cesium Removal (TCCR) system is designed to remove Cs-137 from high level waste solutions.

There are several underground tanks at Savannah River Site (SRS) that contain legacy waste with high levels of Cs-137. SRS is operating the legacy waste for the Department of Energy (DOE) and is in the process of treating and stabilizing the high level waste and closing the older style underground tanks. Acceleration of the tank closure is required to meet the Federal Facility Agreement (FFA) commitments between the US Department of Energy and the state of South Carolina. The storage tank for TCCR first run is Tank 10H. The goal of the TCCR is to remove cesium from dissolved Tank 10H saltcake waste so that the cesium-free solution is suitable for disposal in on-site Savannah River facilities.

The saltcake waste mostly consists of solid sodium salts of nitrate, nitrite, and hydroxide, with other salts, sulfate and carbonate making up much of the remainder. The saltcake is contaminated with radioactive material, the major gamma emitter and dose source being Cs-137. Sr-90, Pu-239, Pu-238, and other fission products and actinides are also present. The most recent analysis of Tank 10H is from 2004, Reference [1].

DESCRIPTION

Westinghouse is performing engineering, design, fabrication and testing in order to provide SRS a modular (TCCR) system consisting of process equipment housed in a modular equipment enclosure similar in exterior appearance to a shipping container. The TCCR system provides operational simplicity by utilizing shielded ion exchange (IX) columns that can be loaded to remove 100,000 curies of Cs-137, then placed into interim safe storage (ISS). This "cartridge" approach combined with the high cesium selectivity of Crystalline SilicoTitananate (CST) ion exchange media provides for optimal resin utilization on four shielded column assemblies. The process equipment will be housed in an approximately forty foot long portable building, which will contain pre-filters and ion exchange columns to remove insoluble particulates and ionic species, mainly Cs-137. The main TCCR process building is shown in Figure 1 as a partial cutaway. The design used experience gained during the Fukushima Simplified Active Water Retrieve and Recovery sYstem (SARRY) design and use.

An airlock portion of the main TCCR process module will have a programmable logic controller (PLC) package in it as well as non-radioactive system portions (chemical injection pumps etc) and control elements.

In addition to the main TCCR process module a Heating Ventilation Air Control (HVAC) system capable of meeting the air quality and flow requirements is provided.

An additional ten foot van is planned for the control station and operator controls. The control van will contain the human machine interface (HMI) allowing the

operator to monitor the status of the system and control valves, as needed. The control van will be equipped with climate control for comfort to the operators during operation.

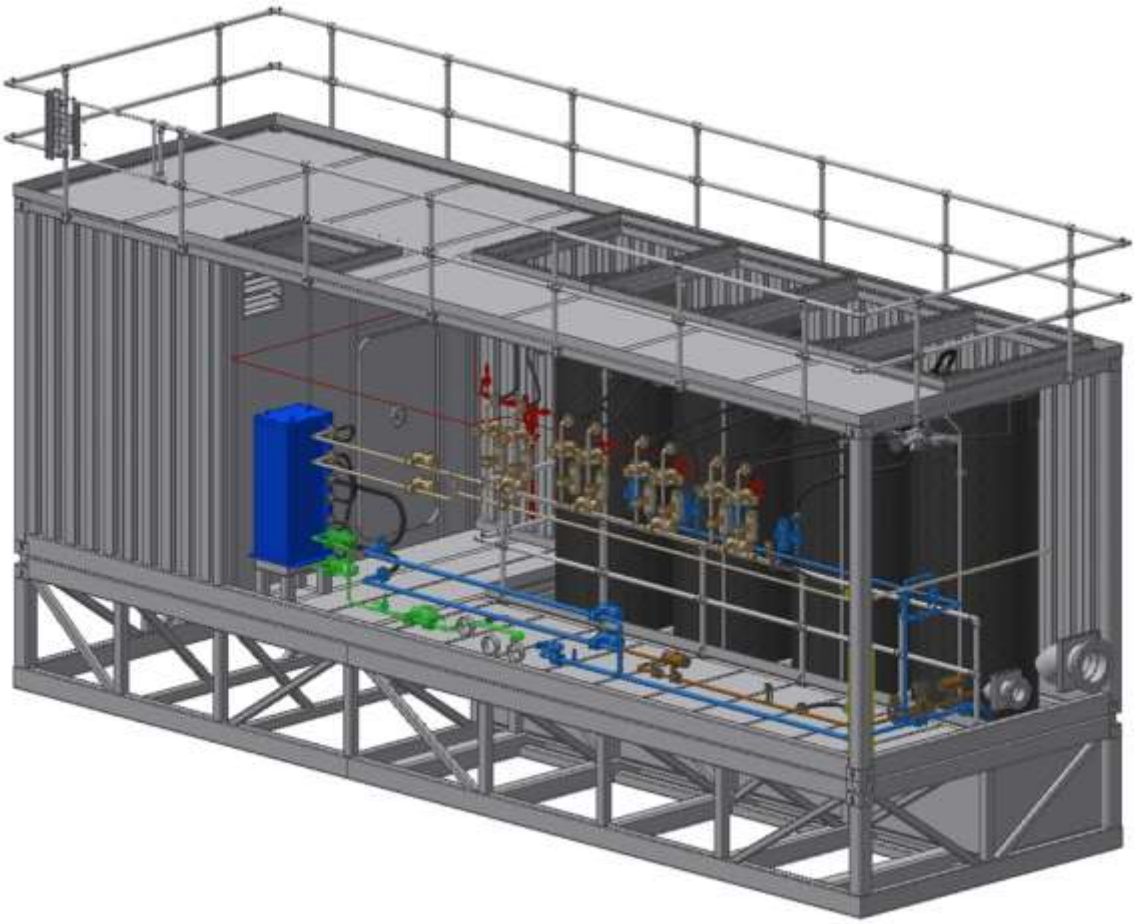

Fig. 1 3D Cutaway of the main process enclosure and TCCR equipment

The process module and other TCCR equipment will be sited near the feed (Tank 10H) and product (Tank 11H) tanks, as shown in Figure 2.

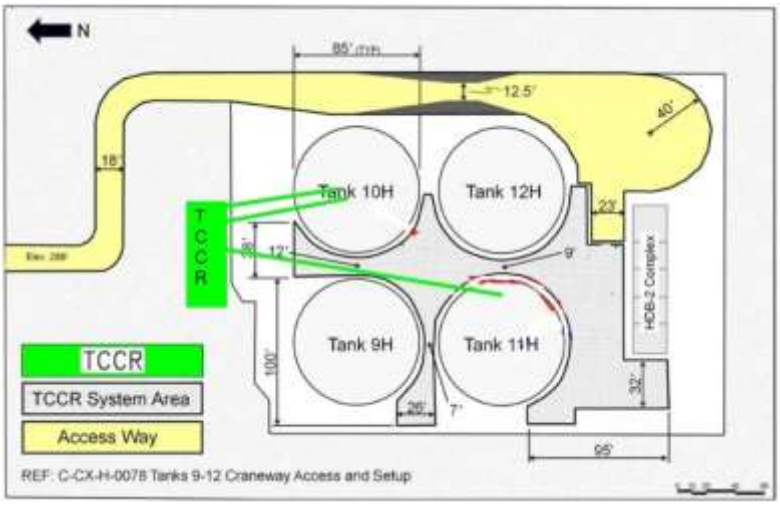

Fig. 2 Site Layout

DISCUSSION

The TCCR process will consist of startup preparation then waste stream flow through the TCCR system. At the conclusion of the cesium removal campaign, the system is flushed, drained, the ion exchange columns are dried and removed from the TCCR enclosure. The ion exchange columns are then stored at the ISS location.

Startup:

Before processing starts, system preparation will commence with a reverse flow well water flush of the IX columns to wet the columns. After the water flush, the CST will be flushed with sodium hydroxide to pre-condition the resin.

Process:

Process flow from Tank 10H will be started by energizing the feed pump located at the bottom of Tank 10H. The feed stream from Tank 10H will be operated in a loop with a control valve determining the flow rate through the filter assembly and the rest of TCCR. The control system will monitor for pressure differentials across the filters and when needed automatically divert feed flow from one filter assembly to the other and start a backwash cycle. Two single stage filter assemblies will be utilized in parallel in order to maintain flow to the IX columns. A dirty filter will be backwashed with filtered waste solution from the other filter to Tank 10H. After the process flows through the pre-filters, the flow will be to the IX columns for removal of Cs-137. There will be four IX columns in a series in the process flow stream. The design of the system is that any of the four IX columns can be valved in series to obtain the optimal performance of the IX columns. The flow through the IX columns can be manipulated in any order to meet the needs of the process and to obtain the optimal performance of the IX columns. After the flow stream is processed through

the IX columns, removing the Cs-137, the effluent will be sent to Tank 11H. Figure 3 shows the process flow diagram for the TCCR system.

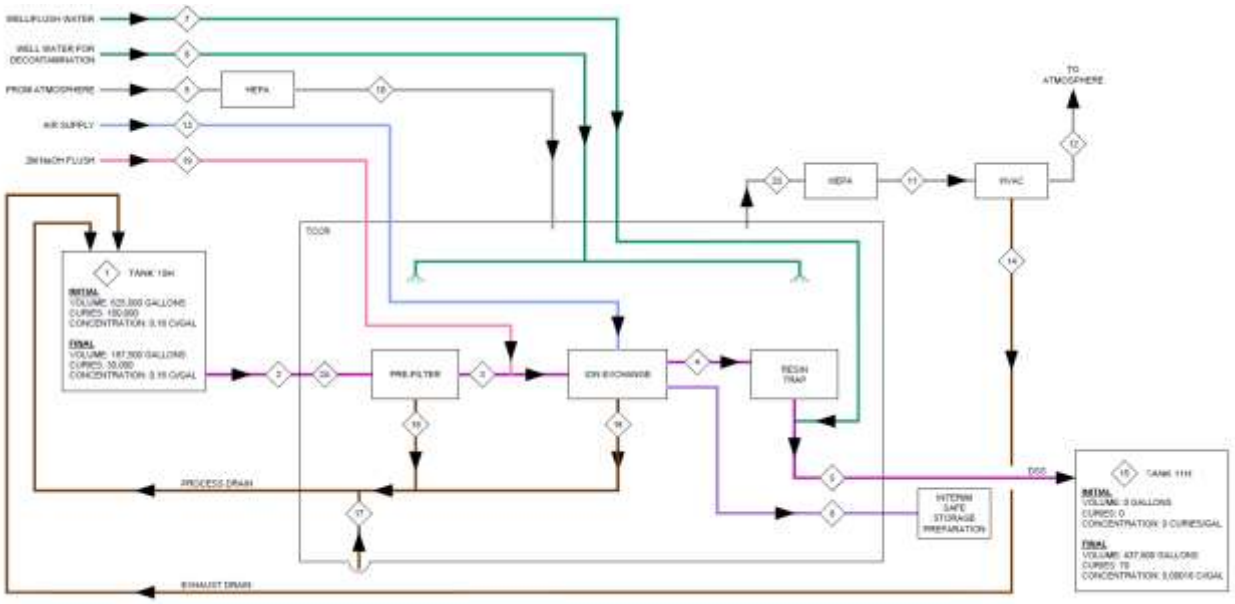

Fig. 3 TCCR Process overview

Radiation detectors on both the inlet and outlet streams will be used to determine the efficiency of the column(s). The major criterion for project success is a bucket-average (overall) decontamination factor of 1000.

While no personnel entries are planned to the processing section of the TCCR unit for a tank campaign, the system is capable of gravity draining unshielded piping and flushing to lower dose rates prior to any entry.

The TCCR ion exchange process is based on the use of a crystalline silico-titanate (CST, UOP IonSiv™ R-9120, formerly known as IE-911)[a], a highly cesium specific ion exchange material. This material is inorganic, stable at the very high pH (12 to 14) values found in SRS waste tank solutions, and has significant test , and operational history.

The test history includes laboratory scale tests at Savannah River and Hanford, with actual high-level, complex Department of Energy waste streams, References [2] [3].

The operational history also includes an operation demonstration at Oak Ridge in which 9000 Ci (~1/10th scale to the system proposed) was removed from waste tanks with similar chemical characteristics to SRS tanks, such as high sodium, nitrate, nitrite and hydroxide, Reference [4].

Figure 4 shows the loading results of the actual waste tests and operation (red X's). The colored lines show the wide range of isotherms (loadings) calculated for SRS feed streams. The isotherm fitted to the test data is shown as a dotted line and represents a conservative (low) estimate of the possible cesium loading on the CST. The TCCR loading value was based on the fact that the tests were only run to 50% breakthrough (C_o/C =0.5). TCCR, while all TCCR columns will be run to their maximum equilibrium loading. In addition, the level of potassium, a competitor for cesium on CST was about 10 times the level in the tests compared to the TCCR feed range.

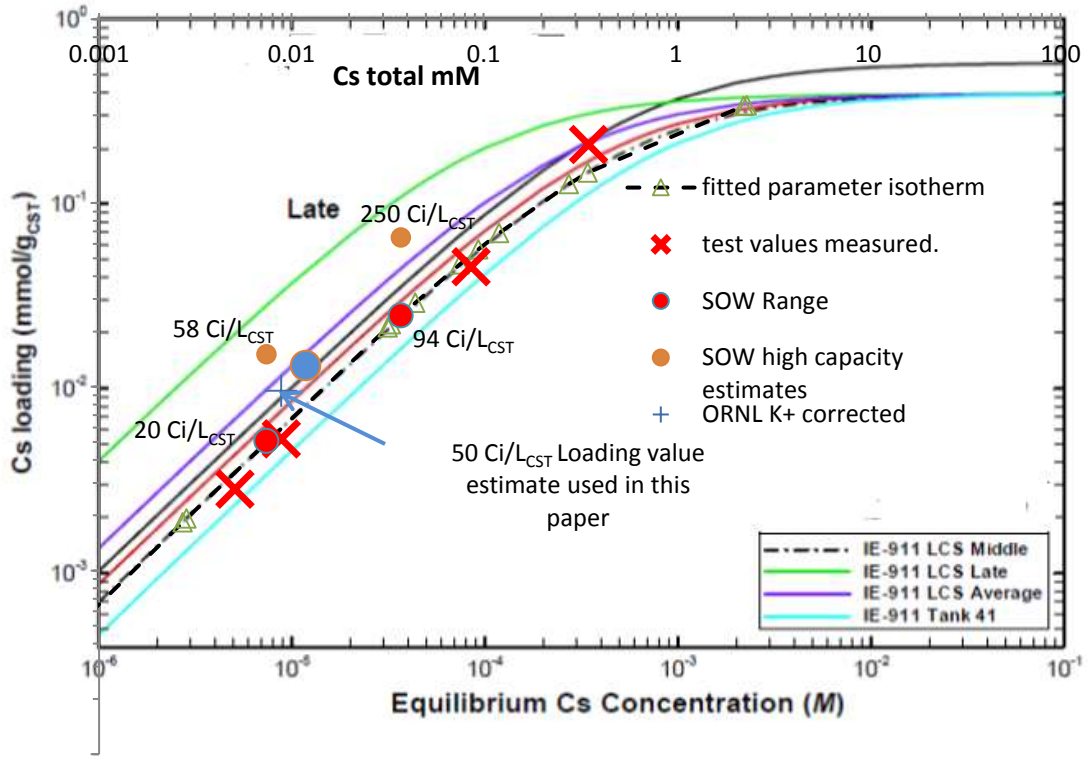

Fig. 4 Loading results CST versus input Cesium concentration, actual waste tests and operations

CST is also compatible with vitrification processes, Reference [5], which is important as vitrification is one of the possible future disposition methods for spent (loaded) CST. This is out of the immediate scope of TCCR, but was still considered.

The use of CST allows operational latitude (freedom from exact feed specifications, and temperature bounds) and simplicity compared to other possible ion exchange media (zeolite or organic resins) or processes (example: solvent extraction). The use of CST increases safety margins compared to organic IX resins that may generate hydrogen, or degrade in a high radiation field, even when dry. Table 1 shows some of the selection criteria for TCCR ion exchange media.

CST is part of the class of materials called zeolites. Zeolites have been used for several decades in removing cesium from high level Department of Energy wastes. CST was developed based on zeolite use and can be thought of as zeolite specially tuned to maximize cesium adsorption.

TABLE I Selection Criteria for TCCR

Property	CST	Other zeolite	Organic Resin
Cs specific	Yes	No	No
Radiation sensitive	No	No	Yes
Radiolytic Hydrogen generation when dry	No	No	Yes
Regeneration Operations necessary	No	No	Yes
Solid Cs end form	Yes	Yes	No
Relative Cs capacity	High	Low	Low
Volume needed	Low	High	Low if regen

Closeout:

After the process (100,000 Ci, 625,000 gallons) is complete, each of the IX columns will be dewatered using dry air/nitrogen to minimize gas generation. Each of the columns will then be removed from the sea-land van as a single shielded unit and stored at the ISS facility at SRS in preparation for final disposition. The columns will have vents with HEPA filters as further mitigation of gas generation issues. Piping to support sluicing of the IX media should that be desired at a future date will also be built into the column.

CONCLUSIONS

This paper presented the conceptual design of the modular system, noting the key benefits of specific components in the overall technology basis. Since this system is a first-of-a-kind in this specific application, lessons learned will be provided for future tank closure activities.

Footnotes:

[a] IonSiv™ is a registered trademark of UOP LLC, A Honeywell Company

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ACKNOWLEDGEMENT

The authors would like to thank the team at Columbia Energy and Environmental Services for their work on this project, specifically Greg Bogen for the basis of the presentation.