Facility Upgrades for Receipt from Actinide Removal and Modular Caustic Side Solvent Extraction Processes at the Savannah River Site

T.L. Fellinger, B.A. Davis, B.H. Culbertson, A.V. Staub, S.G. Phillips
Defense Waste Processing Facility
Savannah River National Laboratory
Westinghouse Savannah River Company
Aiken, SC 29808
USA

ABSTRACT

The Savannah River Site (SRS) is currently on an aggressive program to empty its High Level Waste (HLW) tanks and immobilize its radioactive waste into a durable borosilicate glass in the Defense Waste Processing Facility (DWPF). As a part of that program, two new processes will be brought on-line to assist in emptying the HLW tanks. These processes are in addition to the current sludge removal process and are called the Actinide Removal Process (ARP) and the Modular Caustic Side Solvent Extraction (MCU) Process. In order to accept and process the streams generated from these two new processes, several facility modifications are required and are broken down into several projects. These projects are handling the facility modifications required for the Tank Farm (241-96H), and DWPF vitrification facility (221-S), and DWPF ancillary facilities (511-S, and 512-S). Additional modifications to the 221-S building were required to address the flammability concern from the solvent carryover from the MCU process. This paper will describe a summary of the modifications impacting the 511-S, 512-S, and the 221-S facilities in order to receive the new streams from the ARP and MCU processes at the DWPF.

INTRODUCTION

Currently there is a critical shortage of HLW tank storage at SRS. This is due to several reasons, one being the complex chemical compositions of the waste, another being the amount of recycle water being received from the DWPF and other site processes (i.e. Tank Farm evaporator processing), and the delay of Salt processing due to the benzene generation experienced from the catalytic decomposition of tetraphenylborate for the In Tank Precipitation Process (ITP). As a result of the benzene generation for the ITP process, alternate technologies were evaluated and a caustic side solvent extraction technology was selected for Salt processing. In addition to this technology, another technology is being used to remove the Sr and actinides from the salt solution prior to processing of the salt solution through the solvent extraction process. These two technologies will be deployed in order to help restore the capacity in the HLW tank farms until the Salt Waste Processing Facility (SWPF) is brought on line at a later date.

Two process flow sheets have been developed based on these two technologies and they are called ARP and MCU. The ARP flowsheet involves two strike tanks where Mono Sodium Titanate (MST) is added to the salt solution in the 241-96H Tank Farm facility. The MST is added to remove the majority of the soluble Sr and actinides from the salt solution. The MST/salt solution is then transferred to the Late Wash Precipitate Tank (LWPT) in the 512-S facility for filtration. Two streams are generated as a result of this filtration, a MST/sludge solution and a clarified salt solution (CSS). The MST/sludge solution is transferred to the 511-S facility to the Low Point Pump Pit –Precipitate Pump Tank (LPPP-PPT), via LWPT, where it is stored until it is transferred to the Precipitate Reactor Feed Tank (PRFT) in the 221-S building for incorporation into the final glass product. The CSS, generated from the filtration in 512-S facility is stored in the Late Wash Hold Tank (LWHT) until it is transferred to the MCU facility.

The facility that will contain the MCU process is a new facility and has just finished construction. At the MCU facility, the CSS is processed through a solvent extraction process which generates a solution containing concentrated Cs and a decontaminated salt solution. The decontaminated salt solution (DSS) is sent to the Saltstone Processing Facility (SPF) via Tank 50 for further processing. The concentrated Cs solution, called strip effluent (SE), is stored in a tank called the Strip Effluent Hold Tank (SEHT) until it is transferred to the Strip Effluent Feed Tank (SEFT) in the 221-S facility through the 511-S facility. As a by-product of the MCU process, a small amount of solvent remains in the SE. The solvent contains a flammable component called Isopar® L, presenting a flammability concern for DWPF. Figure 1 provides an overview of the transfer paths for both flow sheets.

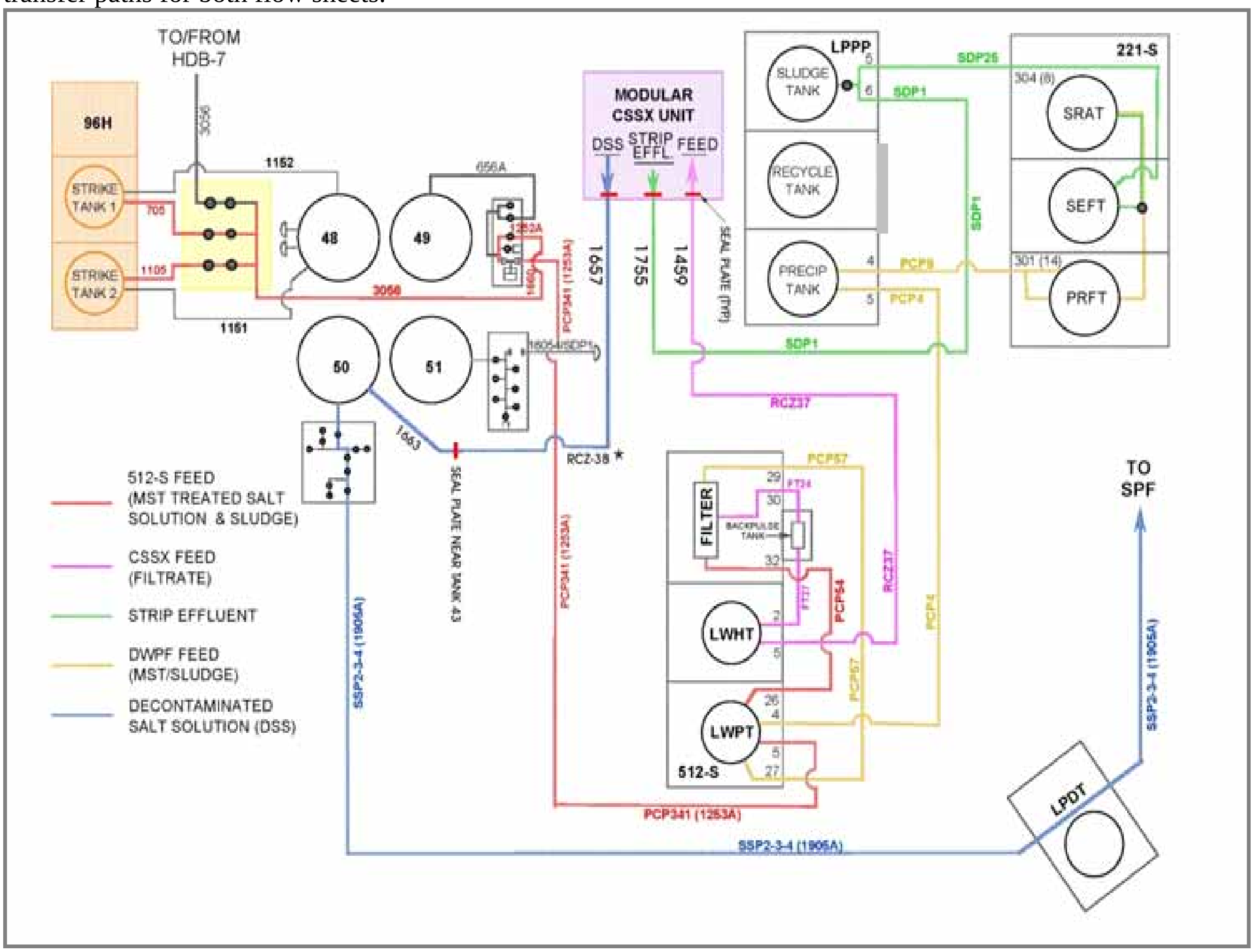

Fig. 1. Overview of the Transfer Paths for the ARP and MCU Flow Sheets

To address the flammability concerns and the design and installation of the modifications required to implement these two flow sheets in the DWPF, several projects were created to handle the scope of work. These projects are called Waste Transfer Line (WTL), MCU, and ARP projects. These projects encompass the design, modifications, and installation for the underground transfer lines, and equipment in the 511-S, 512-S and 221-S facilities. It should be noted that the 511-S and 512-S facilities are a part of the DWPF. The next section of this paper provides information regarding the scope and installation of modifications ongoing/completed for the projects.

PROJECT SCOPE AND MODIFICATIONS

This section provides a condensed version of the scope and modifications of several projects. A list of the required modifications to implement the ARP and MCU flow sheets in DWPF are provided below.

- Excavate and modify the sludge underground transfer lines in the Tank Farm to allow new transfer paths.
- Provide new and/or revise existing control logic to allow transfers between 241-96H and 512-S facilities, between 512-S and MCU, 511-S and 221-S, and between MCU and 221-S.
- Return two process vessels (PRFT and SEFT) and associated equipment back to service in the 221-S building. Fabricate and install several process jumpers. Provide new and/or revise existing control logic for equipment being returned to service.
- Install new hardwired safety interlocks for three process vessels in the 221-S building to address the flammability issue with the solvent carry over in the SE stream from MCU.

Based on the list above, subheadings have been created for each modification. These subheadings contain the function of the equipment, the modification, and a status of the modification.

Modifications of the Underground Transfer Lines

The underground transfer lines and headers are used to provide an inter-area transfer capability between facilities so that HLW solutions can be processed. As a part of the MCU Project, three new transfer lines (WTS-L-1459, 1657, and 1755) along with seal plates and shielding are to be installed and tied into two existing transfer lines (RCZ37/WTS-L-1663 and SDP1). Upon completion of this modification, new transfer paths into and out of the MCU facility will be provided.

In order to accomplish this modification, process outage windows (i.e. no sludge slurry transfer) for DWPF were arranged, physical barriers were established at the MCU and ARP facilities to reduce radiological hazards, and existing transfer lines were flushed prior to tie in activities. The underground transfer lines are 3 inch schedule 40 stainless steel pipes with either a 4 inch schedule 40 carbon steel jacket or a 10 inch schedule 20 carbon steel jacket. The existing transfer lines were excavated and modified and new transfer lines (~50 linear feet) were installed. The modification was broken down into two major tasks. The first task involved the removal of a section of the core pipe and jacket for line RCZ37 (i.e. 1663 in Figure 1), the rerouting of RCZ37 to tie in with line 1657, the renaming of the section of piping from 1663 to 1657 from RCZ37 to RCZ38, and the rerouting of the remaining section of piping for RCZ37 to tie into line 1459. The second task involved line SDP1 which allowed sludge slurry transfers from Tank 51 to the 511-S facility. This line was modified to isolate the exit of line SDP1 out of the Tank 51 valve box by capping it and deactivating the automatic valve and rerouting the remaining section of pipe to tie into line 1755. Figure 2 provides a close – up of the tie in locations discussed above.

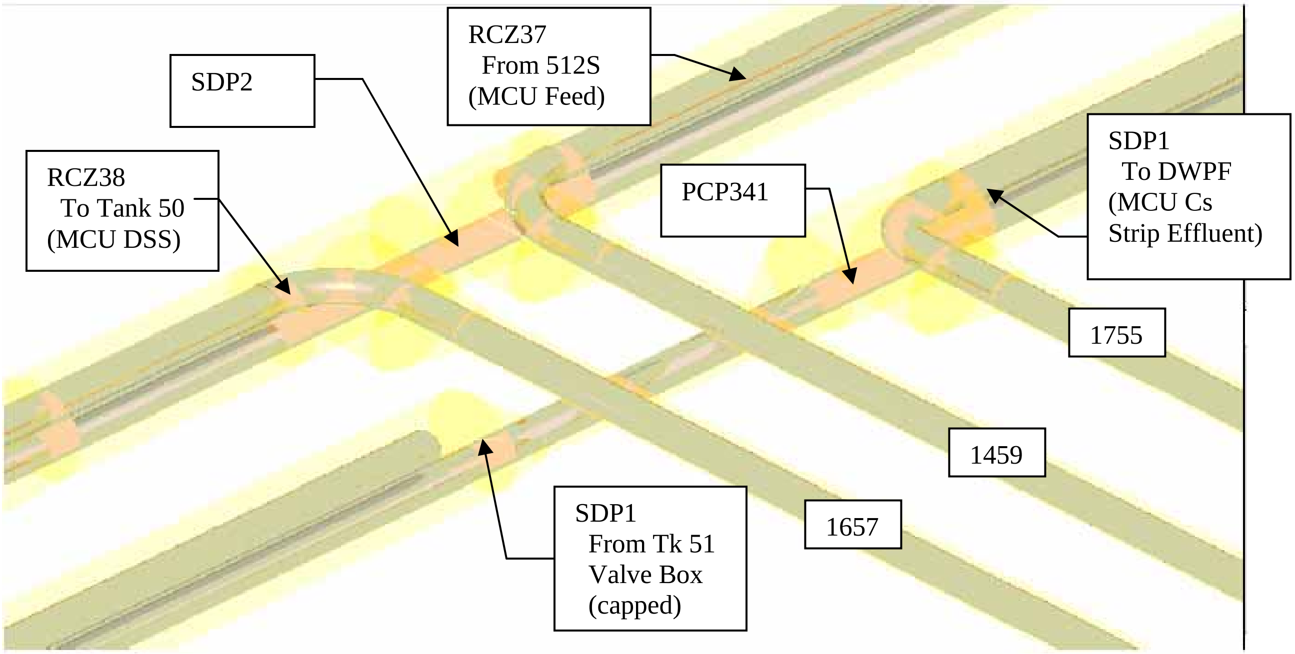

Fig. 2. Tie in points for transfer lines

The first task provided a new route for the transfer of DSS from the MCU facility to Tank 50 and a new route for the transfer of CSS from the 512-S facility to the MCU facility. The second task provided a new route for the SE stream from MCU via the 511-S facility to the 221-S facility. The tasks for this modification are complete with the exception of the shielding installation and the removal of caps from lines 1657, 1459, and 1755 at the MCU facility. The shielding installation and cap removal is expected to be completed early in 2007.

Control Logic to Accommodate Modifications for ARP and MCU Processes

In order to control the transfers made between the MCU, 241-96H, 511-S, 512-S and 221-S facilities, (via the new underground transfer lines) existing computer logic on the Distributed Control System (DCS) was modified or new computer logic was created. Figure 1 can be used as an aid for the computer control logic discussion of the transfer paths below.

For the interface between 512-S facility and the 241-96H facility, software logic was created to allow the transfer of the MST treated salt solution from the 241-96H facility to the LWPT at the 512-S facility. Some of the features of this software included software interlocks prevent or stop running of the 241-96H transfer pumps when there is a high liquid level in the LWPT or high level in the sump for the LWPT cell or low instrument nitrogen pressure. To accomplish the software logic modifications, level signals from the level transmitters for the LWPT at the 512-S facility were routed to the H area control room and levels of the 241-96H strike tanks were added to the LWPT DCS computer graphic at the DWPF. The transfer from the 241-96H tanks will be controlled by the H-area control room.

For the interface between 512-S facility and the MCU facility, software logic was added for the transfer of the CSS from the LWHT at 512-S to MCU facility. The features of this software are similar to those described above. The software logic stops or prevents the running of the LWHT transfer pump upon a high level in the receiving tank or high level in the sump at the MCU facility. To accomplish the software logic modifications, level signals from the LWHT were routed from the DWPF control room to the H-area control room and graphics of the MCU receipt tanks were added to the LWHT DCS computer graphic at the DWPF. The transfer from the LWHT will be controlled by the DWPF.

Since the computer software logic existed for the transfer from the 512-S facility to the 511-S facility, no changes had to be made to the control logic. However, software logic used to control the process at the 511-S and 221-S facility required change to address the physical modifications to the underground transfer lines and new routes of the ARP material and MCU material to the 221-S facility. The software changes included deleting software and the graphic for transferring sludge from Tank 51 (H-area Tank Farm) to the LPPP-PPT in 511-S, providing software logic to transfer the contents of the LPPP-PPT to the PRFT located in 221-S, deletion of software logic for the transfer of the LPPP-PPT to the SEFT, and updating DCS graphics to reflect the first two software changes. Similar controls were implemented as described above; high levels, etc. will prevent or stop the running of the transfer LPPP-PPT pump.

For the interface between MCU facility and the 221-S facility, software logic was added for the transfer of the SE from the MCU facility via the 511-S facility to the SEFT in 221-S facility. The features of this software are similar to those described above. The software logic stops or prevents the running of the MCU transfer pump upon a high level in the receiving tank or high level in the sump at the 511-S facility, or high level in the sump at the 221-S facility, and low SEFT instrument air pressure. The transfer from the MCU facility will be controlled by the DWPF.

The majority of the software modifications listed above are complete. The remaining modifications are expected to be complete by January 2007.

Returning the PRFT and SEFT to Service in the 221-S Facility

In order to accommodate the MST/sludge and SE streams, two tanks and associated equipment located in the 221-S facility will be brought back into service and new transfer paths will be established. The two tanks being brought back into service are called the SEFT and the PRFT. The SEFT will be utilized to receive the SE stream and the PRFT will receive the ARP stream. A transfer path from these tanks to the Sludge Receipt Adjustment Tank (SRAT) will need to be established. In the SRAT, the streams will be processed along with the sludge slurry and will become a part of the final glass product. The SEFT had been recently modified by another project, thus the modifications required are for its new intended mission. Since there are numerous modifications for each vessel, a table has been created for each vessel. Table I contains the modifications for the PRFT and Table II contains the modifications for the SEFT.

Table I. PRFT Modifications to Return the Vessel to Service

Modification	**Description**
Jumpers*	• Fabricated a feed jumper to provide a path from the LPPP-PPT to the PRFT inside the 221-S Facility. • Fabricated a jumper to provide level indication for the PRFT. • Fabricated a jumper to ventilate the PRFT vessel. Removed existing jumper in order to provide new ventilation path. • Fabricated a jumper with a restricting orifice plate for the PRFT transfer pump. This jumper will provide a transfer path from the PRFT to the SRAT inside the 221-S Facility. • Established a new transfer path from the sump to the PRFT. Re-installed existing jumper. Removed existing jumper with motor operated valve from sump pump along with 2 other jumpers to allow for new transfer path. • Fabricated replacement jumpers for the cooling water return and supply, sample pump discharge/return, sample pump power, and agitator lube oil/Hg seal/grease. • Re-installed purge jumper to provide a purge to the PRFT.
Equipment	• Installed safety grade filters, regulators, differential pressure gauges, orifice plate and needle valves to provide a purge to the PRFT. • Installed Hazelton pump with a variable frequency drive (VFD) to provide transfer capabilities from the PRFT to the SRAT. Removed an installed mechanical seal and replace with packing. • Removed existing PRFT sample pump and remove installed mechanical seal and replace with packing. Provided VFD for sample pump. • Restored sampling equipment related to the PRFT. • Removed circular blinds that currently block liquid flow to the PRFT (cooling water, etc.) • Provided instrument air to PRFT pneumatic operated valve operators, PRFT instrument purges, sump level purges, and sump sparger valve operator. • Calibrated instruments associated with the PRFT (i.e. tank level, temperature instruments, etc.)
Software Logic	• Provided software logic for transfer from PRFT to SRAT. Included logic to control 3 way valve selection on the SEFT transfer pump discharge jumper. The PRFT transfer path utilizes the SEFT transfer pump discharge jumper to send material to the SRAT. • Restored software programming to start/stop PRFT pumps, start/stop sump pump, start/stop agitator, control of process cooling water, level indication, vessel temperature, pump and agitator power, equipment status and process graphics. • Provided new logic for the new transfer path from the sump to the PRFT.

* Jumpers provide connections for services such as electrical, air, chemical, etc. so that equipment can be remotely operated in the 221-S facility.

Table II. SEFT Modifications to Return the Vessel to Service

Modification	Description
Jumpers*	• Fabricated seven jumpers to provide a flow path from the MCU to the SEFT inside the 221-S Facility. • Fabricated a jumper with a restricting orifice plate for the SEFT transfer pump. This jumper will provide a transfer path from the SEFT to the SRAT inside the 221-S Facility. This jumper also includes a 3-way motor operated valve to select flow from the SEFT or the PRFT to the SRAT (via a branching design). • Provided a jumper for the power/signal for the motor operated valve.
Equipment	• Installed new transfer pump with a variable frequency drive (VFD) to provide transfer capabilities from the SEFT to the SRAT.
Software Logic	• Provided software logic for motor operated valve power, controls and valve position for SEFT transfer pump. • Change software programming to reflect that name change of the vessel to SEFT.

* Jumpers provide connections for services such as electrical, air, chemical, etc. so that equipment can be remotely operated in the 221-S facility.

The jumper and equipment modifications are complete and the software logic changes are expected to be complete in January 2007.

Installation of New Hardwired Safety Interlocks for the PRFT, SEFT and SRAT Vessels

As a by-product of the MCU process, a small amount of solvent may be carried over into the SE stream and transferred to the SEFT. The solvent in this stream contains a flammable component called Isopar ®L. Isopar ®L can be present in the vapor space at low temperatures, and poses a flammability concern. Based on the configuration of the PRFT and SEFT there is a potential for the PRFT to receive the SE stream via leaks, inadvertent transfers, etc.. These process upset scenarios were identified during a consolidated hazards analysis process. In order to limit the contribution of Isopar ®L to the vapor space of the PRFT and SEFT, temperature controls are required. By limiting the temperature of the tank, one can limit the amount of Isopar ®L in the vapor space of the tanks. This is accomplished by using resistance temperature devices (RTDs) to monitor the temperatures of the tanks. Upon exceeding a high temperature in the tanks, the temperature switches actuate hardwired interlocks that de-energize the transfer pump motor, the sample pump motor, and power from the agitator motor. By limiting the temperature through the use of a temperature interlock, an existing safety purge can be employed. The purge maintains the vapor spaces of the tanks below 60% of a Composite Lower Flammability Limit (CLFL) for radiolytic hydrogen and Isopar ®L, and thus prevents a subsequent detonation/deflagration of the tanks during a seismic event.

The processing strategy for the ARP and SE streams is to add these homogenized streams during the SRAT cycle while the SRAT vessel contents are boiling. This ensures that the Isopar ®L is readily released to the vapor space of the SRAT where the existing safety purge maintains the vapor space below 60% of CLFL for hydrogen and Isopar ®L. Inadequate homogenization of the strip effluent stream can lead to high concentrations of Isopar® L being feed to the SRAT. High concentrations of Isopar ® L (when combined with hydrogen) in the vapor space of the SRAT could exceed the CLFL of the SRAT vapor space. Also, when fed in high concentrations, Isopar ® L could condense in the SRAT condenser train where it could impact other downstream processing vessels. In order to prevent a high concentration of Isopar ® L from being fed to the

SRAT, a low agitator power limit and minimum agitation time are required for the PRFT and SEFT. To maintain the contents of the SRAT at boiling conditions, RTDs will be used to monitor the temperature of the tank and flow indicating transmitters will be used to monitor steam flow. If the temperature and/or steam flow of the SRAT drops below the desired set points, the temperature and/or flow switches actuate hardwired interlocks that de-energize the transfer pump motors for both the SEFT and the PRFT.

In order to implement the scope of changes described above to safely operate the 221-S facility, a design change package was developed. The scope of the design change package included the following:

- Redundant safety interlocks to limit the temperature in the SEFT and the PRFT,
- Redundant safety interlocks to stop transfers from the SEFT and PRFT to the Sludge Receipt Adjustment Tank (SRAT) on low agitator power from the SEFT or PRFT, and
- Redundant safety interlocks to stop transfers from the SEFT and PRFT when low SRAT heating coil steam flow and/or temperature of the SRAT liquid is achieved.

To implement the design, existing equipment as well as new equipment was used. The major pieces of new equipment include; six safety contactor panels, two safety fuse boxes, two safety local control stations, safety conduits, safety cables, safety supports, safety steam flow meter for the SRAT, twelve safety trip units, four safety watt transducers, production support conduits and PS cables. The design also includes a re-work of the existing SRAT steam pipe to accommodate the upstream and downstream pipe lengths for the new steam flow meter. The design also used existing equipment in the canyon, RTDs, field termination cabinets and wall termination boxes. Figure 3 provides an overview of the safety design modifications for the SEFT, PRFT, and SRAT.

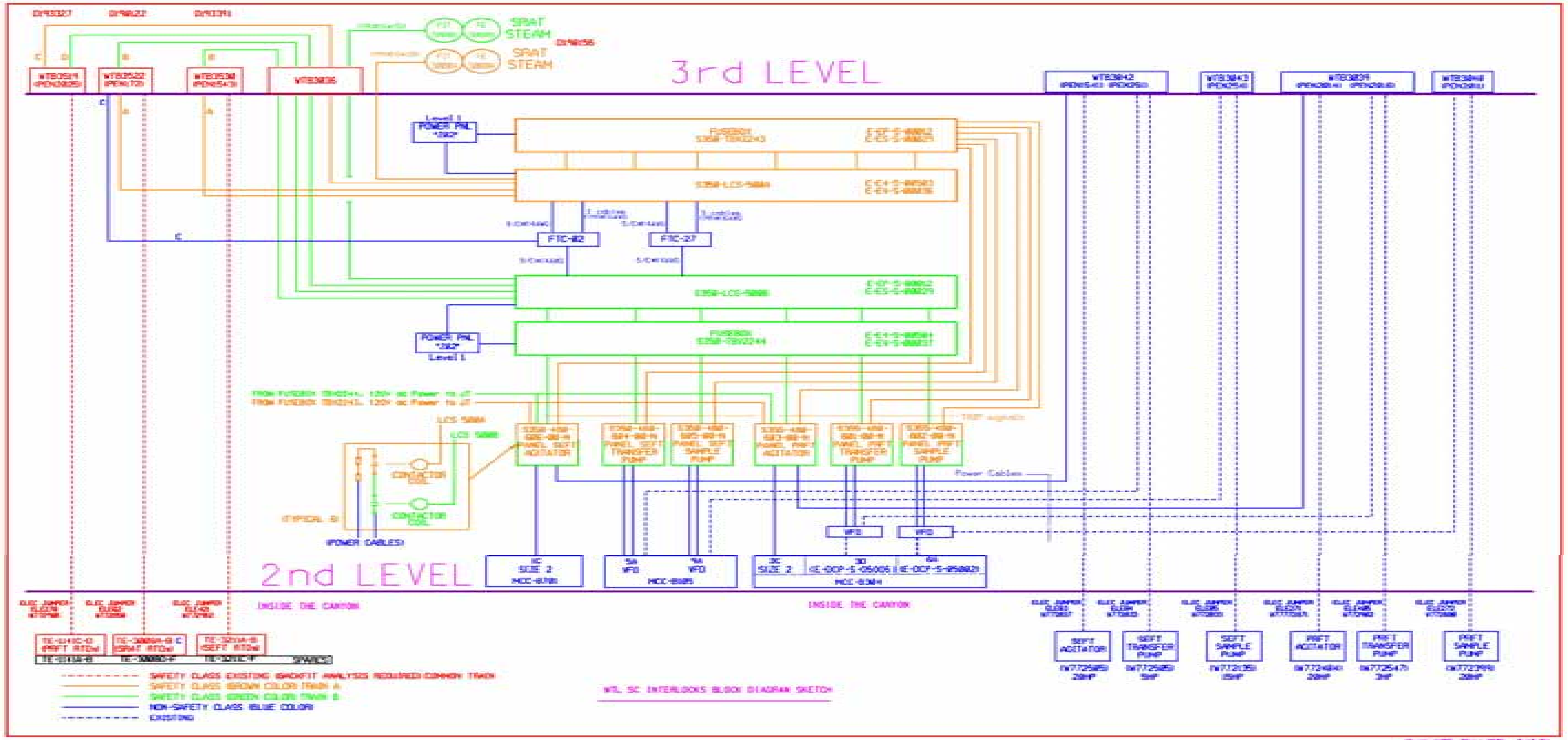

Fig. 3. Overview of the Safety Design Modifications for the SEFT, PRFT, and SRAT

As can be seen in Figure 3, the design and installation of the modifications impacted the first, second and third levels of the 221-S facility. The colors used in Figure 3 distinguish between safety and non-safety equipment, existing equipment versus new equipment, and distinguishes between the redundant trains. The black lines on the drawing distinguish where the equipment is located in the facility. In order to accomplish this modification, a phased approach was used to work the modification in known process outage windows for 221-S. Approximately 90% of this design has been installed in the 221-S facility. The remaining 10% is scheduled to be completed by January 2007.

CONCLUSIONS

In order to alleviate the HLW tank space issue at the SRS, the ARP and MCU processes will be brought on line. To safely implement these new processes, new equipment and existing equipment were installed or modified in several facilities. The majority of the modifications are complete. The remaining modifications are anticipated to be complete by January 2007 to support startup testing programs for the MCU, 511-S, 512-S, and 221-S facilities.

ACKNOWLEGEMENTS

The authors of the paper would like to thank Bob Ervin for providing the sketch of the “Overview of the Transfer Paths for the ARP and MCU Flow Sheets” and Rajan Iyer for providing the sketch of the “Overview of the Safety Design Modifications for the SEFT, PRFT, and SRAT”.