# Examination program
# Level 1
# Marine metallic structures application sector

## Program of the theoretical session « Common Core »

The level of knowledge of the different chapters shall be progressively increased from Level 1 to Level 4 to conform to the levels of competency defined in Clause 4 of EN ISO 15257 :2017 standard and the tasks defined in the program of the practical session.

| Description of knowledge |
|---|
| Electricity relevant to CP application and measurements |
| Corrosion, electrochemistry and coatings relevant to CP |
| Theory, principles and criteria of CP |
| Requirements related to application of CP |
| Application methods of CP, galvanic anodes, impressed current |
| CP measurements and test procedures |
| Relevance of voltage gradient errors and influence on structure to electrolyte potential measurement |
| Factors influencing the correct selection of reference electrodes for potential measurements |
| Effects of excessive CP on coatings, high-yield strength steels and corrosion-resistant alloys |
| Diagnostics of CP systems |
| Interference conditions (alternating current and direct current) |
| Standards and codes of practice in the relevant application sector |

The knowledge required to meet the descriptions in the table above to prepare a Level 1 certification in the marine metallic structures application sector includes:

### Electricity relevant to CP application and measurements

- Direct current (DC)
  - Notion of circuit, conventional current direction
  - Potential difference, current intensity, Ohm's law
  - Direct current generators, batteries, other sources
- Measurements and measurement equipment
  - Voltage, intensity, resistance
  - Multimeters, input impedance and its influence on the measurement
  - Notions of electric direct current and of current density
- Electrical protection, safety
  - Electrical safety of people during interventions (individual protections, insulating tools)

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## Corrosion, electrochemistry and coatings relevant to CP

- Terminology
  - Atoms, electrons, ions, chemical reactions
  - Notions electronic conductors and ionic conductors
  - Notions of resistivity
  - Metals
- Electrodes reactions
  - Anode, cathode, electrode
  - Electrode potential and reference electrodes
  - Notion of galvanic series
  - Notions about the Faraday's law
- Electrolytic environments
  - Specific environments: Natural waters, seawater, soils, concrete
- Metals and aaloys
  - General information about the main families of industrial metallic materials concerned with cathodic protection
- Corrosion
  - Definition
  - Measurement of the electrode potential of a metal in an electrolyte
  - Notions of passivation
- Types of corrosion
  - Generalized corrosion
  - Localized corrosions
  - Corrosion by direct stray
- Corrosion rate
  - Notions et units

## Coatings

- Roles of coatings
  - Coating supplementing cathodic protection
- Main properties of coatings
  - Risks of corrosion under non adherent coatings to steel (maintaining adhesion)
- The detrimental effects of cathodic protection
- Control of electrical insulation of coatings

## Theory, principles and criteria of CP

- Definitions and basic principles
- Criteria of steels in different environments
- Cathodic protection systems[2]:
  - Impressed current system
  - Galvanic anodes system

## CP Application Requirements

- Implementation of a passive protection
- Insulation of the structure to be protected from other structures

## CP application methods, galvanic anodes, impressed current

- Protection system using galvanic anodes
  - Anodic materials (open circuit potential and closed circuit potential)
- Impressed current protection system
  - Impressed current anodes: Materials that can be used
  - Selection criteria of anodic material in the main electrolytic environments
  - Various types of stations : by impressed current, by impressed voltage, servo-control systems using a pilot reference electrode
- Auxiliary equipment: cables, isolating joints, potential test points

## Measurement and CP monitoring procedures

- Equipment
  - Voltage measurement
  - AC or DC measurement: Ammeter, use of shunts, AC or DC amperometric clamps
  - Checking of the reference and measurement electrodes compared to a calibrated electrode
  - Metrological monitoring of measurement and control devices
  - Metallic coupons, associated or not with a reference electrode
  - Switchers
- Potential measurement
  - “ON” current measurement: punctual or with recording
  - Notion of ohmic drop related to the location of the reference electrode compared to the controlled metallic surface
- Measurements of intensity and current density
  - Measurement of the direction and of the intensity of a current that circulates in a structure
  - Determination of the current densities on structures or metallic coupons. Factors influencing the results
- Various measurements
  - Measurement of the resistivity of an electrolyte

## Relevance of errors due to the potential gradient and influence on the measurement of the structure/electrolyte potential

Not studied

### Factors influencing the correct selection of reference electrodes for potential measurements

It is necessary to know :
- Reference electrodes and measurement electrodes used according to the various environments
- Les facteurs influençant la mesure
    - influence of chlorides
    - influence of temperature
    - influence of light

### Effects of excessive CP on coatings, high strength steels and corrosion resistant alloys

Not studied

### PC system diagnostics

Not studied

### Interference conditions

- Name the different sources of interference (continuous) and the associated risks of corrosion

### Standards and practical recommendations in the relevant application sector

Need to know the purpose of the following standards :

- EN ISO 15257 :2017 Cathodic protection — Competence levels of cathodic protection persons — Basis for a certification scheme
- Main standards related to CP practice in the relevant application sector.

## Program of the theoretical session « Submerged structures »

### Corrosion and materials

- Sea water, brackish water, salinity, chemical composition, resistivity and conductibility
- Sea-bed, resistivity, presence of bacteria
- Main metals and alloys used in sea water
- Order of magnitude of the potentials of main metals and alloys in sea water
- Corrosion in marine environments
    - Order of magnitude of the corrosion rate for carbon steel according to the different exposure zones
    - Localized corrosions of stainless steels (punctures, cavernous corrosion)

### General theory of cathodic protection

- Measurement electrodes used in seawater, checking
- Protection criteria expressed with these electrodes, matching
- Protection current density in seawater and sea-beds
- Study of coatings

## Cathodic protection systems

- Protection systems by galvanic anodes used on structures in seawater
    - Most used anodic materials, main characteristics, practical mass consumption, potential, selection criteria
    - Main examples (harbours, ships, offshore structures, immersed pipelines, etc)
- Impressed current protection system used in seawater
    - Most used impressed current anodes (platinized Titanium, MMO Titanium, etc) and main characteristics
    - Main examples (harbours, ships, offshore structures, immersed pipelines, etc)

## Measurement techniques – equipment

- Equipment used in seawater, specific material for subaqueous measurements
    - O Potential measurement starting from the surface with mobile electrodes moved by a diver, a remotely operated vehicle (ROV) or in free immersion
    - O Potential measurement starting from the surface with fixed monitoring electrodes
    - O Potential measurement using a self-contained equipment ("gun") operated by a diver or a remotely operated vehicle (ROV)
- Current measurements on the surface (electric cables of impressed current anodes) using shunts or amperometric clamp
- Subaqueous current measurements on electric cables of impressed current anodes or in galvanic anodes supports using marinized amperometric clamp
- Specificities of measurements on longilineal structures (immersed pipelines)
    - O Potential measurement using uncoiled wire
    - O Potential measurement with " endless " electrode
    - O Measurement of close potential gradients
- Resistivity measurement of an electrode and resistance measurement

## Coatings

- Roles of coatings applied to sea structures
- Types of coatings used on compact sea structures (harbour structures, ships)
- Types of coatings used on longilineal sea structures (pipelines, " risers")
- Main properties of coatings used on sea structures
    - Mechanical damages
    - Cathodic protection effects

# Practical session program

**Tasks to be fulfilled in all application sectors for Level 1**

- Check calibration validity of CP measuring and testing equipment based on documentation
- Measure structure to electrolyte potential
- Perform verification test of working portable reference electrode against master electrode of the same type based on measurement
- Identify a wrong polarity of the CP system by structure to electrolyte potential measurement
- Record and report results of the measurements in a comprehensible format
- Measure current and voltage in the CP circuit
- Carry out basic maintenance work on CP systems
- Inspect and measure of DC power supply output current and voltage
- Inspect and maintain DC power supply output terminations if accessible without exposing persons to live AC equipment
- Verify DC power supply voltage and current outputs with portable calibrated meter
- Ensure compliance with safety requirements related to application of CP in the application sector, task and competence level
- Perform risk assessment of safety requirements related to application of CP in the application sector, task and competence level
- Set up measuring and testing equipment and verify equipment settings

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**Specific tasks for marine metallic structures application sector for level 1**

- Measure structure to electrolyte potential in seawater from surface with portable reference electrode
- Measure structure to electrolyte potential in seawater from surface with monitoring systems (permanent reference electrodes and connection by cables or acoustic transmission)
- Measure structure to electrolyte potential in seawater with portable reference electrode connected to measurement system on surface
- Measure structure to electrolyte potential in seawater by combined measurement device including reference electrode, voltmeter and contact tip
- Measure anode current output from surface using monitoring systems (monitored anodes and connection by cables or acoustic transmission)
- Measure current output of stand-off anodes using underwater clamp meter
- Measure current and voltage in the CP circuit
- Inspect and measure DC power sources output current and voltage
- Inspect and maintain DC power sources output terminations and check polarity
- Verify DC power sources voltage and current outputs with portable calibrated meter