HI-STAR 100 AND MPC-68 FULL-SCALE PROTOTYPE FABRICATION

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INTRODUCTION

A good deal of the present frustration with the spent fuel storage cask supply has centered around problems with manufacturing and operation of unproven technologies (coated carbon steel in boric acid water environment, defective steel welding procedures, untested NDE techniques, excessive grinding and wall thinning of canister walls, defective concrete pours .....). Combine with this the fact that no one has ever built an Multiple Purpose Canister (MPC) system and the potential for failure becomes readily apparent. With the challenge of making such a system under the most rigorous code (ASME Section III, NB) requirements and under the watchful eye of the NRC, and it is also apparent that construction of a full-scale prototype would facilitate this undertaking by proving out production and quality assurance processes before starting production of the Commonwealth Edison / Holtec International HI-STAR 100 and MPC-68 dry storage casks for the Dresden Unit 1 Decommissioning project.

The main purpose of the prototype fabrication program is to identify, develop and confirm tooling, fixtures and special manufacturing and operating processes, qualify manufacturing and inspection personnel and challenge the Holtec/ComEd/UST&D quality assurance programs and procedures to verify their adequacy. This will also debug and improve the HI-STAR 100 and MPC-68 fabrication sequence and schedule. To satisfy this objective, UST&D will construct all four major HI-STAR 100 components; the basket, canister, overpack and impact limiter, to precisely the same Codes and fabrication procedures that will be used in making the production units. Future uses of the prototype include; training of ComEd personnel in cask loading, canister welding and unloading operations; thermal testing; optimization of operations procedures and auxiliary equipment for ALARA; quality and safety evaluations; and dry-run training for ComEd personnel and possibly other utility personnel. The prototype fabrication hardware work is scheduled to commence in January of this year and be complete in July. This paper describes the activities that have been performed to prepare for and satisfy the objectives of the HI-STAR 100 and MPC-68 full-scale prototype fabrication project.

FABRICATION SHOP CAPABILITIES

First and most important is the physical plant and company organization equipped with the necessary manufacturing equipment and intellectual infrastructure to accomplish high quality construction. UST&D has a successful history of design and fabrication of spent fuel storage equipment including fuel racks and storage cask baskets. In 1975 UST&D began designing, licensing and fabricating spent fuel storage racks and, since 1990, has been the fabricator of Holtec International designed spent fuel racks. During this period, UST&D fabricated over 900 racks with the capacity to store more than 90,000 spent fuel assemblies. Additionally, in 1990 UST&D developed with Transnuclear Inc., the design and manufacturing technology for construction of the TN-40 and TN-32 cask baskets. The patented UST&D fusion welding process used in these baskets was developed by UST&D and has been utilized in the manufacture of 350 spent fuel racks.

Over the years, UST&D has consistently increased its fabrication capability and capacity, having now grown to 100,000 square feet in factory floor space. Included in these confines are large capacity vertical and horizontal boring and milling machines, bridge cranes to handle up to 125 ton lifts, Conrail and Union Railroad sidings into the shop floor and the various metal cutting and welding systems required to fabricate heavy walled structures and internals required for dry storage of spent nuclear fuel. It is ironic that our facility at Keystone Commons in Pittsburgh Pennsylvania, is located upon the 92 acre site where Westinghouse Electric Corporation once constructed electrical generators for the nuclear utilities. Our 140 ton, dual table vertical boring and milling machine, in an earlier life, machined the internal stator components for General Electric steam turbines used by nuclear utilities.

In 1994, UST&D revised its 10 CFR 50, appendix B quality assurance program to incorporate the quality requirements of ASME Section III, NCA 3800 and NCA 4000. With this enhanced quality program, UST&D applied for and received the ASME N and NPT certification for design and manufacture of ASME class 1, 2 and 3 components and supply of section III ferrous and nonferrous materials. This program will be used in the manufacture of the HI-STAR 100 basket and overpack pressure vessels and for procurement and upgrading of the safety related materials incorporated in the HI-STAR 100 design.

WELD PROCEDURE QUALIFICATIONS

In addition to more than 100 weld Procedure Qualification Records (PQR's) that UST&D has developed for welding nuclear spent fuel racks, heat exchangers and pressure vessels, UST&D has developed nineteen additional welding procedures specifically for HI-STAR 100. The following list indicates the base materials to be welded, the weld processes to be utilized and testing requirements to qualify these welds:

	PQR No.	Material	P No's	Weld Process	PWHT	Time PWHT	Inspect Testing Temp. ft-lbs @F
1	9Q	516-70 to self	P1 G2	SMAW	No		15@-40F
2	9M	516-70 to self	P1 G2	SMAW	Yes	6 hrs	15@-40F
3	9R	516-70 to self	P1 G2	FCAW	No		15@-40F
4	9N	516-70 to self	P1 G2	FCAW	Yes	6 hrs	15@-40F
5	9P	516-70 to self	P1 G2	SAW	No		15@-40F
6	9O	516-70 to self	P1 G2	SAW	Yes	6 hrs	15@-40F
7	9X	516-70 to 203 E	P1 G2 to P9B G1	SMAW	Yes	6 hrs	15@-40F
8	9Y	516-70 to 203 E	P1 G2 to P9B G1	FCAW	Yes	6 hrs	15@-40F
9	9Z	516-70 to 203 E	P1 G2 to P9B G1	SAW	Yes	6 hrs	15@-40
10	9U	203 E to self	P9B G1 to self	SMAW	Yes	12 hrs	50@-60F
11	9S	203 E to self	P9B G1 to self	SAW	Yes	12 hrs	50@-60F
12	9T	203 E to self	P9B G1 to self	SAW	Yes	12 hrs	50@-60F
13	9V	203 E to self	P9B G1 to self	SAW	Yes	12 hrs	50@-60F
14	23A	Inco 182 clad on 203E	F43 to P9B G1	SMAW	Yes	12 hrs	
15	23	Inco 182 clad on 17-4	F43 to 17-4	SMAW	Yes	1150HT	
16	23B	Inco 182 clad 17-4 to Inco 182 clad 203E	F43 to F43	SMAW	No		
17	23C	Inco 182 clad 17-4 to 516-70	F43 to P1 G2	SMAW	No		
18	23D	Inco 182 clad 17-4 to 516-70	F43 to P1 G2	FCAW	No		
19	23E	Inco 182 clad 17-4 to 516-70	F43 to P1 G2	GMAW	No		

COMED QUALITY INITIATIVE

As the subcontractor to Holtec International for the Dresden Unit 1 dry storage casks, early last year UST&D was invited to be a charter member of the ComEd Dresden Unit 1 Quality Initiative Team. The charter of this ten member team was to develop a project quality plan which, when implemented, would enable the safe, reliable construction and operation of dry cask storage at Dresden. The vision of this quality initiative is the flawless transfer of Dresden Unit 1 spent fuel from pool storage to on-site cask storage to provide long-term, safe, storage ready for off-site transport. The plan also includes steps to monitor the implementation of action items and a plan by which to analyze data to improve quality. The following objectives are being addressed by the Quality Initiative Team:

1. Identify behaviors, processes and tools to enable the project team to achieve results that meet or exceed stakeholder and customer expectations. This objective is being satisfied by use of; quality function deployment (QFD)processes, process management systems, identification and modeling of behaviors that help support the successful conclusion of the project, application of corrective action systems and project communication systems.

2. Implement systems and processes that will enable the project team to share in lessons learned, to anticipate problems and capture all commitments within the project. This objective is being addressed by the use of a lessons learned program, a commitment management process and a anticipation of problems system.

3. Implement a short-term recovery plan for the project which ensures project excellence and establishes creditability both internally and externally. This plan covers organizational effectiveness, schedule management, cost management and contract effectiveness.

MANUFACTURING PLANS AND PROCEDURES

UST&D utilizes an integrated manufacturing quality plan system called the Production Work Routing Plan (PWRP). This system, which can also incorporate process flow charts is commonly called a production traveler system. The term "traveler" reflects the manner by which the PWRP forms and documents travel throughout the shop floor with the various parts, subassemblies and final assemblies. The PWRP's are designed to provide detailed information about the various manufacturing and inspection activities, provide alternate methods for accomplishing the required outcome should one method not work properly and elicit accountability from each project participate. The travellers and flow charts are created by a team of UST&D production, project management, engineering and quality assurance personnel. Customer input is also included through a review and approval process which includes establishment and agreement on quality inspection witness and hold points to be observed during the manufacturing process.

Although many manufacturing and inspection procedures are standardized, project specific procedures are often required. When approved by the customer they also become a part of the PWRP. Specific HI-STAR 100 manufacturing and inspection procedures have been developed for the following activities:

Materials Procurement
Welding
Load Tests
Hydrostatic Tests
Neutron Shield Tests
Cell Drag Test
Shell Rolling Qualifications
Final Cleaning
Production Work Routing
Non Destructive Testing
In Process & Final Inspection
Leakage Tests, Overpack & MPC
Overpack Thermal Acceptance
Grinding Control
Post Weld Heat Treatment
Sandblasting & Painting

PROJECT MANAGEMENT

UST&D is using Quality Function Deployment (QFD) and Process Management practices to manage its projects. QFD is a powerful design methodology that originated in Japan in the early 1970's. It is a method for developing a design aimed at satisfying the consumer and then translating the consumer's demands into design targets and major quality assurance points to be used throughout the production stage. In other words, QFD contributes to the creation of quality by infusing quality (as defined by the customer) into every function or part of the product or service.

In a purely philosophical sense, QFD is a way of thinking, a way of approaching and organizing the product or service development process to focus on designing quality into a process rather than back-fitting it in later. In more practical terms, QFD is a structured, systematic process for developing new products or services or for redesigning ones. It is also a tool for achieving the design or redesign at the lowest possible cost with the highest possible quality.

UST&D is applying QFD in many areas to improve manufacturing processes, design tooling and fixtures, change employee behavior and company culture. A QFD evaluation of project materials control practices led to changing practices to focus more on the importance of personal accountability and training in the handling and documentation of safety related materials. A QFD evaluation by shop employees about what could be changed to make working conditions more efficient and reduce re-work lead to the institution of a plant-wide "heads-up board" where the latest technical changes on each job in the shop are displayed to everyone daily. This is a supplement to the documentation required by the UST&D quality assurance program. It does not replace the program requirements, but rather makes it easier for all personnel to identify requirements and changes as they occur.

UST&D process flow charts and the shop travelers are another part of the project management system. These tools provide clear direction about the various manufacturing activities, assign individual accountability and provide alternates in advance for making changes to processes or operations if problems are encountered.

QUALITY ASSURANCE

UST&D has established a quality assurance program to assure that all construction of items and supply of material and services are in accordance with the ASME Boiler and Pressure Vessel Code Section III, Division I, 10CFR50 Appendix B, and specific customer contract requirements. The program has eighteen criteria which cover areas ranging from the company organization layout, product design control, procurement document control, non-conforming materials to corrective action, internal audits, etc. The present UST&D Quality Assurance Department is directed by a Manager of Quality Assurance, a QA Administrative Assistant and five ASNT-TC-IA and ANSI N45.2.6 certified inspectors.

In addition to the requirements mandated by the formal quality program, UST&D utilizes root cause analysis procedures, failure mode effects analysis and apparent cause evaluations in its everyday operations to identify and address potential discrepancies, problems, nonconformances and conditions adverse to quality. For the Holtec International/ComEd Dresden 1 Dry Cask Project, a commitment management system has been developed to provide the designers, fabricators and installers with a database for obtaining the necessary information required for compliance and establishes a central computer based system for tracking commitments, corrective actions and lessons learned.

A Management Overview and Assessment process has been established to provide reviews and evaluations of key elements and emergent quality issues on the project. These assessments and overviews are reviewed by a Project Quality Council for potential areas of concern and establishment of additional overview and assessment activities. The Project Quality Council consists of quality/management members from each project organization.

MATERIAL PROCUREMENT AND CONTROL SYSTEM

The UST&D Quality Program utilizes specific procedures and practices for controlling material procurement and subcontracting processes. These Quality Control Program (QCP) procedures cover the following basic areas; order entry, design specification review, design input requirements, document control, vendor evaluation, receipt inspection, material release and, processing of customer furnished drawings. Most recently a team of UST&D employees from Project Management, Engineering, Quality Assurance, Production and Purchasing, evaluated these processes using QFD methodology. This resulted in the creation of new project management procedures (PMP's) which deal with related areas of organizing and maintaining project files and handling of project procurement related documents.

VENDOR SURVEILLANCE

UST&D vendors who supply material, items or services are required to have a Quality Assurance Program consistent with the requirements of ASME Boiler and Pressure Vessel Code, Section III, Division I. Pursuant to this, UST&D has established an Approved Vendors List (AVL) to assure that only vendors with quality programs and facilities that have been evaluated and approved are used for procurement of material, items and services. Vendors are audited by UST&D on a preset schedule, which is determined by and set by the UST&D Quality Assurance Manager. Currently, UST&D has thirty-five approved vendors for ASME Section III and 10CFR50 Appendix B materials and services, twenty-seven approved subcontractors and thirty-one approved commercial suppliers on its AVL.

FABRICATION OVERSIGHT COMMITTEE

A HI-STAR 100 Fabrication Oversight Committee has been formed and held its first meeting at UST&D in October of 1997. Representatives from ten different utility organizations, Holtec International and UST&D attended this kick-off meeting. The purpose of this ongoing activity is to provide a continuing critique of the HI-STAR 100 fabrication efforts to improve confidence in quality of the production units. The concensus of the committee members is that; Holtec and UST&D will benefit from interaction with knowledgeable utility personnel, utilities will benefit from firsthand knowledge of lessons learned during the prototype fabrication effort, and utilities by becoming more knowledgeable customers can help raise the level of quality and performance of other dry storage system vendors. The following areas of interest were identified for ongoing follow; monitoring the translation of design requirements to fabrication activities, monitoring the interface between Holtec and UST&D, provide lessons learned from the prototype effort to the industry, broaden utility participation, improve the regulator interface and project quality.

FULL-SCALE PROTOTYPE FABRICATION OBJECTIVES

UST&D has started the hardware construction part of the prototype project. This is planned to be a six month effort during which a full-scale basket, canister, overpack and impact limiter will be fabricated to the exact requirements and with the exact materials of the production HI-STAR 100 units. The discussion that follows describes what will be learned and/or confirmed about each hardware part and manufacturing process:

Basket

The HI-STAR 100 basket is fabricated from slit stainless steel plates, or plates and alternating full length strips which in either case are joined at their junctions by continuous fillet welding on all sides. This is accomplished in a fixture system with robotic welding. A neutron absorbing material is applied to two sides of the resulting box cross sections under a hermetically sealed welded stainless steel cover skin before the above fixturing operation. The prototyping of the basket is intended to evaluate the integrity of both weld joint configurations, the resultant flatness and straightness of cell walls, finished cell size and overall basket sizing relative to fit-up with the basket canister inside diameter.

Canister

The canister is an ASME Section III, NB stainless steel pressure vessel. It is fabricated from plate stock rolled into a cylinder with one or two longitudinal seam welds. Two cylinders may be utilized, in which case an additional circumferential weld is required. The bottom is a flat section welded to this cylinder and all pressure boundary welds are volummetrically inspected. Basket and lid supports are attached to the cylinder inside diameter. The canister lid is a heavy wall circular plate machined for welding to the canister inside diameter. The objective of the canister prototype is to check for circularity and diameter before and after welding, weld integrity, accuracy of basket and lid support locations and overall fit-up with the overpack.

Overpack

The overpack is a carbon steel multi-layer heavy wall vessel consisting of a cryogenic steel inner shell built to ASME Section III, NB requirements and shell layers. Forged cryogenic steel bottom and top rings are welded to these layers in a hydraulically operated assembly fixture. Lifting and handling trunnions are attached by threading to the top and welding to the bottom. An outer shell of light gage painted carbon steel has internal pockets containing Holtite neutron absorber material. The overpack lid is a heavy wall forged plate machined for "O"-ring seals and closure bolts. The main objectives of the overpack prototype are to check welds for integrity, check effectiveness of fixturing to control shell circularity and surface contact between layers, determine post weld machining requirements, check sealing surfaces, check for Holtite installation voids, and overall fit-up with the canister.

Impact Limiter

The HI-STAR 100 AL-STAR impact limiters utilize a multi-directional expanded aluminum honeycomb material encapsulated in a light gage stainless shell bolted to the overpack during transportation operations. The objective of this protytype is to check the integrity of the inner shell welds, check that the cross-layered chevrons fit without excessive gap, check fit-up between the impact limiter and overpack, and assess the integrity of the internal welds under severe transport conditions.

PRE-PROTOTYPE EVALUATIONS

Various tests and mock-ups have already been performed, or are currently being finalized, to prove out possible problem manufacturing operations with the HI-STAR 100 design prior to full-scale prototyping. The areas chosen as being questionable in nature were those areas where either the design engineers or manufacturing personnel had not performed the task previously or simply wanted to ensure themselves of the feasibility of the approach. In all cases, the actual testing and mock-up results have been factored into the final design to guarantee analytical and dimensional compliance with the design parameters. The full-scale prototype of the entire HI-STAR 100 system will be the final proving ground of this highly researched system. The following areas of interest have already been evaluated:

OVERPACK

Intermediate Gamma Shell Layering

Full diameter mock-ups of the inner shell and subsequent gamma shell layers were manufactured. These experiments were used to determine the best initial plate size to use, plate end preparation, plate finish, and handling techniques. Close scrutiny was paid to ensuring contiguous fits between each successive layer. These mock-ups provided valuable information and insight into this very innovative assembly technique.

Internal Shell Roundness

Full-scale sections of the internal pressure retaining containment boundary were constructed to verify manufacturing tolerances and clearances. Actual weld geometries and fixturing equipment were used to confirm accurate results. The results of these tests have been incorporated into initial material sizing.

Heat Conductance Test

A heat conductance test has been performed to verify appropriate heat transfer from the internals of the system through the gamma shells. Multitudes of thermal couples were placed around a truncated, full-scale section of the intermediate system to assure congruity between analytical and actual results.

Weld Shrinkage Tests

Numerous weld shrinkage and distortion tests have been performed on the many weld joints. Various weld joint geometries have been researched to determine their effects. Weld joint geometries, weld processes, interpass requirements, and weld sequencing have been selected to meet design parameters.

Fixturing Mock-Ups

Mock-ups of anticipated fixturing and tooling have been fabricated and used to guarantee adequate manipulation and presentment of the materials of construction to meet drawing requirements. Structural sizing, manipulation methodology, frictional interactions, weld induced stresses and handling are only some of the myriad of areas where valuable insight was gained from these models.

MPC-68 SYSTEM

Cell Dimensional Stability

A full-scale, multi-cell mock-up of the MPC-68 basket assembly was constructed. Assembly techniques and fixturing approaches were allowed to vary from cell to cell. Dimensional information was recorded for each combination of assembly technique and fixturing approach used. The results of these tests and information subsequently gained has been incorporated into the assembly fixturing, design, and fabrication sequence.

Weld Distortion Tests

Numerous weld distortion tests have been performed on critical weld joints in the basket design. Various weld joint geometries have been researched to determine their effects. Weld joint geometries, weld processes, interpass requirements, and weld sequencing have been selected to meet design parameters.

Weld Delivery System

Weld delivery system tests were performed to establish the best welding process, joint presentation, weld sequence, deposition rate, and actual torch delivery mode. Results proved that a custom system had to be developed to work within the confines of a six inch cell opening.

Neutron Absorber Degradation Tests

Testing was performed to ensure that no degradation to the basket neutron absorber material would occur during closure welding. Full-scale samples were subjected to normal and excessive weld cycles to assure acceptability. No degradation of the poison material was detected.

Heat Affected Zone Testing

Tests were performed on the heat affected zones resulting from the various cutting processes. Appropriate construction techniques were established and incorporated into the fabrication sequence to ensure sound attachment of mating parts.

IMPACT LIMITER

Dimensional Stability

Models of the impact limiters were fabricated in accordance with design requirements and dimensional information was obtained. Results proved that the honeycomb materials of construction were much more easy to handle and could be assembled with much more ease and accuracy than wooden materials used in other limiter designs. This coupled with the material's ready availability make it an ideal choice for the application.

Crush Strength Testing

Tests were performed to ensure the behavior of the impact limiter honeycomb material during various loadings. Static and dynamic crush tests were performed to confirm correlation with design requirements. The data acquired from these tests have been incorporated into the final design of the limiters.

PROTOTYPE SCHEDULE

The HI-STAR 100 overpack and MPC-68 canister prototypes are scheduled for completion in July 1998. Full-scale production is scheduled to begin immediately upon HI-STAR system certification by the NRC which is expected by year end.