# Corrosion Engineering and Metallurgical Services

Tricontinental Oil Services Limited provides metallurgical and corrosion engineering services for industries such as oil and gas, petrochemical, aerospace, fertilizer, steel manufacturing, chemical production, food processing, breweries, pipelines, electric utilities, pulp and paper, etc. Our field engineering and design services include:

- Consultancy Services in Corrosion
- Failure Analysis
- Materials Selection
- Metallurgical Engineering Services
- Corrosion evaluations and assessment
- Welding consulting
- Laboratory testing
- Specification, application and inspections of coatings and linings
- NDT and Field Inspection Services
- Microstructral evaluation of materials
- Inhibitor programs and water treatment services
- Corrosion Monitoring
- Cathodic Protection Services
- Life Prediction/Assessment
- On-the-job Training Programs
- Pipeline Integrity Management

## 1. CONSULTATION SERVICES IN CORROSION, FAILURE ANALYSIS AND METALLURGICAL ENGINEERING SERVICES

Materials engineering is the science and study of a material's physical, mechanical and corrosion properties. It is a large field with applications in many diverse industries. A common denominator in these industries is the processing and storage of flammable, toxic and corrosive liquids. Of paramount importance, both from an economic and safety viewpoint, is proper selection of materials to safely contain these environments. In an ideal world, the application of materials engineering knowledge would be confined to initial materials selection. Experience suggests however, that an ideal world does not exist, therefore the need for related material's disciplines to anticipate, evaluate and solve problems related to equipment and component failures. Our primary business focus is studying the root cause of mechanical and corrosion-related

equipment failures. We apply that knowledge to the prevention of failures through proper materials selection, corrosion monitoring, and suitability-for-service and remaining-life evaluations.

## 2. INHIBITOR AND WATER TREATMENT PROGRAMS

Tricontinental Oil Services Limited experts have developed a wide range of novel and cost effective corrosion inhibitors. In addition, we work with the world's best known manufacturers of corrosion inhibitors for protection of industrial facilities and to mitigate materials degradation in plants that are caused by corrosion.

Health, safety and pollution control.
Our formulations, using the newest chemical technology available, help alleviate concerns in the areas of health, safety, flammability and pollution control.

Multimetal protection.
A full range of corrosion inhibitors is available to protect ferrous and non-ferrous metals, including formulations that protect combinations of metals.

Short- and long-term protection.
We provide solutions for temporary protection during in-plant processing, medium-term protection for shipment and storage or extended protection for lay-up, mothballing and field service.

For a variety of environmental conditions.
We provide chemicals that will effectively protect metals and products against humidity and aggressive atmospheres as well as against corrosive industrial, marine and tropical atmospheres.

## 3. CORROSION MONITORING PROGRAMS

Corrosion monitoring is the process of acquiring additional information to evaluate the susceptibility to potential integrity concerns related to external corrosion, internal corrosion, 3rd party damage, and other modes of pipeline or equipment deterioration. For example, the development and implementation of an in-line inspection or close-interval survey program can be used to further evaluate the susceptibility to external corrosion-caused metal loss. Over 30 years ago, on-line corrosion monitoring was first applied in the oil production and refinery industry. The list of industries using on-line corrosion monitoring has since expanded to include water treatment, oil and gas transmission, chemical process, pulp and paper, electric power, and nearly every industry where corrosion is

a serious problem. On-line corrosion monitoring can be used to assess the integrity or remaining life of equipment, select new materials, and to assess equipment performance. With the advent of microprocessors, corrosion monitoring instruments have improved significantly. They now include "smart" instruments which increase the probability of collecting accurate data and make process control more reliable.

On-line corrosion monitoring can employ a continuous measure of corrosion rate, such as electrochemical techniques, or it can utilize periodic measures of corrosion. Examples of periodic measures of corrosion include: weight (mass)-loss coupons, electrical resistance (ER), and non-destructive testing (NDT). Electrochemical techniques that can be used for continuous monitoring and process control include: Linear Polarization Resistance (LPR), galvanic currents, Electrochemical Noise (EN), and Electrochemical Impedance Spectroscopy (EIS). Other measurements that are related to corrosion and can be used for monitoring include: potential, hydrogen detection, temperature, pH, and conductivity.

Each plant and process stream is different and selection of a compatible monitoring system is critical. Our staff are expert at analyzing a plant's needs and designing a monitoring system best suited to accomplish the desired goals.

Tricontinental Oil Services Limited can assist pipeline operators in the development of programs for corrosion control and on-line inspection and provide personnel to carry-out these programs. Typical monitoring programs are:

- On-Line Inspection
- Cathodic Protection
- Coating Survey
- Excavation Program
- Modeling
- Defect Assessment
- Structure Integrity Assessment
- SCADA (Supervisory Control and Data Acquisition)

In addition to this valuable service, corrosion monitoring can be used as a pro-active tool to assist with operating the plant in a more effective way, thereby prolonging life and gaining optimum throughput. For example, in the oil & gas industry the produced hydrocarbon liquids or gas and associated water are to some degree

variable in composition, temperature, pressure and flow rate. This causes complex corrosion and erosion problems in the production process equipment that are often episodic in nature.

Most operators seek to solve these problems by using some form of chemical treatment in conjunction with careful materials selection. In each case a fine balance must be found between the cost of treatment, the rate of plant deterioration and the rate of production if the business objective is to be met. Corrosion Monitoring is a key tool for this, advising when to treat and what the corrosion rate will be in any given mode of operation. This is information that can drive a continuous improvement process.

If you have the means to measure internal corrosion quickly and accurately you can control the level of damage that internal corrosion inflicts on your production systems.

Inspection techniques can only detect the loss of large amounts of material, so too much damage is done while you wait to find out about it. Our sensors are capable of detecting the loss of a few nanometers ($10^{-6}$ mm) of metal, a level of performance that is essential to achieve proactive control, prevent damage and extend plant life.

Measuring the effects of corrosion or erosion as they take place is the gateway to reduced capital costs, longer plant life and reduced risk.

Tricontinental Oil Services Limited can provide advanced sensors for measuring metal loss. The sensors can detect the loss of minute amounts of material as they are corroded or eroded away by the effects of oil & gas production in pipelines, vessels and flowlines. Applications include:

- Corrosion management and inhibitor optimization of topsides facilities
- Subsea systems such as flowlines, subsea manifolds and wellheads
- Long life monitoring of baseline locations and safe access to difficult locations

Each application group has its own carefully thought out solutions, tailored to the engineering needs of the application to deliver real cost benefits.

Decisions regarding the future integrity of a structure or its components depend entirely upon an accurate assessment of the conditions affecting its corrosion and rate of deterioration. With this

information, an owner can make an informed decision as to the type, cost and urgency of remedial measures. Monitoring corrosion characteristics of a proposed or existing structure can lead to the proper selection of longer life materials, durable and protective coatings, and corrosion control measures through cathodic protection or water treatment.

## 3. CATHODIC PROTECTION SERVICES

Cathodic Protection is used to control the corrosion of a wide variety of buried and submerged metallic structures. It has been demonstrated to be a cost effective way to extend the life of a structure and to ensure integrity throughout its operating life. Tricontinental Oil Services Limited will assist clients in choosing the correct application of cathodic protection technology. We have designed systems to operate and control corrosion in virtually every environment where cathodic protection presents a viable solution. We have proven record of designing new and more effective cathodic protection systems for extremely aggressive environments. Our extensive knowledge of the operating parameters and long-term performance characteristics of system components, allows us to choose the most appropriate systems to achieve the technical objectives, while carefully considering the client's economic requirements.

Tricontinental Oil Services Limited has developed new methods for monitoring the effectiveness of cathodic protection for complex structures in complex environments.

## 4. LIFE PREDICTION/ASSESSMENT

The strategy to develop and implement integrity management programs is unique for each pipeline operator. Typically, the status of integrity programs is a function of operational experience, corporate philosophy and mandates, regarding asset management. As a result, there is no singe approach that provides the best solution for all pipeline systems.

Tricontinental Oil Services Limited brings a balanced approach to pipeline integrity through four components: **Assessment, Monitoring, Mitigation, and Life Extension**. These components provide the means to develop a comprehensive integrity management program tailored to meet specific needs and situations for each pipeline operator and pipeline system.

**ASSESSMENT** is the process of evaluating relevant technical information and date to assess the integrity of the system. This assessment can focus on particular failure modes, such as external or internal corrosion, or consider all potential failure modes and consequences. These types of assessment provide the relevant data required to develop a formalized risk assessment model.

**MITIGATION** is the action required to address integrity concerns. These actions can include redemption through excavation and/or repair, modifications to operations and maintenance (cathodic protection, operating conditions), and monitoring programs. Tricontinental Oil Services Limited can assist pipeline operators in the development and design of mitigation strategies to address integrity concerns.

- Cathodic Protection System
- Re-coating
- Pipe Replacement
- Repair Options
- Cleaning and Inhibiting
- Geo-technical
- Operations
- Hydrostatic Testing

**LIFE EXTENSION** is the process of using all of the results acquired through the assessment, monitoring, and mitigation strategies to develop a long term integrity management program. The results of this process are used to identify the most appropriate strategy for continued monitoring, mitigation, and re-assessment. Tricontinental Oil Services Limited can identify the most appropriate future actions and schedules required to maintain the long term integrity of the pipeline system.

- Maintenance Strategies
- Growth Analysis
- Re-inspection
- Re-survey
- Fitness for Purpose Assessment
- Cost-Benefit Analysis
- Root-cause Forensics

## 5. COATING APPLICATION AND INSPECTION SERVICES

The coating inspector is a quality assurance person whose job it is to ensure that all aspects of a coating job are handled according to the written coating specification, assuming one is available. Essentially, the inspector is a third party observer who understands

all aspects of the job but performs none of the individual tasks; he/she makes sure that the job is done in the specified way with the specified materials by the proper procedure.

For good long-term performance of a coating application, an essential component is to have a trained, qualified coating inspector. Tricontinental Oil Services Limited offers NACE certified coating inspection for QA on coating jobs.

In addition to traditional coating inspection duties, Tricontinental Oil Services Limited can offer expert consultation on matters above and beyond the normal duties of the inspector. These include specification development and review, laboratory testing of coatings, on-site QC testing, assistance with materials selection, and corrosion surveys.

## 6. NDT LAB AND FIELD INSPECTION SERVICES

Our NDT service is led by specialists who have over 20 years of experience in NDT, and who hold ASNT level III certificates. We provide timely and quality inspection services in both traditional and advanced NDT capabilities.

**The Fields/Areas We Cover**

- Oil and Gas Pipeline
- Petrochemical Plant
- Power Plant (including nuclear power plant)
- Construction
- Aerospace and Aircraft
- Fabrication
- Railroad

**Available NDT Methods - UT, RT, MT, PT, VT, ET, AE, and IR**

- Radiographic Inspection: x-ray (110KV - 400KV) and r-ray
- Ultrasonic Inspection:
    1. Conventional Ultrasonic Inspection:
        - Flaw detection of welding, casting, forging, other metal and non-metal materials (pipe, tube, plate, bar), concrete structure, and rubber, etc.
    2. Advanced Ultrasonic Inspection:
        - Mechanized/Automated Ultrasonic Inspection:

- **Multichannel automatic pipeline, pressure vessel, and tank inspection**
- Advanced B, C, 3D scan image ultrasonic inspection
- TOFD scanning with B-scan inspection.
- Internal rotary inspection system for heat exchanger tube and boiler tube
- Lamb guide wave inspection for tube and plate structure and aircraft composite materials

- Eddy Current Inspection:

1. Remote field eddy current inspection for ferromagnetic boiler tube and heat exchanger tube
2. Eddy current inspection for non-ferromagnetic materials
3. Alloy sorting
4. Thickness measuring

- Liquid Penetrant Inspection:

  Fluorescent and visible liquid penetrant inspection for the detection of surface defects on metal or non-metal

- Magnetic Particle Inspection:

  Magnetic particle inspection for detection of surface or subsurface defects of ferromagnetic materials.

## 7. TRAINING PROGRAM

The goal of the program is to provide engineers through in-house training with a basic overview of corrosion and material science. This basic knowledge is aimed to enhance the ability of the engineers to conduct **basic** studies on the mitigation of corrosion and other material degradation problems in industrial services. The training program will be conducted by acclaimed world experts in the field over a period of 1 to 2 weeks depending on the need the of the client.

WHO SHOULD ATTEND? Plant inspectors, Maintenance Engineers and Technologists, Process and Mechanical Engineers, Chemical Engineers, Design Engineers, Graduate and Technical Engineers new to Oil and Gas industry

**Objective of the training program:**

By the end of the program, delegates will:

- Understand the fundamentals of corrosion
- Appreciate the significant factors influencing corrosion in oil and gas production
- Have devised strategies for corrosion monitoring and inspection
- Understand the concepts of corrosion, risk assessment and corrosion management planning