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PNNL-35731 Rev. 0

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U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

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Summary

This document provides design recommendations for an intermediate scale test platform (ISTP) that can be integrated into the 200 West Area (200W) pump-and-treat (P&T) facility to evaluate alternative hybrid ion exchange (IX) resin performance. IX resin performance will be evaluated primarily for the treatment of three contaminants of concern – technetium-99 (Tc), uranium (U), and hexavalent chromium (Cr(VI)) – and for any incidental removal of iodine-129 (I-129). Current IX resins deployed in 200W P&T are selective for only one contaminant (U or Tc). Alternative hybrid IX resins are designed to remove more than one contaminant; thus, providing opportunities to further optimize treatment unit capacities for IX and/or provide options for additional treatment for other contaminants such as Cr(VI) and/or incidental removal of I-129.

The testing of the new hybrid resins using the ISTP is recommended to include two phases. Each phase will rely on the same ISTP design with 8 columns. Phase 1 is intended to be short duration (~3 months) testing to screen candidate hybrid resins, in parallel individual columns, for the treatment of multiple contaminants of concern (COCs) under field-specific conditions. Phase 2 would use a series of up to four treatment columns in sequence to match the bed depth and residence time of a current 200W P&T treatment vessel. Phase 2 may also include mixed resin bed testing, e.g., two or more resins in one column, and allow for the deployment of these mixed bed columns in sequence to evaluate COC removal kinetics and chromatographic effects due to competitive contaminant removal processes. COC effluent concentrations measured during Phase 1 will be used to inform which resins to test in Phase 2. Key elements of the ISTP design and testing recommendations are described below.

- Eight (8) individual treatment columns to allow for the simultaneous evaluation of up to 8 different resins under the same flow rate and influent groundwater contaminant concentrations in Phase 1.

- Bed depth scalability to match groundwater residence time in 200W P&T operations by configuring up to four (4) of the 8 individual treatment columns in sequence. Sequential IX beds in Phase 2 will be used to evaluate competing ion effects, with valves to transition from 8 columns in parallel to two parallel trains of 4 columns in series that allow sampling between each column.

- Evaluation of hybrid IX resin performance as a function of influent groundwater chemistry, where the compact size and mobility of the ISTP will allow testing at different locations within 200W P&T. Potential influent access locations identified include: (1) downstream of collection tank Y10 before the Dowex 21K IX resin treatment train for removing U, (2) the Y32 cross transfer line that brings 200 East Area (200E) groundwater to 200W P&T with relatively high concentrations of all four contaminants of concern, (3) the new IX treatment train that will treat groundwater from 200E C and A-AX tank farms with elevated concentrations of Tc and I-129, and (4) downstream of collection tank Y20 before the Purolite A532E IX treatment train for removing Tc.

- Adaptable test duration. Shorter duration tests (~3 months) with individual treatment columns would be used to identify top performing resins in Phase 1. Longer duration tests (~9 months or more) that incorporate scalable bed depth and groundwater residence time may be performed using multiple ISTP treatment columns configured in sequence in Phase 2.

- Scalable flow rate. The ISTP column diameter and flow rate will be selected to reach linear velocities between 0.44 – 1.18 ft/min, with an average linear velocity of 0.88 ft/min (calculated), to match those in the 200W P&T IX resin vessels for scalability.

It is recommended that an adaptive sampling frequency be adopted for all ISTP tests, where previous laboratory tests, ISTP tests, and/or earlier sampling results (e.g., from Phase 1) are used to identify the number and frequency of samples required to provide sufficient data points that resolve the start, end, and curve shape of breakthrough events. This approach is especially advantageous for Phase 2, where the breakthrough curves collected for most hybrid resins in Phase 1 will provide better insight into the recommended sampling frequency than predictions based solely on laboratory scale tests. For the first ISTP test under Phase 1, the proposed sampling schedule emphasizes high sampling frequency (5+ solution samples per day) during the first four days to capture early breakthrough of groundwater anions, e.g., nitrate and sulfate, and non-selective contaminants. After the early breakthrough period, samples will be collected daily and with decreasing frequency as the test progresses to provide sufficient data to resolve breakthrough curves for contaminants and analytes that strongly interact with hybrid IX resins. Samples are required from the ISTP feed tank, the combined effluent, and after individual treatment columns. Samples will be analyzed for Tc, U, Cr(VI), I-129, and/or other groundwater analytes of interest. In addition to these samples, in-line monitoring for pH, flow rate (total volume treated), and temperature are also recommended at key ISTP locations.

The results of these tests will be used to provide a technical basis for recommendation to deploy hybrid IX resins in future 200W P&T operations.

Acknowledgments

Funding for this work was provided by the U.S. Department of Energy Richland Operations Office under the Deep Vadose Zone – Applied Field Research Initiative. The Pacific Northwest National Laboratory (PNNL) is operated by Battelle Memorial Institute for the Department of Energy under Contract DE-AC05-76RL01830.

PNNL thanks Matthew Schinnell, Dean Neshem, and Byron Miller of the Central Plateau Cleanup Company for providing regular ISTP design feedback.

Acronyms and Abbreviations

200W	200 West Area
200E	200 East Area
ASC	Analytical Service Center
Bi	Bismuth
$CaCO_3$	Calcium carbonate
CCl_4	Carbon tetrachloride
Ce	Cerium
Cl^-	Chloride
COC	Contaminant of concern
CPCCo	Central Plateau Cleanup Company
Cr(VI)	Hexavalent chromium
CrO_4^{2-}	Chromate
ERDF	Environmental Restoration Disposal Facility
Fe	Iron
FY	Fiscal year
I-127	Iodine-127
I-129	Iodine-129
IO_3^-	Iodate
ISTP	Intermediate Scale Test Platform
IX	Ion exchange
K_d	distribution coefficient
Mn	Manganese
NO_3^-	Nitrate
OU	Operable Unit
P&T	Pump-and-treat
SBA	Strong base anion
SO_4^{2-}	Sulfate
Tc	Technetium-99
TcO_4^-	Pertechnetate
U	Uranium

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1.0 Introduction

This document outlines design recommendations for an intermediate scale test platform (ISTP) that can be integrated into the 200 West Area (200W) pump-and-treat (P&T) facility for evaluation of alternative hybrid ion exchange (IX) resin performance. Based on previous laboratory evaluations (Appendix A and references therein), further testing of alternative hybrid resins is warranted in site specific conditions to analyze their ability to selectively remove multiple contaminants of concern (COCs) simultaneously through specific design configurations. The results from the ISTP will be used to provide and/or support developing a technical basis for identifying potential benefits of using hybrid IX resin(s) in future 200W P&T facility operations.

Resin performance during the ISTP operation will be evaluated primarily based on the concentrations of three COCs in the effluent from the ISTP, including technetium-99 (Tc or Tc-99), uranium (U), and hexavalent chromium (Cr(VI)). The concentration of iodine-129 (I-129) in the effluent from the ISTP will also be evaluated for an assessment of the potential incidental removal capacity, to a lesser degree, shown by hybrid resins in previous laboratory experiments to provide an understanding of the potential incidental removal. More details of the testing evaluation approaches and factors are discussed in later sections of this document.

The document is organized to provide some relevant background information in Section 2.0, including a brief background of 200W P&T facility operation, planned expansion efforts, and motivation for evaluating alternative hybrid resin types for the treatment of co-mingled Tc, U, Cr(VI), and/or I-129. Section 3.0 outlines the ISTP test objectives, potential access locations within the 200W P&T to connect the ISTP to site-specific influent chemistries, and phased testing approach. Section 4.0 outlines the technical basis for the ISTP design recommendations. Proposed methods for sampling and analysis are provided in Section 5.0 followed by a test evaluation discussion in Section 6.0. References are provided in Section 7.0, Appendix A provides a summary of the types of hybrid resins being considered for testing along with the performance observed in lab scale tests. Appendix B provides safety data sheets for potential hybrid resins, where available.

2.0 Motivation for Potential Hybrid Resin Use at 200W P&T

2.1 Current and Future Operation of the 200W P&T Facility

The 200 West P&T was originally designed to capture and treat contaminated groundwater in the Hanford Site's Central Plateau for carbon tetrachloride (CCl_4), total chromium, Cr(VI), nitrate (NO_3^-), trichloroethene, Tc, and U (see Table 1). Following treatment, the water is injected into the aquifer to serve as a recharge source and to provide flow path control.

Table 1. 200 West P&T Treatment Process Units[1]

Treatment Process Unit	Constituents Removed
Ion exchange	Technetium-99, uranium
Air stripping	Carbon tetrachloride, chloroform, other volatile organic contaminants
Biological treatment*	Nitrate, chromium

*Biological treatment has been suspended during the 200-ZP-1 Optimization Study period

The 200W P&T uses IX treatment units, each in a three vessel configuration with lead-lag-polish columns to treat Tc and U (Figure 1).[2-3]

Contaminated groundwater from operable units (OUs) 200-UP-1 and 200-BP-5, perched water from the 200-DV-1 OU, and Hanford's Environmental Restoration Disposal Facility (ERDF) leachate is treated to reduce the U concentration to <30 µg/L (internal effluent target for this treatment process unit is 18 µg/L) via one of the IX treatment trains. This treatment train uses a gel strong base anion (SBA) exchange resin, Dowex 21K (also marketed as AmberSep 21K), to remove U. Dowex 21K is selective for hydrophilic multivalent anionic species, and removes U as uranyl carbonate species (e.g., $UO_2(CO_3)_x^{2-2x}$).[4] The effluent from the Dowex 21K treatment train is then directed to Tc IX treatment trains.

After pretreatment for U, contaminated water from 200-UP-1 OU, 200-DV-1 OU perched water, 200-BP-5 OU, and ERDF leachate is combined with water from selected wells in the 200-UP-1 OU, near S-SX Tank Farms, and 200-ZP-1 OU (as shown in Figure 1), and is treated to reduce Tc to <900 pCi/L (internal effluent target for this treatment train is 540 pCi/L) via two parallel treatment trains of 3 vessels. Tc contaminated water is treated using the gel SBA resin, Purolite® A532E, which is selective for hydrophobic anions including pertechnetate (TcO_4^-).

In addition to the existing system, 200W P&T is currently being expanded to treat extracted groundwater from the C and A-AX Tank Farm areas in the 200-BP-5 and 200-PO-1 groundwater OUs under the recent interim record of decision.[5] The target contaminant in these areas for treatment is Tc (to be treated by a new IX train dedicated to this influent stream for Tc removal), however, significant concentrations of I-129 are also expected in the extracted groundwater. Currently, no *ex-situ* treatment technology for I-129 has been identified that can achieve the drinking water standard of 1 pCi/L.[6] Without a dedicated treatment process for I-129, the only approach for meeting the facility effluent criteria of 1 pCi/L is to utilize the blending capacity of the treatment plant. Therefore, any incidental removal of I-129 via hybrid resins is considered a benefit for the optimization of the P&T facility treatment effectiveness under this study.

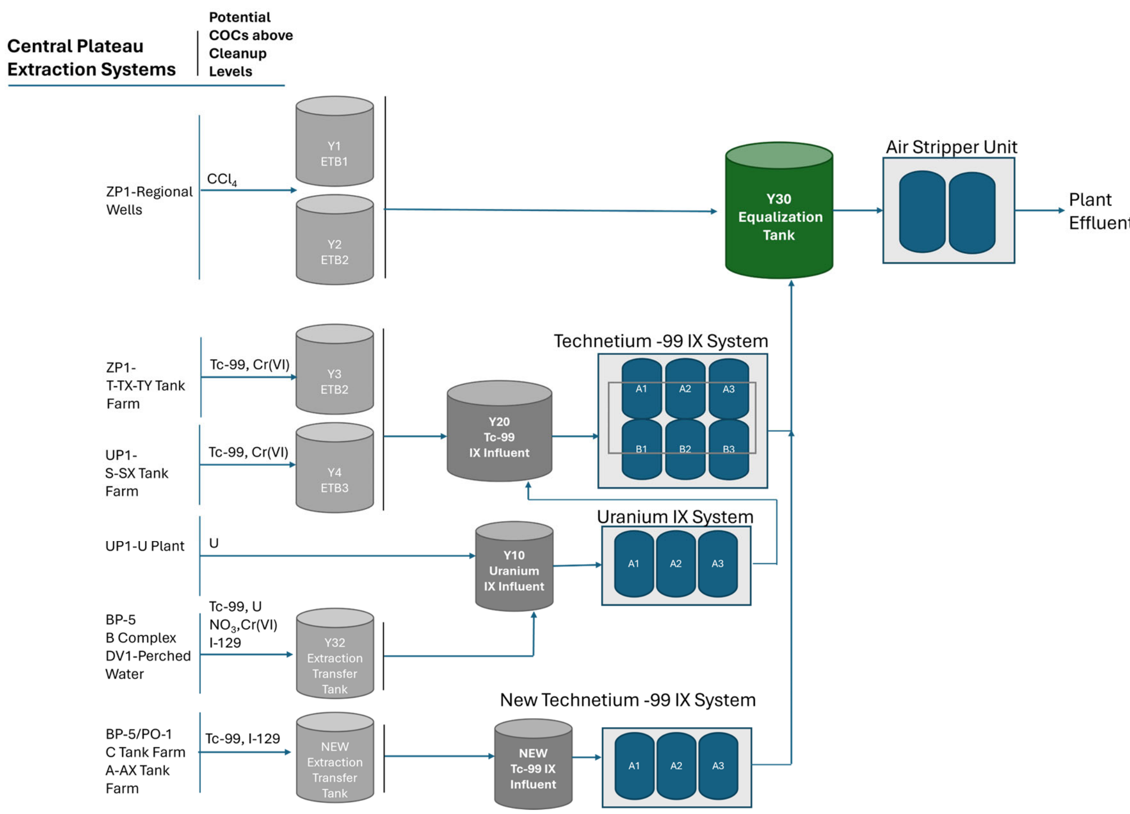

Figure 1. Schematic of the 200W P&T facility process.

Furthermore, the removal of Cr(VI) from groundwater at the 200W P&T facility was addressed via anaerobic microbial reduction, until the fluidized bed bioreactor was suspended in 2020.[8] Currently, a small amount of Cr(VI) is removed by the existing IX treatment trains but optimization efforts may require more effective IX treatment of Cr(VI) to meet remedial objectives.

Modifying P&T infrastructure to incorporate new treatment trains for additional single ion-selective IX resins, e.g., for Cr(VI), into facility operations is expensive and time-consuming. Furthermore, the new C/A-AX farm influent stream will require blending for I-129 and will be routed to the air stripper for treatment, reducing the available treatment capacity for CCl_4. Additional capacity optimization could be achieved if IX systems can treat U and Tc simultaneously. Hybrid resins that remove multiple contaminants in a single IX system may present an alternative approach to addressing Tc, U, and Cr(VI) groundwater treatment needs as well as I-129 blending needs in the facility.

2.2 Hybrid Resins for Multi-Contaminant Groundwater Treatment

For the co-treatment of Tc, U, and/or Cr(VI), and/or incidental treatment of I-129, two classes of hybrid IX resins have been investigated in laboratory studies over the last few years: (i) IX resins with incorporated metal (e.g., cerium, iron, bismuth, and manganese) oxyhydroxides; and (ii) IX resins where the polymer backbone has been functionalized with a redox active group. A current list of potential hybrid resins under consideration for ISTP testing based on observed removal of Tc, U, Cr(VI), and/or I-129 in the laboratory is provided in Table 2. The characteristics and laboratory performance of these resin types are discussed in more detail in 7.0Appendix A.

Table 2. Potential hybrid resins for multi-contaminant removal in ISTP tests

<table>
<tr><th colspan="5">Redox Active Weak Base Hybrid Resins</th></tr>
<tr><th>Resin</th><th>Manufacturer</th><th colspan="2">Manufacturer Exchange Capacity (meq/mL)</th><th>Potential Contaminants Treated</th></tr>
<tr><td>SIR-700-HP</td><td>ResinTech</td><td colspan="2">>2.1</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><td>WBG30*</td><td>ResinTech</td><td colspan="2">2.8</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><td>SIR-400-MP</td><td>ResinTech</td><td colspan="2">>1.6</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><td>S106</td><td>Purolite</td><td colspan="2">>2.0</td><td>Cr(VI), U</td></tr>
<tr><td>S920</td><td>Purolite</td><td colspan="2">>1.0</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><td>AmberSep 43600C</td><td>Dupont</td><td colspan="2">≥0.7</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><th colspan="5">Hybrid Resins with Metal Oxyhydroxides</th></tr>
<tr><th>Resin</th><th>Manufacturer</th><th>Hybrid Metal</th><th>Hybrid Metal Loading (g/kg moist resin)</th><th>Potential Contaminants Treated</th></tr>
<tr><td>CHM-10</td><td>ResinTech</td><td>Ce</td><td>55.1</td><td>Tc, I-129</td></tr>
<tr><td>SIR-110-MP-Ce</td><td>ResinTech</td><td>Ce</td><td>67.9</td><td>Tc, I-129</td></tr>
<tr><td>SIR-110-HP-Ce</td><td>ResinTech</td><td>Ce</td><td>Unknown</td><td>Tc, I-129</td></tr>
<tr><td>CHM-20</td><td>ResinTech</td><td>Ce</td><td>55.4</td><td>Tc, I-129</td></tr>
<tr><td>SIR-1300</td><td>ResinTech</td><td>Mn</td><td>9.6</td><td>I-129</td></tr>
<tr><td>SIR-110-MP-Bi</td><td>ResinTech</td><td>Bi</td><td>31.3</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><td>SBG1-Bi</td><td>ResinTech</td><td>Bi</td><td>22.8</td><td>U, Tc, Cr(VI), I-129</td></tr>
<tr><td>SIR-110-HP-Fe</td><td>ResinTech</td><td>Fe</td><td>Unknown</td><td>Tc, I-129</td></tr>
<tr><td>SIR-110-MP-Fe</td><td>ResinTech</td><td>Fe</td><td>41</td><td>Tc, I-129</td></tr>
<tr><td>ASM-10-HP</td><td>ResinTech</td><td>Fe</td><td>96.3 - 115</td><td>Tc, I-129</td></tr>
<tr><td>ASM-125</td><td>ResinTech</td><td>Fe</td><td>122</td><td>Tc, I-129</td></tr>
<tr><td>FerrIX A33E</td><td>Purolite</td><td>Fe</td><td>Unknown</td><td>I-129</td></tr>
<tr><td colspan="5">* May replace SIR-700-HP.</td></tr>
</table>

3.0 ISTP Test Objectives and Approach

The proposed design recommendations will be used to construct an ISTP that will be deployed at 200W P&T by the current contractor, Central Plateau Cleanup Company (CPCCo), as early as fiscal year (FY) 2025 subject to funding. ISTP tests will be used to evaluate the performance of different hybrid resins for the removal of Tc, U, Cr(VI), and/or I-129 from Hanford Site groundwater extracted from the Central Plateau under field relevant test conditions. Hybrid resin performance will be evaluated using effluent concentrations and breakthrough[1] curves of Tc, U, Cr(VI), I-129, and/or other groundwater anions, e.g., nitrate (NO_3^-), sulfate (SO_4^{2-}), chloride (Cl^-), and alkalinity as calcium carbonate ($CaCO_3$). Breakthrough curves will also be used to assess system factors that influence removal efficiency and change-out-frequency estimations, such as:

- Effects of pH, oxidation-reduction potential, electrical conductivity, and/or temperature,
- Contaminant uptake mass and percent for a given amount of time,
- Retained contaminant mass and percent for a given amount of time,
- Initial bleed through time,
- Equilibration time, if any, based on reaction kinetics,
- Ability to maintain loading, and
- Co-contaminant interferences based on relative breakthrough curve start, end, and shape.

To satisfy these test objectives and to perform comparative analyses of the final test results, it is important that: (1) the influent stream for the ISTP is representative of the actual groundwater currently being treated by the existing IX system and/or systems that will be in use in the near future where multiple targeted contaminants are co-mingled; and (2) the design of the ISTP captures the hydraulic characteristics (e.g., linear velocities and residence times) of the existing IX systems at the facility. More information on the design factors is given in Section 4.0.

In terms of the representativeness of the influent groundwater, four potential integration points (i.e., facility access locations) have been identified for the ISTP within the actual treatment chain of the 200W facility (see Figure 2):

- Access location #1, downstream influent from the Y10 influent tank before U treatment by Dowex 21K;
- Access location #2, downstream of the Y32 tank where the transfer line from 200E Area is received in the facility;
- Access location #3, the new IX treatment train influent extracted from the A-AX and C tank farms in the 200E Area; and

[1] Breakthrough is defined here as a measurable effluent concentration, i.e., above the analytical detection limit, sustained for a period of time, e.g., 5 sequential sampling events.

- Access location #4, downstream from the Y20 influent tank before Tc treatment by Purolite A532E treatment trains.

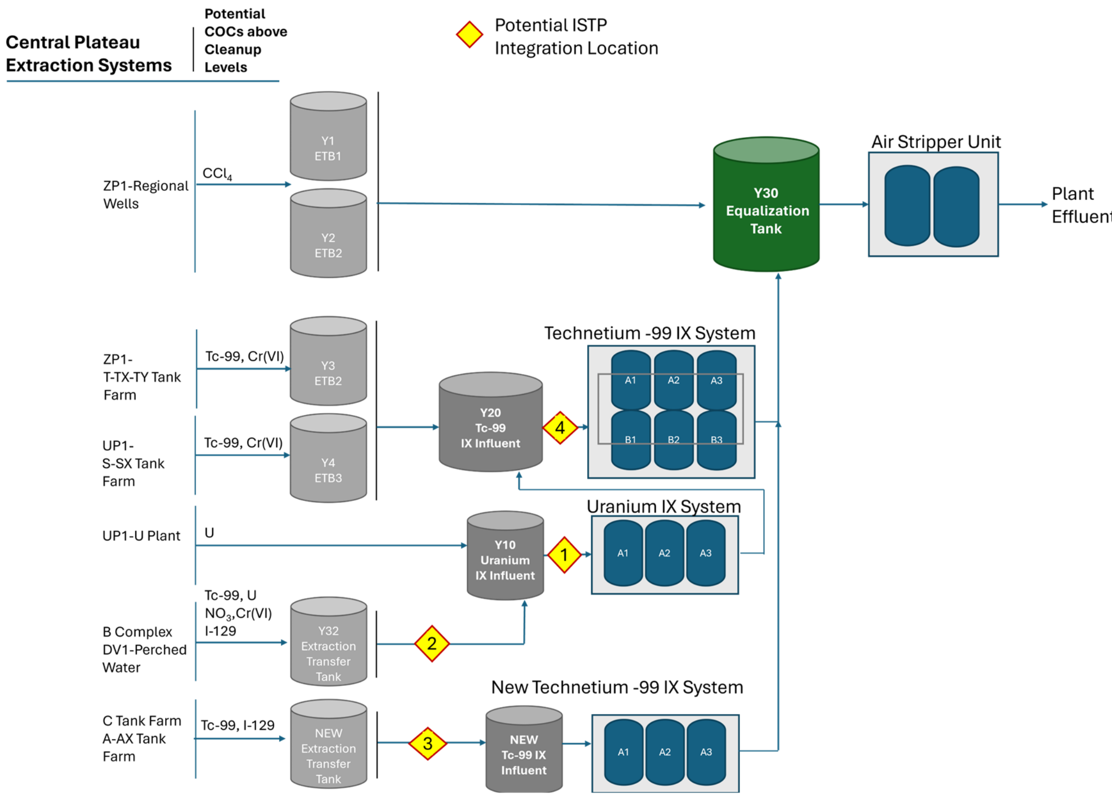

Figure 2. 200W P&T process flow diagram schematic showing potential integration/access points (yellow diamonds) for the ISTP to test selected hybrid resins.

The groundwater influent at each access location will contain different amounts of Tc, U, Cr(VI), and I-129. The presence or absence of specific contaminants will influence the resins that are selected for testing. The access locations have been ranked in Table 3, based on the relative current or anticipated contaminant concentrations in the influent groundwater at the time of document issuance, the number of influent COCs present, and the test objectives of the ISTP. The groundwater influent at location #2 (Y32) is extracted from DV-1 perched water, and provides the best opportunity for evaluating hybrid resin treatment of all four contaminants, even though the concentration for each contaminant may not be the highest compared to other access locations. The presence of all four contaminants may result in faster breakthrough during testing. Therefore, location #2 is considered the top priority access location for testing (ranked 1st in Table 3).

Location #3 represents a new influent stream (Table 3) that will come from the 200E expansion of the P&T operations at C and A-AX Tank Farms. This influent stream will have high concentrations of Tc co-mingled with significant concentrations of I-129, but the U concentration is below the level that requires treatment. Currently, this influent stream is planned to be treated in a new IX train as the existing Tc IX system is operating at or near its full capacity. This integration point is identified for assessing new hybrid resin performance for Tc removal and any incidental I-129 removal, and is ranked 2nd for testing in Table 3. Testing at location #3 is contingent on the completion of currently ongoing plant upgrades and modifications.

The access locations #4 and #1 indicate the chemical characteristics of the main influent stream currently treated by the existing IX systems. Location #4 is identified to potentially assess the performance of new hybrid resins for the co-treatment of Tc-99 and Cr(VI) without U – representative of the 200-ZP-1 T-TX-TY and 200-UP-1 S-SX Tank Farm areas – and has a priority ranking of 3rd for testing. While location #1 is representative of the treated concentrations/actual loading for the U IX system, similar COC test conditions are achieved at location #2 where U, Tc-99, and I-129 concentrations are all higher and the concentration of Cr(VI) is only marginally lower (5.9 µg/L) compared to location #1 (6.6 µg/L). For this reason, access location #1 is ranked the lowest in priority for testing. One or two of these locations will be selected for the study per discussions with the project team based on testing objectives and potential future benefits.

Table 3. Proposed 200W P&T Access Locations for ISTP Integration

Access Location	Ranking for Test Objectives[*]	Valve	Tc[^]	U[^]	Cr(VI)[^]	I-129[^]	Pre-Filtered	Influent pH Buffered?	Comments
			pCi/L	*µg/L*	*µg/L*	*pCi/L*	Yes/No		
#2 (Y32)	1	V47-Y32B or V43-Y32C or V43-Y32D	5792	326	5.9	3.0	Yes	No[#]	Cross transfer line from 200E Area 200-BP-5 and 200-DV-1 OU extraction wells, including influent from the perched water zone. Pros: Evaluate removal of comingled Tc, U, Cr(VI) and I-129. Higher concentrations of Tc, U and I-129 than Y10 will result in more rapid breakthrough. Cons: Low level of Cr(VI) in the influent. ISTP may require a filtration unit if upstream (V47-Y32B) of the filter housings, and pH buffering depending on resin test parameters.
#3 (New IX)	2	To be determined	11,326	3.2	9.9	4.7	No/ Unknown	No[#]	New extraction wells from 200E Area C and A-AX Tank Farms. Contaminant concentrations are the projected flow weighted average for the first 4 years of operation. The new IX treatment train dedicated to this influent stream is expected to come online at the end of FY24. Pros: Evaluate Tc-99 removal and incidental I-129 removal. Cons: ISTP would require a filtration unit and pH buffering.
#4 (Y20)	3	V06-Y20	1401	1.9	17.2	0.7	Yes	No[#]	Downstream of Y20, influent routed into the 200W P&T A532E treatment train for the removal of Tc. Pros: Evaluate removal of Tc-99 and Cr(VI) Cons: Low level of U and I-129 in the influent
#1 (Y10)	4	V06-Y10	2256	167	6.6	1.4	Yes	Yes	Downstream of Y10, influent routed into the 200W P&T Dowex 21K treatment train for the removal of U. Pros: Evaluate removal of Tc-99, U and some I-129 Cons: Low level of Cr(VI) in the influent

^ Concentration data consolidated by Matthew Schinnell (CPCCo) using 200W P&T chemistry data entries in the Hanford Environmental Information System. Y10 data extracted from October 2015 (startup) through December 2023. Y20 data extracted from November 2012 (startup) through December 2023. Y32 concentrations were determined from data entries between January 2008 and December 2023 for groundwater wells 299-E33-(268, 344, 350, 351, 360, and 361). The new IX concentrations are estimated from the 299-E27-21 and 299-E25-93 monitoring wells in C and A-AX tank farms from December 2003 – December 2023. Data processing included removing unfiltered Cr(VI), filtering data points to align with process monitoring, setting concentration values to the minimum detectable activity level when radionuclides were below it, and removing reject, suspect, and outlying values. Outlying concentration values were typically chronologically early values that were much higher than the global trend.

* Access locations are ranked based on the testing objectives of the ISTP, the current or anticipated COC concentrations, and the number of COCs present in the influent at the time of document issuance.

The recommended ISTP design (Section 4.0, Figure 3) includes a feed tank where pH adjustments can be made to the ISTP influent before contact with IX resins under evaluation.

Hybrid resin performance testing will consist of at least two evaluation phases. Each phase will rely on the same 8-column ISTP design discussed in Section 4.0. Phase 1 is intended to screen candidate hybrid resins in parallel individual columns for the treatment of multiple COCs under field-specific conditions; shorter testing durations will be achieved using shorter bed depths and, correspondingly, shorter residence times. Phase 2 is expected to use a series of up to four treatment columns in sequence to match the bed depth and residence time of a current 200W P&T treatment vessel. Phase 2 may also include mixed resin bed testing of two or more resins in one column, and allow for the deployment of these mixed bed columns in sequence to evaluate COC removal kinetics and chromatographic effects due to competitive contaminant removal processes. The results from Phase 1 will inform which resins to test in Phase 2. The technical objectives and success criteria for each evaluation phase are described below.

3.1 Phase 1 Testing

The primary objective of Phase 1 is to identify which hybrids show improved performance for groundwater treatment when compared against the performance of the Purolite A532E and/or Dowex 21K resins currently in use at 200W P&T. A comparative evaluation in this phase will focus on the following improvements to baseline:

- A demonstrated capacity to remove multiple contaminant anions from groundwater,
- Measurable removal of Cr(VI) and/or I-129, since any removal would be an improvement,
- Effluent contaminant concentrations are below the final cleanup level for one or more contaminant: Tc = 900 pCi/L, U = 30 µg/L, Cr(VI) = 48 µg/L, and I-129 = 1 pCi/L,[9]

  and/or

- Observed breakthrough of Tc or U from the tested hybrid resin columns that occurs later than the observed breakthrough of Tc or U from A532E or Dowex 21K resin columns, respectively.

The performance of up to eight (8) IX resins or mixed resins (two or more resins packed into a single column) will be evaluated simultaneously for the removal and retention of Tc, U, Cr(VI), and/or I-129 from facility influent groundwater source(s). These resins will include (i) Purolite A532E and Dowex 21K IX currently being used at the 200W P&T facility for Tc and U treatment (required for establishing baseline resin performance under ISTP test conditions), (ii) weak base hybrid anion exchange resins, like ResinTech SIR-700, and/or (iii) IX resins hybridized with metal phases such as Ce, Bi, Fe, and Mn. The resins to be evaluated in this phase will be selected based on: (1) laboratory tests for the removal of multiple COCs from simulated groundwater representative of the Hanford Central Plateau; and (2) selected influent streams (i.e., access points) and their chemical characteristics. Results from laboratory batch tests with SIR-700 suggest that this resin can remove both Cr(VI) and U carbonate species.[10] Batch and column tests performed in FY23 and FY24 using ResinTech SIR-110-MP strong base anion IX resin hybridized with Ce, Fe, or Mn suggest these hybrid resins are candidates for Tc and I-129 removal.[11] Laboratory tests using optimized and new hybrid resins are continuing through FY24 and the results will be used to select the resins that will be tested in Phase 1.

Phase 1 tests will use one treatment column for each resin. While not representative of residence time in a 200W P&T vessel, the short bed depth and groundwater residence time in a single ISTP treatment column allow for rapid screening to select the resins that will move forward to testing under more representative conditions in Phase 2. Phase 1 is expected to last approximately 3 months (90 days). This estimate is based on the ISTP design recommendations presented in Section 4.0, the time required by current 200W P&T resins, Purolite A532E and Dowex 21K, to reach measurable effluent concentrations of Tc and U, respectively, representing baseline operations, and the expected period required to collect sufficient information to make a resin down-selection for testing in Phase 2. The duration of Phase 1 would increase if more than one access location is to be tested, e.g., two access locations would require approximately six months with additional time for disassembling, moving, and setting up the ISTP at a second location.

Resins that improve baseline 200W P&T operations will be considered for testing in Phase 2. The down-selection of candidate hybrid resins for Phase 2 will be based on the evaluation criteria stated above. The selection criteria allow for scenarios where, for example, the Tc or U removal capacity of the resin is less than the current baseline, but the uptake of additional contaminants add sufficient value for consideration in Phase 2. In such instances, mixed-bed or mixed-train configurations (i.e., where more than one resin could be used in different columns or in a single column in a treatment train to target multiple contaminants simultaneously) to meet Tc and U removal performance of the currently used IX resins may be advantageous.

3.2 Phase 2 Testing

The primary objective of Phase 2 is to use a series of treatment columns in sequence to evaluate chromatographic effects caused by competitive contaminant removal, interactions, and reaction kinetics that would impact resin removal efficacy and change-out frequency in 200W P&T. The potential for using mixed resin bed treatment configurations may also be evaluated in Phase 2, where two or more resins may be packed in each sequence column and/or each sequence column contains one resin but the resin in each column may be different. Phase 2 tests will be performed using a bed depth and groundwater residence time that is closer in scale to operation of a single 200W P&T resin vessel to capture the potential chromatographic effects that are not resolved in single column tests performed in Phase 1. This will be accomplished by configuring up to four of the ISTP vessels in series. The empty bed residence time in this configuration will match that in the full-scale vessels at the typical flow rate. With this configuration, at least two tests may be run simultaneously for longer periods than in Phase 1, e.g., ISTP vessels A1 – A4 (Figure 3) are used for testing one resin (or mix of resins) and vessels B1 – B4 (Figure 3) are used to test a different resin or mix of resins. The duration of a single Phase 2 test is expected to last approximately 9 months (270 days).

4.0 ISTP Design Recommendations

A schematic of the proposed ISTP is shown in Figure 3. A comparison of example ISTP design dimensions and operational parameters to a single 200W P&T vessel is provided in Table 4. The final design of the ISTP should, at a minimum, be able to match the linear velocities and residence times experienced in a single 200W P&T IX vessel. This will allow the number of bed volumes required to reach breakthrough in the ISTP to be compared with resin performance expected under normal 200W P&T operations. The installation of lift-points or wheels would allow the ISTP to be moved and transported to different access locations within 200W P&T (Section 3.0).

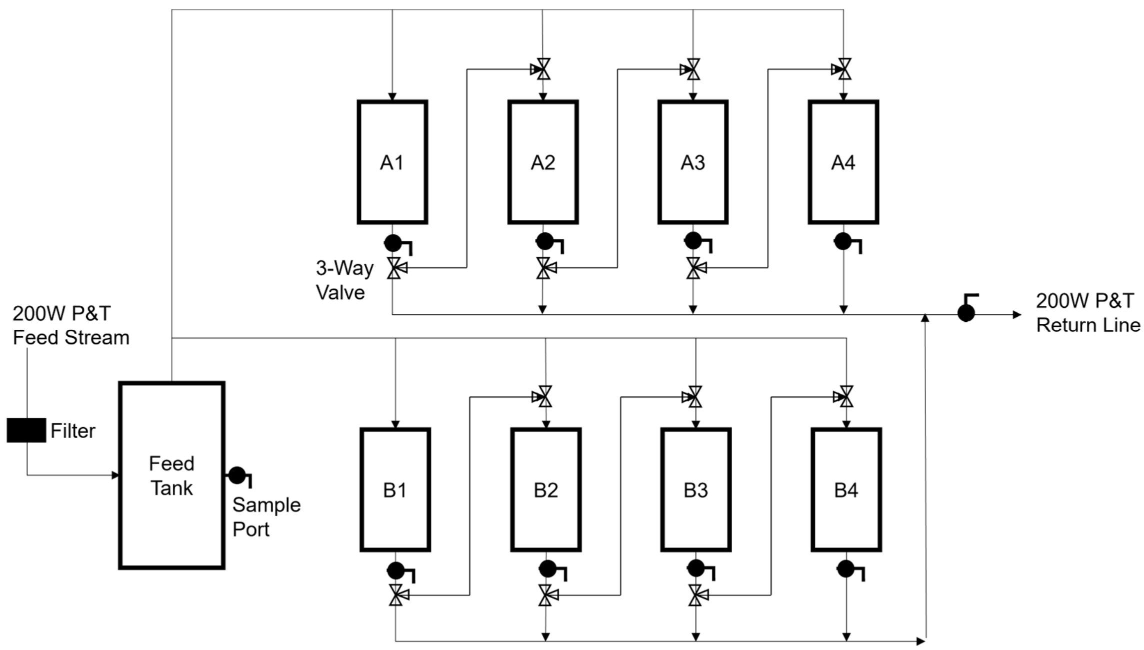

Figure 3. General configuration of the proposed ISTP design. Treatment vessels for evaluating different resins are labeled as A1 – A4 and B1 – B4. Each vessel may be operated individually or in sequential order if within the same group (A or B). Note that the diagram shows 3-way valves as one option. A pair of 2-way “on/off” valves can be used in lieu of a single three-way valve should that be preferable for construction or operation. Recommended sampling ports are located at the influent feed (collection) tank, after each treatment column, and on the effluent return line to 200W P&T.

Table 4. Comparison of 200W P&T design and operation parameters to an ISTP design example.

Design Element or Test Parameter	200W P&T			ISTP[*]					
Vessel Count	1			1 (e.g., A1 in Figure 3)			3[%] (in sequence, e.g., A1 – A3 in Figure 3)		
Vessel Inner Diameter (in [ft])	91.2 [7.6][^]			7.4 [0.6]					
Cross Sectional Area of Packed Bed (ft^2)	45			0.30					
Vessel Height (in, [ft])	72 [6][^]			24 [2]			72 [6]		
Bed Volume (ft^3)	272			0.60			1.81		
Bed Depth (in, [ft])	72 [6]			24 [2]			72 [6]		
Flow Rate (gal/min)	Min[#]	Avg[^]	Max[#]	Min	Avg	Max	Min	Avg	Max
	150	300	400	1.00	2.00	2.67	1.00	2.00	2.67
Linear Velocity (ft/min)[**]	0.44	0.88	1.18	0.44	0.88	1.18	0.44	0.88	1.18
Residence Time (min)[**]	13.57	6.79	5.09	4.52	2.26	1.70	13.57	6.79	5.10

[*] ISTP design elements and test parameters listed are used to compare scaled test conditions to 200W P&T operations, e.g., ISTP minimum, average, and maximum flow rates are scaled to achieve linear velocities that match the 200W P&T operational linear velocities. They represent one potential design that meets the ISTP design requirements for completing the outlined test objectives.
[%] ISTP vessel count determined based on target bed depth required to match the residence time of a single 200W P&T.
[**] Values calculated using the minimum, average, or maximum flow rate identified in the same column.
[#] From Carlson 2017.[12]
[^] From CPCCo correspondence regarding 200W P&T vessel dimensions.

A cartridge filter compatible with flow rates greater than the maximum flow rate of the ISTP and a particle size cut-off matching the 200W P&T facility filters should be installed upstream of the feed tank. The cartridge filter will reduce the chances of particulate material interfering with the operation of the ISTP. The flow rate should be controlled with a throttle valve/flow control valve. ISTP effluent will be routed back to 200W P&T in a manner that does not impact the Tc and U mass removed under normal 200W P&T operations.

One of the primary design criteria for the ISTP is to maintain a linear velocity through each treatment vessel that falls within the linear velocity range expected for current 200W P&T operations. This criterion is required to reproduce the conditions representative of full-scale operation. The calculated linear velocities for a 200W P&T IX vessel are between 0.44 and 1.18 ft/min with an average linear velocity of 0.88 ft/min. These velocities were based on an operable flow rate range of 150 – 400 gal/min, an average flow rate of 300 gal/min, and the 200W P&T

vessel dimensions provided in Table 4. These target linear velocities would be achieved using the vessel diameters and operable flow rates provided as examples in Table 5.

Table 5. Target ISTP operable flow rates based on vessel diameter.

Vessel Diameter (D)	Minimum Flow Rate*	Average Flow Rate*	Maximum Flow Rate*
inches (mm)	*gal/min*	*gal/min*	*gal/min*
2.0 (50)[#]	0.07	0.14	0.19
6.0 (152)	0.65	1.30	1.73
7.4 (189)	1.00	2.00	2.67
12 (305)	2.60	5.20	6.93

* Calculated minimum, average, and maximum flow rates that will reach the minimum, average, and maximum linear velocity targets of 0.44, 0.88, and 1.18 ft/min, respectively.

[#] Minimum D selected based on a maximum resin diameter (d) of 1.68 mm (reported for SIR-700-HP) to keep D/d ≥30 and avoid wall effects.

Another design criterion for the ISTP is the groundwater residence time in the treatment column(s), which is dependent on resin bed depth, and linear velocity. A total of eight IX resin treatment columns are proposed for the ISTP. These columns are labeled as A1 – A4 and B1 – B4 in Figure 3. For Phase 1, it is expected that each treatment column will contain a different IX resin and will be monitored as individual columns. This configuration allows the performance of hybrid IX resins to be screened over a shorter period (~3 months). To reach full bed depth, treatment columns A1 – A4 and B1 – B4 may be operated in sequence. This sequential configuration will be used in Phase 2 to match the bed depth and residence time of a 200W P&T vessel (average residence time is approximately 6.79 min, Table 4). For the example ISTP treatment column dimensions provided in Table 4, operating at an average flow linear velocity and residence time requires a bed depth of 72 in (6 ft) which is accomplished by operating three 24 in (2 ft) treatment columns in sequence. A fourth column is recommended for instances where the maximum flow rate is used for testing, which in the provided example would require a 96 in (8 ft) bed depth to match the average 200W P&T residence time. For all columns in the ISTP, the influent should flow from top to bottom.

The installation of an ISTP influent tank is recommended to condition the groundwater so that each ISTP treatment column experiences the same influent chemistry, and to avoid stop-flow events due to pauses in 200W P&T operations. The ISTP feed tank should accommodate approximately 3000 gallons of influent or more. If all eight treatment columns are operating individually at a flow rate of 1.25 gpm, uninterrupted flow from the feed tank would sustain operation of all eight treatment columns for approximately 5 hours. This configuration allows for easier monitoring and offers the opportunity to adjust the feed chemistry, e.g., pH, as needed. A cartridge filter of similar pore size to those upstream of the existing IX vessels will reduce the chances of particulate material interfering with the operation of the ISTP.

Also shown in the proposed ISTP schematic are sampling port locations for the feed tank, after each treatment column (A1 – A4, B1 – B4), and the combined effluent being routed back into the 200W P&T process feed. These sampling ports are to support the periodic collection of groundwater samples for analyses outlined in Section 5.0. Analysis of these grab samples will be used to construct COC and groundwater anion breakthrough curves that will be used to determine resin performance. In addition to sampling ports, installation of in-line monitoring probes for pH and flow rate and flow totalizers to record total volume treated are recommended near all sampling port locations. Temperature probes for monitoring the feed tank is also recommended.

The location of treatment column pump(s) that will flow influent from the feed tank into each ISTP treatment column will be determined by the site contractor (CPCCo) in a separate ISTP design document. This separate document will also describe mechanical controls for preventing backflow, cross-contamination, and for maintaining the target flow rate as deemed necessary by CPCCo. Procedures for pH buffering influent entering the feed tank may also be included for access locations with influent groundwater that is not already pH buffered and for adjusting the influent pH to be within the optimal operable range of some resins, e.g., SIR-700-HP performance is optimized around pH 5.

5.0 Sampling and Analysis

A summary of the expected maximum number of ISTP sampling events and analytical recommendations is provided in Table 6. The number of samples and sampling frequency is based on historical breakthrough data for baseline resins, Dowex 21K and Purolite A532E, used in the 200W P&T facility, assumes a fixed sampling schedule, and continuous operation of the ISTP (no stop flow events) during active testing. It is recommended that an adaptive sampling frequency be used for all ISTP tests, where previous laboratory tests, ISTP tests, and/or earlier sampling results (e.g., from Phase 1) are used to identify the number and frequency of samples required to provide sufficient data points that resolve the start, end, and curve shape of breakthrough events. This approach is especially advantageous for Phase 2 testing, where the breakthrough curves collected for most hybrid resins in Phase 1 will provide better insight into the recommended sampling frequency than predictions based solely on laboratory scale tests.

The primary method for sampling will be the use of grab samples from sampling ports at the feed tank, after each treatment column on the ISTP, and the effluent line. At least 200 mL of groundwater should be sampled during each sampling event to provide sufficient volume for solution analyses and an archive sub-sample for reanalysis should data anomalies arise. Analyses should be performed at a laboratory with a quality assurance program compliant with ASME NQA-1. A recommended analysis turnaround time is 7 - 14 days from sample receipt, with samples sent to the chosen laboratory within one week of their collection date. Sample delivery and analysis turnaround time may be adjusted as needed under an adaptable sampling and analysis approach. For instance, samples collected in the first 5 – 10 days may require a faster sample delivery and analysis turnaround time than what is recommended above. Flow rate, solution pH, and temperature will be monitored by flow meter (or flow totalizer) or immersion probe at a frequency equal to or greater than grab sample collection events.

Based on historical 200W P&T data for Dowex 21K and Purolite A532E, and laboratory experiments evaluating Tc, U, Cr(VI), and I-127 (non-radiological surrogate for I-129) uptake by select candidate hybrid resins, grab samples collected at least 5 times a day (assuming 10 hour coverage, e.g., sampling at 2-hour intervals) for the first four days of testing is recommended to resolve the I-129 and Cr(VI) breakthrough curves from a ISTP single treatment column (not in sequence). After this 4-day period of high frequency sampling, grab samples will be collected daily through the first 10 days (Monday – Sunday). For tests days 11 – 90, daily sampling will continue but for normal working days only (Monday – Thursday). Those ISTP tests carried out for more than 90 days in Phase 2 will continue sampling at a frequency of 2 days per week within the normal Monday – Thursday work schedule (e.g., sample on Monday and Thursday). The sampling frequency described may be changed to capture the anticipated different breakthrough curves for Tc, U, Cr(VI), and I-129 and/or decreased during periods of equilibrium or little change in breakthrough.

For Phase 1, where hybrid resin performance is being compared to the breakthrough curves of Purolite A532E and/or Dowex 21K, tests should be carried out until the start of breakthrough is observed for Tc on Purolite A532E and U on Dowex 21K. Note, that for these resins, observation of complete breakthrough is not required. It is anticipated that these tests will require up to approximately 90 days to meet this criterion, but if breakthrough occurs before or after the 90th day, the duration of the test may be adjusted. This assumes that the ISTP is operating at an average linear velocity (0.88 ft/min) and breakthrough is monitored for individual treatment columns (not sequentially configured).

For Phase 2, each treatment column added to the treatment sequence will increase the test duration. For example, using columns A1, A2, and A3 will likely require 270 days to complete the same test. The flow rate and resin column configuration may be used to adjust the duration of a test. The sampling frequency is expected to decrease after early contaminant breakthrough curves are collected in Phase 2 based on results from the Phase 1 testing.

After test completion, a sub-sample of the resin from each column used during the evaluation will be collected and sent to PNNL for further characterization. An estimated 50 mL of resin is needed for characterization purposes, but this amount may be adjusted as needed.

All samples collected during ISTP testing will be labeled with the following information using water resistant materials:

- Unique sample identification number
- Sample collection date/time
- Volume of water treated (provided by sampling location flow totalizer)
- Name of person collecting the sample
- Analyses required
- Preservation method (if required)
- Sampling authorization form

A barcode or quick-response code that may be scanned to retrieve this information may also be used as a method of labeling per approval of the technical lead and demonstration that quality control procedures are followed.

Table 6. Summary of ISTP sampling events and analytical recommendations[*]

ISTP Sampling Metrics			
Parameter	*Recommendation*		*Comment*
Aqueous Grab Sampling Frequency	5+ per day	Days 1 - 4	Resolve early breakthrough of non-selective COCs, e.g., Cr(VI) and I-129, and anions
Aqueous Grab Sampling Frequency	Daily (Monday – Sunday)	Days 5 - 10	Resolve possible delayed breakthrough of non-selective COCs, e.g., Cr(VI) and I-129, and anions
Aqueous Grab Sampling Frequency	Daily (Monday – Thursday)	Days 11 - 90	Resolve breakthrough curves of removed COCs through individual or the first treatment column in a sequence
Aqueous Grab Sampling Frequency	2x weekly (Monday and Thursday)	Days 91+	Resolve breakthrough curves of removed COCs in sequenced treatment columns (Phase 2)
Number of Sampling Events	70	Phase 1	Assumes a 3-month test with samples collected
	122	Phase 2	Assumes a 9-month test with samples collected
Total Samples Collected	700[*]	Phase 1	Assumes a 3-month test, 8 resins tested in parallel
	1220[*]	Phase 2	Assumes column sequence sets A1 – A4 and B1 – B4 are operated for a 9-month test. If less columns are used, the number of samples will decrease.
Grab Sample Volume	200 mL		Sufficient for solution analyses and an archive sub-sample for re-analysis if data anomalies are identified.
Spent Resin Sample	50 mL		For solid phase characterization

Recommended Analysis Requirements[**]			
Analytical Constituent	*Suggested Method*[^]	*Precision*	*Required Quantitation Limit*
Cr(VI)	IC – ICP-MS for Cr(VI) speciation	±25%	5 µg/L
Total Cr	ICP-MS	±25%	10 µg/L
I-129	ICP-MS or Separation/Gamma Spectroscopy	±25%	0.001 µg/L (0.18 pCi/L)
Tc	ICP-MS (or LSC)	±25%	0.01 µg/L (170 pCi/L)
U	ICP-MS	±25%	5 µg/L
Nitrate	IC	±25%	75 µg/L
Nitrite	IC	±25%	75 µg/L
Sulfate	IC	±25%	75 µg/L
Chloride	IC	±25%	75 µg/L
Cations	ICP-OES	±25%	10 µg/L
Alkalinity	Titration	±25%	1 µg/L
TOC	Carbon analyzer	±25%	1 µg/L
TC	Carbon analyzer	±25%	1 µg/L
pH	Immersion probe	±0.2 Standard Units	0.01 Standard Units
Temperature	Immersion probe	±2 °C	±0.1 °C

[*] This sampling plan represents a fixed sampling schedule and the expected number of samples and analyses performed are for the purpose of budgeting and planning ISTP tests. The breakthrough curves collected from Phase 1 will be used to revise the sampling frequency and analyses in Phase 2.

[**] Analyses should be performed at a laboratory with a quality assurance program compliant with ASME NQA-1.

[^] IC: ion chromatography; ICP-MS: inductively coupled plasma mass spectrometry; ICP-OES: inductively coupled plasma optical emission spectroscopy; LSC: liquid scintillation counting.

6.0 Resin Performance Evaluation

The performance of each resin will be based on Tc, U, Cr(VI), and/or I-129 removal as defined by the concentrations of the contaminants in the effluent and their breakthrough curves. The best performing resins are expected to demonstrate: (i) capacity to remove multiple contaminant anions from groundwater; (ii) measurable removal of Cr(VI) and/or I-129, and/or (iii) contaminant removal to below the final cleanup level for contaminants targeted by the resin: Tc $\leq$ 900 pCi/L, U $\leq$ 30 µg/L, Cr(VI) $\leq$ 48 µg/L, and I-129 $\leq$ 1 pCi/L. Other factors contributing to resin performance evaluation include resin cost, and the performance of the resins for Tc and U removal compared to the IX resins currently used in 200W P&T to treat these contaminants, Purolite A532E and Dowex 21K. These resins are expected to be used as single-use resins and regeneration is not an evaluation factor.

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Appendix A – Hybrid Resins Background Information

Commercial ion exchange (IX) resins are based on a polymer backbone, such as epoxy, or a copolymer of styrene and divinylbenzene, that is functionalized with IX sites. By incorporating different functional group(s), IX resins can selectively remove ions with specific properties, like size, charge, and hydration energy. Due to this ion specificity, different IX resins are required to sequentially remove each contaminant separately from the groundwater. The resins currently in use at 200W P&T are strong base anion (SBA) resins, Purolite A532E and Dowex 21K. Purolite A532E consists of bifunctional quaternary amine (triethylammonium and trihexylammonium) functional groups to remove the large, weakly hydrated pertechnetate anion. Dowex 21K contains trimethylammonium functional groups to remove uranyl carbonate species.

The properties of IX resins can be tuned by optimizing several parameters (Table A1). In addition, resins can be hybridized to remove multiple contaminants by incorporating metal oxyhydroxides (Appendix A.1), or redox active functional groups (Appendix A.2). The concurrent removal of co-mingled U, Tc, Cr(VI), and I-129 by several emerging and commercially available hybrid IX resins has been evaluated in laboratory tests (Table A2). The performance of these resins in laboratory testing will be used to select candidate resins for ISTP test campaigns.

Table A1. Anion IX resin characteristics that can be optimized for performance

Resin Characteristics	Examples
Parent backbone	• Styrene and divinylbenzene copolymer • Epoxy polyamine
Physical form	• Gel – no porosity in dry state (higher capacity) • Macroporous –permanent pores even in dry state (faster kinetics)
Functional groups	• Trimethylamine • Dimethyl-ethanolamine • Tetraethylenepentamine
Metal	• Iron • Cerium • Bismuth • Manganese
Metal form	• Oxide • Oxyhydroxide • Hydroxide • Chloride • Oxychloride
Exchangeable ion	• Chloride • Nitrate • Sulfate • Carbonate
Anion removal mechanism	• Ion exchange • Ion complexation • Sorption • Redox reaction and precipitation

Table A2. Selected candidate resins for contaminant removal from groundwater

SBA (Parent) Resins					
Resin	*Manufacturer*	*Functional Group(s)*	*Structure*	*Manufacturer Exchange Capacity (meq/mL)*	*Potential Contaminants / Anions Treated*
A532E	Purolite	Trihexylamine, Triethylamine	Gel	>0.6	TcO_4^-, NO_3^-
Dowex 21K	Dowex	Quaternary Trimethylammonium	Gel	>1.2	U, SO_4^{2-}
SIR-110-MP	ResinTech	Tributylamine	Macroporous	>0.6	TcO_4^-, NO_3^-, I^-
SIR-110-HP	ResinTech	Tributylamine	Gel	>0.8	TcO_4^-, NO_3^-, I^-
SBG1	ResinTech	Trimethylamine	Gel	>1.4	U, $Cr(VI)O_4^{2-}$, NO_3^-, SO_4^{2-}, trace contaminants
SBG2	ResinTech	Dimethylethanolamine	Gel	>1.4	U, $Cr(VI)O_4^{2-}$, NO_3^-, SO_4^{2-}, CO_3^{2-}, trace contaminants
PGW6002E	Purolite	Quaternary Ammonium	Gel	>1.65	U, $Cr(VI)O_4^{2-}$, SO_4^{2-}

WBA Hybrid Resins					
Resin	*Manufacturer*	*Functional Group(s)*	*Structure*	*Manufacturer Exchange Capacity (meq/mL)*	*Potential Contaminants / Anions Treated*
SIR-700-HP	ResinTech	Tetraethylenepentamines	Gel	>2.1	$Cr(VI)O_4^{2-}$, U, TcO_4^-, IO_3^-
SIR-400-MP	ResinTech	Thiouronium	Macroporous	>1.6	$Cr(VI)O_4^{2-}$, U, TcO_4^-, IO_3^-
S106	Purolite	Polyamines	-	>2.0	$Cr(VI)O_4^{2-}$, U
S920	Purolite	Thiouronium	Macroporous	>1.0	$Cr(VI)O_4^{2-}$, U, TcO_4^-, IO_3^-
AmberSep 43600 C	Dupont	Thiouronium	Macroporous	≥0.7	$Cr(VI)O_4^{2-}$, U, TcO_4^-, IO_3^-

Hybrid Resins						
Resin	*Manufacturer*	*Parent Resin*	*Hybrid Metal*	*Hybrid Metal Phase*	*Hybrid Metal Loading (g/kg moist resin)*	Potential Contaminants / Anions Treated
CHM-10	ResinTech	SBG1	Ce	Ce(III/IV) Oxide/hydroxide, Ceria *(assumed)*	55.1	IO_3^-, I^-, TcO_4^-
SIR-110-MP-Ce	ResinTech	SIR-110-MP	Ce	Ce(III/IV) Oxide/hydroxide, Ceria[13]	67.9	IO_3^-, I^-, TcO_4^-
SIR-110-HP-Ce	ResinTech	SIR-110-HP	Ce	Ce(III/IV) Oxide/hydroxide, Ceria *(assumed)*	Unknown	IO_3^-, I^-, TcO_4^-
CHM-20	ResinTech	SBG2	Ce	Ce(III/IV) Oxide/hydroxide, Ceria[14]	55.4	IO_3^-, I^-, TcO_4^-
SIR1300	ResinTech	SBG1	Mn	Mn (oxyhydr)oxide[13]	9.6	IO_3^-
SIR-110-MP-Bi	ResinTech	SIR-110-MP	Bi	Bismutite, Bismuclite[13]	31.3	TcO_4^-, CrO_4^{2-}, U, IO_3^-
SBG1-Bi	ResinTech	SBG1	Bi	Bismuclite[14]	22.8	TcO_4^-, CrO_4^{2-}, U, IO_3^-
SIR-110-HP-Fe	ResinTech	SIR-110-HP	Fe	Ferrihydrite[15]	Unknown	IO_3^-, TcO_4^-
SIR-110-MP-Fe	ResinTech	SIR-110-MP	Fe	Ferrihydrite[16]	41	IO_3^-, TcO_4^-
ASM-10-HP	ResinTech	SBG2	Fe	Ferrihydrite[14]	96.3 – 115	IO_3^-, TcO_4^-
ASM-125	ResinTech	SBG1	Fe	Ferrihydrite, Hematite[14]	122	IO_3^-, TcO_4^-
FerrIX A33E	Purolite	Unknown	Fe	Fe Oxide	Unknown	IO_3^-

A.1 Hybrid IX resins with incorporated metal oxyhydroxides

In addition to IX, hybrid resins can target removal of specific contaminant(s) by a secondary mechanism involving the incorporation of a metal oxyhydroxide. Several materials, including cerium (Ce), bismuth (Bi), manganese (Mn), and iron (Fe) oxyhydroxides, have been shown to remove IO_3^-, TcO_4^-, CrO_4^{2-}, and/or uranyl carbonates from Hanford groundwater.[14-15,17-18] A limited number of hybrid resins that incorporate these metal oxyhydroxides within an SBA resin have been synthesized by resin manufacturers and are described below.

A.1.1 Cerium (Ce)-Based Hybrid Resins

Several Ce-based hybrid resins have been produced by ResinTech Inc. (Camden, NJ), including CHM-10, CHM-20, and SIR-110-MP-Ce. The CHM-10 and CHM-20 hybrid resins have a SBA parent backbone containing trimethylamine groups (SBG1, ResinTech) and a SBA parent backbone containing dimethylethanolamine groups (SBG2, ResinTech), respectively, with Ce(III/IV) oxide/hydroxide dispersed through the polymer. In a study by Cordova et al. (2020), batch experiments showed that 0.2 mg of iodine (added as IO_3^-) per gram of CHM-20 could be removed from a synthetic Hanford groundwater solution within 24 hours using a 200 mL/g solution:solid ratio, resulting in a calculated distribution coefficient (K_d) value of 1.27×10^6 mL/g for iodine as iodate.[14] Sulfate (SO_4^{2-}) was also removed by CHM-20, suggesting that SO_4^{2-} (present in the 200W P&T remediation area at concentrations in the hundreds of mg/L range [19-20]) may compete for active sites during removal of IO_3^- from actual Hanford groundwater. CHM-20 also removed IO_3^- in column studies under flow conditions, with 50% breakthrough reached after 324 pore volumes (pore volume = 0.575 mL).[14] The CHM-20 hybrid resin was analyzed by X-ray diffraction (XRD), with the broad peaks in the diffraction pattern corresponding to nanocrystalline ceria (CeO_2). However, batch sorption tests with just nano-CeO_2 revealed very little IO_3^- removal, suggesting that CeO_2 was an inactive component. Therefore, the removal mechanism was hypothesized to be sorption/reaction with an amorphous Ce hydroxide phase in CHM-20, with iodine remaining in the +V oxidation state, as no reduction to iodide was observed. CHM-20 was also shown to remove technetium (as TcO_4^-) in batch experiments (K_d of 3.92×10^5).

The SIR-110 Ce hybrid resins have an SBA parent backbone containing tributylamine groups (SIR-110, ResinTech) with Ce (III/IV) oxide/hydroxide dispersed through the polymer. This hybrid resin is available in two different polymer matrices: (1) SIR-110-HP, a gel polystyrene structure with 8% divinylbenzene crosslinking and nm sized pores; and (2) SIR-110-MP-HP, a macroporous polystyrene structure with 20-25% divinylbenzene crosslinking and an average pore size of 0.6 µm.[21] In general, the stability and radiation resistance of IX resins increase with increasing cross-linkage, [22] and water retention is ~11 % higher for macroporous than for gel-type resins.[23] Asmussen et al. (2023) used both CHM-20 and the gel SIR-110-HP-Ce hybrid resins to remove iodine as both iodide (I^-) and IO_3^- from a simulated nuclear waste stream.[15] CHM-20 removed 87-89% of IO_3^- (14 µM, 2 mg/L I as IO_3^-) and SIR-110-HP-Ce removed ~49% of IO_3^- and 99.7% of I^- added to the nuclear waste simulant in 2 hours. CHM-20 did not perform as well in column tests, revealing the potential kinetic limitations of the resin under flow conditions.[15]

A.1.2 Iron (Fe)-Based Hybrid Resins

Natural and engineered Fe-based materials have been shown to remove many contaminants from solution. For example, zero valent iron and Fe(II)-based materials facilitate redox reactions that convert metal contaminants, such as Cr(VI) and Tc(VII), to stable, reduced forms that limit their mobility and toxicity in the environment.[18] In addition to redox reactions, the Fe phases formed often have the capacity to incorporate these contaminants into their crystal structure, making contaminants less susceptible to reoxidation and release into the environment.[18,24-29]

Several Fe-based hybrid resins have been produced by ResinTech Inc., ASM-10-HP is an SBA resin with dimethylethanolamine groups (SBG2) that contains hydrated iron oxide as the functional material. ASM-125 hybrid resin also uses hydrated iron oxide but with an SBA resin backbone functionalized with trimethylamine groups (SBG1). The gel SIR-110-HP-Fe hybrid resin has hydrated iron oxide with an SBA parent backbone, functionalized with tributylamine groups (SIR-110-HP). SIR-110-HP-Fe is also available in macroporous form (SIR-110-MP-Fe).

Cordova et al. (2020) reported an iodine K_d value of 1.14×10^5 mL/g for ASM-125 resin and 8.57×10^5 mL/g for ASM-10-HP in batch experiments with synthetic Hanford groundwater using a 200 mL/g solution:solid ratio.[14] As with the Ce-based hybrid resins, this shows that the dimethylethanolamine groups in ASM-10-HP had a higher affinity for IO_3^- than the trimethylamine groups in ASM-125. Technetium K_d values of 5.63×10^5 mL/g for ASM-125 resin and 4.08×10^5 mL/g for ASM-10-HP were also measured. XRD analysis revealed that the iron-bearing phase in the ASM-10-HP resin is two-line ferrihydrite ($Fe^{3+}{}_{10}O_{14}(OH)_2$), which performs well by itself as a sorbent material for IO_3^- (K_d = 83900 mL/g). Two-line ferrihydrite was also found in SIR-110-HP-Fe,[15] and SIR-110-MP-Fe as well.[13] However, the ASM-125 XRD pattern contains hematite (Fe_2O_3) as well as ferrihydrite.[14] Ferrihydrite gradually transforms into more thermodynamically stable and more crystalline hematite over time, but the transformation rate increases with increasing temperature, suggesting that the synthesis conditions for ASM-125 likely involve higher temperatures than for ASM-10-HP.[30] Transformation of ferrihydrite to hematite results in a decrease in surface area and a corresponding reduction in sorption capacity of the functional material, which may explain why ASM-125 has a lower iodine K_d value than ASM-10-HP. Both ferrihydrite and hematite are Fe(III)-based minerals; therefore, the removal mechanism for both Fe-based hybrids would not involve reduction of IO_3^-, TcO_4^-, CrO_4^{2-}, or uranyl carbonate.

A.1.3 Bismuth (Bi)-Based Hybrid Resins

Bi-based materials are gaining attention as viable remediation technologies for groundwater contamination because they are inexpensive, commercially available, easy to deploy as an in situ treatment, and environmentally friendly.[16,31-32] Lawter et al. (2021) showed that Bi oxyhydroxide ($(BiO)_x(OH)(NO_3)_m(CO_3)_n$) exhibited high uptake capacity for removal of the negatively charged, co-mingled contaminants of concern (IO_3^-, CrO_4^{2-}, TcO_4^-, and uranyl carbonate species) from simulated Hanford groundwater.[31,33] Bi-based materials have an adaptable structure that transforms on contact with aqueous solutions to incorporate, sorb, or exchange different contaminant species. The transformation of Bi-based materials is driven by aqueous chemistry, and this can affect how, and to what extent, contaminants are removed by these materials. For example, in simulated Hanford groundwater, Bi oxyhydroxide transforms to bismutite ($Bi_2O_2(CO_3)$) which can (i) incorporate CrO_4^{2-} and IO_3^- anions through IX with CO_3^{2-} in the structure; (ii) immobilize uranium through complexation with CO_3^{2-} in the structure; and (iii) uptake TcO_4^- through formation of an outer-sphere complex.[31]

Co-mingled contaminant removal by Bi-based materials has led to the development of ex situ deployable forms. ResinTech has synthesized Bi-based hybrid resins with an SBA resin backbone and trimethylamine functional groups (SBG1) or tributylamine functional groups (SIR-110-MP), using two different Bi precursors (Bi-chloride, $BiCl_3$, or Bi-nitrate, $Bi(NO_3)_3$). Currently, these deployable resins containing Bi-based materials have only been reported in the literature for removal of IO_3^-.[14-15]

The Bi-based functional material in SBG1, prepared using $BiCl_3$ as the precursor, was determined to be poorly crystalline Bi oxychloride (BiOCl) by XRD.[14] This SBG1-Bi hybrid resin had an iodine K_d value of 1.54 × 10^4 mL/g (when the mass of hybrid resin was added to give a metal content of 0.1 g), which is an order of magnitude less than the K_d value determined for Fe-based SBG1 and SBG2 hybrid resins (ASM-125 and ASM-10-HP), and two orders of magnitude less than Ce-based SBG2 hybrid resin (CHM-20).[14] Asmussen et al. (2023) also showed that this ResinTech SBG1-Bi hybrid resin (synthesized from $BiCl_3$) only removed ~50% of IO_3^- from a high carbonate simulated spent caustic scrubber solution containing IO_3^- (14 μM, 2 mg/L I as IO_3^-) within 2 hours [15]. Previous studies have shown that BiOCl is not the active form involved in uptake of anionic contaminants [31]. Therefore, a Bi-based hybrid resin (SIR-110-MP-Bi) prepared by ResinTech using $Bi(NO_3)_3$ as the precursor and a SBA parent backbone functionalized with tributylamine groups (SIR-110-MP-HP) was evaluated for IO_3^- removal. SIR-110-MP-Bi did not remove any IO_3^- during batch tests. The lack of IO_3^- removal suggests that the bismutite and bismuclite phases (confirmed by XRD) incorporated into the hybrid resin are ineffective at removing IO_3^- and the large crystal size of these phases limited access to IX sites.[13] Thus, the Bi-based hybrid resins require further optimization, and demonstrated performance in laboratory tests, to be considered as candidates for ISTP tests.

A.1.4 Manganese (Mn)-Based Hybrid Resins

Manganese oxyhydr(oxides) participate in oxidation, reduction, and sorption processes with anionic species in solution, including arsenate (AsO_4^{3-}). ResinTech Inc. has produced an Mn-based hybrid resin, SIR-1300, with an SBA parent backbone containing dimethylethanolamine groups (SBG2, ResinTech) and manganese oxide dispersed through the polymer matrix. SIR-1300 is used for the removal of ferrous iron (Fe^{2+}) from potable water, via reduction to insoluble ferrous ion (Fe^{3+}) oxides. There were no discernable features in the XRD pattern for SIR-1300 beyond the broad peak from the parent resin; therefore, the Mn oxyhydr(oxide) phase is amorphous.[13] In deionized water, with no competing ions present, the amount of IO_3^- removed from solution by SIR-1300 was the same as that for the SBG2 parent backbone, suggesting that IX was the dominant removal mechanism and addition of Mn oxyhydr(oxide) did not offer significant improvement.

A.2 Hybrid IX resins with redox active functional groups

Weak base anion (WBA) resins are functionalized with primary (R-NH2), secondary (R-NHR'), or tertiary (R-NR'2) amine groups that only sorb strong acids, with a limited exchange capacity above pH 7.0. WBA *hybrid* resins incorporate additional removal mechanisms, including redox reactions and precipitation. One example of a WBA hybrid resin is ResinTech's SIR-700 (SIR-700) designed to remove Cr(VI) via a two-step removal process that has successfully been implemented at P&T facilities for groundwater remediation in the 100 Area (river corridor) at the Hanford Site.[10,34-36] In its acid sulfate (HSO_4^-/SO_4^{2-}) form, SIR-700 first exchanges CrO_4^{2-} for SO_4^{2-} present in the resin through electrostatic interactions with protonated amine sites on the resin backbone. Then, by addition of sulfuric acid to decrease the groundwater pH from >7 to between 5 – 7, a secondary reaction occurs that causes chromium to precipitate inside the resin matrix. More specifically, by decreasing the groundwater pH to below 7, CrO_4^{2-} converts to $HCrO_4^-$ and the acidic environment of the resin allows further protonation to form H_2CrO_4. It is hypothesized that H_2CrO_4 can then oxidize the secondary alcohols on the resin backbone to ketones via the Jones reaction and in the process Cr(VI) is reduced to Cr(III) to form an amorphous Cr(III) hydroxide phase.[10,36] This class of hybrid resins can be superior to SBA exchange resins – like

Purolite A532E and Dowex 21K – for Cr(VI) treatment when there are higher concentrations of competing anions and/or total dissolved solids present, as these resins are less impacted by competing species.[36-37] Furthermore, previous work has shown that SIR-700 has the potential to remove all contaminants of interest (CrO_4^{2-}, TcO_4^-, IO_3^-, and $UO_2(CO_3)_x^{2-2x}$).[10] Other examples of a WBA hybrid resins include ResinTech's SIR-400, Purolite's S920 and Dupont's AmberSep 43600C, designed to remove mercury and remove/recover precious metals. The thiouronium functional group in these resins could potentially act as a reducing agent for redox active contaminants of interest, resulting in the reductive precipitation of Cr(III) hydroxide, $Tc(IV)O_2$, and $U(IV)O_2$ within the resin, and/or reduction of $I(V)O_3^-$ to I^- with subsequent capture of I^- by IX. SIR-400 will be evaluated in FY24 laboratory tests.

Appendix B – Available Hybrid Resins Safety Datasheets

SAFETY DATA SHEET

ASM-10-HP

(Strong Base Anion Exchange Resin in the Chloride Form impregnated with hydrated iron oxide) Effective date 1 January 2021

SECTION 1: Identification	
1A: Product Name	ResinTech ASM-10-HP
1B: Common Name	Strong base anion resin in the chloride form impregnated with hydrated iron oxide.
1C: Intended use	Arsenic removal from potable water and other general anion exchanges.
1D: Manufacturer Address	ResinTech, Inc. 1801 Federal Street, Camden, NJ 08105 USA
Contact Information:	856-768-9600 ixresin@resintech.com

SECTION 2: Hazard Identification	
2A: OSHA Hazard classification 0 = Negligible 1 = Slight 2 = Moderate 3 = High 4 = Extreme	Not hazardous or dangerous Health - 0 (0 = Negligible) Fire - 1 (1 = Slight) Reactivity - 0 (0 = Negligible) Special – N/A
WARNING	(contains ion exchange resin) H320: Causes eye irritation (Category 2B)

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SECTION 2: Hazard Identification Continued	
Precautionary Statements	P264: Wash hands thoroughly after handling. P280: Wear protective gloves/protective clothing/eye protection/face protection P305+351+338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing. P333+313: If skin irritation or a rash occurs: Get medical advice/attention. P337+313: If eye irritation persists get medical advice/attention. P403+233: Store in a well-ventilated place. Keep container tightly closed. P411: Store at temperatures not exceeding 50 °C/ 122 °F.
2B: Product description	Black or red colored solid beads approximately 0.6 mm diameter with little or no odor.
2C: Precautions for use	Safety glasses and gloves recommended. Slipping hazard if spilled.
Potential health effects	Will cause eye irritation. May cause mild skin irritation. Ingestion is not likely to pose a health risk.
2D: Environmental effects	This product may alter the pH of any water that contacts it.

SECTION 3: Composition/ Information on Ingredients	
3A: Chemical name	Dimethyl ethanolamine functionalized chloromethylated copolymer of polystyrene in the chloride form impregnat-ed with hydrated iron oxide.
3B: Ingredients: Ferric hydroxide	CAS# 20344-49-4 (10 – 20%)
Dimethyl-ethanolamine functionalized chloromethlyated copolymer of styrene and divinylbenzene in the chloride form	CAS# 69011-15-0 (35 - 50%)
Water	CAS# 7732-18-5 (30 – 45%)

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RESINTECH INC.
INNOVATIONS IN ION EXCHANGE

SECTION 4: First Aid Measures	
4A: Inhalation	No adverse effects expected- normal use of product does not produce odors or vapors.
4B: Skin	Wash with soap and water- seek medical attention if a rash develops.
4C: Eye contact	Wash immediately with water-seek attention if discomfort continues.
4D: Ingestion	No adverse effects expected for small amounts, larger amounts can cause stomach irritation. Seek medical attention if discomfort occurs.

SECTION 5: Fire Fighting Measures	
5A: Flammability	NFPA Fire rating = 1
5B: Extinguishing media	Water, CO_2, foam, dry powder
5C: Fire fighting Procedures	Follow general fire fighting procedures indicated in the work place. Seek medical attention if discomfort continues.
5D: Protective Equipment	MSHA/NIOSH approved self-contained breathing gear, full protective clothing.
5E: Combustion Products	Carbon oxides and other toxic gasses and vapors.
5F: Unusual Hazards	Product is not combustible until moisture is removed. Resin begins to burn at approximately 230º C. Auto ignition can occur above 500º C.

SECTION 6: Accidental Release Measures	
6A: Personal Precautions	Keep people away, spilled resin can be a slipping hazard, wear gloves and safety glasses to minimize skin or eye contact.
6B: Incompatible Chemicals	Strong oxidants can create risk of combustion products similar to burning.
6C: Environmental Precautions	Keep out of public sewers and waterways.
6D: Containment Materials	Use plastic or paper containers.
6E: Methods of Clean-up	Sweep up material and transfer to containers.

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SECTION 7: Handling and Storage	
7A: Handling	Avoid prolonged skin contact. Avoid contact with salts or with salty water to prevent premature exhaustion of the resin. Keep resin moist and avoid allowing resin to completely dry.
7B: Storage	Store in a cool dry place (0º to 45º C) in the original shipping container. This product is thermally sensitive and will have reduced shelf life if subjected to extended periods of time at temperatures exceeding 45º C. Although freezing does not usually damage ion exchange resins, avoid repeated freeze thaw cycles.

SECTION 8: Exposure Controls/Personal Protection	
8A: Personal Precautions	None noted.
8B: Incompatible Chemicals	Provide adequate ventilation.
8C: Personal Protection Measures	Eye Protection- Safety glasses or goggles. Respiratory Protection - Not required for normal use. Protective Gloves - Recommended for extended contact.

SECTION 9: Physical and Chemical Properties	
Appearance	Black or red beads approx 0.6 mm diameter.
Flammability or explosive limits	Flammable above 500º C
Odor	Little or no odor
Physical State	Solid
Vapor pressure	N/A
Odor threshold	N/A
Vapor density	N/A
pH	Near neutral.
Relative density	Approx 800 grams/Liter
Melting point/freezing point	Does not melt, freezes at approx. 0 C
Solubility	Insoluble in water and most solvents
Boiling point	Does not boil
Flash point	Approx 500º C
Evaporation rate	Does not evaporate

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SECTION 9: Physical and Chemical Properties Continued	
Partition Coefficient (n-octonol/water)	Not applicable
Auto-ignition temperature	Approx 500º C
Decomposition temperature	Above 230º C
Viscosity	N/A

SECTION 10: Stability and Reactivity	
10A: Stability	Stable under normal conditions.
10B: Conditions to Avoid	Heat, exposure to strong oxidants.
10C: Hazardous by-products	Dimethyl-ethanolamine, charred polystyrene, aromatic acids and hydrocarbons, organic amines, nitrogen oxides, carbon oxides, chlorinated hydrocarbons.
10D: Incompatible materials	Strong oxidizing agents (such as HNO_3)
10E: Combustion Products	Does not occur

SECTION 11: Toxicological Information	
11A: Likely Routes of Exposure	Oral, skin or eye contact.
11B: Effects of exposure	Delayed - None known. Immediate (acute) - None known. Chronic - None known.
11C: Toxicity Measures	Skin Adsorption - Unlikely, Ingestion - Oral toxicity believed to be low but no LD50 has been established. Inhalation - None known.
11D: Toxicity Symptoms	Skin Adsorption - Mild rash. Ingestion - Indigestion or general malaise. Inhalation - Unknown.
11E: Carcinogenicity	None known

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corporate headquarters 1801 Federal Street Camden, NJ 08105 USA phone 856.768.9600 fax 856.768.9601 email info@resintech.com web resintech.com

ResinTech Inc. INNOVATIONS IN ION EXCHANGE

SECTION 12: Ecological information	
12A: Eco toxicity	Not acutely harmful to plant or animal life.
12B: Mobility	Insoluble
12C: Biodegradability	Not biodegradable.
12D: Bioaccumulation	Insignificant.
12E: Other adverse effects	Not Harmful to the environment.

SECTION 13: Disposal Considerations	
13A: General considerations	Material is non-hazardous.
13B: Disposal Containers	Most plastic and paper containers are suitable.
13C: Disposal methods	No specific method necessary
13D: Sewage Disposal	Not recommended
13E: Precautions for incineration	May release organic amines and toxic vapors whenburned.
13F: Precautions for landfills	Resins used to remove hazardous materials may then become hazardous mixtures.

SECTION 14: Transportation Information	
14A: Transportation Class	Not classified as a dangerous good for transport by land, sea, or air.
14B: TDG	Not regulated.
14C: IATA	Not regulated.
14D: DOT (49 CFR 172.101)	Not regulated.

SECTION 15: Regulatory Information	
15A: CERCLA	Not regulated
15B: SARA Title III	Not regulated
15C: Clean Air act	Not regulated
15D: Clean Water Act	Not regulated
15E: TSCA	Not regulated
15F: Canadian Regulations	WHMIS - Not a controlled product TDG - Not regulated
15G: Mexican Regulations	Not Dangerous

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ResinTech Inc. INNOVATIONS IN ION EXCHANGE

SECTION 16: Other Information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features. Regulatory requirements are subject to change and may differ from one location to another. It is the buyer's responsibility to ensure that their activities comply with federal, state, and local laws.

16A: Date of Revision	1 January 2021

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RESINTECH INC. INNOVATIONS IN ION EXCHANGE

SAFETY DATA SHEET

ASM-125

(Strong Base Anion Exchange Resin in the chloride form impregnated with hydrated iron oxide)

Effective date 1 January 2021

SECTION 1: Identification	
1A: Product Name	ResinTech ASM-125
1B: Common Name	Strong base anion resin in the chloride form impregnated with hydrated iron oxide.
1C: Intended use	Arsenic removal from potable water and other general anion exchanges.
1D: Manufacturer Address	ResinTech, Inc. 1801 Federal Street, Camden, NJ 08105 USA
Contact Information:	856-768-9600 ixresin@resintech.com

SECTION 2: Hazard Identification	
2A: OSHA Hazard classification 0 = Negligible 1 = Slight 2 = Moderate 3 = High 4 = Extreme	Not hazardous or dangerous Health - 0 (0 = Negligible) Fire - 1 (1 = Slight) Reactivity - 0 (0 = Negligible) Special – N/A
! WARNING	(contains ion exchange resin) H320: Causes eye irritation (Category 2B)

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RESINTECH INC.
INNOVATIONS IN ION EXCHANGE

SECTION 2: Hazard Identification Continued	
Precautionary Statements	P264: Wash hands thoroughly after handling. P280: Wear protective gloves/protective clothing/eye protection/face protection P305+351+338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing. P333+313: If skin irritation or a rash occurs: Get medical advice/attention. P337+313: If eye irritation persists get medical advice/attention. P403+233: Store in a well-ventilated place. Keep container tightly closed. P411: Store at temperatures not exceeding 50 °C/ 122 °F.
2B: Product description	Black or red colored solid beads approximately 0.6 mm diameter with little or no odor.
2C: Precautions for use	Safety glasses and gloves recommended. Slipping hazard if spilled.
Potential health effects	Will cause eye irritation. May cause skin irritation. Ingestion is not likely to pose a health risk.
2D: Environmental effects	This product may alter the pH of any water that contacts it.

SECTION 3: Composition/ Information on Ingredients	
3A: Chemical name	Trimethylamine functionalized chloromethylated copolymer of polystyrene in the chloride form impregnated with hydrated iron oxide.
3B: Ingredients: Ferric hydroxide	CAS# 20344-49-4 (10 – 20%)
Trimethylamine functionalized chloromethlyated copolymer of styrene and divinylbenzene in the chloride form	CAS# 60177-39-1 (35 - 50%)
Water	CAS# 7732-18-5 (30 – 45%)

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RESINTECH INC. INNOVATIONS IN ION EXCHANGE

SECTION 4: First Aid Measures	
4A: Inhalation	No adverse effects expected- normal use of product does not produce odors or vapors.
4B: Skin	Wash with soap and water- seek medical attention if a rash develops.
4C: Eye contact	Wash immediately with water-seek attention if discomfort continues.
4D: Ingestion	No adverse effects expected for small amounts, larger amounts can cause stomach irritation. Seek medical attention if discomfort occurs.

SECTION 5: Fire Fighting Measures	
5A: Flammability	NFPA Fire rating = 1
5B: Extinguishing media	Water, CO_2, foam, dry powder
5C: Fire fighting Procedures	Follow general fire fighting procedures indicated in the work place. Seek medical attention if discomfort continues.
5D: Protective Equipment	MSHA/NIOSH approved self-contained breathing gear, full protective clothing.
5E: Combustion Products	Carbon oxides and other toxic gasses and vapors.
5F: Unusual Hazards	Product is not combustible until moisture is removed. Resin begins to burn at approximately 230º C. Auto ignition can occur above 500º C.

SECTION 6: Accidental Release Measures	
6A: Personal Precautions	Keep people away, spilled resin can be a slipping hazard, wear gloves and safety glasses to minimize skin or eye contact.
6B: Incompatible Chemicals	Strong oxidants can create risk of combustion products similar to burning.
6C: Environmental Precautions	Keep out of public sewers and waterways.
6D: Containment Materials	Use plastic or paper containers.
6E: Methods of Clean-up	Sweep up material and transfer to containers.

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ResinTech Inc.
INNOVATIONS IN ION EXCHANGE

SECTION 7: Handling and Storage	
7A: Handling	Avoid prolonged skin contact. Keep resin moist and avoid allowing resin to completely dry.
7B: Storage	Store in a cool dry place (0º to 45º C) in the original shipping container. This product is thermally sensitive and will have reduced shelf life if subjected to extended periods of time at temperatures exceeding 50º C. Although freezing does not usually damage ion exchange resins, avoid repeated freeze thaw cycles.

SECTION 8: Exposure Controls/Personal Protection	
8A: Personal Precautions	None noted.
8B: Incompatible Chemicals	Provide adequate ventilation.
8C: Personal Protection Measures	Eye Protection- Safety glasses or goggles. Respiratory Protection - Not required for normal use. Protective Gloves - Recommended for extended contact.

SECTION 9: Physical and Chemical Properties	
Appearance	Amber, yellow, or red beads approx. 0.6 mm diameter.
Flammability or explosive limits	Flammable above 500º C
Odor	Little or no odor
Physical State	Solid
Vapor pressure	N/A
Odor threshold	N/A
Vapor density	N/A
pH	Near neutral. (6 to 8 typical)
Relative density	Approx 800 grams/Liter
Melting point/freezing point	Does not melt, freezes at approx. 0 C
Solubility	Insoluble in water and most solvents
Boiling point	Does not boil
Flash point	Approx 500º C
Evaporation rate	Does not evaporate

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SECTION 9: Physical and Chemical Properties Continued	
Partition Coefficient (n-octonol/water)	N/A
Auto-ignition temperature	Approx 500º C
Decomposition temperature	Above 230º C
Viscosity	N/A

SECTION 10: Stability and Reactivity	
10A: Stability	Stable under normal conditions.
10B: Conditions to Avoid	Heat, exposure to strong oxidants.
10C: Hazardous by-products	Trimethylamine, charred polystyrene, aromatic acids and hydrocarbons, organic amines, nitrogen oxides, carbon oxides, chlorinated hydrocarbons.
10D: Incompatible materials	Strong oxidizing agents (such as HNO_3)
10E: Combustion Products	Does not occur

SECTION 11: Toxicological Information	
11A: Likely Routes of Exposure	Oral, skin or eye contact.
11B: Effects of exposure	Delayed - None known. Immediate (acute) - None known. Chronic - None known.
11C: Toxicity Measures	Skin Adsorption - Unlikely, Ingestion - Oral toxicity believed to be low but no LD50 has been established. Inhalation -Unknown, vapors are very unlikely due to physical properties (insoluble solid).
11D: Toxicity Symptoms	Skin Adsorption - Mild rash. Ingestion - Indigestion or general malaise. Inhalation - None known.
11E: Carcinogenicity	None known

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RESINTECH INC. INNOVATIONS IN ION EXCHANGE

SECTION 12: Ecological information	
12A: Eco toxicity	Not acutely harmful to plant or animal life.
12B: Mobility	Insoluble
12C: Biodegradability	Not biodegradable.
12D: Bioaccumulation	Insignificant.
12E: Other adverse effects	Not Harmful to the environment.

SECTION 13: Disposal Considerations	
13A: General considerations	Material is non-hazardous.
13B: Disposal Containers	Most plastic and paper containers are suitable.
13C: Disposal methods	No specific method necessary
13D: Sewage Disposal	Not recommended
13E: Precautions for incineration	May release organic amines and toxic vapors when burned.
13F: Precautions for landfills	Resins used to remove hazardous materials may then become hazardous mixtures.

SECTION 14: Transportation Information	
14A: Transportation Class	Not classified as a dangerous good for transport by land, sea, or air.
14B: TDG	Not regulated.
14C: IATA	Not regulated.
14D: DOT (49 CFR 172.101)	Not regulated.

SECTION 15: Regulatory Information	
15A: CERCLA	Not regulated
15B: SARA Title III	Not regulated
15C: Clean Air act	Not regulated
15D: Clean Water Act	Not regulated
15E: TSCA	Not regulated
15F: Canadian Regulations	WHMIS - Not a controlled product TDG - Not regulated
15G: Mexican Regulations	Not Dangerous

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ResinTech® Inc.
INNOVATIONS IN ION EXCHANGE

SECTION 16: Other Information	
This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features. Regulatory requirements are subject to change and may differ from one location to another. It is the buyer's responsibility to ensure that their activities comply with federal, state, and local laws.	
16A: Date of Revision	1 January 2021

Revision 1.0

corporate headquarters 1801 Federal Street Camden, NJ 08105 USA phone 856.768.9600 fax 856.768.9601 email info@resintech.com web resintech.com

RESINTECH INC.
INNOVATIONS IN ION EXCHANGE

SAFETY DATA SHEET

SIR-110-MP, SIR-110-MP-HP

(Perchlorate Selective Macroporous Strong Base Anion Exchange Resin Chloride Form)

Effective date 1 January 2021

SECTION 1: Identification	
1A: Product Names	ResinTech SIR-110-MP, SIR-110-MP-HP
1B: Common Name	Perchlorate, PFAS and nitrate selective macroporous strong base anion resin in the chloride form.
1C: Intended use	Removal of perchlorate, iodide, and from water.
1D: Manufacturer Address	ResinTech, Inc. 1801 Federal Street, Camden, NJ 08105 USA
Contact Information:	856-768-9600 ixresin@resintech.com

SECTION 2: Hazard Identification	
2A: OSHA Hazard classification 0 = Negligible 1 = Slight 2 = Moderate 3 = High 4 = Extreme	Not hazardous or dangerous Health - 0 (0 = Negligible) Fire - 1 (1 = Slight) Reactivity - 0 (0 = Negligible) Special – N/A
! WARNING	(contains ion exchange resin) H320: Causes eye irritation (Category 2B)

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RESINTECH INC.
INNOVATIONS IN ION EXCHANGE

SECTION 2: Hazard Identification Continued	
Precautionary Statements	P264: Wash hands thoroughly after handling. P280: Wear protective gloves/protective clothing/eye protection/face protection P305+351+338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing. P333+313: If skin irritation or a rash occurs: Get medical advice/attention. P337+313: If eye irritation persists get medical advice/attention. P403+233: Store in a well ventilated place. Keep container tightly closed. P411: Store at temperatures not exceeding 50 °C/ 122 °F.
2B: Product description	Light cream to light yellow colored solid beads with little or no odor.
2C: Precautions for use	Safety glasses and gloves recommended. Slipping hazard if spilled.
Potential health effects	Will cause eye irritation. May cause mild skin irritation. Ingestion is not likely to pose a health risk.
2D: Environmental effects	Little or none.

SECTION 3: Composition/ Information on Ingredients	
3A: Chemical name	Tributylamine functionalized chloromethylated copolymer of polystyrene in the chloride form.
3B: Ingredients: Water	CAS# 7732-18-5 (30 – 45%)
Tributylamine functionalized chloromethlyated copolymer of styrene and divinylbenzene in the chloride form	CAS# 116565-72-1 (55 - 70%)

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RESINTECH INC.
INNOVATIONS IN ION EXCHANGE

SECTION 4: First Aid Measures	
4A: Inhalation	No adverse effects expected. Normal use of product does not produce odors or vapors.
4B: Skin	Wash with soap and water- seek medical attention if a rash develops.
4C: Eye contact	Wash immediately with water-seek attention if discomfort continues.
4D: Ingestion	No adverse effects expected for small amounts, larger amounts can cause stomach irritation. Seek medical attention if discomfort occurs.

SECTION 5: Fire Fighting Measures	
5A: Flammability	NFPA Fire rating = 1
5B: Extinguishing media	Water, CO_2, foam, dry powder
5C: Fire fighting Procedures	Follow general fire fighting procedures indicated in the work place.
5D: Protective Equipment	MSHA/NIOSH approved self-contained breathing gear, full protective clothing.
5E: Combustion Products	Carbon oxides and other toxic gasses and vapors.
5F: Unusual Hazards	Product is not combustible until moisture is removed. Resin begins to burn at approximately 230º C. Auto ignition can occur above 500º C.

SECTION 6: Accidental Release Measures	
6A: Personal Precautions	Keep people away, spilled resin can be a slipping hazard, wear gloves and safety glasses to minimize skin or eye contact.
6B: Incompatible Chemicals	Strong oxidants can create risk of combustion products similar to burning.
6C: Environmental Precautions	Keep out of public sewers and waterways.
6D: Containment Materials	Use plastic or paper containers.
6E: Methods of Clean-up	Sweep up material and transfer to containers.

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ResinTech Inc.
INNOVATIONS IN ION EXCHANGE

SECTION 7: Handling and Storage	
7A: Handling	Avoid prolonged skin contact. Keep resin moist and avoid allowing resin to completely dry.
7B: Storage	Store in a cool dry place (0º to 45º C) in the original shipping container. This product is thermally sensitive and will have reduced shelf life if subjected to extended periods of time at temperatures exceeding 50º C. Although freezing does not usually damage ion exchange resins, avoid repeated freeze thaw cycles.

SECTION 8: Exposure Controls/Personal Protection	
8A: Personal Precautions	None noted.
8B: Incompatible Chemicals	Provide adequate ventilation.
8C: Personal Protection Measures	Eye Protection- Safety glasses or goggles. Respiratory Protection - Not required for normal use. Protective Gloves - Recommended for extended contact.

SECTION 9: Physical and Chemical Properties	
Appearance	Light cream to light yellow beads approx. 0.6 mm diameter.
Flammability or explosive limits	Flammable above 500º C
Odor	Little or no odor
Physical State	Solid
Vapor pressure	N/A
Odor threshold	N/A
Vapor density	N/A
pH	Near neutral
Relative density	Approx 680 grams/Liter
Melting point/freezing point	Does not melt, freezes at approx. 0 C
Solubility	Insoluble in water and most solvents
Boiling point	Does not boil
Flash point	Approx 500º C

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SECTION 9: Physical and Chemical Properties	
Evaporation rate	Does not evaporate
Partition Coefficient (n-octonol/water)	N/A
Auto-ignition temperature	Approx 500º C
Decomposition temperature	Above 230º C
Viscosity	N/A

SECTION 10: Stability and Reactivity	
10A: Stability	Stable under normal conditions.
10B: Conditions to Avoid	Heat, exposure to strong oxidants.
10C: Hazardous by-products	Tributylamine, charred polystyrene, aromatic acids and hydrocarbons, organic amines, nitrogen oxides, carbon oxides, chlorinated hydrocarbons.
10D: Incompatible materials	Strong oxidizing agents (such as HNO_3)
10E: Combustion Products	Does not occur

SECTION 11: Toxicological Information	
11A: Likely Routes of Exposure	Oral, skin or eye contact.
11B: Effects of exposure	Delayed - None known. Immediate (acute) - None known. Chronic - None known.
11C: Toxicity Measures	Skin Adsorption - Unlikely Ingestion - Oral toxicity believed to be low but no LD50 has been established. Inhalation - Unknown, vapors are very unlikely due to physical properties (insoluble solid).
11D: Toxicity Symptoms	Skin Adsorption - Mild Rash. Ingestion - Indigestion or general malaise. Inhalation - Unknown.
11E: Carcinogenicity	None known

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RESINTECH® INC. INNOVATIONS IN ION EXCHANGE

SECTION 12: Ecological information	
12A: Eco toxicity	Not harmful to plant or animal life.
12B: Mobility	Insoluble
12C: Biodegradability	Not biodegradable.
12D: Bioaccumulation	Insignificant.
12E: Other adverse effects	Not Harmful to the environment.

SECTION 13: Disposal Considerations	
13A: General considerations	Material is non-hazardous.
13B: Disposal Containers	Most plastic and paper containers are suitable.
13C: Disposal methods	No specific method necessary.
13D: Sewage Disposal	Not recommended
13E: Precautions for incineration	May release tributylamine and toxic vapors when burned.
13F: Precautions for landfills	Resins used to remove hazardous materials may then become hazardous mixtures

SECTION 14: Transportation Information	
14A: Transportation Class	Not classified as a dangerous good for transport by land, sea, or air.
14B: TDG	Not regulated.
14C: IATA	Not regulated.
14D: DOT (49 CFR 172.101)	Not regulated.

SECTION 15: Regulatory Information	
15A: CERCLA	Not regulated
15B: SARA Title III	Not regulated
15C: Clean Air act	Not regulated
15D: Clean Water Act	Not regulated
15E: TSCA	Not regulated

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ResinTech Inc. INNOVATIONS IN ION EXCHANGE

SECTION 15: Regulatory Information	
15F: Canadian Regulations	WHMIS - Not a controlled product TDG - Not regulated
15G: Mexican Regulations	Not Dangerous

SECTION 16: Other Information	
This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features. Regulatory requirements are subject to change and may differ from one location to another. It is the buyer's responsibility to ensure that their activities comply with federal, state, and local laws.	
16A: Date of Revision	1 January 2021

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ResinTech Inc.
INNOVATIONS IN ION EXCHANGE

SAFETY DATA SHEET

SIR-700

(Chromate Selective Weak Base Anion Exchange Resin)

Effective date 1 January 2021

SECTION 1: Identification	
1A: Product Names	ResinTech SIR-700
1B: Common Name	Chromate selective weak base anion resin
1C: Intended use	Chromate selective weak base anion resin
1D: Manufacturer Address	ResinTech, Inc. 1801 Federal Street, Camden, NJ 08105 USA
Contact Information:	856-768-9600 ixresin@resintech.com

SECTION 2: Hazard Identification	
2A: OSHA Hazard classification 0 = Negligible 1 = Slight 2 = Moderate 3 = High 4 = Extreme	Not hazardous or dangerous Health - 1 (1 = Slight) Fire - 1 (1 = Slight) Reactivity - 0 (0 = Negligible) Special – N/A
! WARNING	(contains acid form weak base anion resin) H316: Causes mild skin irritation (Category 3) H319: Causes serious eye irritation (Category 2A)

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SECTION 2: Hazard Identification Continued	
Precautionary Statements	P264: Wash hands thoroughly after handling. P280: Wear protective gloves/protective clothing/eye protection/face protection P305+351+338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing. P333+313: If skin irritation or a rash occurs: Get medical advice/attention. P337+313: If eye irritation persists get medical advice/attention. P403+233: Store in a well ventilated place. Keep container tightly closed. P411: Store at temperatures not exceeding 50 °C/ 122 °F.
2B: Product description	Yellow or orange colored irregular pieces approximately 1.0 mm with little or no odor.
2C: Precautions for use	Safety glasses and gloves recommended. Slipping hazard if spilled.
Potential health effects	Will cause serious eye irritation. Will cause skin irritation. Ingestion is not likely to pose a health risk.
2D: Environmental effects	This product may alter the pH of any water that contacts it.

SECTION 3: Composition/ Information on Ingredients	
3A: Chemical name	Epoxy polyamine condensate polymer in the acid salt form.
3B: Ingredients: Water	CAS# 7732-18-5 (40 – 55%)
Epoxy polyamine condensate polymer	CAS# 26658-42-4 (40 - 55%)
Hydrochloric acid	CAS# 7647-01-0 (0 – 10%)
Sulfuric acid	CAS# 7664-93-9 (0 – 10%)

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RESINTECH INC. INNOVATIONS IN ION EXCHANGE

SECTION 4: First Aid Measures	
4A: Inhalation	No adverse effects expected- normal use of product does not produce odors or vapors.
4B: Skin	Wash with soap and water- seek medical attention if a rash develops.
4C: Eye contact	Wash immediately with water-seek attention if discomfort continues.
4D: Ingestion	No adverse effects expected for small amounts, larger amounts can cause stomach irritation. Seek medical attention if discomfort occurs.

SECTION 5: Fire Fighting Measures	
5A: Flammability	NFPA Fire rating = 1
5B: Extinguishing media	Water, CO_2, foam, dry powder
5C: Fire fighting Procedures	Follow general fire fighting procedures indicated in the work place. Seek medical attention if discomfort continues.
5D: Protective Equipment	MSHA/NIOSH approved self-contained breathing gear, full protective clothing.
5E: Combustion Products	Carbon oxides and other toxic gasses and vapors.
5F: Unusual Hazards	Product is not combustible until moisture is removed. Resin begins to burn at approximately 230º C. Auto ignition can occur above 500º C.

SECTION 6: Accidental Release Measures	
6A: Personal Precautions	Keep people away, spilled resin can be a slipping hazard, wear gloves and safety glasses to minimize skin or eye contact.
6B: Incompatible Chemicals	Strong oxidants can create risk of combustion products similar to burning, exposure to strong bases can cause a rapid temperature increase.
6C: Environmental Precautions	Keep out of public sewers and waterways.
6D: Containment Materials	Use plastic or paper containers, unlined metal containers not recommended.
6E: Methods of Clean-up	Sweep up material and transfer to containers.

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SECTION 7: Handling and Storage	
7A: Handling	Avoid prolonged skin contact. Avoid contact with salts or with salty water to prevent premature exhaustion of the resin. Keep resin moist and avoid allowing resin to completely dry.
7B: Storage	Store in a cool dry place (0º to 45º C) in the original shipping container. This product is thermally sensitive and will have reduced shelf life if subjected to extended periods of time at temperatures exceeding 50º C. Although freezing does not usually damage ion exchange resins, avoid repeated freeze thaw cycles.
7C: TSCA considerations	Ion exchange resins should be listed on the TSCA Inventory in compliance with State and Federal Regulations.

SECTION 8: Exposure Controls/Personal Protection	
8A: Personal Precautions	None noted.
8B: Incompatible Chemicals	Provide adequate ventilation.
8C: Personal Protection Measures	Eye Protection- Safety glasses or goggles. Respiratory Protection - Not required for normal use. Protective Gloves - Recommended for extended contact.

SECTION 9: Physical and Chemical Properties	
Appearance	Yellow irregularly shaped pieces approx. 0.8 mm diameter.
Flammability or explosive limits	Flammable above 500º C
Odor	Little or no odor
Physical State	Solid
Vapor pressure	N/A
Odor threshold	N/A
Vapor density	N/A
pH	Slightly acidic when mixed with water
Relative density	Approx 680 grams/Liter
Melting point/freezing point	Does not melt, freezes at approx. 0 C
Solubility	Insoluble in water and most solvents

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SECTION 9: Physical and Chemical Properties	
Boiling point	Does not boil
Flash point	Approx 500º C
Evaporation rate	Does not evaporate
Partition Coefficient (n-octonol/water)	N/A
Auto-ignition temperature	Approx 500º C
Decomposition temperature	Above 230º C
Viscosity	N/A

SECTION 10: Stability and Reactivity	
10A: Stability	Stable under normal conditions.
10B: Conditions to Avoid	Heat, exposure to strong oxidants.
10C: Hazardous by-products	Charred epoxy, aromatic acids and hydrocarbons, organic amines, nitrogen oxides, carbon oxides, chlorinated hydrocarbons.
10D: Incompatible materials	Strong oxidizing agents (such as HNO3)
10E: Hazardous Polymerization	Does not occur

SECTION 11: Toxicological Information	
11A: Likely Routes of Exposure	Oral, skin or eye contact.
11B: Effects of exposure	Delayed - None known. Immediate (acute) - Rash or burn caused by acidity. Chronic - None known.
11C: Toxicity Measures	Skin Adsorption - Unlikely, some transfer of causticity is possible. Ingestion - Oral toxicity believed to be low but no LD50 has been established. Inhalation - Unknown, vapors are very unlikely due to physical properties (insoluble solid).
11D: Toxicity Symptoms	Skin Adsorption - Rash or burn. Ingestion - Indigestion or general malaise. Inhalation - Unknown.
11E: Carcinogenicity	None known

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SECTION 12: Ecological information	
12A: Eco toxicity	Not acutely harmful to plant or animal life.
12B: Mobility	Insoluble, acidity may escape if wet.
12C: Biodegradability	Not biodegradable.
12D: Bioaccumulation	Insignificant.
12E: Other adverse effects	Not Harmful to the environment.

SECTION 13: Disposal Considerations	
13A: General considerations	Material is non-hazardous. However, unused material can cause a pH decrease when wetted.
13B: Disposal Containers	Most plastic and paper containers are suitable. Avoid use of unlined metal containers.
13C: Disposal methods	No specific method necessary.
13D: Sewage Disposal	Not recommended
13E: Precautions for incineration	May release trimethylamine and toxic vapors when burned.
13F: Precautions for landfills	pH of spent resin may be low. Resins used to remove hazardous materials may then become hazardous mixtures.

SECTION 14: Transportation Information	
14A: Transportation Class	Not classified as a dangerous good for transport by land, sea, or air.
14B: TDG	Not regulated.
14C: IATA	Not regulated.
14D: DOT (49 CFR 172.101)	Not regulated.

SECTION 15: Regulatory Information	
15A: CERCLA	Not regulated
15B: SARA Title III	Not regulated
15C: Clean Air act	Not regulated
15D: Clean Water Act	Not regulated
15E: TSCA	Not regulated

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corporate headquarters 1801 Federal Street Camden, NJ 08105 USA phone 856.768.9600 fax 856.768.9601 email info@resintech.com web resintech.com

ResinTech Inc.
INNOVATIONS IN ION EXCHANGE

SECTION 15: Regulatory Information	
15F: Canadian Regulations	WHMIS - Not a controlled product TDG - Not regulated
15G: Mexican Regulations	Not Dangerous

SECTION 16: Other Information	
This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features. Regulatory requirements are subject to change and may differ from one location to another. It is the buyer's responsibility to ensure that their activities comply with federal, state, and local laws.	
16A: Date of Revision	1 January 2021

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SAFETY DATA SHEET

SIR-1300

(Redox media for iron and manganese removal from water)

Effective date 1 January 2021

SECTION 1: Identification	
1A: Product Names	ResinTech SIR-1300
1B: Common Name	Redox catalyst media.
1C: Intended use	Iron and manganese removal from water.
1D: Manufacturer Address	ResinTech, Inc. 1801 Federal Street, Camden, NJ 08105 USA
Contact Information:	856-768-9600 ixresin@resintech.com

SECTION 2: Hazard Identification	
2A: OSHA Hazard classification 0 = Negligible 1 = Slight 2 = Moderate 3 = High 4 = Extreme	Not hazardous or dangerous Health - 1 (1 = Slight) Fire - 1 (1 = Slight) Reactivity - 0 (0 = Negligible) Special – N/A
WARNING !	(contains ion exchange resin) H320: Causes eye irritation (Category 2B)

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RESINTECH INC. INNOVATIONS IN ION EXCHANGE

SECTION 2: Hazard Identification Continued	
Precautionary Statements	P264: Wash hands thoroughly after handling. P280: Wear protective gloves/protective clothing/eye protection/face protection P305+351+338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing. P333+313: If skin irritation or a rash occurs: Get medical advice/attention. P337+313: If eye irritation persists get medical advice/attention. P403+233: Store in a well-ventilated place. Keep container tightly closed. P411: Store at temperatures not exceeding 50 °C/ 122 °F.
2B: Product description	Solid black beads approximately 0.6 mm diameter with little or no odor.
2C: Precautions for use	Safety glasses and gloves recommended. Slipping hazard if spilled.
Potential health effects	Will cause eye irritation. Will cause skin skin irritation. Ingestion is not likely to pose a health risk.
2D: Environmental effects	This product contains manganese.

SECTION 3: Composition/ Information on Ingredients	
3A: Chemical name	Trimethylamine functionalized chloromethylated copolymer of polystyrene in the chloride form.
3B: Ingredients: Water	CAS# 7732-18-5 (35 – 65%)
Trimethylamine functionalized Chloromethlyated copolymer of Styrene and divinylbenzene in the Chloride form	CAS# 60177-39-1 (35 - 65%)
Manganese oxide	CAS# 1313-13-9 (1 – 10%)

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SECTION 4: First Aid Measures	
4A: Inhalation	No adverse effects expected- normal use of product does not produce odors or vapors.
4B: Skin	Wash with soap and water - seek medical attention if a rash develops.
4C: Eye contact	Wash immediately with water-seek attention if discomfort continues.
4D: Ingestion	No adverse effects expected for small amounts, larger amounts can cause stomach irritation. Seek medical attention if discomfort occurs.

SECTION 5: Fire Fighting Measures	
5A: Flammability	NFPA Fire rating = 1
5B: Extinguishing media	Water, CO_2, foam, dry powder
5C: Fire fighting Procedures	Follow general fire fighting procedures indicated in the work place. Seek medical attention if discomfort continues.
5D: Protective Equipment	MSHA/NIOSH approved self-contained breathing gear, full protective clothing.
5E: Combustion Products	Carbon oxides and other toxic gasses and vapors.
5F: Unusual Hazards	Product is not combustible until moisture is removed. Carbon begins to burn at approximately 230º C. Auto ignition can occur above 500º C.

SECTION 6: Accidental Release Measures	
6A: Personal Precautions	Keep people away, spilled resin can be a slipping hazard, wear gloves and safety glasses to minimize skin or eye contact.
6B: Incompatible Chemicals	Strong oxidants can create risk of combustion products similar to burning.
6C: Environmental Precautions	Keep out of public sewers and waterways.
6D: Containment Materials	Use plastic or paper containers.
6E: Methods of Clean-up	Sweep up material and transfer to containers.

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RESINTECH INC. INNOVATIONS IN ION EXCHANGE

SECTION 7: Handling and Storage	
7A: Handling	Avoid prolonged skin contact. Keep resin moist and avoid allowing resin to completely dry.
7B: Storage	Store in a cool dry place (0º to 45º C) in the original shipping container. This product is thermally sensitive and will have reduced shelf life if subjected to extended periods of time at temperatures exceeding 50º C. Although freezing does not usually damage ion exchange resins, avoid repeated freeze thaw cycles.
7C: TSCA considerations	Ion exchange resins should be listed on the TSCA Inventory in compliance with State and Federal Regulations.

SECTION 8: Exposure Controls/Personal Protection	
8A: Personal Precautions	None noted.
8B: Incompatible Chemicals	Provide adequate ventilation.
8C: Personal Protection Measures	Eye Protection- Safety glasses or goggles. Respiratory Protection - Not required for normal use. Protective Gloves - Not required for limited exposure but recommended for extended contact.

SECTION 9: Physical and Chemical Properties	
Appearance	Black beads approx. 0.6 mm diameter.
Flammability or explosive limits	Flammable above 500º C
Odor	Little or no odor
Physical State	Solid
Vapor pressure	N/A
Odor threshold	N/A
Vapor density	N/A
pH	Near neutral (6 to 8 typical)
Relative density	Approx 710 grams/Liter
Melting point/freezing point	Does not melt, freezes at approx. 0 C
Solubility	Insoluble in water and most solvents
Boiling point	Does not boil

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SECTION 9: Physical and Chemical Properties	
Flash point	Approx 500º C
Evaporation rate	Does not evaporate
Partition Coefficient (n-octonol/water)	N/A
Auto-ignition temperature	Approx 500º C
Decomposition temperature	Above 230º C
Viscosity	N/A

SECTION 10: Stability and Reactivity	
10A: Stability	Stable under normal conditions.
10B: Conditions to Avoid	Heat, exposure to strong oxidants.
10C: Hazardous by-products	Trimethylamine, charred polystyrene, aromatic acids and hydrocarbons, organic amines, nitrogen oxides, carbon oxides, chlorinated hydrocarbons.
10D: Incompatible materials	Strong oxidizing agents (such as HNO_3)
10E: Hazardous Polymerization	Does not occur

SECTION 11: Toxicological Information	
11A: Likely Routes of Exposure	Oral, skin or eye contact.
11B: Effects of exposure	Delayed - None known. Immediate (acute) - None known. Chronic - None known.
11C: Toxicity Measures	Skin Adsorption - Unlikely, some transfer of causticity is possible. Ingestion - Oral toxicity believed to be low but no LD50 has been established. Inhalation - Unknown, vapors are very unlikely due to physical properties (insoluble solid).
11D: Toxicity Symptoms	Skin Adsorption - Mild Rash. Ingestion - Indigestion or general malaise. Inhalation - Unknown.
11E: Carcinogenicity	None known

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SECTION 12: Ecological information	
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16A: Date of Revision	1 January 2021

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