DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

June 13, 2011 to August 19, 2011

Formed Core Sampler

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ABSTRACT

The tank farms at the Savannah River Site (SRS) contain large amounts of radioactive waste generated from the chemical separation processes which were conducted in H- and F- Canyons. The waste is classified as two types: high-level and low-level. The high-level waste is the high-density, high-radioactivity material known as the sludge. The low-level waste is the high-volume, low-radioactivity supernate liquid known as the salt. The high-level waste is processed in the Defense Waste Processing Facility and combined with a glass for disposition. The low-level salt is combined with grout and placed in large vaults in the Saltstone Facility. The Saltstone Production Facility (SPF) and the Saltstone Disposal Facility (SDF), both located at the Savannah River Site, were built to stabilize and dispose of low-level radioactive liquid salt waste.

The SPF combines low-level radioactive salt solution with slag, fly ash, and cement to create Saltstone grout, a low-level waste form that contains the radionuclides upon curing. The SDF contains and monitors the solidified material poured into the vaults. Samples of the cured grout at varying elevations within the salt monoliths are required by the Nuclear Regulatory Commission (NRC) to verify the integrity of the grout. Historically, samples have been taken using drill coring methods. The current coring method has significant issues, including possible sample integrity issues, excessive contaminated dust generation, and difficulty of operation.

After review of potential alternatives to the coring method, the Savannah River National Laboratory (SRNL) Research and Development Engineering (R&DE) proposed a system which involves the installation of formed core sampler vials within the vaults prior to pouring the grout. The principal objective of the formed core system is to maintain the integrity of the samples by avoiding the process of drilling. This is done in such way that the formed cores are easily removed after the grout has cured, reducing time and effort related to conventional core drilling techniques. The implementation of this system will eliminate the difficult task of drilling at different levels of the vault, reduce operator exposure, and allow for recovery of a structurally intact sample.

A full-scale mockup of the sampling system has been built and installed at the Research & Development Engineering facility high bay. Saltstone grout, simulated with non-radioactive salt solution, was poured in multiple lifts to replicate the process in the Saltstone facility. After a curing period of six weeks, the samplers will be removed from the FCSS. This technical paper will describe the general elements of the system as well as the methods to be used for its evaluation. Some recommendations will be made to improve the manufacturing and implementation of the current design.

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1. INTRODUCTION

The low-level waste at the Savannah River Site is safely disposed at the Saltstone facilities. The construction of the first two disposal vaults was completed in 1988 and radioactive operations started in 1990 [3]. The process at this facility begins with the mixing of the low-radioactive treated salt solution with cement, fly ash and slag. The resulting mixture stabilizes the radioactive properties of the salt. After the filling process is complete, the vaults will be capped with clean concrete to isolate it from the environment. A series of studies have concluded that the waste to be disposed at this facility will not result in releases of radioactive materials to the surrounding areas that would exceed the drinking water standards established by the U.S. Environmental Protection Agency.

There is a major interest in the viability of sampling the liquids and solid grouts that have ben placed in the vaults at Saltstone [1]. Prior to the selection of the formed core sampler, other techniques were evaluated and several factors involving their implementation were analyzed, including the budget and schedule estimates. . The methods considered for this evaluation were drilled core, in situ analysis and formed core (Figures 1 to 3).

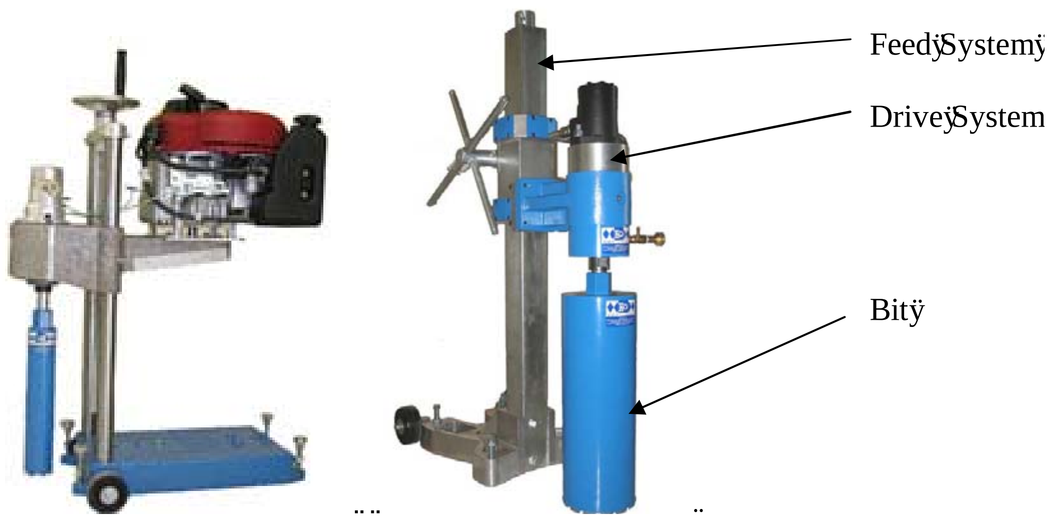


Figure 1. Conventional drill core system [1].

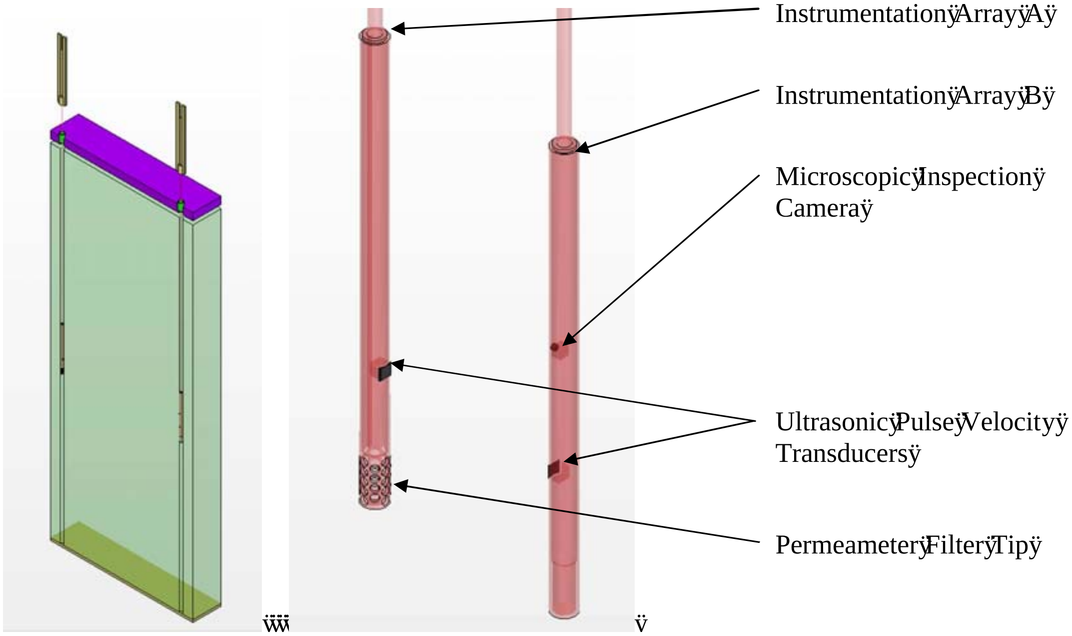


Figure 2. In situ analysis [1].

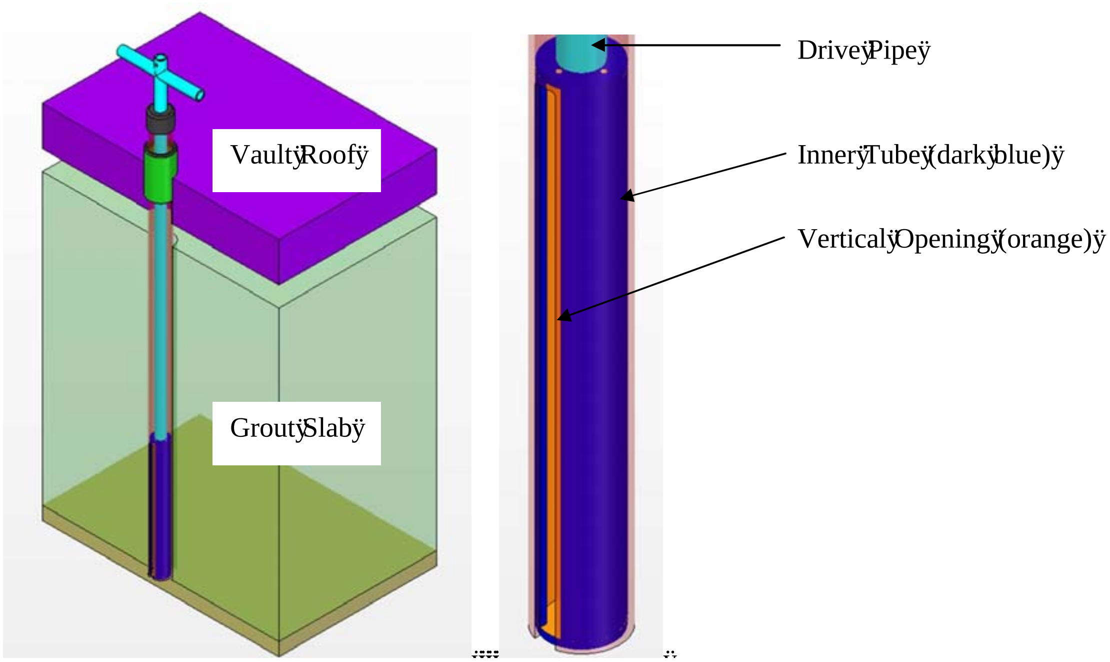


Figure 3. Formed core system [1].

The following table shows an order of magnitude estimate for each of the sampling methods.

Table 1. Project Cost/Time Comparison [1]

Activity Description	Duration (weeks)	Cost ($K)
Drilled Core Sampling System	28	208
Formed Core Sampling System	24	148
In Situ Analysis System	50	420
Liquid Sample Valve	20	80

After the evaluation of these three methods, the Saltstone engineering requested RSE to develop a formed-core sampler that will greatly reduce the time and effort associated with traditional core sampling techniques. The Formed Core Sampler System (FCSS) contains a sampler tube and this tube is placed inside a pipe at a sampling location. The sampler tube is designed to yield cylindrical testing. A mockup of the formed core sampler was fabricated to test the filling process (Figure 4). This prototype helped to understand the manufacturing challenges and the considerations to be taken when implementing the system at the actual site.

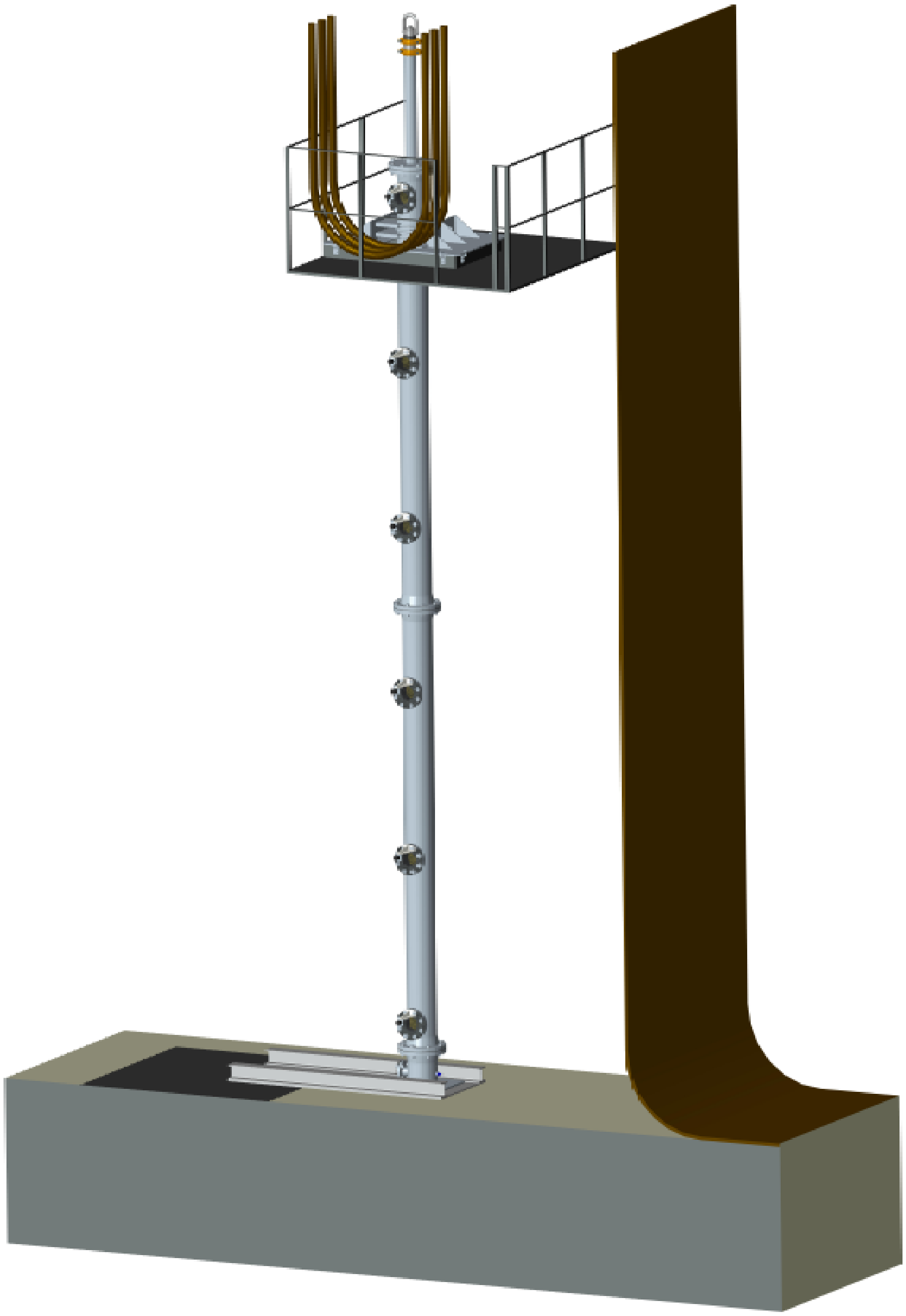


Figure 4. FCSS mockup model (Pro-Engineer) [2].

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the U.S. Department of Energy's Environmental Management (DOE EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2011, a FIU DOE Fellow intern (Mr. William Mendez) spent 10 weeks doing a summer internship at SRNL's Research and Development Engineering (RDE) under the supervision and guidance of Mr. Luther Reid and Mr. Dale Marzolf. This internship was organized and directed by the DOE Fellowship program and the RDE group. The intern's project was initiated on June 13, 2011 and continued through August 19, 2011, with the objective of analyzing the Formed Core Sampler System (FCSS) and participating in its design validation.

The FCSS was developed at the RDE of SRNL in order to collect core samples from concrete vaults that will be used to store low-level radioactive material in the form of a grout mixture that will stabilize the radioactivity of the waste. A mockup model was built within the facilities of RDE in order to validate its design. The outer structure of the system was scaled but the formed core elements were kept to the original size. The manufacturing of this scaled model was very difficult; therefore, modifications to the original design needed to be made and validated.

3. SYSTEM DESCRIPTION AND RESULTS

The FCSS is placed before pouring of the mixture. The system has a series of cavities where a core recovery system is placed. As the mixture is being poured, the cavities are filled, forming the core to be extracted through the inner tube (Figure 5).

The following figure shows the inner tube of the system, which is made of a long pipe. This configuration makes the manufacturing and the core extraction from the system very difficult. One concept for modification is to divide this part into threaded tubes that will work as sub-assemblies for the entire part. This would help in the process of manufacturing and during the extraction of the cores. The concept includes connecting an individual metal wire to every core recovery system, which would allow for the extraction of individual cores.

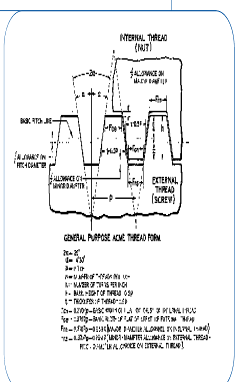
Figure 5. FCSS concept.

The pipe requirements to make the modification are as follows:

- 21/2 Schedule 10
    - Nominal diameter: 2 ½”
    - Inside diameter: 2.635”
    - Outside diameter: 2.875”
    - Thickness (t): 0.120”

- Stainless
- Smooth bore
- Electro-polished

Once the specifications of the pipe were assigned, a process of thread selection from the ACME was done in order to meet the safety requirements for the system.



General Purpose

With clearance on all diameters for free movement, general purpose Acmes are used for a wide variety of parts including all types of vise and jack screws where holding major diameter is not a critical consideration.

Three classes of thread fit tolerances are available: 2G, 3G and 4G. Basic Acme dimensions are given in accompanying tables.

Centralizing

Centralizing Acmes have limited clearance at the major diameter of screw and nut and are used extensively for feed screws. The limited clearance enables a bearing at the major diameter to maintain alignment of the thread axis preventing wedging on the flanks and part sagging.

Five classes are used: 2C, 3C, 4C, 5C, and 6C. Classes

Types of Acme Threads

ACME FORM BASIC DIMENSIONS

					Width of flat		45° chamfer, crest of centralizing screws			Fillet radius at minor diameter of centralizing screws	
Threads Per Inch.	Pitch P	Depth of thread (basic) h= p/2	Total depth of thread (all screws)	Thread thickness (basic,) t	Crest of nut (basic), FCN= 0.307p	Root of nut[1] Frn= 0.3707p-0.259x allowance[a]	Minimum depth 0.05p	Minimum width of flat 0.0707p	Maximum fillet radius root of centralizing tapped hole, 0.06p	Minimum classes 5 and 6 only, 0.07p	Maximum all classes 0.10p
1	2	3	4	5	6	7	8	9	10	11	12
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch
16	0.06250	0.03125	0.0362	0.03125	0.0232	0.0206	0.0031	0.0044	0.004	0.0044	0.0062
14	.07143	.03571	.0407	.03571	.0265	.0239	.0036	.005	.004	.0050	.0071
12	.08333	.04167	.0467	.04167	.0309	.0283	.0042	.006	.005	.0058	.0083
10	.10000	.05000	.0600	.05000	.0371	.0319	.0050	.007	.006	.0070	.0100
8	.12500	.06250	.0725	.06250	.0463	.0411	.0062	.009	.0075	.0088	.0125
6	.16667	.08333	.0933	.08333	.0618	.0566	.0083	.012	.010	.0177	.0167
5	.20000	.10000	.1100	.10000	.0741	.0689	.0100	.014	.012	.0140	.0200
4	.25000	.12500	.1350	.12500	.0927	.0875	.0125	.018	.015	.0175	.0250
3	.33333	.16667	.1767	.16667	.1236	.1184	.0167	.024	.020	.0233	.0333
2-1/2	.40000	.20000	.2100	.20000	.1483	.1431	.020	.028	.024	.0280	.0400
2	.50000	.25000	.2600	.2500	.1853	.1802	.025	.035	.030	.0350	.0500

[1]Values tabulated in column 7 are for the general purpose nut only. The basic width of flat at the root screw. Frs is equal to value for Frn in column 7 minus .0259 times the pitch diameter allowance.
[a]For allowance see table XII. 4, column 3 in Screw Thread Standards For Federal Services, Handbook H-28 (1957) Part III.

GENERAL PURPOSE AND CENTRALIZING ACME TOLERANCES

Basic diameters

Figure 6. ACME thread standards.

From the above figure a thread profile was design (Figure 6). The following figure shows the selected thread chosen from the ACME standards (Figure 7).

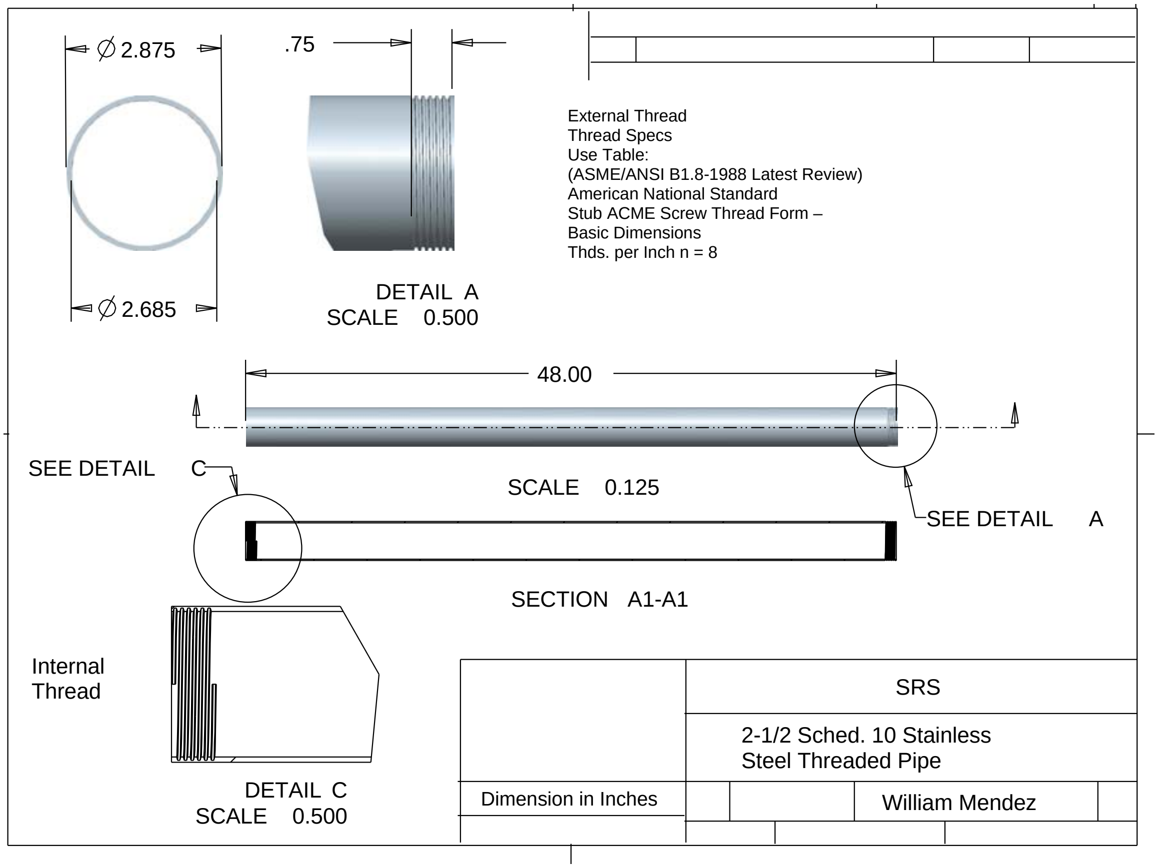


Figure 7. Final design thread profile selected.

Figure 8 illustrates the final assembly using the four-foot pipe shown on the previous figure. Final technical drawings were developed for the modified system.

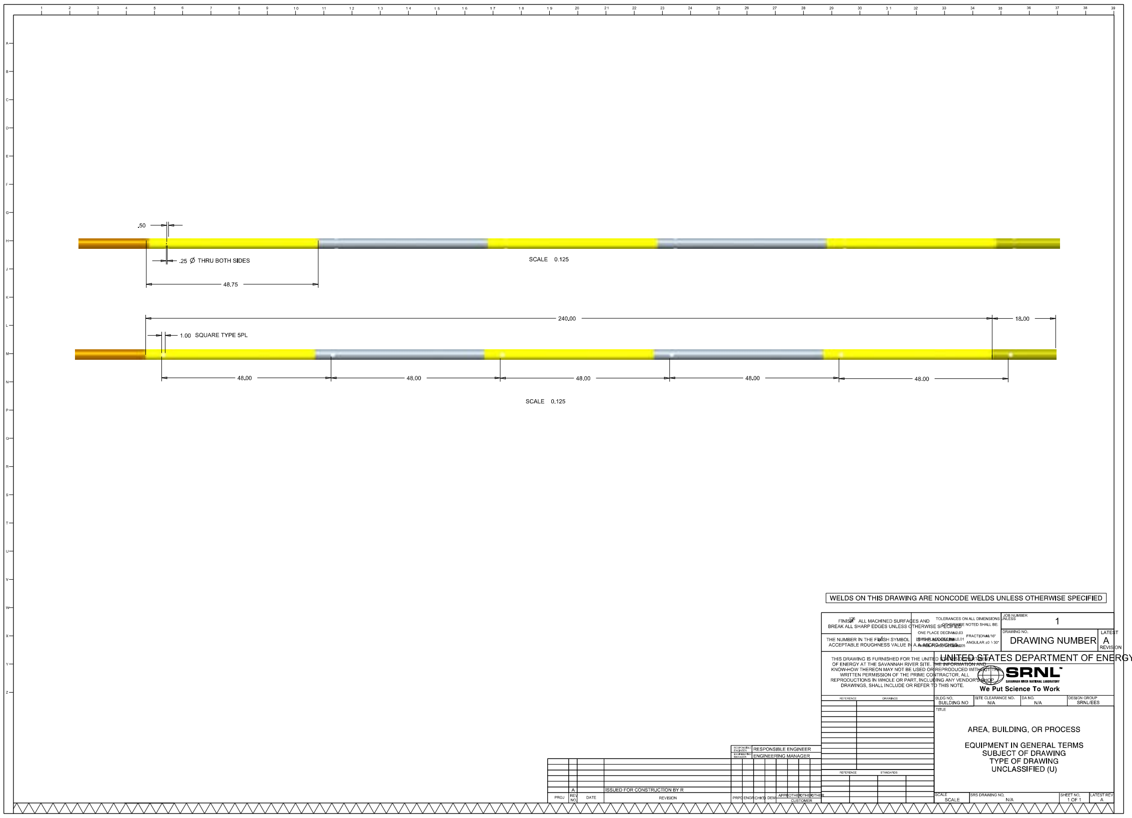


Figure 8. Final assembly of inner tubing of the FCSS.

The following are the overall results obtained from the internship period:

- Completed CAD models on the second generation of the sample sleeve system
- Completed technical drawings
- Manufacturing validation
- Submitted abstract on the FCSS to the Waste Management Conference 2012.

4. CONCLUSION

The FCSS system has proven to be a more efficient method for collecting core samples and avoiding the efforts of drilling. By implementing this technique, a great deal of time will be saved and work safety improved. The cores collected during the experiments have proven to be in optimal condition for analysis. However, the actual design represented a tremendous challenge in terms of manufacturing and core retrieval. This brought up the need for a new design that will help to efficiently manufacture the system and reduce the required force required to retrieve each of the samples.

The new implementation design was successfully validated. The thickness of the specified pipe represented a challenge in terms of selecting an appropriate thread profile. The ACME thread for pipes with small thickness was selected and implemented. A new-scaled assembly should be done prior to manufacturing a full-scale version of the system. This will finally validate the interaction between the different elements of the FCSS.

5. REFERENCES

[1] Review of Grout Sampling Methods for Saltstone Facility Vaults, Technical Report SRNL-RSE-2008-00029.

[2] Design and Testing of the Formed – Core Sampler System for Saltstone Facility Vaults, Technical Report SRNL-STI-2010-00167.

[3] Saltstone Facilities, Savannah River Remediation (SRR). Public Document.