SRR-CWDA-2014-00011
Revision 0

KEYWORDS:
Performance Assessment
Saltstone
UWMQE
SDU 4

RETENTION: PERMANENT

Evaluation of Vendor Supplied Clean Cap Material for Saltstone Disposal Units

March 2014

Prepared by: Savannah River Remediation LLC
Waste Disposal Authority
Aiken, SC 29808

Prepared for U.S. Department of Energy Under Contract No. DE-AC09-09SR22505

REVIEWS AND APPROVALS

Author:

F. M. Smith
Waste Disposal Authority
Savannah River Remediation

4/9/14
Date

Technical Review(s):

S. P. Simner

4/9/2014
Date

SRR Grout SME
Waste Disposal Authority
Savannah River Remediation

M. H. Layton
Waste Disposal Authority
Savannah River Remediation

4/14/14
Date

Management Review:

K. H. Rosenberger
Waste Disposal Authority
Savannah River Remediation

4/14/2014
Date

TABLE OF CONTENTS

REVIEWS AND APPROVALS 2
TABLE OF CONTENTS 3
LIST OF TABLES 3
ACRONYMS 4
1.0 PURPOSE 5
2.0 PROPOSED ACTIVITY 5
3.0 APPLICABLE CRITERIA 5
4.0 BACKGROUND 6
4.1 Problem Description 6
4.2 Saltstone Production Facility Process Description 6
4.3 Sources and Fate of Process Liquids 6
5.0 CLEAN CAP LABORATORY TESTING 7
6.0 EVALUATION OF PROPOSED ACTIVITY 7
6.1 Chemical Impacts 7
6.2 Physical Impacts 8
6.2.1 Water-to-Premix Ratio 8
6.2.2 Mixing 8
6.2.3 Caustic Additive 8
7.0 CONCLUSION 8
8.0 REFERENCES 9

LIST OF TABLES

Table 2.0-1, Key Parameters of Specification C-SPP-Z-00012 Clean Cap Formulations 5

ACRONYMS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
GGBFS	Granulated Ground Blast Furnace Slag
CA	Composite Analysis
PA	Performance Assessment
SA	Special Analysis
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SPF	Saltstone Production Facility
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation LLC
SRS	Savannah River Site
UWMQE	Unreviewed Waste Management Question Evaluation
VSL	Vitreous State Laboratory
WD	Waste Determination

1.0 PURPOSE

The purpose of this document is to support the issuance of an Unreviewed Waste Management Question Evaluation (UWMQE) that assesses the use of vendor supplied clean cap material proposed for use in Saltstone Disposal Units at the Saltstone Disposal Facility (SDF).

2.0 PROPOSED ACTIVITY

In order to provide shielding and to fill void space for long term stability above radioactive saltstone, clean cap grout is generated by the Saltstone Production Facility (SPF) and transferred to the disposal units via the grout line. The proposed activity is to produce clean cap material (in accordance with specification C-SPP-Z-00012) at a commercial vendor, transport the material to the SDF, and place inside a Saltstone Disposal Unit (SDU) to minimize the addition of liquids into the SDU. Three potential clean cap formulations, all based upon the standard 45/45/10 (flyash, slag, cement) dry feeds mixture, are contained in the specification as presented in Table 2.0-1.

Table 2.0-1, Key Parameters of Specification C-SPP-Z-00012 Clean Cap Formulations

Dry Feeds Ratio (Flyash / Slag / Cement)	Water to Pre-mix Ratio	Caustic Addition
45/45/10	0.5	6 wt% (1.6 M) NaOH
45/45/10	0.5	N/A
45/45/10	0.45	N/A

3.0 APPLICABLE CRITERIA

Proposed activities at the SDF are reviewed in accordance with SRR Manual S4, Procedure ENG 46 to ensure that inputs, assumptions, results and conclusions of the DOE-approved Performance Assessment (PA), Waste Determination (WD), SRS Composite Analysis (CA), and any associated Special Analyses (SA’s), and Unreviewed Waste Management Question Evaluations (UWMQE’s), remain valid.

SRR-CWDA-2011-00196, Revision 1, *Unreviewed Waste Management Question Requirements Document for Saltstone Facility*, defines specific criteria that must be met for processing and disposal activities. Specific criteria that could be impacted by the proposed activity are:

Criteria #12: SDU’s contain only cementitious materials that come directly from the SPF facility.

4.0 BACKGROUND

4.1 Problem Description

Rainwater has infiltrated cracks in the SDU 4 roof and accumulated inside the cell. Water within the cell is exposed to radioactive constituents present within the cell. Liquids can accumulate at the wall surface, creating head pressure, as well as a reservoir of liquid that can escape through imperfections in the concrete wall. Water that exits within the cell can carry radioactive contaminates outside the cell.

A project has been initiated to stabilize these conditions at SDU 4. The current project scope is to install clean caps within appropriate cells for dose control purposes, then apply appropriate coating to the concrete roof surfaces to mitigate rainwater intrusion through the roof. Future project scope includes completely filling the SDU 4 cells with clean cap material.

The addition of clean cap materials into the SDU from the SPF introduces liquid in the form of bleed water and flush water. Since the presence of liquid can lead to the spread of contamination through the cell walls and into the environment, it is desirable to minimize the amount of liquids introduced into the unit.

Utilization of vendor supplied clean cap material eliminates the need for a large source of water from the SPF system flushes. Since the SPF production process is well understood, the addition of grout from alternate sources must be evaluated to ensure that the alternate sources and delivery methods provide grout of equivalent properties as that produced from the SPF process.

4.2 Saltstone Production Facility Process Description

The SPF normally blends decontaminated salt solution (DSS) sent from Tank 50 with a blend of dry feed material consisting of 45 wt% grade 100 or 120 ground granulated blast furnace slag (GGBFS) (specification X-SPP-Z-00003), 45 wt% class C fly ash (specification X-SPP-Z-00002), and 10 wt% Type II Portland cement (specification X-SPP-Z-00004). Clean caps are also routinely produced by the production facilty using clean inhibited water instead of decontaminated salt solution. The mixed dry feed material is pneumatically pumped to the dry feed bin and ultimately fed into the paddle mixer, where it is blended with the salt feed solution. The liquid grout is pumped via a 3-inch grout line to a disposal unit where it hardens into a waste form termed saltstone. The nominal water to premix ratio of the mix is 0.6. The proportions of each component of the dry feeds have been tested in various laboratory conditions to arrive at an optimal blend of dry feeds as well as water to pre-mix ratio.

4.3 Sources and Fate of Process Liquids

After placement and before setting, the grout material can form bleed water (also known as bleed). Bleed is the water component that is not physically or chemically retained within the grout matrix. The amount of bleed has not been defined for normal clean cap operations.

In addition, since the grout is a cementitious material and will set, periodic flushes of water are used to clear the grout production systems of cementitious material that remain and will eventually harden within the system. Typical system flushes with approximately 50 gallons of

water occur approximately every 45 minutes, and at the end of every day with approximately 1500 gallons.

Bleed water and flush water may be shed to the sheet drains installed in the disposal unit for collection and transfer back to the production facility. In a typical disposal unit, this liquid is collected and pumped back to the production facility for incorporation into a subsequent batch of grout.

As some of the grout fines (i.e., smaller than the sheet drain fabric pore size) penetrate the sheet drain fabric, the sheet drains and associated collection headers in SDU 4 exhibit some degree of performance degradation. The current functionality of these systems heightens the importance of ensuring that the rate of grout additions and associated bleed/flush water from the clean cap process remain within the capabilities of the installed systems.

5.0 CLEAN CAP LABORATORY TESTING

To ascertain the salient properties of the clean cap formulation (i.e., total bleed, re-absorbtion time, flowability, uniformity, etc.), production, and delivery, Vitreous State Laboratory (VSL) tested the standard dry feeds mix (i.e., 45/45/10 ratio of fly ash, slag, and cement respectively) while varying the water-to-premix ratio and adding NaOH solution. VSL report VSL-14R3330-1 documents details of the testing. Salient features of the test are provided for context.

Each formulation proposed in specification C-SPP-Z-00012 was mixed using a standard drum mixer configuration and a rotary blender configuration to assess the effect of mixing on various clean cap formulations. The blend times bounded the expected mix times of 30 and 90 minutes typical of a concrete plant production and delivery process.

As expected, lower water-to-premix formulations produced less bleed water but also reduced the flowability of the mix. In addition, use of 6 wt% (1.6M) NaOH decreased the total bleed while still maintaining sufficient slump to facilitate flow once discharged into the SDU. The use of a caustic solution was intended to simulate the average concentration of free hydroxide in the DSS; the presence of hydroxide is known to enhance the dissolution of the slag component and the rate of slag hydration, which subsequently increases the degree of water chemically incorporated into the saltstone matrix.

6.0 EVALUATION OF PROPOSED ACTIVITY

Evaluation of the proposed activity requires that the clean cap material display chemical and physical characteristics equivalent to that produced by the SPF and assumed in the Performance Assessment / Special Analysis modeling.

6.1 Chemical Impacts

The reduction capacity of cementitious materials (i.e., clean cap and saltstone) and pH conditioning of pore water moving through the clean cap is a function of the cementitious materials composition. The chemical properties of the pore water impact the rate at which contaminants are released from the saltstone which ultimately reach the environment. Since the

proposed activity does not change the dry cementitious materials formulation (i.e., 45/45/10 mix) the reduction capacity and pH conditioning is not affected by the proposed activity.

6.2 Physical Impacts

The transport model uses the saturated hydraulic conductivity to assess the rate at which water moves through saltstone and to subsequently determine the rate at which contaminants migrate from the disposal unit.

6.2.1 Water-to-Premix Ratio

The proposed formulations reduce the typical production water-to-premix ratio of the clean cap formulation from 0.6 to between 0.45 and 0.5. Savannah River National Laboratory (SRNL) (SRNL-STI-2012-00558) has performed saturated hydraulic conductivity testing of saltstone formulations with water to pre-mix ratios between 0.51 and 0.73, and demonstrated that hydraulic conductivity decreases with lower water to pre-mix ratios. Reductions in hydraulic conductivity with decreased water to pre-mix ratios over the range of interest are also consistent with industry expectations (Ahmad et. al.). Thus, it is reasonable to expect that the hydraulic conductivity will be bounded by assumptions in the transport modeling.

6.2.2 Mixing

The SPF relies on a paddle type mixer to blend dry feed material with liquids. VSL conducted testing of conventional blending and small scale concrete drum mixing. This testing (VSL-14R3330-1) demonstrated negligible impact to flow and a moderate reduction in bleed characteristics for 30 to 90 minute mixing times, which is standard practice for concrete vendors. In addition, observations of the mixing vessels demonstrated that the proposed formulations and mix times resulted in a uniform, well mixed product.

6.2.3 Caustic Additive

6 wt% (1.6 M) NaOH is a proposed addition to the mixture. 1.6 M is within the range of NaOH concentrations measured for decontaminated salt solution. Previous testing of saltstone formulations for hydraulic conductivity included NaOH in the test samples. Hydraulic conductivity of these samples is used as a basis in the transport modeling. Therefore, the addition of 6 wt % NaOH to the clean cap formulation is already incorporated into assumptions.

7.0 CONCLUSION

Comparison of the Saltstone Production Facility supplied material versus vendor supplied material for grout formulation, mixing, and placement indicates that there is reasonable assurance that vendor supplied grout will be functionally equivalent or better than the materials produced by the production facility with respect to PA assumptions.

8.0 REFERENCES

C-SPP-Z-00012, *Vault 4 Clean Cap Grout*, Procurement Specification, Savannah River Site, Aiken, SC, Rev. 0, March 2014.

Shamsad Ahmad, Abul Kalam Azad, and Kevin F. Loughlin, *Effect of the Key Mixture Parameters on Tortuosity and Permeability of Concrete*, Journal of Advanced Concrete Technology, Vol 10, 86-94, March 2012.

SRNL-STI-2012-00558, *Process Formulations and Curing Conditions that Affect Saltstone Properties*, Rev. 0, September 2012.

VSL-14R3330-1, *Saltstone Clean Cap Grout Assessment*, EnergySolutions, Federal EPC, Inc, Columbia, MD, Rev. 0, March 2014.

X-SPP-Z-00002, *Specification for Procurement of Thermally Beneficated Class F Fly Ash for SPF*, Procurement Specification, Savannah River Site, Aiken, SC, Rev. 0, March 2014.

X-SPP-Z-00003, *Specification for the Procurement of Slag for the SPF*, Procurement Specification, Savannah River Site, Aiken, SC, Rev. 2, February 2011.

X-SPP-Z-00004, *Specification for the Procurement of Portland Type II Cement for the SPF*, Procurement Specification, Savannah River Site, Aiken, SC, Rev. 3, February 2011.