

# Cathodic Protection for Port Infrastructure

## INTRODUCTION

- Corrosion is a common and a very expensive problem in most of the industry it is very obvious in chemical, oil and gas industry and in petrochemical, pipelines and storage tanks are most subjected to this problem learning how to reduce it and to eliminate it in few cases can be very useful and highly recommended.
- An understanding of corrosion and its control is vital for any company hoping to avoid the high costs that can be directly or indirectly attributed to corrosion.
- There are a variety of techniques which are designed to protect vital components and installations against corrosion. One particular and important corrosion minimisation technique is Cathodic Protection. This technique can be divided into Sacrificial Anode or Impressed Voltage.
- This 5-day Cathodic Protection for Port Infrastructure training programme provides you with fundamental principles, evaluation and applications of Cathodic Protection, helping participants recognise and then select Cathodic Protection control methods.
- Particular emphasis will be on the corrosion and Cathodic Protection of port infrastructures, including pipelines, storage tanks and concrete structures.

## OBJECTIVES

- Understand the general principles of corrosion and corrosion protection techniques
- Understand different types of corrosion
- Understanding the corrosion and protection of port infrastructures, including pipelines, storage tanks and concrete structures
- Understand the Cathodic Protection systems; namely sacrificial anode and impressed current
- Appreciate the differences between sacrificial anode systems
- Understand the principals behind impressed current Cathodic Protection
- Know the influence of coating properties and their influence on Cathodic Protection
- Understand the methods of line and coating inspection
- Learn how to making basic field measurements for Cathodic Protection applications
- Learn how to make line current measurements
- Learn about the maintenance, rehabilitation and corrosion inspection of concert structures
- Understand and use the governing Cathodic Protection mathematical equations
- Corrosion test methods and interpretation of results
- Understand the economic considerations of Cathodic Protection systems

## **TRAINING METHODOLOGY**

- This Cathodic Protection for Port Infrastructure training course combines structured and focused presentations and discussions of topics covered with relevant examples and question & answer sessions to maximize the benefits to the participants.
- Additional simulations and videos will be used. Participants will be provided with comprehensive course notes and Electronic copies of all presentation material. These will be very valuable for detailed study and future reference.

## **ORGANISATIONAL IMPACT**

- The company will achieve improved and optimised corrosion protection for various structures and components, including pressure equipment, piping systems and process equipment
- Optimised, Cathodic Protection, criteria will increase and predict the life of components and equipment under various corrosion types and conditions
- Damage to process equipment and risk due to failure will be significantly reduced through the proper selection of Cathodic Protection corrosion reduction criteria, maintenance and materials selection
- Improved competencies will result in higher staff productivity and effectiveness
- The company will achieve improvement in loss prevention and safety as well as in financial performance

## **PERSONAL IMPACT**

- Participants will gain sound and practical understanding of corrosion principles and types of corrosion that are related to oil, gas and water
- Participants will also extend their knowledge of various types of corrosion inspection and Cathodic Protection, methods, with emphasis on port infrastructures
- Participants will have a better understanding of corrosion maintenance, trouble shooting and minimising the cost of corrosion, in relation to process equipment

## **WHO SHOULD ATTEND?**

- Personnel needing a basic understanding of corrosion principles and Cathodic Protection and how to eliminate or protect equipment, pipelines, storage tanks, concrete structures, etc.

This training course is also suitable for:

- Engineers
- Inspectors
- Managers
- Metallurgists

## Course Outline

### Principals and Types of Corrosion

- Introduction to Principles of Corrosion
- Corrosion Cycle
- Kinetics of the Corrosion Reaction
- Electrochemical Reactions
- Anodic and Cathodic Reactions
- Galvanic Series
- Corrosion Rates
- Materials of Construction, Types and Properties of Steel

### Forms of Corrosion

- Uniform Corrosion
- Bimetallic Corrosion
- Pitting Corrosion
- Concentration Cell Corrosion
- Stress Corrosion Cracking
- Erosion Corrosion
- Corrosion and Fatigue

### Types of Cathodic Protection

- Electrochemical Basis for Cathodic Protection, Sacrificial and impressed current, comparisons, advantages and disadvantages, general applications to pipes, tanks, offshore, etc.

### Resistivity of Soils

- Resistivity units, types of soil, area surveys, two-terminal and four-terminal resistivity determination

### Potential Surveys

- Pipe-to-soil potentials: electrodes, electrode placement, pipe line connection, surface potential survey for corrosion, pipe-to-soil potential as a criterion of Cathodic Protection

### Line Currents

- Measurement of line current in test section, current requirements, stray-current studies, long-line currents, Cathodic Protection tests, IR tests, current distribution and attenuation

## Concrete Corrosion

- Defects in Concrete Structures
- Corrosion Process in Concrete Structures
- Concrete System Corrosion Timeline
- Influence of the Environment
- Macro-cell Corrosion of Steel Reinforcement
- pH Levels and Alkalinity of Concrete
- Influence of Hydroxides
- Influence of Aggressive Agents and Solutions, Carbon Dioxide, Sea Water, etc.
- Carbonation
- Chloride Contamination
- Chloride Limits for Various Types of Concrete Systems, Reinforced, Pre-stressed, etc.
- Penetration of Concrete Structures
- Porosity and Permeability
- Corrosion Induced Cracking of Concrete

## Principals of Cathodic Protection

### Cathodic Protection Systems, Ground Beds and Installation

- Types, Permanent and Temporary Ground Beds, Design, Installation and Applications, Galvanic (Sacrificial) Anode and Impressed Current Cathodic Protection Systems, Ground beds and Installation, Galvanic Anodes Connection to Structure, Galvanic Anode Test Station Location and Function
- Types of Impressed Current Anode Beds, Impressed Current Cathodic Protection Systems, Distributed Impressed Current Cathodic Protection Systems, Impressed Current Rectifier Installation, Impressed Current Test Station
- Connecting Cables

### Cathodic Protection Problems, Hazards, safety and Control

- Detecting and Control of Interference, Anode Bed Location, Direct Bonding, Resistive Bonding, Non-Conductive Barrier, Stray currents, Interference of Foreign Lines with Insulating Joints

### Cathodic Protection of Port Infrastructures, Pipelines, Storage Tanks, Concrete, etc.

#### Anode Types and Beds

#### Pipe Coatings

- Types of Coatings, Metallic Coatings, Polymer Coatings, Fusion Bonded Epoxy, Coating Efficiency

## Coating Inspection and Testing

- Construction Inspection, Coating or Leakage Conductance, Coating Tests, Pipe Coating Holiday (loss of coating) Inspection Methods

## Cathodic Protection Interference

- Stray-current, Sources and Detection of Stray Currents, Crossing Bonds, Auxiliary Drainage, Foreign Lines, Secondary Exposure, Basic Solutions

## Rehabilitation and Cathodic Protection of Concrete Structures

- Sacrificial Concrete Anode Systems and Anode Mesh Systems
- Thermal Spray Anodes
- Reinforced Steel Coatings
- Repair and Rehabilitation of Concrete
- Identify Rehabilitation Alternatives
- Relevant Standards

## Concrete Survey Methods

- Determining Possible causes of Failure
- Preliminary and Detailed Inspections
- Delamination Survey
- Core Extraction and Testing
- Nondestructive Testing of to Determine Concrete Cracks
- Crack Survey
- Pachometer (Cover) Survey
- Chloride Content Determination
- Moisture Content Determination
- Half-cell Potential

## CATHODIC PROTECTION Maintenance and Monitoring Techniques

- Pipe and Coating Monitoring, Pearson Surveys, Close Interval Potential Survey (CIPS) technique, Direct Current Voltage Gradient (DCVG) Technique, Signal Attenuation Coating (SAC) Survey

## Equations and Mathematical Calculations of Cathodic Protection

- Group exercises and worked example for the determination and mathematical calculation of, current required, circuit resistance, rectifier voltage, type and number of anodes, life cycle cost and expectancy