CATHODIC PROTECTION MONITORING EFFECTIVENESS

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Critical Safety Issues In Marketing Operations
Striving For Improved Performance
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CORROSION
[ METAL DEGRADATION DUE TO REACTING WITH ENVIRONMENT ]
RAVAGES VALUABLE ASSETS SUCH AS:

- **PIPELINES** [UNDERGROUND / ABOVE GROUND]
- **TANKS** [UNDERGROUND/ABOVE GRADE/MOUNDDED]
- **RUTOR STEEL** IN CONCRETE
- **STRUCTURALS**
- **OTHER ASSETS** [PACE MAKER, JOINTS, DENTAL]
CORROSION
RESULTS IN RUPTURE
CAUSING
HAZARDS — FIRE, POLLUTION, FATALITY
[HUMAN, FLORA, FAUNA]
BESIDES
ECONOMIC LOSSES
DUE TO
PRODUCT LOSS, REPAIR COST, DOWN TIME &
COMPENSATION
TYPES OF PIPELINE FAILURES

- CORROSION FAILURE
- THIRD PARTY INTERFERENCE
  MALACIOUS
  NON-MALACIOUS
- OPERATIONAL ERROR
- NATURAL CALAMITY
- CONSTRUCTION / MATERIAL DAMAGE
- OTHERS.
PIPELINE FAILURES

- ONCE PIPELINE LEAK COMMENCES IT PROGRESSES IN EXPONENTIAL RATE.
- CORROSION CAN BE CONTROLLED WITHIN ACCEPTABLE LIMITS BY APPLICATION OF CATHODIC PROTECTION FROM CONSTRUCTION STAGE.
PITTING NEAR THE JOINT AREA
PIPELINE COATINGS AFTER EXCAVATION
TANK BOTTOM PLATE PITTING CORROSION

Nace Corrosion 2004
PIPE RUPTURE
SEVERE CORROSION
FAILURE FROM THE SEAM

Service failure at Ch. 541.415 Km on 05.12.97 in A-K Section.
Seam opening is clearly visible.
CORROSION CONTROL

• COMPRISSES OF –
  • ENVIRONMENT SELECTION
  • INHIBITION
  • MATERIAL SELECTION
  • PAINTS/COATINGS
  • CATHODIC PROTECTION
CORROSION CONTROL

• THE EFFORT IS TO MINIMIZE CORROSION, A
  NATURAL PHENOMENON, TO AN ACCEPTABLE LIMIT SO THAT ECONOMIC VIABILITY IS ENSURED

• THIS IS BEST ACHIEVED BY PROVIDING A SUITABLE COATING SUPPLEMENTED BY A COMPATIBLE CATHODIC PROTECTION SYSTEM AS A COMPOSITE CORROSION PROTECTION SYSTEM
CORROSION

• Corrosion Reactions:

• \( \text{Fe} \leftrightarrow \text{Fe}^{++} + 2\text{e}^- \) \hspace{1cm} \text{Anodic Reaction (1)}

• \( 2\text{e}^- + 2\text{H}^+ \leftrightarrow 2\text{H} \rightarrow \text{H}_2 \uparrow \) \hspace{1cm} \text{Cathodic Reaction (2)}

• Or \( \text{H}_2\text{O} + 2\text{e}^- + \frac{1}{2} \text{O}_2 \rightarrow 2(\text{OH}^-) \)

• \( \text{Fe}^{++} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2 \)

• \( \text{Fe}(\text{OH})_2 + \frac{1}{2} \text{O}_2 + \frac{1}{2} \text{H}_2\text{O} \rightarrow \text{Fe}(\text{OH})_3 \) \hspace{1cm} [Green Colour]

• \( 2\text{Fe}(\text{OH})_3 \rightarrow 2 \text{Fe}_2\text{O}_3 + 3 \text{H}_2\text{O} \) \hspace{1cm} [Rust, Brown colour]
NOTE. In most cases anodes need to be distributed along the pipeline route.

*Typical cathodic protection of a buried pipeline with prepackaged sacrificial anod*
DISCRETE IMPRESSED CURRENT ANODES
EFFECTS OF SOIL RESISTIVITY ON CURRENT DISTRIBUTION
EFFECTS OF SOIL PROPERTIES ON CURRENT DISTRIBUTION
CATHODIC PROTECTION

• IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM IS THE SECOND METHOD AVAILABLE TO PROTECT THE UNDERGROUND UTILITIES FOR LONGER DURATIONS (UPTO 50 YEARS) AS IN THIS THE POWER SOURCE & HENCE THE PROTECTIVE CURRENT CAN BE CONTROLLED AS REQUIRED TO PROVIDE ADEQUATE PROTECTION THOUGHOUT. THIS INVOLVES USE OF FOLLOWING ANODES;
A JB

+VE ANODE HEADER TO T/R UNIT (50/35mm²)

10 No. ANODE LEAD WIRES
16mm² HMYE/XLPE
ANODE TAIL CABLE

CJB IS USUALLY REQUIRED FOR MULTIPLE DRAINAGE

VER TICAL ANODE GROUND BED

ANODE LEAD WIRE
- 10mm² DIA (SINGLE DORE COPPER)
- XLPE/HMYE/FF/PE/PVC/INSULATED
REFERENCE ELECTRODES

• TO MEASURE REPRODUCIBLE [P-S-P] THE FOLLOWING REFERENCE HALF CELL ARE IN USE

<table>
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<tr>
<th>Cu-CuSO₄(V)</th>
<th>Zn(V)</th>
<th>Ag-AgCl(V)</th>
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<tr>
<td>(-)0.75</td>
<td>(+)0.35</td>
<td>(-)0.7</td>
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<tr>
<td>(-)0.85</td>
<td>(+)0.25</td>
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<tr>
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<td>(+)0.1</td>
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<tr>
<td>(-)2.0</td>
<td>(-)0.9</td>
<td>(-)1.95</td>
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CRITERIA FOR CATHODIC PROTECTION

• THREE PRIMARY CRITERIA FOR CATHODIC PROTECTION OF UNDERGROUND OR SUBMERGED STEEL OR CAST IRON PIPE ARE:

  ➢ (-)0.85V w.r.t. Cu-CuSO₄ HALF CELL REFERENCE ELECTRODE WITH PROTECTIVE CURRENT FOR CATHODIC PROTECTION SYSTEM-APPLIED (ON).

  ➢ (-)0.85V w.r.t. Cu-CuSO₄ HALF CELL REFERENCE ELECTRODE WITH PROTECTIVE CURRENT FOR CATHODIC PROTECTION SYSTEM-NOT APPLIED (INSTANT OFF).
CRITERIA FOR CATHODIC PROTECTION

- 100mV POLARISATION VOLTAGE.

- 300mV SHIFT FROM NATURAL POTENTIALS WITH PROTECTIVE CURRENT APPLIED (ON).
Coating defect epicenter pipe-to-soil potential profile obtained using a Fluke 27 voltmeter at the DCVG ON/OFF pulse rate.
POTENTIAL DISTRIBUTION ALONG THE PIPELINE
PIPELINE COATING AND CATHODIC PROTECTION SYSTEM ASSESSMENT
PIPELINE COATING AND CATHODIC PROTECTION SYSTEM ASSESSMENT
CATHODIC PROTECTION FOR ABOVE GROUND STORAGE TANK BOTTOMS
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Installation of the Anodeflex System. It provides Cathodic Protection on every point without causing any under or overprotection.

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CONCEPTUAL DESIGN OF CP FOR BULLET TANKS

SAND MOUND

REF. ELECTRODE

TO TR UNIT

INLINE SPLICE

CONNECTING CABLES

LPG BULLET

POLYMERIC ANODE
LONG LINE POLYMERIC ANODE SYSTEM FOR MOUNDED BULLET
CONCEPTUAL DESIGN OF CP FOR BULLET TANKS

SAND MOUND

REF. ELECTRODE

POLYMERIC ANODE

BULLET-1

BULLET-2

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Corrosion Monitoring

- Cathodic Protection Of Assets Ensures Prevention of Loss of Metal to Earth due to Soil-side Corrosion

- This is a Dynamic Process & Requires Close Monitoring of C P Parameters

- If C P System Fails or is not performing as per Design, Corrosion Protection is In-Effective

- The Efficacy Of C P depends on continuous Monitoring to Ensure Desired Level of Parameters
Corrosion Monitoring

- Pipe to Soil Potential [P-S-P] is Monitored
  [P-S-P] Vs CSE to be in the Range
  (-)0.85 Minimum to (-) 1.5 V Maximum when Anaerobic Bacteria are absent [No SRB]
  and (-)0.95 Minimum to (-) 1.5 V Maximum when [SRB] are present
Corrosion Monitoring

- Only High Impedance Voltmeter to be used
- Equipment of Standard make & proven capability to be used
- Multichannel Recording capability
- The Record should be field verifiable through computer display in field
- Recorded Data should be Downloaded
Corrosion Monitoring

• For this Reason it is vitally important that utility Operators Maintain accurate, Integrated Information on their utility system from construction and Installation through Operation, Inspection & Maintenance
Corrosion Monitoring

• The Key to Integrity Management Programme is:
  
  1. To Know where Potential Problems Lie
  2. To Understand How Severe the Problem might be
  3. How Best to Manage these Problems
Corrosion Monitoring

• Survey Data to be Collated for Deciphering Problem Areas & Effective Measures to counter the problems detected

• Post Mitigative Measures installation Further surveys to evaluate Adequacy of installed mitigative measures

• Frequency of such surveys thereafter periodically
Corrosion Monitoring

Conclusion

• The Safety factor question has been settled many times by Research, Experience and Tests.

• In service underground utilities are safe if they are maintained properly and protected against Corrosion, that Devours the Vitals unchecked and undetected, and third party damage.
Acknowledgements

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THANKS