Corrosion & Fouling Control at Petrochemical Processes

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The information contained in this presentation is PRIVILEGED AND CONFIDENTIAL. It is the property of the General Electric Company and shall not be used, disclosed or reproduced without the express written consent of the General Electric Company.
• What Is Corrosion?
• Corrosion Mechanism
• Filming Inhibitors
• Neutralizing Inhibitors
• Monitoring & Lab Testing Procedures
• Successful Corrosion Inhibition Treatment
Requirements for Corrosion to Occur

a) Anodic reaction
   Corrosion reaction

b) Cathodic reaction
   Uses the electrons produced at Anode

c) Metallic Path
   Electrons flow from anode to cathode

d) Electrolytic Path
   Flow for ions between anode and cathode
Corrosion?

Electrochemical Process in which metals react with their environment

Anode (oxidation):

- Fe → Fe$^{2+}$ + 2 e$^-$
- Fe → Fe$^{3+}$ + 3 e$^-$
- Fe$^{2+}$ → Fe$^{3+}$ + e$^-$

Summary: The metal ionizes and produces electrons
Corrosion Chemistry

Cathode Reactions (Reduction)

Acidic Environment
- \(2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2\)
- \(\text{O}_2 + 4 \text{H}^+ + 4 \text{e}^- \rightarrow 2 \text{H}_2\text{O}\)

Basic or Neutral Environment
- \(\text{O}_2 + 2 \text{H}_2\text{O} + 4 \text{e}^- \rightarrow 4 \text{OH}^-\)

Summary: Electrons are consumed, in any aqueous environment
Corrosion Chemistry

End Reactions

- Fe$^{3+} + \text{OH}^- \rightarrow \text{Fe(OH)}_3$
- Fe(OH)$_3 \rightarrow \text{Fe}_2\text{O}_3 + 3\ \text{H}_2\text{O}$

These are the distinctive brownish-red rust deposits

They are magnetic (good diagnostic tool)
Visual Corrosion Picture (1)

Step 1: Water reaches equilibrium with environment: becomes basic or acidic, absorbs oxygen.
Visual Corrosion Picture (2)

Step 2: Water droplet contacts metal surface.

Hydrocarbon Fluid

H⁺  O₂
H₂O  OH⁻

Metal Surface
Step 3: The metal oxidizes (anode reactions) producing metal cations and electrons.
Step 4: The electrons are consumed in the cathode reactions (reduction).

\[ 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2 \text{ (Acidic)} \]
\[ \text{O}_2 + 4 \text{H}^+ + 4 \text{e}^- \rightarrow 2 \text{H}_2\text{O (Acidic)} \]
\[ \text{O}_2 + 2 \text{H}_2\text{O} + 4 \text{e}^- \rightarrow 4 \text{OH}^- \text{ (Basic)} \]
**Visual Corrosion Picture (5)**

**Step 5:** The end reactions turn the metal ions into rust particles (Oxygen Corrosion Example).

\[
\begin{align*}
\text{Fe}^{3+} + \text{OH}^- & \rightarrow \text{Fe(OH)}_3 \\
\text{Fe(OH)}_3 & \rightarrow \text{Fe}_2\text{O}_3 + 3 \text{H}_2\text{O}
\end{align*}
\]
Step 6: It starts all over again.
Outline

Forms of Corrosion

a) General (Uniform)
b) Localized (pitting, under deposit & crevice)
c) Galvanic (bimetallic)
d) Velocity related (erosion & cavitation)
e) Intergranular corrosion (weld decay)
f) Dealloying (selective leaching)
g) Cracking (blistering, HIC, SCC)
h) High temp (oxidation, sulfidation, napthenic acid)
Corrosion Causes

Corrosives Species in Petrochemical Processes

a) Chlorides: inorganic - organic
b) Sulphur Compounds
   - H₂S
   - SOₓ
c) Oxygen
d) CO₂ – Forming Carbonic Acid
e) Organic Acids – Acetic Acid, Propionic Acid, Formic Acid, etc.
f) Erosion Corrosion
HCl & Sulfur Corrosion

SWEET
Fe + 2HCl → FeCl₂ + H₂
No H₂S

SOUR
Fe + 2HCl → FeCl₂ + H₂
FeCl₂ + H₂S → FeS + 2HCl
Fe + H₂S → FeS + H₂

• Acid Dew Point Corrosion
• Aggressive corrosion at Initial Condensation Point
Oxidized Sulphur Species

a) Sulphite:

SO2 + H2O → H2SO3 (acid condensation)

HS- + 3/2 O2 → HSO3- → SO32- + H+

(most severe at pH 6 – 7)

2H2S + SO2 → 3S + 2 H2O + O2 → HSO32- + H+
Oxygen Corrosion

The presence of oxygen in the high temperature areas greatly increase the corrosion rates of the carbon steel equipment.

\[4Fe + H_2O + O_2 \rightarrow 4Fe(OH)_3\]

\[2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O \text{ (time & temperature)}\]

With water globes $\rightarrow$ corrosion
Underdeposit $\rightarrow$ PITTING

Fe(OH)₃ is insoluble leading to an increased corrosion rate as more iron is leached out from the metal to maintain the chemical equilibrium.
CO₂ Corrosion

Low pH carbonic acid corrosion

• Carbonic acid is formed when CO₂ dissolves in water and reacts with water:

  \[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^- \]

• \( pK_a \) of \( \text{H}_2\text{CO}_3 \) is 6.37

• \( \text{Fe} + \text{H}_2\text{CO}_3 \rightarrow \text{FeCO}_3 + \text{H}_2 \uparrow \)
Organic Acid Corrosion

Contents naturally in the crude

• Oxidation of unsaturated compounds

• Weak acids (pKa: 3.8 to 4.5)
### Physical Properties of Organic Acids

<table>
<thead>
<tr>
<th>Organic Acids</th>
<th>MW</th>
<th>B.P. °F</th>
<th>pKa</th>
<th>Solub. g/100 g H₂O</th>
<th>HCl Equiv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formic</td>
<td>46</td>
<td>213</td>
<td>3.75</td>
<td>¥</td>
<td>0.79</td>
</tr>
<tr>
<td>Acetic</td>
<td>60</td>
<td>245</td>
<td>4.75</td>
<td>¥</td>
<td>0.61</td>
</tr>
<tr>
<td>Propionic</td>
<td>74</td>
<td>287</td>
<td>4.87</td>
<td>¥</td>
<td>0.49</td>
</tr>
<tr>
<td>Butyric</td>
<td>88</td>
<td>326</td>
<td>4.83</td>
<td>¥</td>
<td>0.41</td>
</tr>
<tr>
<td>Pentanoic</td>
<td>102</td>
<td>401</td>
<td>4.88</td>
<td>3.7</td>
<td>0.36</td>
</tr>
</tbody>
</table>

### Neutralizer Titration Curves

- **HCl Alone**
- **HCl Plus Organic Acids**

The graph shows the pH changes with increasing neutralizer concentration (ppm).
Erosion Corrosion

Factors effecting Erosion Corrosion

• Velocity
• Chemistry
• Geometry
• MOC
Product Mechanisms

How does Chemical Technology work?

- Filmers – Forms Film
- Neutralizers – Neutralize the acidity
Filmers

1. Keep corrosive water off of metal surface
2. Bond to metal & to slough of the corrosion product scale
3. Disperse salts
An Inside Look

This is a typical filming corrosion inhibitor molecule

Two interesting features
An Inside Look

Polar Head
An Inside Look

Paraffinic (Aliphatic) tail
How does it work (1)?

Step 1: The polar end migrates to the metal surface. The paraffinic end floats in the solution.
How does it work?

Water droplets are repelled!

Result: A uni-molecular film coats the entire metal surface.
Neutralizers

Neutralize Acids Condensing in Water Phase

- Low Molecular Weight Amines
Desired Neutralizer Features

1. Low oil/water partitioning coefficient
   - Rekker Fragment Constant Method:
     - Estimates partitioning of amines
     - Expresses results as ppm amine in oil, for each ppm amine in water

2. Low “Vapor-Aqueous” equilibrium ratio (Kva)
   a) In the Water, not the Vapor
      \[
      \text{Kva} = \frac{\text{ppm amine in steam}}{\text{ppm amine in water}}
      \]

3. Cost effectiveness

4. Neutralizer Salt Properties
Monitoring & Lab Testing Procedures
Corrosion Monitoring

1) Water analyses
2) Hydrocarbon analyses
3) Corrosion rate measurement
   > ER Probes
   > Coupons
4) NDT
ER CORROSION PROBE SCHEMATIC

- **Flanged Corrosion Probe**
- **Connection for Probe Reading**
- **2" 150 Lb Flange**
- **2" 150 Lb Nozzle Flange**
- **Flow through the piping**
- **Probe Bottom**
- **Tubular Element**
- **Ceion Probes**
BLACK IRON CORROSION RACK

The Black Iron Corrosion Rack is recommended for corrosion monitoring in high temperature and/or high pressure installations such as steam condensate, high temperature water, hydronic heating, recirculating process systems, etc.

• Maximum Pressure: 200 psig (13.8 bar)
• Maximum Temperature: 160° F (71° C)
Corrosion Simulation Testing
NEW TEST METHODS PROCEDURES

High Temperature and Velocity Autoclaves
- Coupon weight loss
- Realistic velocity effects
- Realistic oil/water ratio and coupon contact
- Realistic Aqueous Chemistry

Rotating Cylinder Electrode (RCE)
- Electrochemical Method
- Realistic velocity, well defined flow regime
- Allows multiple dosages per test
- Test film persistency
- Easy to simulate low pH excursions (pH upset)
Diagnostics - On Stream Monitoring

- Electrical Resistance (ER) Probes
- VTCP (Variable Temp Corrosion Probe)
- COLA (Condensate On-Line Monitor)
  - Simulates Dewpoint
- Continuous pH
- UT / X-Ray Water Analysis
Dew Point Corrosion Simulator

- Capabilities
  - Constructed of 316SS
  - Temp = 350°F
  - Velocity = 50 ft/sec
  - Realistic chemistry
  - Can add appropriate gas (CO2)
  - Can vary oil/water ratio
  - Various metallurgies
  - More Time Consuming Test
Metallurgical Lab Capabilities

Failure/Corrosion Mechanisms
Deposit Analysis
Photography
Visual Analysis
Alloy Verification
Metallography
Hardness/Non-Destructive Testing
Successful Corrosion Inhibition Treatment
**Corrosion Location-CGC Interstage Coolers**

Neutralizer Amine treatment at the CGC Inter-stage coolers to reduce the corrosion in the system due to acid loading in the system.

**RESULTS ACHIEVED:**

The injection of neutralized amines resulted in effectively mitigating the risk of corrosion of the intercoolers. Table III below illustrates a representative pH and iron content before and after the chemical treatment was initiated in the process gas compressor intercoolers.

Table-III: Summary of results before and after chemical treatment in the intercoolers.

<table>
<thead>
<tr>
<th>Intercoolers</th>
<th>Condensate Sample [Before the Chemical Treatment]</th>
<th>Condensate Sample [After the Chemical Treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>Iron (ppm)</td>
</tr>
<tr>
<td>1st Stage Suction Drum</td>
<td>4.2</td>
<td>10.35</td>
</tr>
<tr>
<td>2nd Stage Suction Drum</td>
<td>3.9</td>
<td>5.5</td>
</tr>
<tr>
<td>3rd Stage Suction Drum</td>
<td>3.8</td>
<td>7.8</td>
</tr>
<tr>
<td>4th Stage Suction Drum</td>
<td>4.2</td>
<td>11.74</td>
</tr>
<tr>
<td>5th Stage Suction Drum</td>
<td>9.1</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Corrosion Location-Benzene Column

The major cause of corrosion is hydrochloric acid

- Chemical should be benzene soluble as there is very little water in the benzene column overhead
- Should be non-volatile under process conditions
- Should contain no nitrogen as nitrogen will poison zeolite alkylation catalyst

Technical Paper @ Badger Conference 2005 - “Addressing Process Corrosion Problems in EB/SM Plants”
J. Link - Park, Y.W. - Kim, C. - Yang, H.G.
Major Applications....

**Ethylene Units**
- Oil Quench/Water Quench Overhead Lines & Process Circulation
- Process Water Stripper
- DSG
- CGC Interstage Coolers
- Depentanizers, Dehexenizers Overhead

**Acrylonitrile Units**
- Water Section – Quench Tower, Absorber Column
- Purification Section – Recovery Column

**EDC- VCM Units**
- Oxy-Clorination Water Quench
- Drying Column
- Light ends removal Column

**EB & Styrene Units**
- Dehydro Effluent Condensors
- EB/SM Splitter Overhead
- BT Column Overhead
- Bz Recovery Column Overhead
Fouling & Inhibition
• What Is Fouling?
• Fouling Mechanism
• Various Fouling Areas at Petrochemical Ind.
• Fouling Inhibitors
• Monitoring & Lab Testing Procedures
• Successful Antifouling Treatment
Fouling

- **Definition of Fouling**
  - Deposition/accumulation of unwanted material in process equipments.

- **Fouling Material**
  - Inorganic particles
    - Metal Oxides, Catalyst fines, Corrosion products, Salts, dirt, other insoluble contaminants and Volatile salts.
  
  - Organic particles
    - Polymers, Coke fines
Fouling Mechanism

Inorganic Particles → Agglomeration → Settling Velocity > System Velocity → Deposit → Coke

Organic Particles → Agglomeration → Settling Velocity > System Velocity → Deposit → Coke

Heat ↔ Hydrogen
Polymerization Mechanism

- Free Radical Polymerization
  - Free Radical
    - An Atom or Atomic group which lacks an electron of electron pair
    - Due to the lack of one electron
      - tries to be stable by obtaining an electron
      - unstable and reactive

- 3 steps of Free Radical polymerization
  - Initiation
  - Propagation
  - Termination
Free Radical Polymerization

Thermal/Peroxide Radicals

- Radicals initiate polymerisation
- Dissolved oxygen or oxygen containing organic molecules
- Fast generation of peroxide radicals at low temperature
- At somewhat higher temperatures further chain propagation reactions
- Inhibition method depends on type of radicals

Initiation

- R-H $\xrightarrow{\Delta} \text{R} + \text{H}^+$
- ROOH $\xrightarrow{\Delta \text{metals}} \text{RO} + \text{OH}^-$

Propagation

- R$^\cdot$ + O$_2$ $\rightarrow$ ROO
- ROO$^\cdot$ + R-H $\rightarrow$ ROOH + R

Autooxidation

Polymerization

- R$^\cdot$ + C=C $\xrightarrow{k_p}$ C=CR$^\cdot$

- ROO$^\cdot$ + C=C $\rightarrow$ C-OR$^\cdot$

Inhibition

- R$^\cdot$ + In $\xrightarrow{k_i}$ R-In
- RO$^\cdot$ + In $\rightarrow$ RO-In
- ROO$^\cdot$ + In $\rightarrow$ ROO-In

- < 85 °C : Slow
- 85 - 95 °C : Moderate
- 95 – 120 °C : Fast
Agglomeration of Particles

Diameter increases  □ Easily settles (Stokes law)
Fouling Mechanism

- Fluid Velocity V/s. Settling Velocity

Smaller Particle: Not deposit

Bigger Particle: Deposit
Concern Areas ...

Oil Quench ...

- Free Radical Polymerization of:
  - Styrene
  - Indene
  - Divinylbenzene
  - Naphthalenes

- Precipitation of naphthalenes and asphaltenic compounds

- Complex Hetero-polymeric material consisting of Butadiene, Isoprene, Styrene, Indene, DVB, & Vinylnaphthalenes
Formation of “red oil” from polymerization of carbonyls (acetaldehyde and ketones (acetone))---which are formed in furnaces.

Acetaldehyde forming reaction is furnace is as follows:

- Ethylene + H2O → Acetaldehyde + H2
- Acetylene + H2O → Acetaldehyde (CH3CHO)

When acetaldehyde enter the caustic tower, caustic catalyzes the Aldol condensation reaction, resulting “aldol” (β-Hydroxyaldehyde)

The unsaturated Aldol can further polymerize with another acetaldehyde or another aldol molecule to form higher MW oligomers and polymers which are water insoluble and dark red in color.
DSG ...

- Entrained oil from the Quench System coming to the DSG degrades and the deposit dehydrogenates over time into a coke-like material.
- Heat Induced polymerization of water soluble organics
- Corrosion product (iron) agglomeration acting as a catalyst
- Oxygen initiated polymerization
Ethylene Fractionation Train ...

- Free Radical Polymerization of di-olefins like Butadiene, Isoprene, Propadiene, Cyclopentadiene

- Contamination of feedstock with oxygenated compounds such as ethanolamines will result in peroxide formation, which initiates fouling when heated

- Transition metals, iron and copper, catalyze polymerization and increase fouling potential

- High residence time leads to high fouling potential

- High Unit utilization
Acrylonitrile ... 

- Anionic mechanism
  - HCN polymer
  - Cyanide polymer typically found in Heads column

- Free Radical mechanism
  - AN polymer
    a) Recovery Column Overhead
    b) Heads column bottoms and reboiler
    c) Dryer column and reboiler
EDC/VCM ...

- Polymerization of Chloroprene in light still overhead

- Cracking of EDC and other chlorinated organics due to heat and catalyzed by Ferric Chloride

- Precipitation or loss of solubility of high molecular weight organics in tar still and/or vacuum column bottoms

- Water contamination during distillation causes severe organic fouling
Styrene ...

- SM polymerization due to high operating temperature
- DEB will readily dehydrogenated to DiVinyl Benzene (DVB) which polymerizes readily via free radical mechanism resulting into a cross-linked polymer

- Dehydro Effluent Condenser
- Process Water Stripper
- Off (Vent) Gas Compressor
- SM Distillation Section
Product Mechanisms

GE W&PT offers a complete line of antifoulant products

Types of antifoulant products:

- **Dispersants**
  - Low temperature
  - High temperature

- **Inhibitors**
  - Free radical inhibitors
  - Condensation inhibitors
  - Metal passivators
  - Antioxidants
Antifoulants/Antipolymerants

Antifoulants are chemical additives (one or more functional chemicals) used to protect equipment from loss of heat transfer efficiency.

\[ \text{Inhibition} \]

\[
\begin{align*}
R^\cdot + \text{In} & \xrightarrow{k_i} \text{R-In} \\
R\text{O}^\cdot + \text{In} & \rightarrow \text{RO-In} \\
R\text{OO}^\cdot + \text{In} & \rightarrow \text{ROO-In} \\
R^\cdot + \text{A-In} & \rightarrow \text{R-In} + \text{A}
\end{align*}
\]

\( R^\cdot = \text{ Reactive polymer, monomer radical} \)
\( \text{A-In} = \text{ Hydrogen donating chain-stopper} \)
\( \text{R-In} = \text{ Short chain, terminated radical} \)
\( \text{A.} = \text{ Stable Chain-stopper radical} \)
**Dispersants**

- **Mechanism of Dispersants**

![Diagram](image)

Prevents Particles from Deposition on Metal Surface
Dispersant Functionality

**Features**
- Highly surface active chemistry
- Inorganic and Organic dispersant functionality
- Prevents the agglomeration of solids
- At high dosages may exhibit cleanup capability
- Formulated for process compatibility

**Benefits**
- Prevents deposition of solids
- Effective fouling control of both salt deposition and entrapped hydrocarbons
- Protection for downstream equipment
- Avoids downstream problems
- Provides ability to respond to upsets
- Eliminates concerns for product or downstream contamination

GE Proprietary
Metal Deactivator/ Chelant

Modification of Metal Ion Activity
Reduces Catalytic Activity
Reduces Initiation of Polymerization
Monitoring & Lab Testing Procedures
Monitoring Processes

Operating Conditions

- Flows
- Pressures
- Exchanger temperature
- Heater tube temps
- Compressor vibrations
- Furnace firing rates
- Open bypasses
- Cleaning frequency
- Corrosion rates

- Reboiler and vaporiser U-coefficients
- Multiple Regression Analysis (MRA) and Statistical Process Control (SPC) of heat transfer calculations
- Data plots of other appropriate process data
Tools to Design an Effective Treatment Program

- Experience / Case Histories
- Knowledge of Unit History
- Fluid Characterisation
- Deposit Analysis
- Lab Simulation
- Field Tests
Pressurized Hot Wire (HWT) Apparatus
Dynamic Lab Test - Hot Liquid Process Simulator (HLPS)

- Thermal Fouling Mode
- Rod temperature constant at 260 C
- Oil outlet temp. started at 210 C
- Fluid under 600 psi nitrogen purge
- 5 hour run
## Deposit Analysis Capabilities

<table>
<thead>
<tr>
<th>Loss on Ignition</th>
<th>Organics and Volatile Inorganics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash (100-LOI)</td>
<td>Non-volatile Inorganics</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>Lower Molecular Weight Organics</td>
</tr>
<tr>
<td>Extractables</td>
<td>Including Entrained Hydrocarbons</td>
</tr>
<tr>
<td>Non-Extractables</td>
<td>Coke and Inorganic Content</td>
</tr>
<tr>
<td>Inorganic Analysis</td>
<td>Elemental Composition of Ash (Fe, Cu, Ni, etc...)</td>
</tr>
<tr>
<td>Organic Analysis</td>
<td>Carbon, Hydrogen, Nitrogen Content of Non-Extractables</td>
</tr>
</tbody>
</table>
Deposit Analysis

LOI analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>% Loss on Ignition @</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>105 °C</td>
</tr>
<tr>
<td>1st Stage Intercooler</td>
<td>0</td>
</tr>
<tr>
<td>2nd Stage Intercooler</td>
<td>0.7</td>
</tr>
<tr>
<td>3rd Stage Intercooler</td>
<td>1.1</td>
</tr>
<tr>
<td>4th Stage Intercooler</td>
<td>0.8</td>
</tr>
<tr>
<td>Gasoline fractionator</td>
<td>5.7</td>
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</tbody>
</table>

Metals- ICP-AES analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Al</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Stage Intercooler</td>
<td>373</td>
<td>34</td>
<td>315</td>
<td>73</td>
<td>197</td>
<td>14</td>
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<tr>
<td>2nd Stage Intercooler</td>
<td>1058</td>
<td>99</td>
<td>282</td>
<td>527</td>
<td>47</td>
<td>66</td>
</tr>
<tr>
<td>3rd Stage Intercooler</td>
<td>35</td>
<td>7</td>
<td>101</td>
<td>29</td>
<td>42</td>
<td>49</td>
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<tr>
<td>4th Stage Intercooler</td>
<td>55</td>
<td>17</td>
<td>74</td>
<td>19</td>
<td>72</td>
<td>14</td>
</tr>
<tr>
<td>Gasoline fractionator</td>
<td>345</td>
<td>11</td>
<td>72</td>
<td>68</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1866</td>
<td>168</td>
<td>844</td>
<td>716</td>
<td>387</td>
<td>146</td>
</tr>
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</table>

FTIR spectra of DCM insoluble fraction

SEM-EDX Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight%</th>
<th>Atomic%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C K</td>
<td>71.37</td>
<td>76.92</td>
</tr>
<tr>
<td>O K</td>
<td>28.43</td>
<td>23.08</td>
</tr>
<tr>
<td>S K</td>
<td>0.20</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight%</th>
<th>Atomic%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C K</td>
<td>74.47</td>
<td>79.66</td>
</tr>
<tr>
<td>O K</td>
<td>25.14</td>
<td>20.15</td>
</tr>
<tr>
<td>S K</td>
<td>0.39</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>
Successful Antifoulant Treatment
EDC-VCM Plant in Gulf Region

EDC Furnace Convection Section
- Before treatment run length 3 to 4 months
- After treatment run length 12 to 13 months

HCl Column
- Reboiler run length before treatment 3 to 4 months
- After treatment – 22 to 24 months
- Column run length 4 - 5 yrs after treatment without any limitation

Head & Vacuum Column
- Reboiler run length before treatment – 3 to 4 months
- After Treatment 22-24 months
Caustic Unit at Europe

Sampling on strong & weak caustic loop

Feb. 9th / PF 20Y15 Injection pump failure

Feb. 10th / 1 day after 20Y15 re-injection

Feb. 12th / 3 days after 20Y15 re-injection

Feb. 16th / 6 days after 20Y15 re-injection
Major Applications....

**Ethylene Units**
- Oil Quench/Water Quench
- DSG
- CGC & Interstage Coolers
- Caustic Tower
- Cold Trains
- GHU

**EDC- VCM Units**
- Oxy-Clorination
- Water Quench
- Drying Column
- Light ends removal Column

**Acrylonitrile Units**
- Water Section – Heads, Dryer, Product & Rerun Column
- Purification Section – Recovery Column, Absorber column

**EB & Styrene Units**
- Dehydro Effluent Condensors
- EB/SM Splitter Overhead
- BT Column Overhead
- Bz Recovery Column Overhead
GEWPT Corrosion Inhibitors & Antifoulant Technology

1. Petroflo 21Y.. series as Neutralizer Amines
2. Petroflo OS.. series as Filming Amines
3. Petroflo 21Y..series as non Amine based Filmers
4. Styrex series for Styrene plant on Neutralizers & Antifoulants
5. Petroflo20Y... series as Antifoulants, Dispersants, Surface Modifiers, Metal Deactivators, Antioxidants, etc...
6. Petroflo20Y... Non N based antifoulants
GE WPT Application Global Running Experience

1. 24 applications in Oil Quench Tower for fouling & corrosion control
2. >32 applications in Quench & Dilution Steam Generation System for fouling & corrosion
3. 25 applications in CGC for fouling & corrosion control
4. 19 applications in Caustic Scrubber for fouling control
5. 36 applications in fractionation train for fouling control
6. 24 applications in G.H.U. / Py-Gas stabilisation for fouling and corrosion control
7. 13 applications in crude butadiene for fouling control
8. 10 applications on butadiene for fouling control on EDS & Purification Sections
9. >30 applications on EDC/VCM for fouling control
10. >36 applications on Styrene for corrosion & fouling control
Thank you very much for your attention

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