BOILER MATERIALS FOR ULTRASUPERCRITICAL COAL POWER PLANTS

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Abstract

The U.S. Department of Energy (DOE) and the Ohio Coal Development Office (OCDO) have recently initiated a project aimed at identifying, evaluating, and qualifying the materials needed for the construction of the critical components of coal-fired boilers capable of operating at much higher efficiencies than current generation of supercritical plants. This increased efficiency is expected to be achieved principally through the use of ultrasupercritical steam conditions (USC). A limiting factor in this can be the materials of construction. The project goal is to assess/develop materials technology that will enable achieving turbine throttle steam conditions of 760°C (1400°F)/35 MPa (5000 psi). This goal seems achievable based on a preliminary assessment of material capabilities. The project is further intended to build further upon the alloy development and evaluation programs that have been carried out in Europe and Japan. Those programs have identified ferritic steels capable of meeting the strength requirements of USC plants up to approximately 620°C (1150°F) and nickel-based alloys suitable up to 700°C (1300°F). In this project, the maximum temperature capabilities of these and other available high-temperature alloys are being assessed to provide a basis for materials selection and application under a range of conditions prevailing in the boiler. This report provides a quarterly status report for the period of April 1 to June 30, 2006

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Executive Summary

A. Project Objective

The principal objective of this project is to develop materials technology for use in ultrasupercritical (USC) plant boilers capable of operating with 760°C (1400°F), 35 MPa (5000 psi) steam.

B. Background and Relevance

In the 21st century, the world faces the critical challenge of providing abundant, cheap electricity to meet the needs of a growing global population while at the same time preserving environmental values. Most studies of this issue conclude that a robust portfolio of generation technologies and fuels should be developed to assure that the United States will have adequate electricity supplies in a variety of possible future scenarios.

The use of coal for electricity generation poses a unique set of challenges. On the one hand, coal is plentiful and available at low cost in much of the world, notably in the U.S., China, and India. Countries with large coal reserves will want to develop them to foster economic growth and energy security. On the other hand, traditional methods of coal combustion emit pollutants and CO₂ at high levels relative to other generation options. Maintaining coal as a generation option in the 21st century will require methods for addressing these environmental issues.

This project has established a government/industry consortium to undertake a five-year effort to evaluate and develop advanced materials that allow the use of advanced steam cycles in coal-based power plants. These advanced cycles, with steam temperatures up to 760°C, will increase the efficiency of coal-fired boilers from an average of 35% efficiency (current domestic fleet) to 47% (HHV). This efficiency increase will enable coal-fired power plants to generate electricity at competitive rates (irrespective of fuel costs) while reducing CO₂ and other fuel-related emissions by as much as 29%.

Success in achieving these objectives will support a number of broader goals. First, from a national prospective, the program will identify advanced materials that will make it possible to maintain a cost-competitive, environmentally acceptable coal-based electric generation option. High sulfur coals will specifically benefit in this respect by having these advanced materials evaluated in high-sulfur coal firing conditions and from the significant reductions in waste generation inherent in the increased operational efficiency. Second, from a national prospective, the results of this program will enable domestic boiler manufacturers to successfully compete in world markets for building high-efficiency coal-fired power plants.

The project is based on an R&D plan developed by the Electric Power Research Institute (EPRI) that supplements the recommendations of several DOE workshops on

the subject of advanced materials. In view of the variety of skills and expertise required for the successful completion of the proposed work, a consortium that includes EPRI and the major domestic boiler manufacturers (Alstom Power, Babcock and Wilcox (a division of McDermott Technologies Inc.), Foster Wheeler, Riley Power Inc., and Oak Ridge National Labs) has been developed.

C. Project Tasks

The project objective is expected to be achieved through 9 tasks as listed below:

Task 1.	Conceptual Design and Economic Analysis
Task 2.	Mechanical Properties of Advanced Alloys
Task 3.	Steamside Oxidation Resistance
Task 4.	Fireside Corrosion Resistance
Task 5.	Welding Development
Task 6.	Fabricability
Task 7.	Coatings
Task 8.	Design Data and Rules
Task 9.	Project Integration and Management

D. Major Accomplishments during the Quarter

- Two Scientific papers, one on mechanical properties and a second paper based on overall project results were prepared for the International conference to be held in Liege in September. A paper on Fireside corrosion was prepared for the conference on coal held in Clearwater, FL.
- Creep tests are complete for HR6W and Haynes 230 Alloys. Creep tests on Super 304H have exceeded 25,000h.
- It was shown that SAW of Haynes 230 can reduce its rupture strength substantially while SMAW had no deleterious effect. It was also shown that rupture strength of CCA 617 is only 80% of that of the base metal at 700 and 750C.
- Corrosion probes have been successfully installed at a mid-western utility site.
- A hot wire TIG process qualified for thick section welding was applied to a 3" plate without loss of rupture strength.
- Evaluation of U bend specimens of CCA 617 and Super 304H are complete. No detrimental effects have been noted.
- A draft topical report on the effects of cycling on headers has been prepared and is under review by the members.

E. Plans for the Next Quarter

- Creep-rupture testing of all materials will continue. Pressurized creep testing of Inconel 740 tube bends will continue and creep strain measurements will be made. Microstructural analysis will be completed on ruptured pressurized creep tests. Testing of weldments, including the thick section welds of the CCA617, will continue. Thermal shock testing of Super 304H will be completed and additional tests on CCA617 will begin.
- The first steamside exposure at 750°C (1,000 hours) will be conducted.
- Ongoing exposures at the installed probe sites firing Mid-western and Western coals will be monitored.
- Hosting arrangements and logistics for third host site (Eastern coal) will be completed and probe will be installed.
- Efforts to qualify the welding of the SAVE 12 thick wall pipe material using a submerged arc process will be continued.
- Problems with weld metal cracking in Inconel 740 joint will be pursued by evaluating the use of Nimonic 263 filler in thick section weldments.
- Development of Inconel 740 welding procedures for tube butt joints will be continued.
- Preparation of final comprehensive report will continue.
- Riley Power is still considering the fabrication of a mock-up header/spool piece which would contain tubing components and welding of the HR6W and SAVE12 materials.
- A report of the manufacturing requirements and costs for coating of internal tube surfaces will be issued.
- The task participants will continue to monitor the USC data transfer web site for any additional, completed test results. Evaluations will continue to compare and contrast the strength of the materials with existing databases for similar alloys. Riley will complete the in process summary report of the test results for the HR6W material, with the addition of percent creep strain and stress versus time to rupture plots to the report. It is projected that it will not be possible to work on statistical correlation of data for some time because of the lack of data on which to perform meaningful analysis.

F. Concerns

- Decrease in funding for FY06 has impacted some testing activities. Activities that have been put on hold for FY2006 or have seen reduced effort include:

creep testing a third heat of Inconel 740 (needed for code case), fatigue and creep-fatigue testing, thick-section weldment studies on Haynes 230, multi-axial creep testing, and notched bar creep testing.

- The original third (Eastern coal) host site has changed to 100% low-sulfur PRB (Western) coal. This required that we locate a new host site, firing a different coal (possibly Eastern / PRB blend coal). Negotiations are currently under way with a possible host site within Ohio. This utility has already allowed us to install new penetrations for the probes, during a recent outage. However, if the parties involved were unable to reach a mutual agreement, a new Eastern coal site would have to be selected.
- Submerged arc welding, a high deposition rate process favored by boilermakers for thick sections, does not appear feasible for all nickel base materials. Tests on Haynes 230 and Inconel 740 have been unsuccessful because of cracking and the process was abandoned on these two alloys.
- The unexpectedly high cost of the nickel base alloys will cause the material budgets to be exceeded and might result in program cost overruns and/or reductions in program scope.
- The difficulties encountered while attempting to weld HR6W using matching filler metals proved insurmountable for this program and there will be no further effort in this area.
- Inconel 740 appears to have a heat-to-heat sensitivity with regards to microfissuring and this could require additional constraints on composition.
- The use of matching filler metal for welding thick section CCA 617 plates does not appear practical.

2.0 Taskwise Status

Task 1 Conceptual Design and Economic Analysis (Task lead EPRI)

The objective of Task 1 is to specify the temperature/pressure distribution for 760°C/35 MPa (1400°F/5000 psi) steam inlet conditions so that the data needs and the range of test parameters can be identified and the economics of material selection established.

Task 1A: Alstom Approach (Alstom Power Co.)

Objectives:

The primary objectives of this subtask are:

- Develop a conceptual boiler design for a high efficiency ultra supercritical cycle designed for 1400°F steam temperature.
- Identify tubing and piping materials needed for high temperature surface construction.
- Estimate gas and steam temperature profiles so that appropriate mechanical, corrosion and manufacturing tests of materials could be designed and conducted to prove suitability of the selected alloys.

Progress for the Task

A final report has been completed and distributed.

Task 1B: Babcock Approach

Objective:

The objectives of this subtask are the same as in Subtask 1A.

Progress for the Quarter:

No work was performed on this task this quarter.

Concerns:

Progress for the Next Quarter:

A final report has been completed and distributed.

Task 1C: Economic Analysis

Objective:

The objective of this task is to determine relative economics of the USC plant.

Progress for the Task:

A final report has been completed and distributed.

Concerns:

None

Task 2: Mechanical Properties of Advanced Alloys (ORNL)

The objective of Task 2 is to produce the mechanical properties database needed to design a boiler to operate at the steam conditions within the scope of the project.

Task 2A: Assessment of the Alloy Performance Requirements

Objectives

The primary objectives of this subtask are:

Focus on performance needed for boiler service in the temperature range of 650°C (1200°F) to 871°C (1600°F)

Produce reports that justify the materials selected for the pressure retention components of the USC boiler

Progress

Based comments from the steering committee member reviews, ORNL internal reviews, and conference reviewers, a final version of a paper for the 2006 Liege conference was completed entitled, "Evaluation of the Materials Technology Required for a 760°C Power Steam Boiler."

Task 2B: Detailed Test Plan

Objectives

The detailed mechanical properties test plan is intended to provide guidance on the scope of the mechanical testing for each material to support the resolution of issues related to the tasks undertaken in the project. Categories include: mechanical characterization; data production for the development of code cases; effects of fabrication variables; weldment performance; fatigue and thermal-fatigue behavior; and the like. The six alloys, chemical compositions in Table 1 below, of most interest to the project are: SAVE12, Super 304H, HR6W, Haynes 230, CCA617, and INCONEL 740. Specific heat chemistries are available on the website.

Progress

The characterization testing plans have been completed for the creep-rupture testing of Super 304H, HR6W, alloy 230, CCA617, and INCONEL 740. HR6W and Haynes 230 base metal testing is complete. Weldment test plans continue to evolve as new welded material (mainly thick section plate) becomes available. Further planning is still required for Inconel 740 based on the code-case needs. ORNL will work with B&W and Special Metals to define the testing still needed for a preliminary code case. Currently, two heats of three heats of Inconel 740 are being tested. At a minimum, stress-rupture data

is still needed on a third heat of material, but this testing has been delayed in FY2006 due to funding.

TABLE 1. Compositions of USC Steam Boiler Consortium Materials														
Alloy	Nominal Compositions in Wt%													
	Fe	Cr	Ni	Mn	Mo	Ti	Nb	W	V	C	B	Si	N	Cu
SAVE 12*	bal	11.0		0.2				3.00	0.20	0.10		0.3	0.04	
Super 304H*	bal	18.0	9.0	0.8			0.40			0.10		0.2	0.10	3.00
HR6W*	bal	23.0	43.0	1.2		0.08	0.18	6.00		0.080	0.003	0.4		
Haynes 230*	3.0	22.0	bal	0.5	2.0			14.00		0.10	0.02	0.4		
CCA617	0.6	21.7	bal	0.03	8.6	0.40				0.05	0.002	0.1	0.01	0.01
INCONEL 740	2	24.0	bal	0.3	0.5	2.0	2.0			0.07	0.002	0.5		
*Compositions are nominal and will be replaced by measured compositions in the future														

Task 2C: Long-Term Creep Strength

Objectives

The primary objectives of this subtask are:

Identify the general characteristics of the creep behavior and damage accumulation in the candidate alloys

Verify the creep-strength of code-approved alloys

Assess the creep-strength of non code-approved alloys; and provide creep/creep-rupture data for a code case if deemed appropriate by consortium members

Provide accurate creep data (i.e. creep-curves) for boiler design on the candidate materials

Progress

The major emphasis of the current creep-rupture testing is: (1) completing long-term creep-rupture tests, (2) producing the necessary creep data on three heats of Inconel 740 for a code case, and (3) evaluating the welding processes developed by the consortium for both tubing and thick-section materials through long-term stress-rupture testing of cross-weldments.

Creep tests are complete for HR6W and Haynes 230. Long-term tests in excess of 25,000 hour continue for CCA617 and Super 304H. Limited testing on SAVE12 is also ongoing. Testing is also progressing on the INCONEL 740 tubing and plate. There exist some differences between the heats and heat treatments as well as differences with the AD700 reported data. The longest test times have reached approximately 10,000 hours and lower stress tests have been added to the matrix with expected rupture lives of 10,000 to 20,000 hours. All of these data were updated on the website in the second quarter of FY2006 and another update is planned for the early fourth quarter of 2006.

Task 2D: Microstructural Analysis

Objective

The primary objectives of this subtask are:

Identify the microstructural changes that lead to significant changes in the strengthening, weakening, and internal damage characteristics of each material

Explore how these changes relate to the exposure conditions of the testing

Progress

A significant number of microstructural evaluations were completed this quarter on tube bend and thermal shock test specimens. These will be highlighted in the subtask 2H section. Three papers on the microstructural evaluation of boiler materials performed at the University of Cincinnati are in various stages of completion. One draft paper will be given to the consortium for review next quarter. Current characterization work is focused on evaluating the microstructural changes during creep of Inconel 740.

Task 2E: Assessment of Creep-Fatigue Properties

Objective

The primary objectives of this task are:

Verify the low cycle fatigue, creep-fatigue, and thermal mechanical fatigue properties of the thick section alloys

Develop a database that will lead to practical, yet conservative methods for new materials

Address the issue of creep-fatigue in the boiler materials

Progress

LCF testing on Inconel 740 (Heat #BLT2819 - plate) was stopped this quarter due to mechanical difficulties with the induction heating unit. A replacement unit has been identified and will be installed in the next quarter.

Task 2F: Modeling of Weld Joints

Objectives

The primary objectives of this task are:

Produce the experimental data needed to model dissimilar metal and thick-section weld joints

Progress

Testing is ongoing for the large cross-weld specimens from the SAW and SMAW CCA617 2" thick plate weldments. Rupture results at 700 and 750°C have shown a large reduction in strength compared to the base metal for the SAW, but the results from the SMAW have been within the scatterband for 617. It has been suggested that aluminum content in the weld deposit may have a strong influence on creep properties. ORNL has repeated its request to Alstom for the as-deposited CCA617 weld metal chemistries. Long-term tests on these materials up to 800°C continue.

Testing of butt-welded tubes of CCA617, Super304H, and CCA617 to Super304H continued this quarter. The cross-weld rupture results on the Super 304H to CCA617 DMW matched the rupture life predictions for Super 304H. All of the observed ruptures were in the Super 304H base metal. Haynes 230 ¼" thick welded plate tests continue as well. All results on Haynes 230 show that the Haynes 230 weld metal has 80% the strength of the base metal.

Task 2G: Study of Accelerated Test Methods

Objectives

The primary objective of this task is:

Provide a method to rapidly characterize changes in the strength of candidate materials

Progress

No new materials have been identified for relaxation testing. This task is complete until an evaluation of a new material is needed or Task 8 determines a critical data need.

Task 2H: Model Validation

Objectives

The primary objective of this task is:

Produce a database that can be used to confirm or validate design rules that are developed in Task 8

Progress

Microstructural analysis for cavitation and recrystallization of pressurized creep experiments on Haynes 230 U-bends, to evaluate coldwork effects, was completed this quarter and the results were presented at the steering committee meeting. Two bends were tested which had cold-work beyond ASME code limits. The outer fiber bend strains (OFS) were 33% (3" Dia.) and 20% (5" Dia.) for the two bends. Tests were conducted at 775°C and 5,600 psi. These tests were stopped at ½ life for a straight section tube (~8,000 hours) and destructively evaluated by optical microscopy. For the 33% OFS specimen, recrystallization, figure 1, and extensive cavitation was observed.

However, the cavities could not be directly associated with the areas undergoing recrystallization. In contrast, the 20% OFS specimen showed very minor recrystallization in only the areas of highest strain (near the edge of the extrados) and little to no cavitation was observed, figure 2. These results indicate that the current code rules for cold-bending will be conservative for Haynes 230 and that with more work a higher limit of 20% may be justified.

Pressurized creep testing of two Inconel 740 tube bends continued this quarter. Testing is being performed at 800°C and 7040psi. The tube bend with the highest cold strain (35% OFS) ruptured during the past quarter after 2124.4 hours and the tube bend with 22% OFS ruptured this quarter after 3711.2 hours. Figure 3 is a macro image of the latest rupture showing its location and visible cracking on the extrados of the tube. Destructive metallographic examination was initiated this quarter and results will be available next quarter.

Thermal shock testing on Super 304H was started this quarter. Based on discussions with Task 8, the maximum temperature for the shock was set at 700°C. Currently, the tube has lasted 375 cycles (25 cycle inspection interval) without indications of crack initiation. The previously tested CCA617 thermal shock specimen was metallographically examined this quarter. Figure 4 shows the O.D. cracking and cavitation which initiated and propagated intergranularly. This indicates that creep damage (due to stress redistribution during the hold portion of the thermal cycle) was the failure mechanism for this test. Additional CCA617 thermal shock specimens are currently being fabricated to continue testing next quarter.

Accomplishments

- Initial full-size specimen cross-weld stress-rupture tests on CCA617 indicate that the SAW process welds will require a weld strength reduction but the SMAW process welds do not.
- Completed pressurized creep tests on Haynes 230 cold-bent tubes indicate current ASME B&PV code rules for cold-work are conservative and that higher cold-work limits may be justified
- Microstructural evaluation of the CCA617 thermal shock tests clearly shows a creep damage failure mode on the O.D. as expected by Task 8 models.

Concerns

Decrease in funding for FY06 has impacted some testing activities. Activities that have been put on hold for FY2006 or have seen reduced effort include: creep testing a third heat of Inconel 740 (needed for code case), fatigue and creep-fatigue testing, thick-section weldment studies on Haynes 230, multi-axial creep testing, and notched bar creep testing.

Plans for Next Quarter

Creep-rupture testing of all materials will continue. Pressurized creep testing of Inconel 740 tube bends will continue and creep strain measurements will be made.

Microstructural analysis will be completed on ruptured pressurized creep tests. Testing of weldments, including the thick section welds of the CCA617, will continue. Thermal shock testing of Super 304H will be completed and additional tests on CCA617 will begin.

Task 3 Steamside Oxidation

(B&W)

Task 3A Autoclave Testing

Background

Steamside oxidation tests will be performed on commercially available and developmental materials at temperatures between 650°C and 800°C (1202°F - 1472°F).

Experimental

During the past quarter, all of the efforts in Task 3A were directed to preparing the specimens and test facility for the 750°C (1382°F) test. The current status is as follows: all specimens are machined, specimen cleaning, dimensioning and weighing is underway, and facility preparations are nearly complete.

The nominal compositions of the materials that will be tested in the 750°C test are listed in Table 1. Coupons from the materials designated as "Tube" and "Shot Blasted" have been machined such that the original tubing ID surface has been left intact. These coupons will demonstrate any specific benefits derived from the shot blasting process.

The Deep Rolled 347HFG was prepared by Ecoroll from a tube segment provided by B&W. Ecoroll performed two different levels of deep rolling; one at each end of a tube segment. Both deep rolling levels will be tested.

The chromized, silicon-chromized and aluminum-chromized SUPER304H coupons were prepared by Alstom and are being tested to evaluate any beneficial effect of chromizing processes on the steamside oxidation of SUPER304H.

Coupons from the materials designated as "Weld" have been prepared from matching filler metal weld build-ups. The coupons were prepared such that only weld metal will be exposed to the test environment.

Testing is scheduled to start in late July.

TABLE 1

Material	Nominal Composition
P92	Fe-9Cr-1.5W
MARB2	Fe-9Cr-3.3Co-2.5W
SAVE12	Fe-9.5Cr-3W-2.5Co
VM12	Fe-11.5Cr-1.5W-1.5Co
Alloy 214	Ni-16.5Cr-3.5Fe-4.5Al
347HFG Tube	Fe-18.5Cr-12Ni-1Nb
Shot Blasted 347HFG	Fe-18.5Cr-12Ni-1Nb
Deep Rolled 347HFG	Fe-18.5Cr-12Ni-1Nb
304H	Fe-19Cr-11Ni
SUPER304H	Fe-19Cr-9Ni-3Cu
SUPER304H Tube	Fe-19Cr-9Ni-3Cu
Shot Blasted SUPER304H	Fe-19Cr-9Ni-3Cu
Alloy 282	Ni-19.5Cr-10.5Co-8.5Mo-2Ti-1.5Al
Nimonic 263	Ni-20Cr-19.5Co-6Mo-2Ti
2025+Nb	Fe-25.5Ni-20.5Cr-1.5Mo
CCA617	Ni-22Cr-9Mo-11.5Co-1Al
SAVE25	Fe-22Cr-19Ni-1.5W-4Cu
Alloy 230	Ni-22.5Cr-1.5Fe-1.5Mo-14W
HR6W	Ni-23.5Cr-24Fe-6W
Alloy 740	Ni-24.5Cr-1Fe-19.5Co-2Nb-1.5Ti
RA602CA	Ni-25Cr-9.5Fe-2.5Al
HR120	Ni-26Cr-35Fe-0.5Nb
310HCbN	Fe-26Cr-20Ni-0.5Nb
Chromized SUPER304H	Fe-19Cr-9Ni-3Cu
Silicon-Chromized SUPER304H	Fe-19Cr-9Ni-3Cu
Aluminum-Chromized SUPER304H	Fe-19Cr-9Ni-3Cu
Alloy 230 Weld	Ni-22.5Cr-1.5Fe-1.5Mo-14W
CCA617 Weld	Ni-22Cr-9Mo-11.5Co-1Al
Alloy 740 Weld	Ni-24.5Cr-1Fe-19.5Co-2Nb-1.5Ti

Concerns

None.

Activities Next Quarter

The first exposure at 750°C (1,000 hours) will be conducted.

Task 3B Coating Tests

Background

Coated specimens for steamside oxidation testing will be prepared in conjunction with Task 7 and evaluated after testing.

Experimental

Chromized, silicon-chromized and aluminum-chromized SUPER304H specimens that were prepared by Alstom will be included in the 750°C test. These specimens are prepared and ready for pre-test cleaning, weighing and dimensioning.

Concerns

None

Activities Next Quarter

CrS304H, AlCrS304H and SiCrS304H specimens will be entered into test at 750°C.

Task 3C Assessment of Temperature

Background

Based on the steamside oxidation test results, the practical temperature limits for the materials tested will be determined.

Experimental

Activation energies from B&W and ORNL data have been previously reported. Additional data from the 750°C tests will be included in the calculation of activation energy when results become available.

Concerns

None

Activities Next Quarter

Activation energies will be re-calculated following the 750°C exposures.

Task 3D Review of Available Information & Reporting

Background

Available steamside oxidation literature pertaining to materials and environmental conditions of interest will be reviewed. Project status updates will be prepared and status meetings will be attended as required.

Experimental

Monthly status reports were prepared for April and May, 2006. A Quarterly Report was prepared for January - March, 2006; and for April – June, 2006. A Steering Committee Meeting was attended in Cleveland, OH in May, 2006 where Task 3 results were presented from BWRC and ORNL results.

Concerns

None.

Activities Next Quarter

Monthly status reports will be written for April and May, 2006. A Quarterly Report will be written for April – June, 2006. A Steering Committee Meeting will be attended in Cleveland, OH in May, 2006.

Task 3E Conduct Experimental Exposures

Background

The steam oxidation behavior of model Fe-Cr alloys will be evaluated.

Experimental

B&W is remaining cognizant of the ORNL tests on these model alloys.

Concerns

None.

Activities Next Quarter

BWRC will maintain cognizance of ORNL results.

Task 3F Characterization

Background

Samples of the model Fe-Cr alloys fabricated in Task 3E will be characterized before and after steamside oxidation testing using metallographic and electron optic techniques.

Experimental

None.

Concerns

None.

Activities Next Quarter

None

Task 3G Data Analysis and Coordination

Background

The steamside oxidation results will be evaluated to determine the effects of material properties and environmental factors on oxidation behavior.

Experimental

No progress will be possible until the steamside oxidation tests have been completed (GFY2006).

Concerns

None.

Activities Next Quarter

None.

Milestone Chart

Dates are listed in GFY

Task 4 Fireside Corrosion

(Foster Wheeler)

The objective of the task is to evaluate the relative resistance of various advanced alloys for waterwall and reheater/superheater construction to fireside corrosion over the full temperature range expected for the USC plant. The corrosive environment promoted by three different coals, representative of an eastern coal, a midwestern coal, and a western coal, will be evaluated.

Task 4A Laboratory Testing

Objective

The objective of this sub-task is to perform laboratory corrosion tests on the candidate alloys. This will be accomplished by exposing metal coupons to various deposits and flue gases representative of three coals (e.g., eastern, midwestern, and western) at the range of temperatures expected for the USC plant.

Experimental Progress

During the quarter, analysis of the data from the laboratory tests on both superheater/reheater and waterwall materials was continued in preparation for final report.

Concerns

No concerns at this time.

Plans for Next Quarter

Continue to refine the results of the laboratory tests.

Task 4B Corrosion Probe Testing in Utility Boilers

Objective

The objective of this sub-task is to install corrosion probes comprised of various alloys/coatings/weld overlays at three coal-fired power plants and control them in the temperature range expected for reheater/superheater components in the USC plant. The plants should burn coals representative of the three types specified earlier.

Experimental Progress

- First pair of corrosion probes was installed in a Mid-Western host utility site during January 2006. Exposures for the one-year and two-year probes are ongoing. Figure 4.1 shows the 2-year probe, in the extended position, while Figure 4.2 shows the probe in the retracted position. Figure 4.3 shows a close-up view of the same probe, in the retracted position, in which the sample segments are visible.
- The final equipment for the second pair of corrosion probes has been delivered and installed at a Western utility host site during June 2006. Figure 4.4 shows the equipment layout for the Western utility. The electrical and mechanical on-site work needed to accommodate the new installation has been completed.
- The Western host utility is interested in applying a nano-coating to the corrosion probes, for corrosion performance evaluation, and will make arrangements to apply the coating to certain sections of the probe during July 2006. These additional coatings will be applied to the transition thermocouple sections (every sixth element on each probe), and will not affect the original USC material samples. Figure 4.5 shows two of the transition sections, as indicated by the red arrows, on one of the representative probes.
- Material samples for the third pair of probes (Eastern coal) have been machined and assembled. Deployment of the third pair of probes is pending signing of the host agreement by an Ohio utility.
- Foster Wheeler continues to work closely with the host utility personnel to coordinate continuing exposures, and installation activities, as needed.
- Changes in fuel at the original Eastern coal host site have necessitated locating a new host site. Several discussions were held with a new plant in Ohio to replace the original third host site. Home office and plant personnel have generally agreed to host the third pair of corrosion probes. Final determination should be made shortly.
- New penetrations were installed in the likely third site to accommodate the two Eastern coal corrosion probes. Installation of the probes at this final site is awaiting a legal review and signing of the host agreement.

Figure 4.1 - Corrosion Probe Operating at Mid-western Utility (Extended Position)

Figure 4.2 - Corrosion Probe Operating at Mid-western Utility (Retracted Position)

Figure 4.3 - Close-up View Corrosion Probe Installed at Mid-western Utility

Figure 4.4 - Corrosion Probe Equipment Installed at Western Utility

Figure 4.5 – Identification of Transition Thermocouple Segments of Corrosion Probe

Concerns

The original third (Eastern coal) host site has changed to 100% low-sulfur PRB (Western) coal. This required that we locate a new host site, firing a different coal (possibly Eastern / PRB blend coal). Negotiations are currently under way with a possible host site within Ohio. This utility has already allowed us to install new penetrations for the probes, during a recent outage. However, if the parties involved were unable to reach a mutual agreement, a new Eastern coal site would have to be selected.

Plans for Next Quarter

- Monitor ongoing exposures at the installed probe sites firing Mid-western and Western coals.
- Finalize hosting arrangements and logistics for third host site (Eastern coal).
- Continue site installation tasks for the third site, coordinating with host utility.
- Complete mechanical and electrical modifications at third host site.
- Install probes at remaining host site.

Task 4C Steam Loop Design, Construction, and Testing

Objectives

The objectives of this sub-task are to design, build, and test an experimental USC steam loops that will operate in a commercial boiler at metal temperatures up to 1400°F. The elements of this subtask include the following:

Design and construct the test loop using commercially-available, high-temperature corrosion-resistant alloys selected for the USC Plant.

Install and operate the test loop at the Reliant Electric power plant, which is located in Niles, OH and is burning high sulfur Ohio coal.

Test and monitor the relative performance of the USC tube alloys, coatings, claddings, and weld overlays, which comprise the test loops, for a period of 18 to 24 months.

Experimental Progress

In the May outage, faulty valve equipment and thermocouples were replaced. Prior to the outage, Loop A was operating in the 800° - 1000°F range (because of the steam valve failure in December) and Loop B was operating at metal temperatures up to 1280°F. Upon re-start of the unit, it was learned that there was a wiring problem in the newly-installed valve in Loop A, resulting in continued operation in the 800° - 1000°F range. (Loop B continued to operate at metal temperatures up to 1280°F.) In lieu of waiting for a forced outage to revise the wiring on the incorrectly wired position feedback transmitter, the control logic were reviewed and it was determined that the reverse wiring can be compensated for in the control system. The revised logic has been developed and arrangements have been made to implement the change in the Plant Digital Control System (DCS) on July 5 and 6. Following the revision of the plant DCS control logic, Section A is expected to operate as intended (i.e., at metal temperatures up to 1400°F).

Under the current agreement, the loops are scheduled to operate until the fall of 2006. At that time, there will be discussions between Reliant Energy and B&W regarding an extension to the program.

Plans for Next Quarter

Modify the control system and return Section A to intended operation.

Task 5

Welding Development

(ALSTOM)

Objectives for Task 5 Welding Development:

To define weld metal choices for candidate materials.

To establish acceptable welding procedures and practices.

To evaluate the effects of manufacturing heat treatments and preheat and post weld heat treatments on weldment integrity and properties.

To produce samples needed to determine the properties of candidate ultrasupercritical alloy welds and weldments, including the dissimilar metal weld joints between the various types of material (the actual mechanical and property testing will be performed under Task 2).

These objectives will be accomplished through execution of five sub-tasks. Where activity on these sub-tasks occurred during the reporting period, it is described below.

Task 5B: Optimization of Weld Parameters

Objectives:

The primary objectives of this subtask are to establish the baseline welding parameter values for each material/process/product form combination being studied. Included is the development of preheat and post weld heat treatment requirements.

Progress for the Quarter:

SAVE 12:

- The SAVE12 heavy wall (13.78-inch OD x 2.3-inch wall pipe) weld qualification efforts continued with further investigation of the fluxes and filler metals used for submerged arc welding. Several iterations with various combinations of fluxes and fillers were tried in attempts to find the optimum combination for the deposited weld metal. The testing also included an evaluation of deposition rates and bead placement as related to deep groove configurations and it is believed that an acceptable filler composition, when used with WP 380 flux, has been identified.

Filler wire having the new formulation has been procured and attempts at qualifying the heavy wall welding process are underway.

Inconel 740:

A hot wire gas tungsten arc process that had been qualified for thick sections was used to join three-inch thick coupons, which were given a precipitation hardening heat treatment after completion of the welding. Metallographic evaluation showed some microfissures but most were in the upper half of the joint and this was not considered unusual due to increased restraint in that area. Mechanical testing demonstrated that the microfissures were insignificant and did not affect the test results however the ductility of the weld metal in the aged condition was low and resulted in bend test failures. In order to study the effect of filler metal, a thin section coupon was welded using Nimonic 263 filler and superior ductility is expected.

Welding development efforts were also directed towards tube butt joints and specimens were prepared using a gas tungsten arc process and matching filler metal. Macro examination of the specimens did not reveal any microfissuring and 2T bend test samples did not crack even though the material had been precipitation hardened. Additional mechanical testing for procedure qualification is underway.

General:

A paper was prepared and presented on Inconel 740 weldability at the EPRI conference on Welding and Repair Technology for Power Plants in June. The paper described the successful use of aerospace testing techniques to predict the weldability of superalloys considered for use in ultrasupercritical boilers.

Efforts to prepare a final comprehensive Task 5 report continued.

Concerns:

Submerged arc welding, a high deposition rate process favored by boilermakers for thick sections, does not appear feasible for all nickel base materials. Tests on Haynes 230 and Inconel 740 have been unsuccessful because of cracking and the process was abandoned on these two alloys.

The unexpectedly high cost of the nickel base alloys will cause the material budgets to be exceeded and might result in program cost overruns and/or reductions in program scope.

The difficulties encountered while attempting to weld HR6W using matching filler metals proved insurmountable for this program and there will be no further effort in this area.

Inconel 740 appears to have a heat-to-heat sensitivity with regards to microfissuring and this could require additional constraints on composition.

The use of matching filler metal for welding thick section CCA 617 plates does not appear practical.

Plans for the Next Quarter:

Continue with the efforts to qualify the welding of the SAVE 12 thick wall pipe material using a submerged arc process.

Continue to study the problems with weld metal cracking in Inconel 740 joints by evaluating the use of Nimonic 263 filler in thick section weldments.

Continue development of Inconel 740 welding procedures for tube butt joints.

Continue preparation of final comprehensive report.

Task 5C: Preparation of Laboratory Samples

Objectives:

The primary objective of this subtask is to produce multiple samples representing each of the material/process/product form combinations being studied. These samples will be evaluated by ORNL as part of the Task 2 activities.

Progress for the Quarter:

No progress to report.

Concerns:

None.

Plans for the Next Quarter:

Fabricate Inconel 740 tube butt joint weld samples for ORNL testing.

Using a process that has already been qualified, provide ORNL with a P92 pipe (6.3-inch OD x 1.1-inch wall) butt joint sample for testing.

Task 5: Welding Development - Milestone Chart

(DOE Fiscal Year Basis)

(percentages indicate fraction of workscope completed as of 2006Q3)

Task	Milestone	Year 2002				Year 2003				Year 2004				Year 2005				Year 2006			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
5A	Selection of Weld Filler Material • Procure base metal for weld trials. • Evaluation and selection of filler. • Procurement of candidate fillers.					100% ▲															
		△				100%				▲											
		△				100%				▲											
5B	Optimization of Welding Parameters • Preliminary weld trials and parameter optimization – thin section. • Preliminary weld trials and parameter optimization – thick section.					96%												▲			
						96%												▲			
5C	Preparation of Laboratory Samples • Material preparation. • Sample fabrication.					90%												▲			
						90%												▲			
5D	Weldability Testing									△				100%				▲			
5E	Examination of Dissimilar Metal Welds. • Weld trials • Metallurgical analysis									△ 65%								▲			
										△ 10%								▲			

Task 6: Fabrication (ALSTOM)

- The objective of Task 6 is to establish boiler fabrication guidelines for the high temperature, oxidation and corrosion resistant alloys selected for the USC Project. The principal goals in this joint effort are:
 - To establish fabrication guidelines for the high temperature, corrosion resistant alloys needed for boiler components in the USC power plant.
 - To determine the thermomechanical treatments or other remedial actions necessary to restore material properties which might degrade due to fabrication operations.
 - To investigate prototypical manufacturing operations for producing both thick wall and thin wall components from the USC alloys.
- **Progress for the Quarter:** **Riley Power, Inc.**
 - Riley Power has continued the preparation of summary reports on the history and accomplishments of the materials fabricability efforts. The format established by B&W is being used for the content and assembly of the report.
- **CONCERNS: NONE**
- **Plans for the Next Quarter:**
 - After the controlled strain/recrystallization/precipitation study results are available, Riley Power will determine the appropriate heat treatments applicable to the HR6W and SAVE12 materials, and additional samples of the materials may be sent to ORNL for testing.
 - Riley Power is still considering the fabrication of a mock-up header/spool piece which would contain tubing components and welding of the HR6W and SAVE12 materials.
 - Preparation of Riley Power's contribution to the Task 6 final topical report will be completed.

- **Progress for the Quarter: Alstom Power, Inc.**

- Geometric characterizations and destructive examinations have been completed on the U-bend specimens fabricated from both CCA 617 and Super 304H tubing. These included 3, 5, and 7-inch radius cold bends and 3-inch radius cold bends that were subsequently hot formed to a 2-inch radius. Evaluation of the data did not reveal any detrimental conditions.
- Four CCA 617 cold swage samples were produced with a 1/8-inch reduction in outside diameter, which is the maximum reduction commonly used when working with Type 347 tubing. Two samples were given a standard solution anneal and two were heated slowly to test for susceptibility to strain induced embrittlement. No cracking or other anomalies were detected that might indicate problems could be encountered when swaging CCA 617 material. A similar set of tests is underway using Super 304H tubing.
- Alstom has continued the preparation of summary reports on the history and accomplishments of the materials fabricability efforts. The format established by B&W is being used for the content and assembly of the report.

- **CONCERNS: NO NEW CONCERNS.**

- **Plans for the Next Quarter:**

- Continue the examination of the tapered tubes used for the cold working studies.
- Determine the sensitivity of Super 304H to strain induced embrittlement.
- Preparation of reports summarizing the controlled strain/recrystallization/precipitation studies of S304H and CCA617 will be completed for inclusion in the Task 6 final topical report.
- Preparation of Alstom's contribution to the Task 6 final topical report will be completed.

- **Progress for the Quarter: Foster Wheeler**

- Foster Wheeler has continued the preparation of summary reports on the history and accomplishments of the materials fabricability efforts. The format established by B&W is being used for the content and assembly of the report.
- Three thermal exposures were performed on the strained Save12 tapered tube: 1400°F/76 hrs, 1400°F/190 hrs, and 1400°F/500 hrs. The results were:

- No recrystallization was evident at any of the strain levels in the 1400°F/76 hr exposure.
- In the 1400°F/190 hr exposure, recrystallization was noted at the highest strain level - 35 percent OFS. The recrystallization was accompanied by a significant decrease in hardness - from 30 HRC (286 HB) in the as-strained condition to 83 HRB (159 HB) in the recrystallized zone
- In the 1400°F/500 hr exposure, the recrystallization extended beyond the 35 percent OFS zone to almost the 17.5 percent OFS position on a macro basis. On a micro basis, the start of recrystallization was evident at the 17.5 percent OFS location. The hardness at this location (i.e., the 17.5 percent OFS position) was 94 HRB (205 HB) in the unrecrystallized areas and 80 HRB (150 HB) in the localized recrystallized zone. The figures that follow highlight these results.

TOP: 35, 17.5, 7.5 OFS positions after 1400°F/190 hr exposure – recrystallization is evident at the 35 OFS position

BOTTOM: 35, 17.5, and 7.5 OFS positions after 1400°F/500 hr exposure – recrystallization extended to almost the 17.5 OFS position

TOP: As-strained microstructure at 35 OFS position – 30 HRC (286 HB) hardness

BOTTOM: Microstructure at 35 OFS position after 1400°F/76 hr exposure shows no recrystallization – 20.5 HRC (229 HB) hardness

TOP: Microstructure at 35 OFS position after 1400°F/190 hr exposure shows recrystallization – 83 HRB (159 HB) hardness

BOTTOM: Microstructure at 35 OFS position after 1400°F/500 hr exposure shows recrystallization – 82 HRB (153 HB) hardness

TOP: Microstructure at 17.5 OFS position after 1400°F/190 hr exposure shows no recrystallization – 95 HRB (210 HB) hardness

BOTTOM: Microstructure at 17.5 OFS position after 1400°F/500 hr exposure shows start of recrystallization – 94 HRB (205 HB) hardness in unrecrystallized areas and 80 HRB (150HB) in recrystallized zone

- **Concerns:** None

- **Plans for the Next Quarter:**
 - One additional thermal exposure - 1400°F/1000 hrs. will be conducted on Save 12 material to determine how far the recrystallization advances at the 17.5 percent OFS position and whether it extends to lower strain levels. Results will be completed during the next quarter.
 - Preparation of reports summarizing the controlled strain/recrystallization/precipitation studies of HR6W and Save12 (subcontracted by Riley Power), alloy 230 (subcontracted by B&W) and alloy 740 will be completed for inclusion in the Task 6 final topical report.
 - Preparation of FW's contribution to the Task 6 final topical report will be completed.

- **Progress for the Quarter: B&W**
 - Preparation of B&W's contribution to the Task 6 final topical report continued.
 - Fabrication of Demonstration Article "B" (thick wall header assembly) was completed.

- **Concerns:**
 - None

- **Plans for the Next Quarter:**
 - Preparation of B&W's contribution to the Task 6 final topical report will be completed.
 - Preparation of the Task 6 final topical report on Fabrication, through integration of separate subtask element reports prepared by Riley Power, Alstom, Foster Wheeler, and B&W, will be completed and submitted for review.

Task 6 Schedule and Progress

ID	Task Name	Start	Finish	Status																								
					2002				2003				2004				2005				2006				2007			
					Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2					
1	Task 6: Fabricability	Tue 1/1/02	Fri 12/29/06	In Progress																								
2	6A: Fab Trials for SH	Tue 1/1/02	Fri 12/29/06	In Progress																								
3	6A.1 SH Trial	Tue 1/1/02	Mon 10/10/05	Complete																								
4	Procure Materials	Wed 1/2/02	Fri 5/30/03	Complete																								
5	Shop Sched & Graphics	Tue 4/1/03	Mon 6/2/03	Complete																								
6	Travel to Shop	Mon 6/2/03	Mon 10/10/05	Complete																								
7	Cold Bending Trials	Mon 6/2/03	Fri 3/10/06	In Progress																								
8	Cold Swaging Trials	Mon 6/2/03	Fri 3/10/06	In Progress																								
9	Butt Welding Trials	Mon 6/2/03	Fri 6/4/04	Complete																								
10	Attachment Welding Trials	Mon 6/2/03	Fri 8/6/04	Complete																								
11	6A.2 Reporting	Fri 1/3/03	Fri 12/29/06	In Progress																								
12	6A.3 SH: Met Test & Eval	Fri 1/9/04	Mon 10/10/05	Complete																								
13	6A.3.1 Mic Bends&Welds	Fri 6/4/04	Mon 10/10/05	Complete																								
14	6A.3.2 HT Studies&Mic	Fri 6/4/04	Thu 8/31/06	In Progress																								
15	6B: Fab Thk Wall Comp	Fri 1/9/04	Fri 12/29/06	In Progress																								
16	6B.1 Thick-Wall Fab Trial	Fri 1/9/04	Fri 6/30/06	In Progress																								
17	6B.2 Reporting	Fri 1/9/04	Fri 12/29/06	In Progress																								
18	6B.3 Thick-Wall Comp	Fri 1/9/04	Fri 6/30/06	In Progress																								
19	6B.3.1 Met Analysis	Wed 6/29/05	Tue 11/15/05	Complete																								
20	6B.3.2 PWHT Studies&Mic	Wed 9/29/04	Thu 10/6/05	Complete																								

Task 7: Coatings

(ALSTOM)

Objectives for Task 7 Coatings:

Review state-of-the-art of coating technology and identify development needs.

Develop coating manufacturing techniques, which can provide corrosion/erosion protection for components in USC boilers, cost effectively.

Establish manufacturing techniques for application of internal coatings for oxidation protection, cost effectively.

Provide coated samples for corrosion and oxidation testing in the laboratory and “in the field”.

These objectives will be accomplished through execution of eight sub-tasks. Where activity on these sub-tasks occurred during the reporting period, it is described below.

Task 7G: Manufacturing Guidelines

Objective:

Investigate the requirements for production coating of boiler materials.

Progress for the Quarter:

Work efforts for this task have concentrated on the requirements for diffusion-coating of the internal surface of boiler tubing. Editing of the task report was again deferred to next quarter.

Concerns:

None.

Plans for the Next Quarter:

Issue a report of the manufacturing requirements and costs for coating of internal tube surfaces.

Scope Accomplished Versus Actual Expenditures Task 7 Coatings Alstom Scope

Task 8: Design Methods and Data (ALSTOM)

The major objectives for Task 8 are:

Review the methods used by Section I of the ASME Boiler and Pressure Vessel Code to utilize materials properties and behavior models in the design of ultra-supercritical boilers.

Develop and document methodologies whereby the results of the other tasks within this program may be most effectively applied within the ASME Section I design environment.

Pursue the incorporation of such methodologies into Section I.

These objectives will be accomplished through execution of seven sub-tasks. Where activity on these sub-tasks occurred during the reporting period, it is described below.

Task 8A: Task Management (ALSTOM)

Objective:

The primary objective of this subtask is the overall management of the task, coordinating meetings and preparing progress reports.

Progress for the Quarter:

Progress was made on preparation of the weld literature review. A draft topical report on the header cycling study was issued for review by Task 8 members. Useful interaction occurred with ORNL to understand their thermal fatigue tests of CCA617 and S304H. Limited material data availability and resource issues continue to hamper progress on some tasks.

Concerns:

None.

Plans for the Next Quarter:

Continue general task management activities.

Task 8B: Material Data Collation and Processing (FW)**Objectives:**

The creation of documentation to ensure that quality test data is transferred between tasks and that this data remains traceable. A second objective is the analysis of such data with the objective of improving the statistical correlation. Foster Wheeler is subtask leader, with Riley Power Inc. providing significant input to this subtask.

Deliverables:

Item	Responsible	Status
Material data transfer sheets	ALSTOM	Transfer sheets provided for creep and tensile tests.
Electronic data repository	ORNL	Website complete.
Recommendations for statistical analysis of data		
Data compendia and fits for key materials		
Code case packages and submissions to code committees	ALL	

Progress for the Quarter:

Riley Power Inc. has continued to monitor the USC data transfer website for any added completed test results for the HR6W and SAVE 12 materials, assigned to Riley. Riley continued to generate a summary report of the creep rupture test results for HR6W. All of the scheduled creep rupture tests for the HR6W material have been completed and the results posted. Currently for HR6W, the only missing results are for metallography.

ALSTOM Power Inc. continued to interact with ORNL to discuss mechanical feature testing, specifically the thermal shock testing of CCA617. ORNL provided further test results, including thermocouple traces, from which ALSTOM performed additional structural analysis of the hollow cylindrical specimen, which is heated externally and cooled on the inside bore. Further discussion and data sharing occurred to understand the yield strength of CCA617 as a function of temperature and aging conditions. Updated results of the specimen analysis show that creep cracking could initiate on the OD, while fatigue cracking would be more likely on the ID. This analysis is consistent with test observations. Simulations were also performed for the Super 304H thermal shock test that is presently running at ORNL.

Concerns:

None

Plans for the Next Quarter:

The task participants will continue to monitor the USC data transfer web site for any additional, completed test results. Evaluations will continue to compare and contrast

the strength of the materials with existing databases for similar alloys. Riley will complete the in process summary report of the test results for the HR6W material, with the addition of percent creep strain and stress versus time to rupture plots to the report. It is projected that it will not be possible to work on statistical correlation of data for some time because of the lack of data on which to perform meaningful analysis. Support will be provided to Task 2, as needed, to address issues with additional structural feature tests, or interpretation of existing tests.

Task 8E: Continuum Damage Mechanics (B&W)

Objectives:

The objective of this subtask is to analyze uniaxial and multiaxial creep test data from Task 2 for several (three) materials to:

- establish the continuum damage mechanics (CDM) parameters,
- evaluate multi-axial strength theories and failure criteria,
- assess the implications of cyclic creep for USC materials,
- evaluate and compare CDM, reference stress and Omega models of typical ASME geometries.

Progress for the Quarter:

The continued scarcity of long-term creep data for the candidate materials means that the effort to model the creep response with continuum damage mechanics or other models remains on hold. Furthermore, only limited multiaxial creep rupture data are available (one notch bar test for IN740), so determination of the multiaxial stress rupture criterion cannot proceed.

The study to assess the cycling capability and margins against shakedown and ratcheting for a typical segment from a superheater header was formatted as a draft topical report and issued to the Task 8 members for review and comment. Limited feedback has been obtained; Riley has performed a cursory review and has no significant questions or comments.

Concerns:

Timely availability of creep data on ORNL web site and results of notched bar creep rupture tests.

Plans for the Next Quarter:

Monitor material data web site to see if sufficient data is available to initiate a modeling activity. Check on status of structural feature tests. Issue topical report on the study comparing cycling capability of candidate alloys.

Task 8F: Weld Analysis and Assessment (ALSTOM)

Objectives:

Create simplified analysis models of welds and heat affected zones (HAZ) utilizing material properties obtained from the open literature and from Task 2 to permit accurate creep life assessment of weldments.

Deliverables:

Item	Responsible	Status
Topical review of weld analysis and assessment in creep range.	ALSTOM & RPI	In progress.
Collation of material data for weld metal and HAZ.	RPI	In progress.
Creep models for weld metal and HAZ regions.	ALSTOM	In progress.
Report documenting the simulation of welded specimens and common Code geometries.	ALSTOM	
Report documenting the development and use of approximate weld assessment methods.	ALL	

Progress for the Quarter:

Riley Power Inc. has previously submitted their contribution to the weld literature review and awaits ALSTOM's contribution so that a complete document can be reviewed, edited as necessary and issued to the project team.

ALSTOM continued studies of high-temperature design approaches for weldments. Work continued to explore the application of reference stress methods to weldments and update the topical report. The modified reference stress method was validated against full continuum damage mechanics simulations and compared with other approximate methods for weld life prediction. The results are encouraging, for the limited cases explored, and certainly offer potential for further development, as proposed in the follow-on activities for the USC Boiler Material project. The weld literature review report has been updated to include the latest results and awaits ALSTOM internal review.

Concerns:

None.

Plans for the Next Quarter:

In the next quarter, ALSTOM will complete its portion of the weld literature review and work with Riley Power to issue the weld literature review summary report.

Task 8G: Basic Design Rules for Cylinders (ALSTOM)

Objectives:

Review the various equations used by the ASME Code, Section I for Power Boilers to define the minimum thickness of cylinders under internal pressure and develop a single methodology applicable to ultrasupercritical boilers.

Deliverables:

Item	Responsible	Status
Report summarizing existing approaches and comparing and contrasting their predictions	ALSTOM	Complete (Aug 2003)
Report recommending a single equation with supporting theoretical data.	ALSTOM	Complete (Sept 2003)
Code case submission	ALSTOM	Complete (October 2003)

Progress for the Quarter:

No activity for this quarter.

Concerns:

None.

Plans for the Next Quarter:

None.

Task 9 Project Integration and Management (EPRI)

- The objective of Task 9 is to coordinate the project and provide reporting to DOE and Ohio Coal Development Office (OCDO).

Progress for the Quarter:

- Completed Second Quarterly Report for 2006
- Completed Monthly Reports for March to May 2006
- Monthly conference calls were held and the discussions were documented.
- Defined priorities for add-on work and won committee approval

Concerns

- No concerns at this time

Plans for the Next Quarter

- Issue monthly reports and hold conference calls as required
- Conduct Steering Committee Meeting and provide minutes.