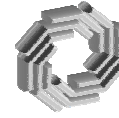


# Reliability and Useful Life of Waste Heat Boilers

Proposed Joint Industry Project  
May 2006 (TP274-5501)



**CC Technologies**  
**A DNV COMPANY**

*Innovative Solutions*

5777 Frantz Road  
Dublin, OH 43017-1386 USA  
TEL/FAX: 614-761-1214/1633  
[www.cctechnologies.com](http://www.cctechnologies.com)

## 1. Introduction

Waste-heat boilers used in ammonia and related types of process plants are prone to unexpected failures. These failures typically result in unplanned plant shutdowns for repair and/or emergency maintenance work. This work and the lost production are costly for the plant operator. Therefore, it is desirable to increase the reliability of waste heat boilers while maximizing their useful life through appropriate inspection, maintenance, and repair work during planned shutdowns and turnarounds.



Internal corrosion pitting of boiler tube

Waste heat boilers may fail by high-temperature corrosion on the gas side, water-side corrosion, creep rupture, fatigue, poor quality control, improper operation, or poor design. These major failure categories also have subcategories. For example, failure mechanisms related to water-side corrosion include caustic corrosion, hydrogen damage, pitting, and stress corrosion cracking, and creep rupture can be caused by either short-term or long-term overheating. CC Technologies, Inc. (*CC Technologies*) proposes a joint industry project (JIP) to develop a recommended practice for increasing the reliability and useful life of waste heat boilers. A JIP provides a highly cost-effective means for a group of companies to combine their resources and address a topic of mutual interest.

## 2. Objective

The objective of the proposed joint industry project (JIP) is to develop a recommended practice for increasing the reliability and useful life of waste heat boilers.

## 3. Expected Results

The expected results of the proposed JIP are (1) a summary report identifying the main causes of waste heat boiler failures and (2) a recommended practice for increasing the

reliability and useful life of waste heat boilers. The recommended practice will include guidelines for design, fabrication, operation, inspection, maintenance, and repair of waste heat boilers. The guidelines will emphasize factors that reduce the risk of unexpected failures and thereby increase the reliability and useful life of waste heat boilers.

## 4. Benefits

The results of this proposed research will provide a number of important benefits to

operators of waste heat boilers in ammonia and related types of process plants. Plant operators will be able to properly identify potential failure modes for their waste heat boilers and then implement appropriate procedures and processes for minimizing the risk of such failures.

The results also will provide guidance on appropriate inspection methods for waste heat boilers, repair techniques, and design modifications, including design for improved inspection access.

### **5. Work Plan**

The proposed project will be undertaken in five separate tasks. Each task is designed to support achievement of the overall project objective.

#### *Task 1. Survey of Literature*

The published technical literature will be surveyed for relevant information on failure of waste heat boilers. Applicable reports and papers in the CC Technologies technical library will be collected and reviewed. In addition, the services of Nerac, Inc. (<http://www.nerac.com>) will be used to perform a computerized literature search. Applicable documents will be identified based on abstracts provided by Nerac and copies will be obtained.

The documents will be reviewed. A topical report will be prepared to summarize and discuss the results of this review. It will include a bibliography. Failures will be classified by type, and actions taken to avoid failures will be discussed.

#### *Task 2. Survey of Industry*

In this task, companies in the ammonia and related process industries will be surveyed for information on the failure of waste heat boilers. Priority will be given to companies that are members of the JIP. Failure analysis reports, especially those that address root-cause analysis, will be reviewed. Where

necessary, supplemental information will be obtained by means of interviews of company personnel who are familiar with the failure(s) described in the report.

The results of this industry survey will be reviewed and documented in a topical report. The report will reference the sources of data, as well as discuss the failure causes. Failures will be compared with those identified in the literature survey and categorized into the same types as those in that survey. Actions taken to avoid failures will be discussed, including the success of those actions.

#### *Task 3. Failure Analysis of Waste Heat Boilers*

In this task, a standard procedure for failure analysis will be developed and applied to a failure case supplied by each JIP member company. The results of these case studies will be documented and incorporated into a topical report. The report will provide a model for documenting waste heat boiler failures.

#### *Task 4. Risk Assessment of Failures*

A qualitative risk assessment will be performed for the various types of failures identified in Tasks 1, 2, and 3. The assessment will consider the likelihood and consequences of each type of failure based on the data obtained in Tasks 1, 2, and 3 and opinions obtained from experts in each member company. The results of the risk assessment will be used to prioritize the types of waste heat boiler failures. Member companies then can use the results to identify which potential failure types are of high priority in their integrity management programs. The results of this work will be documented in a topical report.

#### *Task 5. Recommended Practice for Increasing the Reliability and Useful Life of Waste Heat Boilers*

A recommended practice for increasing the reliability and useful life of waste heat boilers

will be developed. It will be based on the results of Tasks 1 through 4 and formulated so that operators of waste heat boilers can readily apply it. It will include guidance on operations, maintenance, repairs, inspection, and design. The recommended practice will emphasize factors that reduce the risk of unexpected failures and thereby increase the reliability and useful life of waste heat boilers.

## 6. Organization

Dr. Carl E. Jaske, Senior Project Manager at CC Technologies, will be the leader of the proposed project. Dr. Jaske has extensive experience in performing failure and fitness-for-service analysis of equipment used in the ammonia and related process industries, as well as experience with boilers, pressure vessels, and piping used in other industries.

An outstanding team of colleagues at CC Technologies will support Dr. Jaske. Staff members have degrees in a wide variety of technical disciplines, including metallurgical, corrosion, materials, mechanical, electrical, welding, and chemical engineering. CC Technologies also will receive technical input from Det Norske Veritas (DNV), its parent company, and use the services of IESCO, Inc. to provide information on inspection techniques applicable to waste heat boilers.

The companies that join JIP will select an Industry Advisory Committee (IAC). The IAC will be made up of one representative from each of approximately five key companies. They will meet with Dr. Jaske and other CC Technologies staff semi-annually to review the project status and help guide the project work.

Project review meetings will be held annually. All member companies will be invited to attend these meetings where CC Technologies will make detailed presentations of the project. Progress reports will be prepared and distributed to all members before the review meetings. Topical reports will be issued at the end of

Tasks 1 through 4, as indicated previously. The recommended practice will be issued at the completion of Task 5.

## 7. Capabilities and Experience

CC Technologies, with input from DNV and IESCO, has the capabilities, facilities, and experience required to successfully complete the proposed research project. The project leader, Dr. Jaske, played a key role in many engineering projects for companies in the ammonia and related process industries. He has also conducted many failure analyses, including root-cause analyses, of industrial equipment and is experienced in using the results of failure analysis to avoid future equipment failure and improve its reliability. He has lead projects to assess the fitness for service and remaining useful life of boilers, pressure vessels, piping, and tanks.

CC Technologies has performed numerous failure analyses for many industrial clients. This work has included both metallurgical and root-cause analyses. CC Technologies has developed and presented short courses and tutorials on failure analysis for industry. These have been presented directly to individual companies or to members of engineering societies, such as the American Society of Mechanical Engineers. CC Technologies has a large laboratory with equipment for failure analysis, microscopy metallography, corrosion testing, fatigue testing, and materials studies.

## 8. Time and Cost

The project will be completed in two years with an estimated total cost of \$200,000 US. At least five members, each contributing \$20,000 US per year or \$40,000 US total, are required to initiate the proposed project. If more than five sponsors join the project, the scope of the work will be expanded based on the joint agreement of CC Technologies and the Industry Advisory Committee.

**9. Action**

Those wishing to be kept informed as to the status of the proposed project should complete and submit the form below, or they should complete the form on the Internet at <http://www.fitness4service.com/whb.htm>. This action will not obligate your company in any way. For more information, contact Carl Jaske at CC Technologies –

TEL/FAX: (614) 761-1214/1633 or  
E-MAIL: [cjaske@cctechnologies.com](mailto:cjaske@cctechnologies.com).

CC Technologies plans to host a project kickoff meeting during September 2006. Those who complete and submit the form below or the form on the Internet will receive an invitation to attend that meeting.



Creep-rupture failure of boiler tube

---

---

**Reliability and Useful Life of Waste Heat Boilers**

(Return form to Carl Jaske, CC Technologies, Inc., 5777 Frantz Road,  
Dublin, OH 43017-1386 USA, FAX: 614-761-1633).

Name: \_\_\_\_\_ Title: \_\_\_\_\_

Company: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ Mail Code: \_\_\_\_\_ Country: \_\_\_\_\_

TEL: \_\_\_\_\_ FAX: \_\_\_\_\_ E-Mail: \_\_\_\_\_

Comments: \_\_\_\_\_

---