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ULTRASUPERCRITICAL COAL POWER PLANTS**

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Principal Author: R. Viswanathan
K. Coleman
EPRI

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Submitting Organization: The Energy Industries of Ohio, Inc.
Park Center One, Suite 200
6100 Oak Tree Boulevard
Independence, Ohio 44131

Participating Organizations:

Alstom Power, Inc. 2000 Day Hill Road Windsor, CT 06095	Babcock Borsig Power, Inc. 5 Neponset Street Worcester, MA 0615	Foster Wheeler Development Corp. 12 Peach Tree Hill Road Livingston, NJ 07039
McDermott Technology, Inc./ Babcock & Wilcox Company 1562 Beeson St. Alliance, OH 44601	Electric Power Research Institute (EPRI) 3412 Hillview Avenue Palo Alto, CA 94303	Oak Ridge National Laboratory 1 Bethel Valley Road Bldg. 4500S Oak Ridge, NY 37831-6156

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1.0 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, and DOE's Vision 21. 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 and Babcock Borsig Power) 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

- Most materials have been ordered although alternate product forms of some materials are still being sought. Materials are starting to be received.
- A paper was presented at a European conference on Advanced Materials in Liege incorporating results from Task 1. Task 1 is essentially complete except for report writing.
- Received agreement from Dr. Abe to provide some of his new alloy for inclusion in the project.
- A trial run of the steamside oxidation test facility was completed.
- A draft state-of-the-art report on coating was issued.
- A literature review on steam side oxidation resistance was completed in draft form and sent to consortium members for review.
- Oxidation testing plan and coupon sizes were changed to allow for weight change and scale morphology evaluations.
- The Niles plant has agreed to allow corrosion test loops to be installed to test the various alloys. Functional design of the test loops is complete. Outage for installation of the test loops is scheduled for fall, 2003.
- A test run of diffusion coating of samples has been completed.
- Special Metals has agreed to perform some preliminary welding trials with In 740 plate. Alloy 263 wire has been supplied by the consortium for use in these tests.

E. Plans for the Next Quarter

It is anticipated that the following work will be completed during the next quarter:

- Issue report for Task 1 from each organization participating in task.
- Issue literature review on steam side oxidation resistance.
- Continued procurement of test materials
- Perform a second test run of the oxidation test facility
- Start initial welding trials on alloys
- Different coating methods and materials will be evaluated.
- Review of ASME SC VIII, Div 2 re-write to determine how fatigue effects will be handled in the ASME Code.

F. Issues

- Base material sourcing difficulties and long delivery times have in some cases delayed the start of activities by 6 to 9 months. Other product forms and small quantities are being pursued to keep tasks on schedule.
- Unexpected high cost of some alloys may cause material budgets to be exceeded. Consortium task members have had to re-evaluate test plans accordingly to minimize the quantity of materials needed for testing.
- All alloys are not available in desired product forms, especially thick walled pipe. Some testing will have to be changed to accommodate product forms available. Thick plate will be used for some of the thick pipe evaluations.
- The current chemical composition of Alloy 740 may lead to an Eta phase formation at the temperatures proposed for this project. Alternative chemical compositions are being evaluated.

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 1400F 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 Quarter:
- Concerns:
- Plans for the Next Quarter:

Task 1B: Babcock Approach

- Objective: The objectives of this subtask are the same as in Subtask 1A.
- Progress for the Quarter:

Work on the Task 1 Topical report continued this quarter with completion scheduled for mid- October.
Estimating data for material, fabrication and erection costs for comparison to a conventional supercritical boiler cost was collected and a preliminary cost estimate made.
A meeting was held in August to review the current draft of the Task 1 report (on cycle efficiency).
- Concerns: No concerns at this time.

- Plans for the Next quarter:

Release the first draft of report for Steering Committee review, including rough estimation of boiler cost.

Task 1C: Economic Analysis

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

- Progress for the Quarter:

All work is complete on the economic analysis. The analysis compared a new ultrasupercritical plant to a subcritical, conventional supercritical, and IGCC plant. Even at a scale of 750 MW the PC plants have more favorable economics than IGCC plants. This is due to the fact that a PC plant has a much bigger economy of scale since you are scaling up a single boiler. At 750 MW, the IGCC plant consists of three parallel 250 MW trains, so there is not as much savings in going to the larger sizes. My charts show both 500 and 750 MW IGCC plants. Most of our work has been on 2-train IGCC plants at about 500 MW. As a result, I have not changed the breakeven analysis or conclusions.

The following conclusions were determined from the analysis:

- If the USC plant efficiency can be improved to 48%, then the USC Total Plant Cost can be 15% higher at the same cost of electricity as a conventional subcritical PC Plant
- 48% USC efficiency leads to 16% lower USC BOP cost
- USC Boiler/Steam Turbine cost can be 50% higher
- For each efficiency point increase:
 - USC Boiler/ST Cost can increase ~\$14/kW,
 - or ~ 3.8% increase over the subcritical boiler/ST cost
- Concerns: None
- Plans for the Next Quarter:

Issue final report for sub-task.

Task 2: Mechanical Properties of Advanced Alloys

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

Subtask 2A: Assessment of the Alloy Performance Requirements:

This assessment will focus on performance needed for boiler service in the temperature range of 1200°F (649°C) to 1600°F (871°C) and will provide justification for the materials selected for the pressure retention components of the boiler.

The report that provides background and details of the assessment is still being written. For this reason, it was decided to issue the report in several parts. The draft of first part, dealing with 9-12% chromium steels, has a target date of September 15. The second part, dealing with austenitic stainless steels has a target date of October 15. The third part, on high alloys and nickel base alloys has a target date of September 15, while the fourth part, dealing with advanced alloys requiring significant developmental work, has a target date of October 15. Although some progress has been made in completing the report, none of the parts are available for external review.

Task 2B: Detailed Test Plan:

The mechanical properties test plan is being reviewed in light of the materials selected for the initial thrust of the project, and data are being collected for each of the eight alloys identified by the USC Project Team.

The final listing of materials and product forms is sufficient to begin the definition of the testing plan. The scope for the testing lab in Ohio is being defined. The current plan calls for testing of the SAVE 12 steel at the Ohio testing laboratory. These creep tests would include notch bar testing. One austenitic steel will also be tested at the Ohio Laboratory.

Task 2C: Long Term Creep Strength:

The objective of the long-term creep testing is to identify the general characteristics of the creep and damage accumulation in the candidate alloys.

Creep testing of specimens from a HCM12A steel forging is in progress. Temperatures will be in the range of 1200 to 1300°F (649 to 704°C) with emphasis on 1250°F (677°C). The intent of the testing is to explore methods of developing isochronous stress-strain curves and to gather data that can be used

in Dyson's CDM approach to creep modeling. So far, three stress levels have been selected at 1250°F (677°C): 20, 15, and 10 ksi (138, 103, and 69 MPa).

Under sponsorship by a companion program, Professor Roy Faulkner of Loughborough University has agreed to examine the CDM model and alloy development as these topics relate to martensitic steel of interest to the USC Boiler. He will assist in the determination of the critical materials parameters needed to utilize the model. It is intended that graduate students will assist in the extraction of quantitative data from microstructural samples.

Exploratory testing of samples SAVE 25 tubing continues at a low rate of effort.

Exploratory testing of Inconel 740 continues. Specimens are being tested at 1400 and 1500°F

Task 2D: Microstructural Analysis:

The objective of the microstructural analysis is to identify the microstructural changes that significantly lead to strengthening, weakening, and internal damage characteristic of each material and to explore how these characteristics relate to the exposure conditions of the testing.

A microstructural examination of a sample of Inconel 740 that ruptured after 2500 hours at 1500°F(816°C) and 20 ksi (138 MPa) revealed small amounts of the eta phase. Further analysis of the sample is ongoing.

Task 2E: Assessment of Creep-Fatigue Properties:

The objective of the creep-fatigue studies is to develop a database that will lead to practical yet conservative method to address the issue of creep-fatigue damage in the boiler materials.

Four electrohydraulic fatigue testing systems have been relocated to their final sites. The hydraulic power supplies are in place. The installation of hydraulic power lines is 60% completed.

Task 2F: Modeling of Weld Joints:

The objective of Task 2F is to produce the experimental data needed model dissimilar metal and thick section weld joints.

There was no action on Task 2F this month.

Task 2G: Study of Accelerated Testing Methods:

The objective of the accelerated testing is to provide a method to rapidly characterize changes in the strength of the candidate materials.

There was no action on Task 2G this month

Task 2H: Model Validation:

The objective of the model validation testing is to produce a database that can be used to confirm or validate the design rules that are developed in Task 8.

A small subcontract was placed with Stress Engineering Services, Inc. of Cincinnati Ohio for assistance in the specification of test methods to support the development of simplified rules to avoid creep ratcheting in thick section components.

Task B: Steamside Corrosion Resistance

Corrosion testing of model alloys continues at 1292F (700C).

Task 3:

Steamside Oxidation Resistance (Task Lead McDermott Technology, Inc.)

Task 3A Autoclave Testing

Background

Steamside oxidation tests will be performed on commercially available and developmental materials at temperatures between 650°C and 900°C (1202°F - 1652°F).

Experimental

In July 2002, a trial run was performed on the steam oxidation test facility. Water was pumped from the feedtank through ½" Alloy 600 tubing into the furnace where it flashed to steam. The steam flowed into and through the 310SS test vessel. Upon exiting the test vessel and furnace, the steam passed through a cooling coil where it was condensed to water. The test system performed as it was designed and temperatures between 650 and 900°C were achieved within the test vessel.

Preparations are underway for a second trial run of the test system. The objectives of the second trial run are listed below:

Objectives of Second Steam Oxidation Test Facility Trial Run :

1. Determine approximate furnace set points to maintain desired temperatures at different flow rates.
2. Determine front-to-back variations in oxidation behavior as a function of temperature and flow.
3. Compare influent and effluent O₂ levels as a function of temperature, flow and time.
4. Determine temperature variations along the length of the retort as a function of temperature and flow.
5. Determine how the test rack frame and ceramic test rack materials hold up under these conditions.
6. Gain experience in operating the system for longer times.
7. Gain experience in loading and unloading specimens and test rack frame.
8. Gain experience in pre-test and post-test specimen handling.
9. Gain experience in preparing OWT water.
10. Gain experience in changing flow rates during a test.

During the July Status Review meeting, it was observed that the planned test materials list for the Steam Oxidation Tests (Task 3) was different than the planned test materials list for the Fireside Corrosion Tests (Task 4). Discussions have begun with the Task Leader for Task 4, and the list of planned test materials for Task 3 has been modified somewhat. The current list of planned test materials is shown below:

Task 3 & 4 Planned Test Materials

Task 3 Materials	Source	Task 4 Materials*
P92 (F)	V&M Tube	
SAVE 12 (F)	Babcock Borsig (March)	SAVE 12
230 (A)	Haynes	230
HR-120 (A)	Haynes	120
SAVE 25 (A)	MTI (WRM)	
Marko 617 (A)	Alstom (December)	617
Super 304H (A)	Alstom (Dec / Jan)	Super 304
Alloy 740 (A)	Foster Wheeler (January)	Alloy 740
HR6W (A)	Babcock Borsig (March)	
304H (A)	B&W (?)	304
T23 (F)	B&W (?)	T23
"Abe Alloy" (F)	EPRI / NIMS	
VS2161A (F)	ORNL (?)	
VS2129 (F)	ORNL (?)	
347 HFG (A)	?	347HFG
310HCbN (A)	?	HR3C
214 (A)	B&W (?)	
RA602CA (A)	Rolled Alloys	
RA353 (A)	Rolled Alloys	
Nimonic 263	?	
800HT	?	800HT
		T22
		T91
		NF709
		45TM
		T2

- In House

- Promised

- - taken from the Foster Wheeler Status Update on July 10, 2002

During this quarter we received an approximately 2 foot length of ~9"OD x ~3/4" wall P92 pipe for V&M Tubes. We also located SAVE 25 material at MTI and initiated discussions with Dr. Abe regarding his ferritic alloy. If an agreement on terms can be reached, Dr. Abe will furnish some of this ferritic alloy for inclusion in our test program. Other materials that have been discussed for inclusion in the steam oxidation test include Thermie 174 and V&M 614.

In order to facilitate both post-test weight change and scale morphology evaluations, we now plan to test two specimens with the dimensions of 1/2"x1"x thickness instead of 1"x1"x thickness for each material/time/temperature condition. The use of two specimens will permit accurate evaluation of weight change and descaled weight loss on one of the specimens, and scale morphology evaluation on the other specimen.

Activities Next Quarter

Between October and December, 2002, MTI will perform the second Steam Oxidation Test Facility Trial run. Test materials will continue to be collected, and the reconciliation of test materials between Task 3 and Task 4 will be completed. Materials that will not be available for testing will be substituted with available materials. Preparations will begin for the first Steam Oxidation Test run.

Task 3B Coating Tests

Background

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

Experimental

Dialogue continued with Task 7 personnel regarding test materials, specimen size and available test slots.

Activities Next Quarter

Communications will be maintained with Task 7 personnel to coordinate delivery of coated materials for the first Steam Oxidation Test run.

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

No progress will be possible until results from the steamside oxidation tests are available (GFY2003).

Activities Next Quarter

None

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

The literature review (Steamside Oxidation Resistance of Materials for Use in Ultra-Supercritical Coal Power Plants) was completed and sent to Consortium members for review.

Monthly status reports were prepared for July and August, 2002, and a Quarterly Report was prepared for the April - June, 2002 time period.

A presentation was prepared for, and presented at, a consortium Project Review Meeting in Columbus, Ohio on July 10, 2002.

The Abstract shown on the following page was prepared for the 2003 Clearwater Conference. The Abstract was reviewed by Consortium members and was submitted to the Coal Technology Association.

Steam Oxidation Testing of Candidate Ultrasupercritical Boiler Materials

J. M. Sarver
Principal Engineer
McDermott Technology, Inc.
1562 Beeson Street
Alliance, Ohio 44601
Phone (330) 829-7760
Fax (330) 829-7831
jeff.m.sarver@mcdermott.com

J. M. Tanzosh
Babcock & Wilcox

S. Mohammed
McDermott Technology, Inc.

ABSTRACT

Over the past several years, the electric power industry has recognized the need to increase operating temperatures and pressures to increase efficiency and reduce pollutants. As temperatures increase, the ferritic materials presently being used in fossil boilers will not possess adequate steamside oxidation corrosion resistance. Ultrasupercritical boilers are being developed to operate with steam temperatures up to 760°C (1400°F), so new ferritic and austenitic materials must be utilized that possess excellent steamside oxidation resistance while meeting the required mechanical properties.

To this end, McDermott Technology, Inc. (MTI), as a consortium member of the DOE "Boiler Materials for Ultrasupercritical Coal Power Plants" program, will perform steamside oxidation testing of candidate materials for ultrasupercritical boilers. Testing will be performed on ferritic and austenitic materials at temperatures ranging from 650°C (1202°F) to 900°C (1652°F). Specimens will be removed from the test at various times up to 4,000 hours. The specimens will be evaluated for weight change and scale morphology. The test facility, test conditions, test materials, trial results and any available preliminary test results will be discussed. Also, results from a literature review on the steamside oxidation kinetics and behavior of ferritic, stainless and nickel-based alloys will be presented. The literature review provided qualitative information regarding the steam oxidation behavior of these materials at ultrasupercritical temperatures, and approximate temperature usage limits for the different classes of materials.

Activities Next Quarter

The literature review will be revised (if necessary) and issued. Monthly status reports will be written for September, October and November, 2002. A Quarterly report will be written for the July - October, 2002 time period. The contents of the Quarterly report will be disseminated at a consortium Project Review Meeting in Columbus, Ohio on November 20-21, 2002. Work will begin on the 2003 Clearwater Conference paper.

Task 3E Conduct Experimental Exposures

Background

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

Experimental

Since ORNL has some model Fe-Cr and Fe-Ni-Cr alloys available, there appears to be no need for MTI to fabricate any additional model alloys. Current plans are for ORNL to perform the testing of these model alloys. MTI will remain cognizant of the ORNL test results on these model alloys.

Activities Next Quarter

MTI will maintain cognizance of ORNL activities pertaining to model alloy test 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.

Activities Next Quarter

MTI will maintain cognizance of ORNL activities pertaining to model alloy characterization.

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).

Activities Next Quarter

None.

Task 4: Fireside Corrosion Resistance (Task lead Foster Wheeler)

The objective of the task is to evaluate the relative resistance of various advanced alloys to fireside corrosion over the full temperature range expected for the USC plant.

Task 4A Laboratory Testing

- Objective: To perform laboratory tests on candidate alloys exposed to various deposits representative of the three coals at the range of temperatures expected for the USC plant. .
- Results: The materials to test are being finalized and test sample procurement has begun.
- Task Schedule and Concerns: Candidate materials need to be identified and procured.
- Plans for Next Quarter: Finalize materials and procure test materials.

Task 4B Corrosion Probe Testing in Utility Boilers

- Objective: To install corrosion probes of various alloys at three coal fired power plants and control them at the temperature ranges expected for the USC plant.
- Results: Previous corrosion probe designs are being reviewed in light of the higher test temperatures to determine the required probe dimensions. This information will be utilized for probe material procurement.
- Task Schedule and concerns: Identification of correct tubing diameters is crucial before procurement can be specified. Host Utilities must be acquired.
- Plan for Next Quarter: Foster Wheeler will define tube dimensions for probes and begin locating Host Power Plants.

Task 4C Steam Loop Testing

- Objective: To install steam loops at two power stations and evaluate candidate alloys in boilers for fireside corrosion.

- Results: B&W received confirmation in July that the new owner of the Niles plant will cooperate with the project for corrosion test loop testing. This reconfirmation was necessitated due to recent change in ownership of the plant.

Redesign of the test system at Niles to accommodate the new sections and provide the desired higher temperatures continued throughout the quarter including finalizing general loop size and configuration, and attemperation scheme for the high temperature steam before reentering the operating boiler. Functional Design has been completed. Mechanical design and stress analysis are being initiated.

Niles informed B&W that their planned outage schedule is tentatively set for the fall of 2003. This is a change from the earlier outage plan of the spring of 2003.

B&W began work to contact prospective alloy manufacturers for samples of tubing alloys to be included in the test in addition to alloys being procured to support work on other Tasks. Have already been supplied bar of Rolled Alloys RA333 for possible inclusion, and tubing of Alloy 230 has arrived from Haynes.

Babcock-Borsig is reviewing the preliminary concept of the B&W steam test loop and combining that with their previous experience in Europe and beginning discussions to locate a Host plant.

- Task Schedule and concerns: Host Identification and the identification of correct tubing diameters is crucial before procurement can be specified.

Plans for Next Quarter:

- Continue mechanical (stress analysis) design
- Generate specifications for valves, and other appurtenant parts for the steam loop.
- Initiate graphics.
- Continue obtaining test materials.

Task 5: Welding Development (Task Lead – Alstom Power Company)

The major objectives for Task 5 are:

- To define weld metal choices for candidate materials.
- To evaluate weldability issues.
- 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 joint between the various types of material (actual mechanical and property testing will be performed under Task 2).

Progress for the Quarter

The Task 5 efforts were directed towards procurement of the materials that will be used in the program and initial investigation of one of the nickel base alloys. The individual procurement efforts include sufficient material to satisfy the requirements of all the various tasks.

The issue of “dumping charges” has apparently been resolved in that the materials being used in the program are either outside the scope of the import restrictions or, if included, will have the charges waived because the usage is research and not commercial. With regard to each specific material involved in the welding studies:

- Super 304H.
 - Delivery of 250 feet of 2-inch OD X 0.4-inch MWT tubing is scheduled for November 2002.
- CCA 617 (known in Europe as Marekko).
 - Prepared a purchase order for tubing and plate.
 - Delivery of 40 feet of 2-inch X 12-inch plate is scheduled for December 2002.
 - Delivery of ~225 feet of 2-inch OD X 0.4-inch MWT tubing is scheduled for February 2003.
- Haynes 230
 - 150 feet of 2-inch OD X 0.4-inch MWT tubing was delivered.
 - Most of welding filler metal required was delivered.
 - 30 feet of 3-inch X 6-inch plate and the remaining filler metal are scheduled to be delivered in October 2002.
 - Discussed weldability issues with Haynes technical staff.
- Inconel 740
 - Prepared a purchase order to meet the requirements for all tasks.
 - Discussed weldability issues with Special Metals technical staff. Talks focused on background information and plans to develop a technical database for this new alloy.

- Performed initial submerged arc welds on Inconel 740 at Special Metals. These welding trials depleted approximately one half of the aluminum and titanium from the weld deposit and indicated that, if submerged arc welding were to be used on this alloy, a special filler wire chemistry would be needed.
- HR6W
 - **PREPARED A PURCHASE ORDER FOR TUBING ONLY, SHEET AND PLATE ARE NOT AVAILABLE.**
 - **DELIVERY OF 180 FEET OF 2-INCH OD X 0.4-INCH MWT TUBING IS SCHEDULED FOR APRIL 2003.**
- **SAVE 12**
 - **PREPARED A PURCHASE ORDER FOR PIPE ONLY, SHEET AND PLATE ARE NOT AVAILABLE.**
 - **DELIVERY OF 60 FT OF 13.78-INCH OD X 2-INCH MWT PIPE IS SCHEDULED FOR APRIL 2003.**

Concerns

- Base material sourcing difficulties and long delivery times have, in some cases, delayed the start of welding activities by 6 to 9 months. Efforts are underway to expedite shipments of small quantities in advance of bulk order deliveries so studies can start as soon as possible.
- 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.
- That certain alloys are not available in all desired product forms will necessitate changes to the program scope.
- Traditionally the nickel based precipitation hardenable alloys such as Inconel 740 have been used in rocket motor and gas turbine engine applications. These alloys have been used in thin sections, which allow development of mechanical properties through sophisticated thermal treatments. This may not

be possible with thick section boiler components and there is presently not sufficient funding to evaluate this characteristic fully. This family of alloys is also susceptible to ductility dip cracking which will be exacerbated by section thickness.

Activities Planned for Next Quarter

Plans for next quarter include:

- Continue base material procurement.
- Source and procure filler metals.
- Continue review of welding literature regarding alloys to be studied.
- Start initial gas tungsten and submerged arc welding of Haynes 230.
- Obtain additional mechanical property data from initial Inconel 740 welds at Special Metals.

TASK 6: FABRICABILITY (Task Lead Babcock & Wilcox)

Task 6 Objective

The objectives of the task are to establish fabrication guidelines for the candidate alloys for boiler components of the ultrasupercritical plant. To establish the affect fabrication operations have on the properties of these materials of construction, and to determine the remedial actions needed to return the material to their original condition and properties. This will be achieved via prototypic manufacturing operations of both thick and thin components.

The Task is subdivided into three subtasks. Subtask 6A involves manufacturing trials of thin walled components typical of boiler superheaters. Subtask 6B involves fabrication trials of typical thick walled components. Subtask 6C is intended to allow for manufacturing trials of new materials that are introduced late during the span of the contract.

This task has been delayed in starting due to the funding shortfall for this year. Activity was limited to detailed planning, material selection, and material procurement activities. Last Quarter, the best candidate materials for the highest temperature, and most severe duty areas of the USC boiler were identified. The six (6) best candidates were then divided up amongst the four consortium member participants in this task as follows;

- Alstom Power – Super 304H (thick walled) and CCA 617 (thin)
- B&W – Alloy 230 (thick and thin walled)
- Babcock Borsig – Save 12 (thick walled); HR6W (thin)
- Foster Wheeler – Inconel 740 (thick and thin walled)

These materials were also assigned to these same participants for procurement for the amount of material needed for the whole program, including this task. Material quantities for all the tasks were defined and supplied to EPRI.

Material inquiries were generated by each member and vendor quotes were solicited, and vendors selected. A number of important and consequential issues were quickly uncovered. For one, it was generally discovered that the raw material costs were much higher than originally envisioned due to the fact that the alloys are highly alloyed, not always readily available in all product forms, and we were procuring in relatively small quantities which resulted in pricing premiums due to lack of economy of scale. There was also the complication that the alloys procured from foreign material manufacturers would probably be subject to the anti-dumping tariffs that had recently been put in place by the United States government. Some of these issues were still being resolved at the close of the last quarter.

One of the biggest findings with impact on Task 6 during this stage was the fact that for most of the materials, we would not be able to obtain the grades in a thick walled pipe product form. This required that the preliminary

manufacturing trials for thick walled components would have to be modified to adopt a thick, flat plate form rather than a pipe product. It was also necessary to reduce some of the quantities we bought in order to stay within cost limitations. This has forced each consortium task member to re-evaluate the detailed manufacturing plans accordingly. It is an objective of the task to duplicate as much as possible the same manufacturing operations on all the materials of like thickness to allow for direct comparison of material performance.

Activities This Quarter

- The nickel based material assigned to Alstom Power, CCA617, was placed on order from Krupp VDM in a tubular product form. Delivery of approximately 225 feet of the 2.0" OD X 0.400" minimum wall thickness tubing is scheduled for early February 2003.
- Super 304H stainless steel is only available in tubing form, therefore we apparently will not be able to obtain the thick section product of this material. Efforts will continue to try to obtain this grade as thick section plate.
- Babcock Borsig has issued purchase orders with Sumitomo Metals for HR6W and SAVE12 materials. Only tubing is available in HR6W. A total of 180 ft of 2.00" OD X 0.400" MW tubing was ordered. SAVE12 is available in pipe product form only. BBP has ordered 60ft of 13.75" OD X 2.00" MW pipe. Confirmation of orders, conditions, and invoicing is anticipated in October, 2002. Sumitomo anticipates ex-mill production around the end of March, 2003. BBP is continuing to request schedule improvements and is arranging for expedited air shipment of 20 ft of HR6W tubing, and a small portion of SAVE12 pipe material to support activity on other Tasks.
- Babcock & Wilcox received tubing, thin plate, and welding electrode material product forms and quantities of the Alloy 230 material from Haynes International. Thick plate quantities are on order and are expected to be shipped in November, 2002. Quantities received to date include 150 ft of 2.00" OD X 0.400" MW tubing, various 0.25" thick plate segments, 2" and 2.5" OD bar lengths, and both coated electrode and weld wire of 230 matching composition.
- Foster Wheeler continues activity toward procuring Alloy 740 from Special Metals. The program is carefully studying the potential for "conventional" Alloy 740 to be susceptible to eta phase precipitation at our anticipated metal operating temperatures. Special Metals has suggested a modified chemistry to minimize potential degradation of toughness and creep properties, and F-W has negotiated procurement of a small size heat representing the modified composition. Special Metals is also cooperating

in performing some preliminary welding trials of thick section material to assess potential weldability issues. These tests are reported under Task 5.

Concerns

- Raw material costs were higher than originally estimated, and the significant cost adder of anti-dumping tariffs has put a strain on already reduced funding resources
- The long lead times for some of the materials will potentially delay start of manufacturing trials. The earliest fabricated materials will be needed to develop test samples for Task 2 mechanical property testing to assess the effect of these operations on long term creep properties. We will be working closely with Task 2 leadership to determine the necessary timeframe for sample delivery.
- Lack of availability of certain product forms of the candidate alloys will potentially impact the Task planning.

Activities Planned for Next Quarter

- Completion of raw material procurement activity will be accomplished.
- Receipt and inspection of materials, and dispersing the materials needed by other tasks.
- Development of a revised manufacturing trial plan agreeable to all four parties, consistent with their fabrication capabilities, and the available materials and product forms, and that will permit direct comparison of fabrication results from one entity to another.

Task 7 Coatings (Task Lead – Alstom Power Company)

The major objectives for Task 7 Coatings are:

- 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. Progress on these sub-tasks during the reporting period is described below.

Progress for the Quarter

Task 7A: Detailed Study of Current State of the Art

- A draft technical report for this task was completed and circulated internally to Alstom Power for comments.

Task 7B: Coating Feasibility (Internal Coating)

- Technical results on internal tube diffusion coating tests are described in detail in Attachment 1.

Task 7E: Process Scale Up – Preliminary Trials

- Attended the USC Steering Committee meeting in Columbus, OH on July 10, 2002
- Conducted a Cr-Si diffusion coating run on samples of Alloy 230, HR-120, IN 740, IN 617, RA 253, RA 333, RA 353, and RA 602.
- Prepared microstructural specimens of Cr-Si diffusion coated samples using 1-2% bromine in methanol etchant; examined and characterized the microstructures of the coatings.
- Continued receipt inspection of Haynes alloy 230 materials (ordered by B&W) delivered to MTI for interim storage.
- With B&W authorization, distributed from inventory a 25 lb. spool of 263 weld wire (0.062” dia.) to Special Metals for conducting preliminary welding trials (in support of Task 5) with IN 740 plate materials.

Concerns

- None

Activities Planned for Next Quarter

Task 7A:

- Finalize and issue state of the art report.

Task 7B:

- Continue investigation of diffusion coating processes for internal tube surfaces as follows:

1. Pack cementation approach:

Validation tests using samples of T-22, HCM12, 304 H, 347 HFG, Haynes 230, and IN-617. Determination of reproducibility in terms of coating thickness and composition gradients.

- Chromizing ALSTOM formulation
- **Si-Cr Patent # 5,972,429**
- Al-Cr Formulation from M. Zheng and R. Rapp, public domain.
- Preliminary tests for ID coating of T-22 tubing sections using the above mentioned packs.

2. Slurry approach:

Preliminary tests with Cr-, Si-Cr and Al-Cr slurries for ID coating using reticulated alumina inserts in T-22 tubing sections.

- Obtain and evaluate samples of alternative coating methodologies as identified in the Task 7A report

Task 7E:

- Integrate results of literature review of coatings (prepared by Alstom) with Task 7 plans and activities.
- Submit selected alloy samples for coating by laser welding and by thermal spray.
- Assess selected plating processes for coating the I.D. of tubes for oxidation resistance.
- Prepare microstructural specimens of samples to assess and characterize coatings.

Abstract

The chemical vapor deposition technique was used to generate diffusion coatings in ferritic and austenitic alloys. Variants of the process include the pack cementation technique and the use of insulating mats sprayed with pack cementation slurries. The formation of Cr-rich layers in alloys HCM12 and 304 SS was demonstrated using the commercial ALSTOM pack cementation formulation. Si-rich layers and Si-Cr rich layers have also been produced. Using the mat approach, coatings were generated with up to 10 wt% Si, with a processing time less than half of that required by the pack approach. The maximum Si content using the pack approach did not exceed 4 wt% while chromium levels were comparable to those obtained in straight chromizing. Different from the ferritic alloys, the diffusion layers obtained in the stainless steels were of virtual constant composition through the coating thickness.

Introduction

The oxidation characteristics of a material can be modified by changes in alloy chemistry. However, tubular and piping components for boilers are made of materials with adequate high temperature creep properties as required to meet the demands of this application. The addition of well known oxidation resistant alloying elements such as chromium, silicon or aluminum can be detrimental to the strength of the alloy and therefore may be limited to concentrations that are not sufficient to impart satisfactory oxidation resistance.

When changes in the alloy chemistry are not possible, surface modification techniques offer a possible way to achieve an oxidation mitigation barrier. For the application of ID coatings, technology is normally limited to chemical plating methods like chromating or electroless nickel. Another process that generates metallurgical bonded, and when properly formulated, tenacious coatings, is chemical vapor deposition (CVD). Pack cementation, a CVD variant, requires packing the ID of tubing or piping sections with a powder commonly containing the element or elements to be coated and an activator, preferentially a halide, to generate the vapor constituent responsible for the transfer to the component surface. Pack cementation modifications include slurry sprayed onto an insulating mat that is then wrapped around the component to be coated. In the case of ID coating, the slurry can also be directly applied to the ID surface. The use of the slurry or the impregnated mat has certain advantages with commonly shorter processing times.

The current report summarizes the results to date of preliminary approaches to ID coating of Fe-base alloys envisioned to be used in ultrasupercritical (USC) boilers. The formulations for the packs have been selected from a search on pack cementation patents designed to generate rich Cr-, Si-Cr- and Al-Cr diffusion coatings. The diffusion coatings are generated at the expense of the base alloy with only minor dimensional changes, if any.

Experimental

Samples were machined from thick wall tubular sections or from piping sections. The testpieces were degreased in an ultrasonic bath of alcohol-base metallurgical cleaner, then rinsed with ethanol in an ultrasonic bath, dried, weighted and stored in a desiccator. The CVD pack powder was prepared according to specification and milled for ten minutes for homogenization. The mesh size for all powder constituents was minus 200 mesh or higher. The samples were packed in an alumina cylinder using a ratio of about 6 grams of powder per cm² of surface area to coat. The end-cap was screwed on or sealed using alumina-base high-temperature cement. Venting holes were present in the end-cap to allow for the expansion of gases generated by the decomposition of the activator.

When preparing the mat, the powder mixture was blended with water and the viscosity of the slurry adjusted by the addition of Xanthan gum. The samples were then individually wrapped and inserted in the alumina cylinder. A minimum of two samples per material was coated in every run; ferritic alloys were coated separately from the austenitic alloys.

The sealed cylinders were then inserted in a tubular alumina chamber that is sealed and purged with Ar at a rate of 20 ml/s during the course of the heat-up cycle. The alumina chamber was brought to the processing temperature in a horizontal three-heat- zone tubular furnace with a uniform temperature zone of about 12 inches with temperature controlled at ± 5 C. The processing time varied from 4 to 16 hours depending on the CVD approach. The processing temperature was set as high as 1140 °C and as low as 925 °C depending on the specifications of the coating process. After processing, the samples are furnace-cooled.

The samples are then removed from the pack powder or residual mat, washed in warm soapy water, rinse ultrasonically in ethanol, dried and weighted. Next, the testpieces were sectioned and mounted in conductive Bakelite. The characteristics of the coating were determined using optical and scanning electron microscopy. Electron dispersed spectrographic (EDS) analysis was used to determine the coating composition. Back scattered imaging was used to document the appearance of the diffusion layers.

Results

Chromizing:

For the chromizing tests, the proprietary commercial formulation of ALSTOM Power was used. This formulation utilizes low carbon ferro-chrome with a minimum of 70-wt% Cr. The activator is ammonium chloride. Calcined alumina is used to avoid sintering of the powder during processing. The processing temperature was 1140 °C, with a dwelling time of 16 hours. The materials coated were T-11, HCM12 and 304 SS. Table 1 lists the maximum Cr-content and the coating thickness.

Material	Coating Thickness μm (mils)	Max. Cr. Content (wt%)
T-11	300 (11.8)	36
HCM12	350 (13.8)	32
304 SS	150 (5.9)	40

TABLE 1: COATING THICKNESS AND MAXIMUM CR-CONCENTRATION GENERATED DURING CHROMIZING RUN USING ALSTOM PROPRIETARY FORMULATION AT 1140 °C FOR 16 H.

The coating thickness was comparable for the T-11 and the HCM12 samples. The maximum chromium content was around 40-wt% decreasing to around 7-wt% at the coating-base metal interface for the T-11 sample, 14 wt % for the HCM12 samples, and 37 wt% for the 304 SS sample. Different from the ferritic alloys, the chromium concentration in the coating formed on the 304 SS samples remained virtually constant through the thickness of the coating. Figure 1 depicts the characteristics of the coatings. Subsurface porosity is observed in the T-11 sample which is characteristic of chromized low alloy steels.

Attempts to reproduce the chromized layer using the mat approach have not been successful. In the mat approach, the slurry is enriched in activator leading to the generation of appreciable nitrogen gas from decomposition of ammonium chloride. The resulting coating was composed of a 10 micron Cr-nitride surface layer. Nitrogen is an effective nitriding agent at temperatures in excess of 1000 °C. Further effort on the mat approach is planned for the first quarter of the 2003 DOE fiscal year.

Siliconizing:

The pack cementation approach is based on the US Patent # 5,972,429 by Bayer & Wynns. In this patent, a dual activator is used in a single temperature excursion to generate Si-Cr rich coatings of about 4 wt% Si and 35 wt% Cr. The formulation requires the use of pure chromium and silicon in a weight ratio of about 10:1 while the dual activator consists of 1 wt% ammonium chloride and 1 wt% calcium fluoride. Calcined alumina is used to avoid sintering of the powder. The optimum amounts of Cr and Si are set at 25 and 2 wt%, respectively. The materials coated included T-11, HCM12 and 304 SS. The processing temperature was 1140 °C for 16 h. Table 2 lists the coating thickness together with the maximum Si and Cr concentration in the diffusion layers.

Material	Coating Thickness μm (mils)	Max. Si Content (wt%)	Max. Cr. Content (wt%)
T-11	280-325 (11-12.8)	3.2 – 3.5	17.7 – 32
HCM12	380-400 (15-15.8)	2.6 – 3.0	28 – 34
304 SS	190 (7.5)	3.5 – 3.7	39 – 42

Table 2: Coating thickness and maximum Cr- and Si-concentrations generated during pack cementation run using patent # 5,972,429 by Bayer & Wynns at 1140 °C for 16 h.

There is an apparent range in the maximum Si and Cr concentration attainable with the T-11 and HCM12 testpieces while the coating formed in the 304 SS sample shows a maximum of around 42 wt% Cr which decreased to 22 wt% at the coating/base metal interface. The Si-content remained above 2 wt% through the coating thickness with a maximum of 3.7 wt% at the surface. Figure 2 depicts the characteristics of the coatings. Variation in the attainable Si- and Cr-contents may be related to the containment of the pack. The preferred arrangement as described in the patent is a sealed steel retort. Future testing is planned in a test facility using a steel retort that will be sealed using a low melting temperature glass.

The powder composition was adjusted by increasing the activator content and using a molar ratio of Cr:Si of 1:1. The powder was mixed with water and Xanthan gum to form a slurry that was then placed onto a piece of cerwool. The processing temperature was set at 1140 °C for 6 hours. Table 3 lists the maximum Si and Cr concentration together with the coating thickness.

Material	Coating Thickness μm (mils)	Max. Si Content (wt%)	Max. Cr. Content (wt%)
T-11	430-445 (17-17.5)	8.2 - 7	3 – 4.4
HCM12	450-466 (17-18)	7 - 2	12 - 21
304 SS	306 (12)	6 – 8	18 - 20

Table 3: Coating thickness and maximum Cr- and Si-concentrations generated during CVD run using the sprayed mat approach at 1140 °C for 6 h.

The coatings generated exhibited a significant increase in coating thickness with less than half the processing time required with the powder approach. The maximum Si-content was doubled for all alloy systems while the Cr-content showed a modest or no increase at all as compared with the base metal Cr-content. The composition of the coating formed in the 304 SS sample was virtually the same throughout the coating thickness with a Si content of about 7 wt%. The chromium and nickel contents remain at the same levels as in the base alloy. Figure 3 shows the characteristics of the coatings.

Using the mat approach, increasing the ammonium chloride to calcium fluoride molar ratio to 2:1 resulted in a modest increase in the maximum Cr-content for the T-11 sample to 10-wt %. The maximum Si concentration was about 10-wt%. No appreciable changes were determined for the other alloys. In the latter test, a sample of 347 HFG was included. A two-phase coating was generated, Figure 4. EDS analysis revealed the dark phase to contain between 6 and 7 wt% Si, 15 to 18 wt% Cr and 9 to 11 wt % Ni. The light phase contained 10 to 11 wt% Si, 18 wt% Cr and 18wt% Ni. The bright dispersion was Nb-boride. The continuous, bright phase had the composition 30 % Nb-12.5 % Si- 25 % Ni- 4 % Cr- 27 % Fe. The overall thickness of the coating was 300 micron (12 mils).

Aluminum, when heated in the presence of silica, SiO_2 , results in the reduction of silica to generate Si. Slurry normally used for aluminizing, containing pure aluminum powder, –200 mesh, ferro-chrome and a dual activator of ammonium and magnesium chloride was spread on an alumina mat containing 40 wt% silica. Samples of T-11, HCM12 and 304 SS were wrapped with the mat and processed at 1140 °C for 4 hours. Table 4 shows the coating thickness and the maximum Si and Cr contents.

Material	Coating Thickness μm (mils)	Max. Si Content (wt%)	Max. Cr. Content (wt%)
T-11	270-550 (10-20)	6 8	4.8 – 7.8
HCM12	327 (13)	4 – 4.5	12.6 – 17
304 SS	130 (5)	5 – 7	16 – 20

Table 4: Coating thickness and maximum Cr- and Si-concentrations generated during CVD run using a slurry containing Aluminum onto a 40wt% SiO_2 containing mat at 1140 °C for 4 h.

The maximum Si and Cr contents could be adjusted by modifying the formulation in terms of activator and pure metal sources and increasing the processing time to produce greater coating thickness. The coating formed in the samples of 304 SS showed two phases. The Si content of these phases varied slightly between 5 and 6 wt%. The Cr-content was between 16 and 19 wt% while the Ni-content varied between 8 and 11 wt%. This approach represents an alternative to the use of costly Si powder and could be formulated as a powder by replacing some of the calcined alumina by SiO₂. The use of SiC is not recommended since the formation of a flux has been observed in previous attempts.

The siliconizing of Ni-base alloys was attempted with samples of Haynes 230 resulting in the formation of a Ni-12 wt% Si phase that corresponds to a eutectic composition with a melting temperature of 1150 °C. The temperature will be lowered to 1000 °C in the next set of tests.

Aluminizing:

Aluminizing of Fe- and Ni-base alloys has been demonstrated as commercial processes used to generate aluminized tubular components for the petrochemical industry and aluminized blades and vanes for turbine assemblies. So far there is no specific requirement for the coating composition most adequate to mitigate excessive scaling in steam containing environments. It is suspected that rich aluminum coatings may be appropriate. A preliminary test was conducted with testpieces of HCM12 and 304 SS using the mat approach. The processing temperature was 1140 °C with a hold time of 4 hours. The maximum aluminum content in the HCM12 samples was 6 wt%, gradually decreasing through the thickness of the coating to less than 1 wt% at the coating/base metal interface. The coating thickness was between 180 and 200 µm (7 to 8 mils) and the Cr-content remained slightly above that of the base metal, i.e. 13 wt %. The 304 SS samples formed a coating about 150 µm (6 mils) thick with a maximum Al content of 3 wt%. Further effort on the aluminization of Fe- and Ni-base alloys using the pack cementation process has been included in the test matrix for the next quarter.

Conclusions

- ◆ The chromizing, siliconizing and aluminizing of HCM12 and of 304 SS has been demonstrated as feasible processes.
- ◆ The composition of the diffusion layers varied according to the CVD approach.
- ◆ The diffusion layers formed in the stainless steels were of virtually constant composition across the thickness of the coating.
- ◆ Higher silicon contents were attained using the mat approach with virtually no change in the chromium content.
- ◆ The coatings generated with the mat approach were of higher or comparable thickness to those attained using the pack cementation approach with a shorter processing time.

Recommendations:

The current effort on diffusion coatings for steam oxidation applications is benchmarked with respect to the requirements in terms of thickness and composition required for fireside corrosion. Preliminary tests in superheated steam are required parallel to the development process to better define target coating thickness and compositional windows.

The testing in simulated coal ash corrosion conditions is encouraged for samples of stainless steels siliconized using the mat approach. The high silicon contents attained with the mat approach may lead to the formation of silica layers with negligible solubility in molten sulfate systems.

Figure 1. Chromized layers generated in alloys T-11, HCM12 and 304 SS using ALSTOM proprietary commercial formulation.

Figure 2. Si-Cr coating generated in alloys T-11, HCM12 and 304 SS using the pack cementation approach.

Figure 3. Si-Cr coating generated in alloys T-11, HCM12 and 304 SS using the mat approach.

Figure 4. Si-Cr coating generated in alloy 347 HFG using the mat approach.

TASK 8: DESIGN DATA AND RULES (Task Lead – Alstom Power Company)

Background

The primary objective of this task is to explore the application of advanced mathematical models to the design of major pressure parts for the ultra-supercritical boiler as a means of reducing cost and insuring satisfactory serviceability. It is anticipated that the goals of this task will be met through the following:

- The development of standardized design rules and optimized component configurations based on more sophisticated analyses that will provide consistent safety margins and component reliability.
- The development of advanced design life tools to reduce ignorance factors in safety margins based on the levels and details of analysis and available information on materials performance.
- ASME Code approval of the design tools.

Activities This Quarter

A meeting was held on 9/10/02 in Hollywood, FLA, with representatives from Alstom Power, B&W, EPRI, and Oak Ridge National Laboratory in attendance. Discussion focussed on the silence of current ASME SCl rules on the issue of the effects of cyclic operation on component performance, and the need for a more sophisticated design approach to account for creep-fatigue interaction. Actions proposed included the creation of a library of reference stress solutions for typical boiler geometries; consideration of the use of standardized failure criteria and methodologies, such as CDM, for application of the reference stress solutions; a determination of the existence of temperature bounds for creep-fatigue interaction; discussion of the possible creation of a separate high-temperature design division for SCl of the ASME B&PV Code, or of a non-mandatory Appendix to SCl that would consider operational effects ignored by current rules.

Activity of immediate interest to the task include ongoing activity with the Section VIII, Division 2 rewrite being developed by PVRC, the Joint ASME/API Fitness-for-Service Guidelines being developed under PVRC, and the status of elevated temperature design rules and methodology being considered under Subsection NH of Section III of the ASME Code.

Activities Next Quarter

Review the SCVIII, Div. 2 re-write as it becomes available, to determine how fatigue effects will be handled by the ASME Code. Begin preparation of a document that will consider reference stress, including what a reference stress is and how it is obtained, and that will include a compendium of solutions. Joseph Bloom of MTI is planning to attend the PVRC meeting in Houston to participate in the meetings regarding ASME/API Fitness-for –Service rule development, and elevated temperature meetings with the JPVRC.

Task 9: Project Integration and Management (Task lead 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 Third Quarterly Report
 - Completed Monthly Reports for July and August
 - Coordinated a USC Steering Committee Telephone conference on August 21 and September 18, 2002 and provided minutes.
 - Coordinated and provided minutes from a Steering Committee Meeting on July 10, 2002 in Columbus Ohio.
- **Concerns:**
 - None
- **Plans for the Next Quarter:**
 - Hold a Project Steering Committee Meeting on November 20-21, 2002 in Columbus Ohio.
 - Conference calls are to be held on October 16 and December 18, 2002.
 - Issue fourth quarter report for 2002.
 - Issue monthly reports for October and November.