FERTILIZER ACADEMY

Knowledge hub for the Fertilizer industry

Course title:

Extensive General Corrosion Engineering Course

Introduction:

This extensive corrosion engineering training course starts with explanation of the mechanism of electrochemical corrosion reactions. Thermodynamic principles and electrode kinetics are being revealed. The electrochemical corrosion theory is applied on corrosion reactions.

The training describes in detail all possible corrosion failure modes which may occur in all kinds of chemical and petro-chemical process plants. The parameters which will influence these failure modes are extensively described. The training addresses comprehensively the optimal choice of materials of construction in corrosive circumstances out of the wide range of these materials of construction.

In solving corrosion problems this course will support you in selecting the correct trade-off between the different approaches of:

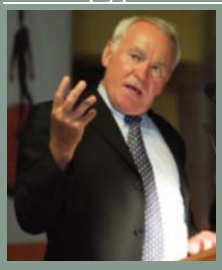
- Changing design.
- Alternative material of construction.
- Application of coating systems.
- Changing electrode potential (anodic or cathodic protection).
- Changing the environment by e.g., application of an inhibitor.

Awareness will be created to implement a risk-based inspection (RBI) philosophy. The results of RBI inspections will contribute to a predictive/preventive maintenance of equipment operating in corrosive circumstances. Such a predictive/preventive maintenance is a pre-requisite for safe operation of (petro-) chemical plants.

Furthermore, attention is paid to quality control of materials of construction, laboratory investigations and on-line corrosion monitoring techniques.

Duration 45 hours

Author(s) / Trainer(s):



Giel Notten

Materials & Corrosion Engineer,

Giel Notten is a materials and corrosion expert who, spent thirty-eight years working with DSM in The Netherlands. After gaining his Chemical Engineering degree he joined DSM's Materials and Corrosion Department and was heading this Department as Managing Senior Corrosion Engineer. In this job he was involved in a broad range of consultancy activities for numerous (petro-)chemical plants. For Stamicarbon, a previous subsidiary company of DSM, and licensing DSM's know-how, he set up programs for lifetime assessment studies, based on RBI philosophy, in numerous urea and ammonia plants and supervised these studies. Giel was also involved in the development of Safurex®, the super-duplex stainless steel grade (developed by Sandvik in cooperation with Stamicarbon) for application in Stamicarbon urea plants.
He was a board member of NACE Benelux and a member of the Contact Group Corrosion of the Dutch Chemical Process Industry.

Since his retirement from DSM, Giel started his own company NTT Consultancy in 2006 and has remained active as a materials and corrosion engineering consultant for many companies all over the world. He has devoted much of his time to passing on his knowledge and experience on the topic of corrosion engineering to a new generation of engineers in corrosion courses and trainings; numerous trainings have been presented. In cooperation with UreaKnowHow (in-house) training sessions have been organized and presented to more than 1000 urea engineers, managers, (shift-) supervisors and operators from all over the world. Several workshops have been presented in cooperation with UreaKnowHow for CRU in Nitrogen & Syngas Conferences.

Giel published many technical papers in reputable industry magazines and collected his knowledge and experience, illustrated with numerous cases of corrosion, in a book entitled Corrosion Engineering Guide.

Course outline:

Module 1: Introduction and Electrochemistry

1. **Introduction.**
   a. Importance of corrosion prevention and control.
   b. Improved equipment reliability by means of Equipment Condition Monitoring.

2. **Electrochemistry.**
   c. Introduction.
   d. Thermodynamic principles:
      - Change in free energy ΔG.
      - Cell potentials and EMF-series.
      - Nernst equation.
      - Pourbaix diagrams.
   e. Electrode kinetics:
      - Polarization.
      - Evans diagrams.
   f. Application of electrochemical corrosion theory on corrosion reactions:
      - Corrosion in acid and neutral/alkaline solution.
      - Passivity.
      - Effect of oxidizers.
      - Velocity effect.
      - Influence of alloy composition.
      - Influence of temperature.

Module 2: Forms of Corrosion: Electrochemical

1. **Introduction.**
2. **Electrochemical forms of corrosion:**
   a. Uniform corrosion.
   b. Galvanic corrosion.
   c. Pitting.
   d. Crevice corrosion.
   e. Intergranular corrosion.
   f. Selective attack.

Module 3: Forms of Corrosion: Electrochemical - Mechanical

1. **Introduction.**
2. **Electrochemical - Mechanical forms of corrosion:**
   a. Stress Corrosion Cracking (SCC).
   b. Corrosion fatigue.
   c. Erosion-corrosion.

Module 4: Forms of Corrosion: Physical - Metallurgical

1. **Introduction.**
2. **Physical-Metallurgical forms of corrosion:**
   a. Hydrogen damage.
   b. Liquid metal embrittlement (LME).

Module 5: Forms of Corrosion: High Temperature corrosion failure modes

1. **Introduction.**
2. **High Temperature corrosion /failure modes:**
   a. Oxidation / sulphidation.
   b. CO-attack.
   c. Metal dusting.
   d. High Temperature Hydrogen Attack (HTHA).
   e. Nitriding.
   f. Creep.
   g. Carburization.

Module 6: Forms / Types of Corrosion: Corrosion Under Insulation (CUI); Atmospheric corrosion

Note: relative short version; separate course for more extensive masterclass training on this topic.

1. **Introduction.**
2. **Morphology of forms of CUI (atmospheric corrosion).**
3. **Conditions / parameters promoting atmospheric corrosion and CUI.**

4. **Preventive measures to minimize the risk of CUI.**
5. **Case histories of atmospheric corrosion and CUI in (petro-) chemical industries.**

Module 7: Forms / Types of Corrosion: Soil Corrosion and Microbiologically Induced Corrosion (MIC)

1. **Soil Corrosion.**
   a. Introduction.
   b. Mechanism and morphology of soil corrosion.
   c. Conditions / parameters promoting soil corrosion.
   d. Preventive measures to minimize the risk of soil corrosion.
   e. Case histories of soil corrosion.

2. **Microbiologically Induced Corrosion (MIC).**
   a. Introduction.
   b. Mechanism and morphology of different types of MIC.
   c. Conditions / parameters promoting MIC.
   d. Preventive measures to minimize the risk of MIC.
   e. Case histories of MIC.

Module 8: Corrosion in Utility Systems: Cooling Water and Steam Systems

Note: relative short version; separate course for more extensive training on both topics.

1. **Corrosion and fouling control in cooling water system.**
   a. Introduction.
   b. Typical corrosion failure modes in cooling water systems; mechanism and morphology.
   c. Parameters promoting the failure modes and preventive measures.
   d. Materials of construction for heat exchangers.
   e. Cooling water treatment programs; inhibitors.
   f. Case histories of corrosion in cooling water systems.

2. **Corrosion control in boiler (-feed) water and steam systems.**
   a. Introduction.

b. Typical corrosion (-erosion) failure modes in steam systems; mechanism and morphology.
c. Parameters promoting corrosion in steam systems.
d. Preventive measures to mitigate corrosion (-erosion) failure modes in steam systems.
e. Case histories of corrosion (-erosion) in steam systems.

Module 9: Corrosion Prevention and Protection

1. **Introduction.**

2. **Design and lay-out**
   a. Introduction.
   b. Relevant design parameters to mitigate corrosion.
   c. Case histories.

3. **Materials selection.**
   a. Introduction.
   b. Carbon steel, low alloy steels and cast iron.
   c. Stainless steels: ferritic, martensitic, austenitic.
   d. Duplex stainless steels.
   e. Nickel and nickel (cobalt) alloys.
   f. Copper and copper alloys.
   g. Aluminum and aluminum alloys.
   h. Titanium, Zirconium and Tantalum (and -alloys).
   i. Plastics.

4. **Protective layers**
   a. Introduction.
   b. Metallic, inorganic, and organic coatings.

5. **Changing corrosive environment.**
   a. Introduction.
   b. Influence of temperature. pH, oxygen content, velocity.
   c. Application of inhibitor systems.

6. **Changing electrochemical potential.**
   a. Introduction.
   b. Cathodic protection (CP).
   c. Anodic protection (AP).

d. Case history: Experiences with anodic protection in a sulphuric acid plant.

7. **Chemical industrial cleaning.**
   a. Introduction.
   b. Corrosion aspects regarding chemical cleaning.
   c. Selection of water quality for flushing or hydrostatic pressure testing of stainless-steel equipment.

Module 10: Corrosion examination, inspection, and monitoring

1. **Introduction.**

2. **Corrosion examination.**
   a. Introduction.
   b. Field exposure testing.
   c. Electrochemical investigation methods.
   d. Laboratory testing.

3. **Quality control of materials of construction.**
   a. Introduction.
   b. Methods of quality testing.

4. **Corrosion inspections.**
   a. Introduction.
   b. Risk Based Inspection (RBI) philosophy.
   c. Non-destructive inspection techniques.

5. **On-line corrosion monitoring.**
   a. Introduction.
   b. On-line monitoring techniques.
   c. Case: Experience with neutron activation for real-time corrosion monitoring in a Urea plant.

Learning outcomes:

By the end of this training course, you will understand:

- The mechanism of the (electrochemical) forms of corrosion.

- The threat of safe operation of your plant without the knowledge to take preventive measures to mitigate the threatening failure modes.
- Your own corrosion problems as a recognition out of the numerous case histories which are reviewed during this training.
- The different approaches to control and to mitigate corrosion: good engineering design. proper selection of materials of construction; changing the corrosive environment (application of inhibitors); application of protective layers; changing the electrode potential (cathodic and anodic protection).
- The importance of inspections based on a Risk Based Inspection (RBI) philosophy. RBI programs should be composed in a multidisciplinary team to create awareness in the whole organisation. The results of an RBI inspection provide reliable data for the maintenance group to perform a predictive/preventive maintenance which is a pre-requisite for safe operation of (petro)chemical plants.
- The necessity of quality control of materials of construction for critical equipment in corrosive circumstances.

Who will benefit:

Employees who are responsible or share responsibility with respect to the mechanical integrity and safe operation of (petro)chemical process plants: process, mechanical, maintenance, corrosion, and inspection engineers.

Employees who work for manufacturers of materials of construction and those who give advice in the application of materials of construction in (petro)chemical process industries.

Employees of companies involved in maintenance projects in the (petrochemical process industries.

Employees of research and investigation institutions involved in corrosion research or corrosion failure modes.

Students at technical universities studying in the field of metallurgy, corrosion, and material science.

Course materials:

- Hand-out presentation slides in PDF format

Price:

€ 4.000

Discounts:

- 2 places – 10% discount
- 3 places – 15% discount
- 4 or more places – 20% discount
- 5 or more places – 25% discount

In-company training:

This course is also available as an in-company course (face-to-face or online) where content can be customised to meet your organisation's specific needs and delivered on a date/location that suits your requirements.

Contact us for more information.

Training code: MAT10

On request the electronic (recently revised) version of the Corrosion Engineering Guide (> 800 pages) is available for additional costs of **€95.00**