ADMINISTRATIVE INFORMATION

1. **Project Name:** Development of Stronger and More Reliable Cast Austenitic Stainless Steels (H-Series) Based on Scientific Design Methodology (CPS#1772)

2. **Lead Organization:** Duraloy Technologies, Inc.
120 Bridge Street
Scottdale, PA 15683-0081

3. **Principal Investigator:** Mr. Roman Pankiw, phone (724) 887-5100 ext. 188, fax (724) 887-5224
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4. **Project Partners:**

Duraloy Technologies Inc.	Roman Pankiw
Bethlehem Steel Corporation	Tony Martocci
The Timken Company	Mark F. Carlson
Energy Industries of Ohio	Bob Purgert
Harper International	William Helfrich
IPSCO	Laurie Collins
NUCOR Steel Corporation	Robert Bennett
Oak Ridge National Laboratory	Vinod K. Sikka

5. **Date Project Initiated:** 3/31/2002

6. **Expected Completion Date:** 3/31/2005

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:**

The objective of this project is to use the scientific and computational alloy development to increase the high-temperature strength by 50% and upper use temperature by 30 to 60°C of H-Series of cast stainless steels, HK, and HP.

8. **Technical Barrier(s) Being Addressed:**

The cast austenitic stainless steels, HP and HK, are used for many industrial applications such as radiant burner tubes, transfer rolls, tubes for ethylene crackers, etc. The application of these steels is limited by two factors: (a) limited high-temperature strength and (b) low upper use temperature. No new research has been done on these steels in the United States in nearly 40 years on improving the performance of these steels. The objective of this project is to use the scientific and computational alloy development methods to increase the high-temperature strength by 50% and upper use temperature by 30 to 60°C for HP and HK alloys.

The technical barriers to meet the project objectives include:

- Validating the predictions of the ThermoCalc™ modeling by actual microstructural analysis
- Identifying new compositions for experimental melting
- Creep testing of the alloys at very high temperatures of 1200 to 1260°C
- Melting and centrifugal casting the identified compositions in 500- to 1000-lb heats

- Developing data on centrifugally cast compositions and comparing results with static experimental castings.

9. **Project Pathway:**

The following pathway is being pursued for achieving the objectives of the project:

- Compile creep data along with chemical analysis on a large number of heats
- Conduct ThermoCalc™ modeling for each of the compositions to identify the phases formed and their stability as a function of temperature
- Validate the phase prediction by microstructural analysis
- Convert the creep data through Larsen-Miller type modeling to predict the 10^3-h creep rupture strength
- Show the correlation of 10^3-h creep rupture strength with one of the precipitate phases
- Identify new compositions for increased strength and higher upper use temperature
- Melt and cast experimental heats of new compositions
- Conduct creep tests at 1200 and 1260°C and validate predictions
- Select compositions for large-scale melting and centrifugal casting
- Conduct creep testing on centrifugal cast tubes
- Identify final compositions for in-plant testing

10. **Critical Technical Metrics:**

Baseline Metrics:

- HP is a Fe-25Cr-35Ni based composition with upper use temperature of 1200°C and a rupture time of 300 to 500 h at 1200°C and 500 psi.
- HK is a Fe-25Cr-25Ni based composition with upper use temperature of 1100°C.

Project Metrics:

- Increase the rupture time of HP alloy from 300 to 500 h to 1000 to 1500 h at 1200°C and 500 psi
- Increase the use temperature of HK from 1100 to 1200°C

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:**

- ThermoCalc™ model predictions for HP alloys have been validated by microstructural analysis.
- HP compositions for increased strength have been identified, cast, and creep tested at 1200 and 1260°C.
- Selected HP compositions have been melted and cast as centrifugal tubes.
- Testing of centrifugal tube is underway.
- ThermoCalc™ modeling has been used to identify HK compositions.

12. **Future Plans:**

The major milestones to be accomplished are to:

- Complete creep testing of centrifugally cast HP alloys
- Complete testing of HT alloys
- Install tubes of selected compositions of HP and HT alloys in plant operating conditions
- Complete microstructural analysis of creep-tested specimens

13. **Project Changes:**

Under the current program there have been no changes in the project direction or timetable.

14. Commercialization Potential, Plans, and Activities:

The end-use applications of these steels are in many of the IOFs. These include radiant burner tubes for annealing furnaces in steel heat treating industry, tubes for the chemical industry, transfer rolls for the steel industry, and kilns for various IOFs. Initial introduction of the new alloys in commercial applications is expected to be in the range of 10-100s of tons/year for each composition. Duraloy Technologies is one of the main producers of these steels and will implement this technology as it develops. The product of research will be alloy compositions, property data, and predicting tools for specific compositions. The outcome of the project is expected to have a significant impact on the steel, chemical, process heating and mining IOFs. Duraloy is working with The Timken Company to finalize the tube sizes and locations for the first installation.

15. **Patents, publications, presentations:** (Please list number and reference, if applicable. If more than 10, please list only 10 most recent.)

2 Patents:
Both patents are in preparation.

2 Publications:
- G. Muralidharan et al., "Effects of Precipitation on Creep Properties of Certain Cast H-Series Austenitic Stainless Steels," Materials Science & Technology 2004, New Orleans, LA, September 26-29, 2004
- G. Muralidharan et al., "Development of Stronger and More Reliable Cast Austenitic Stainless Steels (H-Series) based on a Scientific Design Methodology," Materials Science & Technology 2004, New Orleans, LA, September 26-29, 2004

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