The Impact of Corrosion on Storage Tanks and Piping

Gerry Koch
CC Technologies
Freshwater Spills Symposium
April 6-8, 2004
NACE International – Overview

Our Vision
NACE International will be recognized as a world-class corrosion society by contributing significantly to the enhancement of global corrosion efforts.

Our Mission
To reduce the impact of corrosion.
NACE International – Overview

• Global Forum for Corrosion Technology
• Global Source for Corrosion Education & Training
• Internationally Recognized Standards
NACE International – Overview

- 60th Anniversary
- Not-for-Profit Organization
- 15,000 Individual Members in 91 Countries
- 275 Corporate Members
- Organized in 82 Sections
NACE International – Overview

- Education Programs
- Professional Recognition
- Coating Inspector Training
- Cathodic Protection Certification
NACE International – Overview

• NACE Standards
• Conferences/Expos
  • CORROSION/2004 – New Orleans, LA, March 2004
  • Corrosion Technology Week 2004 – Phoenix, AZ, Sept. 2004
  • Topical
• Periodicals
• Publications & Software
NACE International – Education & Certification

NACE Education Classes Designed To:

• Introduce fundamentals of corrosion control
• Expand existing knowledge
• Provide professional recognition & certification
NACE International – Education & Certification

10 Certification Categories

• Coating Inspector Program
  • Three Courses
  • 5,500 recognized individuals – worldwide

• Cathodic Protection Certification
NACE International – Education & Certification

• NACE Certification Specified Worldwide
• Qualified Personnel
• Ensure Safe Operations
• Extend Asset Life
• Reduce Downtime
• Improved Quality Assurance
NACE International – Standard & Reports

Standards Recognized Worldwide

• 118 NACE Standards
  • 19 Material Requirements
  • 69 Recommended Practices
  • 30 Test Methods
• 60 Technical Committee Reports
What is the Cost of Corrosion?
$276 Billion
The United States Cost of Corrosion Study
Cost of Corrosion – Study Goals

• Determine the cost of corrosion control methods and services
• Determine the cost of corrosion for specific industry sectors
• Extrapolate individual sector costs to a national total corrosion cost
• Assess the barriers to progress and effective implementation
• Develop strategies for realizing cost savings
Cost of Corrosion

• All costs are direct corrosion costs
  • Cost of labor attributed to corrosion management activities
  • Cost of the equipment required because of corrosion related activities
  • Loss of revenue due to disruption in supply of product
  • Cost of loss of reliability
  • Cost of lost capital due to corrosion deterioration
Methods & Services

• All costs are direct corrosion costs
• Disadvantage: many costs are missed
  ➢ Cost of labor attributed to corrosion management activities.
  ➢ Cost of the equipment required because of corrosion-related activities.
  ➢ Loss of revenue due to disruption in supply of product.
  ➢ Cost of loss of reliability.
### Methods and Services

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective Coatings</td>
<td>B$ 108.6</td>
</tr>
<tr>
<td>Corrosion Resistant Alloys</td>
<td>B$ 7.7</td>
</tr>
<tr>
<td>Corrosion Inhibitors</td>
<td>B$ 1.1</td>
</tr>
<tr>
<td>Engineering Plastics/Polymers</td>
<td>B$ 1.8</td>
</tr>
<tr>
<td>Cathodic and Anodic Protection</td>
<td>B$ 1.0</td>
</tr>
<tr>
<td>Corrosion Control Services</td>
<td>B$ 1.2</td>
</tr>
<tr>
<td>Research and Development</td>
<td>-</td>
</tr>
<tr>
<td>Education and Training</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>B$ 121.41</strong></td>
</tr>
</tbody>
</table>
Cost of Corrosion – Industry Sector Analysis

For each sector, details of analysis are different

• Government Reports
• Publicly Available Documents
• Industry Experts
• U.S. Department of Commerce Bureau Census
• Existing Industrial Surveys
• Trade Organizations
• Industry Groups
• Individual Companies
Cost of Corrosion – Industry Sector Analysis

26 Sectors in 5 Categories

- Infrastructure
- Utilities
- Transportation
- Production & Manufacturing
- Government
Cost of Corrosion – Industry Sector Analysis
## Cost of Corrosion – Category: Infrastructure

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost (B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway Bridges</td>
<td>8.3</td>
</tr>
<tr>
<td>Gas &amp; Liquid Transmission Pipelines</td>
<td>7.0</td>
</tr>
<tr>
<td>Waterways &amp; Ports</td>
<td>0.3</td>
</tr>
<tr>
<td>Hazardous Materials Storage</td>
<td>7.0</td>
</tr>
<tr>
<td>Airports</td>
<td>-</td>
</tr>
<tr>
<td>Railroads</td>
<td>-</td>
</tr>
</tbody>
</table>

**TOTAL: B$ 22.6**
**Cost of Corrosion – Category: Utilities**

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost (B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Distribution</td>
<td>5.0</td>
</tr>
<tr>
<td>Drinking Water &amp; Sewer Systems</td>
<td>36.0</td>
</tr>
<tr>
<td>Electrical Utilities</td>
<td>6.9</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>-</td>
</tr>
</tbody>
</table>

**TOTAL: B$ 47.9**
## Cost of Corrosion – Category: Transportation

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost (B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicles</td>
<td>23.4</td>
</tr>
<tr>
<td>Ships</td>
<td>2.7</td>
</tr>
<tr>
<td>Aircraft</td>
<td>2.2</td>
</tr>
<tr>
<td>Railroad Cars</td>
<td>0.5</td>
</tr>
<tr>
<td>Hazardous Materials Transport</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**TOTAL:** 29.7
AIRCRAFT ACCIDENT REPORT
ALOHA AIRLINES, FLIGHT 243
BOEING 737-200, N7371I,
NEAR MAUI, HAWAII
APRIL 28, 1988
## Cost of Corrosion – Category: Production & Manufacturing

<table>
<thead>
<tr>
<th>Industry</th>
<th>Cost (B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil &amp; Gas Exploration &amp; Production</td>
<td>1.4</td>
</tr>
<tr>
<td>Mining</td>
<td>0.1</td>
</tr>
<tr>
<td>Petroleum Refining</td>
<td>3.7</td>
</tr>
<tr>
<td>Chemical, Petrochemical, &amp; Pharmaceutical</td>
<td>1.7</td>
</tr>
<tr>
<td>Pulp &amp; Paper</td>
<td>6.0</td>
</tr>
<tr>
<td>Agriculture Production</td>
<td>1.1</td>
</tr>
<tr>
<td>Food Processing</td>
<td>1.1</td>
</tr>
<tr>
<td>Electronics</td>
<td>-</td>
</tr>
<tr>
<td>Home Appliances</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**TOTAL: B$ 17.6**
## Cost of Corrosion – Category: Government

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defense</td>
<td>B$ 20.0</td>
</tr>
<tr>
<td>Nuclear Waste Storage</td>
<td>B$ 0.1</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>B$ 20.1</strong></td>
</tr>
</tbody>
</table>
## Cost of Corrosion – Summary of Sector Analyses

<table>
<thead>
<tr>
<th>Sector</th>
<th>Cost (B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>22.6</td>
</tr>
<tr>
<td>Utilities</td>
<td>47.9</td>
</tr>
<tr>
<td>Transportation</td>
<td>29.7</td>
</tr>
<tr>
<td>Production &amp; Manufacturing</td>
<td>17.6</td>
</tr>
<tr>
<td>Government</td>
<td>20.1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>137.9</strong></td>
</tr>
</tbody>
</table>


Extrapolated Corrosion Costs: $276 Billion, 3.1% of GDP

- Manufacturing, 31.5% $86.8 Billion
- Services, 5.2% $14.3 Billion
- Federal Government, 7.3% $20.1 Billion
- State and Local Government, 3.0% $8.3 Billion
- Construction, 18.1% $50.0 Billion
- Transportation and Utilities, 34.9% $96.2 Billion
- State and Local Government, 3.0% $8.3 Billion
Non-Technical Preventive Strategies

- Increase awareness of the widespread effects of corrosion
- Build awareness of the huge cost associated with corrosion
- Build awareness of potential savings
- Change the misconception that nothing can be done about corrosion
- Change policies, regulations, standards, and management practices to increase corrosion savings
- Improve education and training of staff
Technical Preventive Strategies

• Advance design practices for better corrosion management
• Advance life prediction and performance assessment methods
• Advance corrosion technology through:
  • Research
  • Development
  • Implementation

Recognize the commonality of the problem throughout all branches of the military; but also that corrosion may manifest itself differently in each branch.
Further Information

- FHWA – RD-01-156 – Full Report
- FHWA – RD-01-157 – Tech Brief

Contact:

- Federal Highway Administration
- Y. Paul Virmani (202) 493-3052

Web Site:

- http://www.corrosioncost.com
Aboveground and Underground Storage Tanks and Associated Piping Systems
Impact of Corrosion

8.5 million tanks in the U.S. (regulated and non-regulated)
$ 4.5 Billion Cost to AST
$ 2.5 Billion Cost to UST
Total Cost of $7 Billion annual cost

Corrosion is one of the leading causes of storage tank and piping failures
Corrosion Control Regulations

• By the Oil Pollution Act of 1990:
  ➢ The owner **must** have a Spill Response Plan
  ➢ The owner **must put in place measures, practices, etc. to limit the possibility of releases** based upon industry accepted sound engineering practice in design, operation, and maintenance of the facility
  ➢ The reg. does not regulate corrosion control, but does say prevent release.

• 1998 EPA Regulation for UST – Requires that all tanks to have corrosion control, as well as overflow and spill protection
Corrosion Control Regulations

Spill Prevention Control and Countermeasure (SPCC) Regulation
(Implementation Required by 2/18/05)

• *Provide buried piping that is installed or replaced after August 16th, 2002 with a protective coating and cathodic protection.*

• *Should a section of line be exposed for any reason it must be inspected for deterioration. If corrosion damage is found you must take additional examination and corrective action.*
NACE Standards

NACE has either developed or is in the process of developing standards to address Tank and Pipeline integrity:

- **RP0169-2002, Control of External Corrosion on Underground or Submerged Metallic Piping Systems**
- **TM0101-2001, Measurement Techniques Related to Criteria for Cathodic Protection**
- **RP0193-2001, External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms**
NACE Standards (con.)

• RP0285-2002, Corrosion Control of Underground Storage Tank Systems by Cathodic Protection

• TM0497-2002, Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
API Standards

• API 570 Piping Inspection Code
• API 651 Cathodic Protection of Aboveground Petroleum Storage Tanks
• API 652 Lining of Aboveground Petroleum Storage Tanks Bottoms
• API 653 Tank Inspection, Repair, Alteration, and Reconstruction
• API 1632 Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems
Thank You!