AREVA MOBILE HOT CELL TECHNOLOGY TO PROCESS, CHARACTERIZE AND PACKAGE TRU WASTE

WM2010, Topic 2.12, Advanced Technologies and Approaches Applied to Problematic, Special Case TRU Waste
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ABSTRACT

The Mobile Hot Cell approach developed and used in France by AREVA for retrieving legacy wastes is being adapted to the retrieval of TRU wastes from the Alpha Caissons located in the 214-W-4B burial ground at Hanford. The Alpha Caisson Mobile Hot Cell will be used for retrieval, size reduction, sorting, characterization, and packaging of remote handled and contact handled TRU waste. The wastes put into the Alpha Caissons came from hot cells that performed fuel examinations and supported the plutonium finishing plan in an era when shipping and waste disposal practices focused on radiological hazards. Available documentation on the Alpha Caissons indicates that the waste stream includes that alkali metals (NaK, Na, K), which are prohibited at Waste Isolation Pilot Plant (WIPP) based on their pyrophoric waste characteristics, as well as combustible materials (solvents, cellulose, plastic, and rubber) and metallographic samples and residues from the examination of spent fuel and fuel cladding. Wastes that are prohibited from shipment to WIPP will be separated from the waste stream and treated to meet the criteria for disposal at WIPP or Hanford's Low Level Waste Burial Ground. The transition design activity to date included the development of requirements, an engineering plan, flow diagrams and throughput analysis, functional diagrams, general layout, mechanical drawings and equipment sketches, utilities definition, cost estimate and schedule, preliminary hazards analysis, and a cross walk of nuclear safety design requirements to design implementation. The hazard controls and list of safety structures, systems, and components is based on the French Mobile Hot Cell Detail Design. The design requirements are based on the Department of Energy's nuclear safety requirements, site specific classification of the Mobile Hot Cell safety systems, and Hanford site design practices.

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INTRODUCTION

AREVA developed Mobile Hot Cell technology to retrieve, process, characterize and package TRU Waste to minimize the dose and hazards to workers and risk of environmental releases. The MHC approach has been demonstrated in France at three locations. The Bituminized Drum Retrieval Facility (ERFB) and Drum Retrieval and Repackaging Enclosure (ERCF) implementations at the Marcoule site demonstrate that this technology is redeployable for use at other waste retrieval and repackaging tasks after refitting the process cell equipment for site specific requirements. The FOSSEA project (*FOSSes Evacuées et Assainies* - Legacy Waste Recovery and Trench Cleanup) at the Cadarache site demonstrated the integration of a separate waste retrieval system with the MHC, which was used for processing of retrieved packages (contamination inspection, characterization, repackaging) and loading transportation casks.

Figure 1 presents pictures of the mobile hot cell at each installation. These applications demonstrate that this technology is redeployable for other waste retrieval and packing tasks with refitting and tailoring of the retrieval equipment, process cell, and site interfaces. The River Protection Project at Hanford selected this technology to process remote handled and contact handled TRU wastes from the Alpha Caissons, including sorting, characterization, size reduction, treatment of WIPP prohibited wastes, and packaging. The process cell will be collocated with the retrieval and lag storage operations at the site. AREVA prepared a design and facility safety crosswalk evaluation of the Mobile Hot Cell approach used in France with the regulatory and safety requirements applicable to the Alpha Caisson Waste Retrieval Project (ACWRP). Since that time both the Conceptual Design effort and safety analysis have matured. The Transition Conceptual Design was tailored to meet the operating and safety requirements at Hanford's Solid Waste Burial Grounds.

Figure 1 : ERFB Installation (Marcoule Site)

Figure 1 :ERCF Installation (Marcoule Site)

Figure 1 :FOSSEA Installation (Cadarache Site)

The alpha caissons were built for retrievable storage of TRU was shortly after the Atomic Energy Commission established the TRU waste category and required the waste to be segregated from other wastes. The caissons are located in the 214-W-4B burial ground in Area 200. The wastes were originally generated from the development of fuel and from the examination of defective fuels. The Alpha Caissons were in use from early 1970 until 1988. The four alpha caissons received over 800 ft^3 of RH-TRU waste from three hot cells, including various sized containers (primarily 1 gallon paint cans), plastic sheets that were used for contamination control when the caissons were filled and loose soil which was thrown in with each disposal. The waste acceptance criteria and record keeping at the time do not meet the standards required for shipment of this waste to WIPP and present challenges for establishing the safety basis for retrieval. The available data on Alpha Caisson waste characteristics is incomplete and is focused on the isotopic data used for ensuring criticality safety. The available documentation indicates that the waste stream includes pyrophoric material (sodium potassium eutectic, sodium and potassium), combustible materials (plastic, paper, rags, and rubber), as well as wire, failed equipment, metal scrap, and small quantities of metallographic samples and residues from the examination of spent fuel and fuel cladding. Solvents and cutting oil are also suspected of having been included in the wastes. The retrieved wastes have to be retrieved, characterized and packaged to meet WIPP waste acceptance criteria. Characterization may be limited to Non Destructive Analysis (NDA) and Real time Radiography (RTR) or may require opening, examining, sampling, and sorting wastes to identify, remove, and treat WIPP prohibited items. Figure 2 is a photograph of the wastes from the top of one of the caissons. Figure 3 is a diagram of a typical caisson.

Figure 2: Photo Looking Down at a Caisson Surface Layer

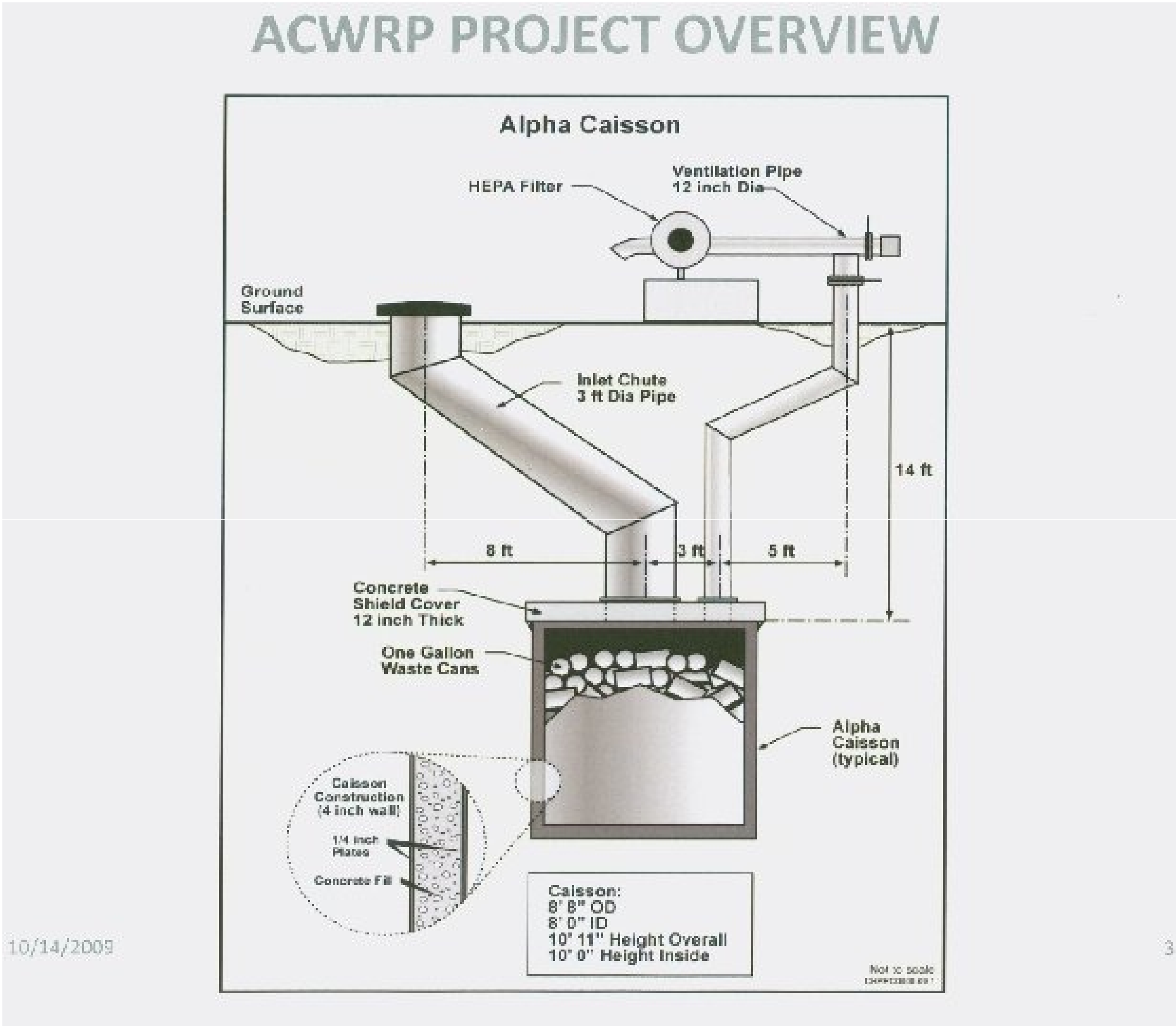

Figure 3: Alpha Caisson Schematic

The goal of the ACWRP is to minimize the staging, storage, and transfer of individual drums, perform all required processing steps as near to the retrieval locations as possible, and to produce a WIPP-compliant container per PRC-MP-MS-40225, *Alpha Caisson Waste Retrieval Project Execution Plan*. The activities will include repackaging and treatment of retrieved container contents to provide a WIPP-compliant package that can be certified without significant further processing.

Figure 4 presents the split of the Alpha Caisson Waste Retrieval Project (ACWRP) between the Waste Retrieval System (WRS) and the Waste Processing System.

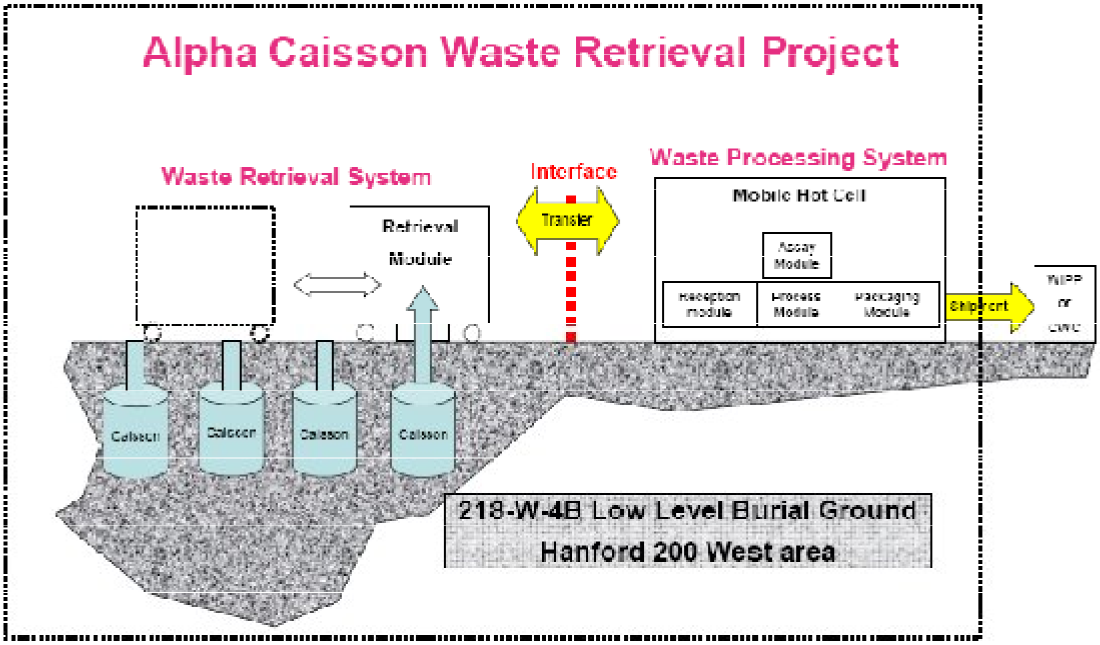

Figure 4: Alpha Caisson Waste Retrieval Project

During the project planning phase the project decided to initiate a Transition Design activity for the Waste Processing System (WPS) that would Americanize the French MHC design and ensure that the project's mission requirements can be successfully met using Mobile Hot Cell technology. The scope of the mission requirements includes waste characterization, sorting, processing, and repackaging as WIPP certifiable waste. The transition design activity to date included the development of requirements, an engineering plan, flow diagrams and throughput analysis, functional diagrams, general layout, mechanical drawings and equipment sketches, utilities definition, cost estimate and schedule, preliminary hazards analysis, and a cross walk of nuclear safety design requirements to design implementation. The objective of the design and safety crosswalk is to ensure integration of U.S safety requirements into the design. Americanization of the design includes also translation of French into English, changing metric units into English units, and identifying U.S. federal, state, and local codes, standards, and regulations required for use of such a system at the Hanford Site.

This paper focuses on the design and safety crosswalk. The design and safety crosswalk includes a comparison of the basis (hazards, waste characteristics) used for the selection of safety features in a format that facilitates comparison of the approach used to select safety features and design requirements in France and by the U.S. Department of Energy (DOE). The design and safety crosswalk also includes a review of Hanford site specific waste characteristics, hazards, and design requirements. The conceptual mechanical design layout developed during the Transition Phase, based on the French Mobile Hot Cell safety systems, was reviewed using DOE and Hanford safety analysis and risk assessment methods. The classification of safety systems was used to identify specific design requirements based on DOE's nuclear safety system and Hanford specific requirements.

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The methodology used to develop the initial design of the Waste Process System (WPS) and safety crosswalk was to:

- Review available information on the Alpha Caisson design, waste characteristics, and safety basis.
- Review the available information on the French Mobile Hot Cell design and safety basis.
- Review the WPS Conceptual design requirements, process flow and functional diagrams and proposed cell configuration.
- Review the Conceptual design safety features using DOE standards and the Hanford Safety Analysis and Risk Assessment Handbook.
- Prepare a table summarizing the hazards of retrieving Alpha Caisson wastes, WPS hazard controls, applicable DOE and French design codes and standards, and issues and recommendations for using the Mobile Hot Cell technology to retrieve the Alpha Caisson wastes.
- Prepared failure modes and effects analysis to identify if additional hazard controls should be considered.

The French Mobile Hot Cell technology was developed specifically to retrieve bituminized waste drums stored in pits. MHC technology has been deployed on three occasions in France; ERFB and ERCF on Marcoule site and the FOSSes Evacuées et Assainies (Drum Evacuation and Assay) (FOSSEA) on Cadarache site. The Hanford MHC will be an evolution of this MHC technology deployed at Marcoule in France. The WPS safety systems are listed on Table 1.

Table 1: WPS safety systems

Radiation Shielding
Radiation Detectors (Direct Radiation and Contamination)
Waste Containers (Drums and Package Baskets)
Confinement Ventilation (Contamination Control and Flammable Atmosphere Control)
Confinement Structure
Fire Suppression System

The hazards which were considered during the design of the French Mobile Hot Cell are summarized on Table 2 (FOSSEA application).

Table 2: Hazards Considered for FOSSEA Safety Evaluation

Nuclear risks	Risk of spread of contamination
	Risk of exposure to external radiation
	Risk of exposure to internal radiation

	Risk of criticality
	Radiolysis
	Radiological heat
Non-Nuclear Risks	Fire
	Explosion
	Handling
	Flooding from internal sources
	Loss of services
	Loss of electrical services
	Human factors
External events	Seismic
	Flooding
	Forest fire
	Aircraft crash
	Industrial environment and communication
	Climatic events

For both French installations and DOE installations, there is the requirement to produce documentation to demonstrate that an installation is safe to operate. Such documentation must show that an installation / task / modification meet the requirements of the regulatory body. However, it was not possible to perform a direct comparison of DOE and French requirements, because of differences in the administration of the regulations. DOE standards and requirements are much more prescriptive than French standards. The U.S. regulatory requirements in 10 CFR 830, Nuclear Safety Management are implemented in a series of DOE orders and guides which specify the codes and standards for design of safety systems. The French regulatory requirements in Decree 2003-296 of 31 March 2003 is codified in Section 8 "Prevention of the risk of exposure to ionizing radiation" in chapter I of part III of book II of the second part of the French Labor Code and French Public Health Code articles R.1333-1 to R.1333-92. This regulation has similar high level requirements as the regulations in the United States – to identify the hazards and hazard controls that will prevent overexposure of workers and the public under normal and accident conditions. The French approach leaves the identification of safety systems and selection of design codes to the license applicant, with the regulatory authorities reviewing and approving the safety basis. AREVA's design procedure and company standards are more prescriptive than the regulations and requires designing to ISO standards. For example, ISO 17873:2004, Criteria for the design and operation of Ventilation Systems for Nuclear Installations other than Nuclear Reactors, was used to design the Mobile Hot Cell ventilation confinement.

Experience on the Hanford Tank Waste Treatment and Immobilization Plant has shown that it can be difficult to prescriptively apply U.S. design codes to technology and design solutions developed elsewhere without tailoring the solution within the safety basis and obtaining approval from DOE; reference "Application of ASME AG-1 to the DOE Hanford Tank Waste Treatment and Immobilization Plant", 28th Nuclear Air Cleaning Conference. Because it is not possible to perform a direct comparison of DOE and

French requirements for each system in the design, the design and safety cross walk was made by identifying the hazard controls used in the French Mobile Hot Cell design and the controlling DOE standards. The development of the Conceptual Design safety document includes the identification of the applicable U.S codes and standards based on U.S. regulatory requirements.

The most significant challenge in adapting the MHC technology to the Alpha Caisson waste retrieval mission of recovering and repackaging is that the data on Alpha Caisson waste characteristics is incomplete. Available documentation indicates that potential fire hazards in the waste stream include: pyrophoric materials (NaK, Na and K), combustible materials (solvents, cellulose, plastic, and rubber) and pieces of nuclear fuel whose ignition and combustion characteristics have not been determined. Remote-handled TRU wastes intermingled with contact-handled (CH) waste will be handled in the WPS modules based on As Low As Reasonable Achievable (ALARA) and efficiency considerations. These wastes will typically be above the CH dose limit of 200 mR/hr at contact, and special design features and planning will be in place to assure adequate controls to minimize dose. The Mobile Hot Cell safety design crosswalk was developed to evaluate the use of MHC technology to waste processing (visual examination (VE), sorting, sampling, Non Destructive Examination [NDE], and Non Destructive Analysis [NDA]) and repacking of RH-TRU waste.

The hazards of retrieving and processing the Alpha Caisson wastes using the MHC was evaluated by reviewing a preliminary conceptual design using the methods described in the DOE nuclear safety standards and the Hanford Safety Analysis and Risk Assessment Handbook. The conceptual design was also reviewed against the hazard controls recommended in DOE-STD-5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. A qualitative hazard assessment was developed by performing a failure modes and effects of the proposed hazard controls and estimating the consequences from published safety analysis of similar events that could occur at the Solid Waste Operations Complex at Hanford.

The failure modes and effects analysis of the hazard controls included in the original conceptual design solution concluded that the designers should incorporate additional features for controlling potential fires initiated during retrieval and processing of containers of sodium potassium metal and combustible volatile organic compounds. These recommendations were incorporated in the next phase of Conceptual design. One of the biggest changes was to separate the retrieval and waste processing functions into two processing units, the Waste Retrieval System (WRS) and the Waste Processing System (WPS). The WRS function includes placing the waste material in 30 gallon containers, which allows visual inspection and radiation measurements of the waste before it is inserted into the Shielded Transfer Container (STC) transferred to the WPS. This also allows controlling the quantities of flammable and radioactive material in the WPS, limiting fire and release hazards. WPS retained all of the other functions required to obtain acceptable knowledge and package the wastes for shipment to WIPP. An interface control document is used to define the technical specifications and assumptions used in the design and safety analysis of the WPS.

The WPS design requirements and criteria were updated to reflect the new approach for reducing the inventory of flammable and hazardous material in the waste processing system to reduce the risk of a release. A cross walk of DOE Nuclear Safety requirements, codes and standards to the design was also prepared as part of the conceptual design hazard analysis. 10 CFR 420 and DOE's implementing orders and guides require that all new construction must, as a minimum, conform to the model building codes applicable for the state or region, supplemented with additional safety requirements associated with the hazards. Table 3 lists the top level nuclear safety requirements and the safety systems in the conceptual design. No gaps were discovered at the conceptual design level.

Table 3: Safety Requirements and WPS Safety Systems

Multiple layers of protection against releases
• Radiation Shielding
• Radiation Detectors (Direct Radiation and Contamination)
• Waste Containers (Drums and Package Baskets)
• Confinement Ventilation (Contamination Control and Flammable Atmosphere Control)
• Confinement Structure
• Fire Suppression System
Defense in depth
• Criticality controls,
• Multiple confinement barriers
• Administrative limits,
• Fire protection,
• Monitoring and emergency planning
Adequate Site, Design and Construction
• Design Criteria, Codes and Standards
Confinement - normal & abnormal conditions
General:
• Decontamination & Decommissioning,
• Reliability, Availability, Maintainability, and Inspectability
• ALARA
Waste Minimization
• Generated wastes will be packaged in the WPS product drums
• No liquid effluents are planned
• Package baskets and drums from retrievals will be reused in process
Quality Assurance
• QA program
• Safety Design Integration

Scoping analysis of unmitigated accidents were developed and used to estimate potential on-site and off-site consequences. The accident consequences are used to classify the safety systems, which is used in conjunction with DOE's nuclear safety standards to identify specific design codes and standards, seismic design criteria, shielding, and for identifying administrative controls and emergency response plans. These analyses require best estimates of the waste stream chemical and nuclear characteristics as well as the bounding inventory in the mobile hot cell. As described earlier, the waste stream includes a wide variety of materials which are distributed in layers. Half of the Beta-Gamma content in Alpha Caisson 1 was in one shipment, a layer representing <7% of the wastes in that caisson. The chemical fire and explosion hazards vary depending on when the wastes were placed in the caissons. Untreated NaK was not accepted after 1980. Free organics were prohibited after 1984.

A conservative yet reasonable estimate of the material at risk was developed by compiling the solid waste burial ground inventory records, evaluating the quality and distribution of the existing data, and selecting an appropriate statistical method using the DOE-STD-5506 methodology for “limited characterization” waste. Estimates of Pu content, Fissile content, and Beta-Gamma Ci content were developed for the worst case can, worst case drum, and the worst case layer of wastes. Possible chemical constituents were developed after reviewing the reports summarizing the decontamination and decommissioning of the hot cells as well as the current safety basis documents for the Alpha Caissons. The hot cell shielding is being based on a 50 Ci Beta-Gamma source, which is the mean value for ~95% of the cans and represents the mean value for one 30 gallon drum of waste. The records indicate that there are 17 cans with >50 Ci. The hottest can has ~1,600 Ci. Temporary shielding and administrative controls will be used when cans with >50 Ci are processed.

The layout of WPS is shown on Figure 5.

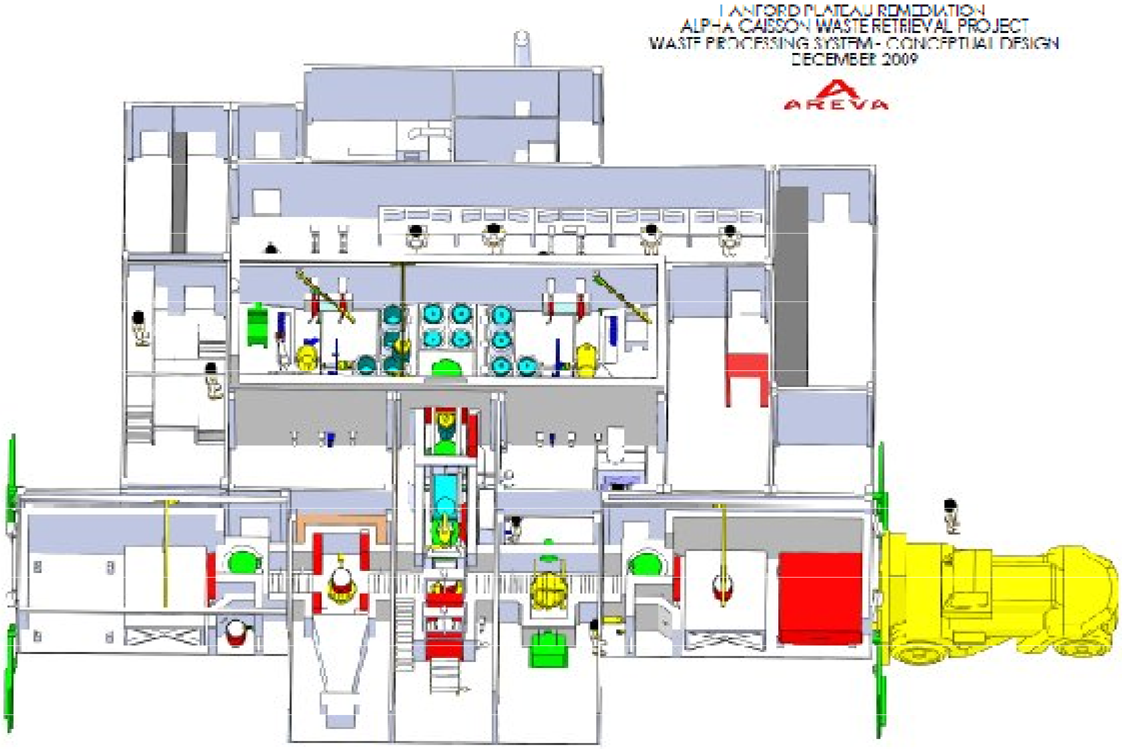

Figure 5: Layout

The process cell is where sorting and visual examination occur and where cans are opened, emptied, and the contents are examined and sampled. This area is designed for high level of airborne contamination. Waste are introduced and removed from the process area in a drum liner transfer basket through a double air lock. The drum lid lock is removed and reinstalled remotely before the drum is inserted into the airlock and drum liner is lifted out using an overhead crane and moved to the process cell insertion side of the double airlock. The drum lid is removed remotely when the drum is mated to the airlock. The NDA and RTR stations are in the transfer module, which uses a conveyor system for drum handling. Drums are loaded onto the conveyor from a Shielded Transfer Container (STC), which is used to transfer wastes from the WRS to lag storage and WPS. Product drums are transferred from WPS to a STC after NDA and RTR confirm that the data complies with the WIPP Waste Acceptance Criteria. Wastes that don't meet the criteria are returned to the Waste Processing module (Sorting Station). The WPS structure is made of modules that are ISO container sized. The walls of processing area (process cell, airlock, and transfer modules) are shielded. The air flows from occupied zones towards areas that are expected to be more contaminated, and are processed through a HEPA filter before discharge to the atmosphere. Manipulators and remote tools are used to empty drums, vent cans, sort wastes, take samples, neutralize WIPP prohibited items, and package wastes. The product drums are checked for contamination and decontaminated if necessary before insertion into the STC. The design includes radiation detectors in occupied areas which may exceed ALARA doses.

The project follows DOE's approach of having an integrated review of the design by operations and environmental, health and safety specialists. The design criteria for in-cell lag storage was reduced based on their review of the preliminary hazard and consequence analysis. Early involvement of the operations staff ensured that other planned operations at the site were not overlooked in the development of the design safety basis. The operators staff knowledge of past waste disposal practices was the driver for considering the possibility that liquid wastes may have been included in the wastes sent to the Alpha Caissons from the hot cells, even though reports of those activities indicate that those wastes should have been sent to another disposal facility.

CONCLUSION

The MHC design used in France can be adapted to the Alpha Caisson mission at the Hanford Site. The safety basis for the French design was based on a similar rationale as that used in U.S. – identification of hazards and safety systems that will prevent overexposure of workers and the public under normal and accident conditions. The Americanization of the technology includes the selection of U.S. design codes and standards. This includes the review of site specific hazards, the classification of the safety systems, and selection of appropriate design criteria. We are convinced that this technology can be tailored to retrieval of legacy wastes at other locations as well using a similar approach to integrating safety into the design.