# DONG YANG CORROSION ENG.

# Introduction

To our valued customers and friends,
Dong Yang Corrosion Engineering Co., Ltd. (DYCE) has been acknowledged as the most experienced corrosion engineering company in South Korea and has accomplished numerous projects worldwide since 1970.

DYCE is staffed with most experienced managers, the best corrosion engineers and technicians, and its labor force is dedicated and well-trained in this fields.

With these facts, you can be assured of DYCE as one of the most reliable companies in the world. Members of DYCE proudly would like to assure that our company is in a good position to meet your requirements to be satisfied. We sincerely hope that the information furnished here will receive your kind attention and consideration.

Sincerely yours,
Sang Wha Jung / Chairman
Dong Yang Corrosion Engineering Co., Ltd.

# CONTENTS

# I. COMPANY

## History

| | |
|---|---|
| 1970.07.07 | Dong Yang Cathodic Protection Construction Co., Ltd. founded in Seoul, Korea |
| 1972.09.20 | Acquired Patent No.3822 (Zinc Alloy Anode), No. 3825 (Pt-Ti Anode) |
| 1972.10.18 | Acquired Patent No.3885 (Al Alloy Anode) |
| 1973.05.01 | Approved by U.S. Army Corps of engineers as material and design supplier of Cathodic protection for the first time in Korea |
| 1976.08.21 | Made inroads into market of the Middle east |
| 1978.05.16 | Obtained license for contracts of 1st class Electric Works |
| 1981.12.18 | Made inroads into market of Libya |
| 1982.05.29 | Designated as local manufacturer of cathodic protection material & equipment for KEPCO (Korea Electric Power Corporation) |
| 1983.03.29 | Made a contract with Marjan Offshore Platforms no.2,3,4 to provide material and design of cathodic protection |
| 1984.03.13 | Received the Citation of Prime Minister on Marine Transportation Day |
| 1984.07.20 | Selected as promising company by Small & medium-Business Corporation |
| 1985.11.18 | Selected as superior enterprise by Industrial Bank of Korea |
| 1989.02.28 | Obtained license for Trade business |
| 1989.04.17 | Designated as manufacturer of nuclear power plant field for KEPCO |
| 1991.11.09 | Received the Technology Award of Korean Association for Corrosion Study |
| 1995.02.21 | Acquired utility model rights No.086099 (Protective Cover for Pile Landing Pier) |
| 1997.04.22 | Obtained ISO9001 Certification |
| 1998.01.29 | Obtained Quality Certificate for Al-anode from Japan Government (SCOPE) |

2000.08.15 Registered with Qatar General Petroleum Corporation (Qatar) as supplier

2001.06.02 Registered with Kuwait National Petroleum Company (KNPC) as supplier

2002.03.01 Registered with GMRA (Great Man-Made River Authority) in Libya

2003.02.10 Registered with ARAMCO in Saudi Arabia

2003.12.24 Acquired NET (New Excellent Technology) No.N038 (Manufacturing Technology of Mixed Metal Oxide for Cathodic Protection System)

2004.02.18 Received the Mayor Award by Choenan city, Korea

2004.03.31 Received the Export Leadership Award by Small and Medium Business Administration

2004.11.17 Acquired utility model rights No.0368788 (Remote Corrosion Monitor and Electrolytic Protection Control System of Underground Facilities)

2005.10.23 Registered with KHNP (Korea Hydro & Nuclear Power Co., Ltd.) as supplier

2006.06.30 Developed "Steel Cored Zn Ribbon Type Anode by continuous casting method" with Kongju National University

2007.12.24 Registered with U.A.E. GASCO as supplier

2008.10.28 Obtained ISO14001:2004 Certification and OHSAS 18001:2007

2009.10.28 Registered with U.A.E. Abu Dhabi Gas Liquefaction Company Ltd. (ADGAS) as manufacturer

2009.12.18 Received the Best Supplier Award of SK Engineering & Construction

2010.07.22 Registered with Kuwait Oil Company (KOC)

2010.11.30 Received the $10million Export Award by Korea International Trade Association

2010.12.13 Registered with U.A.E. Abu Dhabi Company for Onshore Oil Operations (ADCO) as manufacturer

2011.08 Established Kuwait Branch office

2011.08.24 Registered with Saudi Basic Industries Corporation (SABIC) as supplier

2013.01.01 Registered with Saudi Electricity Company (SEC) as supplier

2013.10.05 Registered with U.A.E. ADMA as supplier

2014.02.17 Acquired Patent No.10-1366371 (Cathodic Protection Management Apparatus and the Potential Detection Method Using the Apparatus)

2014.04.30 Acquired Patent No.10-1393191 (Cathodic Protection Management Apparatus and the CIPS Detection Method Using the Apparatus)

2014.10.14 Acquired Patent No.10-1452847 (Optical Fiber Sensor Probe for Pitting Corrosion Detection and Oil or Gas Leak Detection System of Oil Pipeline using the same)

2015.01.01 Received the NACE Gold Corporate Membership

2015.12.02 Registered with Saudi Arabia National Water Company (NWC) as supplier

2016.01.06 Registered with Program No.C-2016-000528~30 (CPRMCS : Cathodic Protection Remote Monitoring Control System) by Korea Copyright Commission

2016.02.22 Registered with Oman JSRS and Ministry of Oil & Gas (Oman) as supplier

2017.01.11 Registered with Fluor as manufacturer

# 2. SCOPE OF CATHODIC PROTECTION BUSINESS

## ■ Engineering Services for Cathodic Protection

- Field Survey
- Basic and Detail Design
- Installation and Supervision
- Testing and Commissioning
- Operation and Maintenance
- Evaluation for Cathodic Protection Facilities
- Inspection
- Training
- Direct Current Voltage Gradient (DCVG) and Close Internal Potential Survey (CIPS)

## ■ Corrosion Consulting

- Material & Corrosion Engineering
  - FEED (Front End Engineering Design)
  - Material Selection
  - Corrosion Study (CCD, CCM, CRA)
  - OSI Program – TML Selection
- Corrosion Control & Inspection System
  - RBI (Risk Based Inspection)
  - Corrosion Control
  - Plant Corrosion / Inspection Guide & Practice
- Asset Assessment & Evaluation
- Failure Analysis

## ■ Material Supply for Cathodic Protection

- Mg Anode
- Al Anode
- Zn Anode
- MMO (Mixed Metal Oxide) - Ti Anode
- HSCI (High Silicon Cast Iron) Anode
- Pb-Ag, Pt-Ti, Pt-Nb Anode
- Liner Anode
- Transformer-Rectifier (Manual / Auto)
- Remote Monitoring & Control System (RMCS)

## ■ Miscellaneous Material Supply

- Portable & Permanent Reference Electrode - Cu/$CuSO_4$, Ag/AgCl, Zn
- CP Coupon
- HMWPE (High Molecular Weight Polyethylene) cable & other CP cable
- Cadweld Powder & Mold
- Coke breeze
- Pull Box, Junction Box, Terminal Box, Test Equipment

# 3. CATHODIC PROTECTION SYSTEM

## Corrosion and Cathodic Protection

When a metal corrodes in contact with an electrolyte (soil, water), neutral atoms pass into solution by forming positively charged ions, leaving excess electrons in the metal. The process is indicated for iron as followings: $Fe \rightarrow Fe^{++} + 2e^-$

Thus corrosion is accompanied by a flow of electric current from metal to electrolyte due to the movements of positive ions into the electrolyte and of electrons into the metal.

Any area where current flows in this direction is referred to as an anodic area, and the reaction is called an anodic reaction. The metallic ions may react with negative ions in the electrolyte to give insoluble corrosion products (for example, rust in the case of steel: $Fe(OH)_2$, $Fe_2O_3$)

**Anodic Area:**

· $Fe \rightarrow Fe^{++} + 2e^-$

**Cathodic Area:**

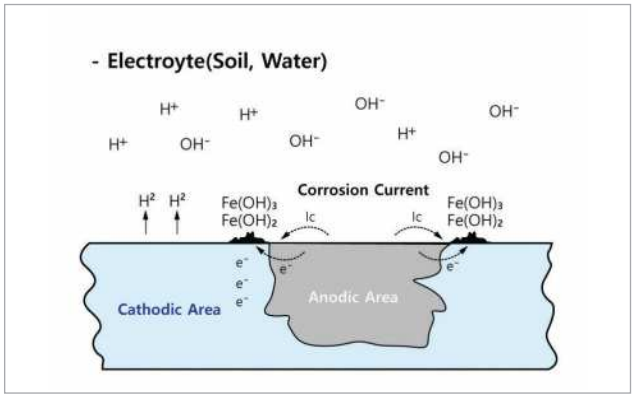
· $4H^+ + O_2 + 2e^- \rightarrow 2H_2O$

· $2H^+ + 2e^- \rightarrow H2 \uparrow$

**Electrolyte:**

· $Fe^{++} + 2OH^- \rightarrow Fe(OH)_2$
[Ferric hydroxide]

· $4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$
[Ferrous hydroxide]




**Principle of corrosion**

Therefore, corrosion on anodic site of steel surface can be described as following:

1) Process of energy discharge
2) Oxidation reaction
3) Electric current discharge

There are a great number of anodic and cathodic sites on steel surface that is immersed, submerged, or buried in electrolyte. Corrosion cells are formed in the anodic and cathodic sites and the corrosion cells are batteries and all batteries are corrosion cells.

As mentioned previously, corrosion only happen on anodic areas of steel surface and cathodic areas on steel surface are prevented from corrosion.

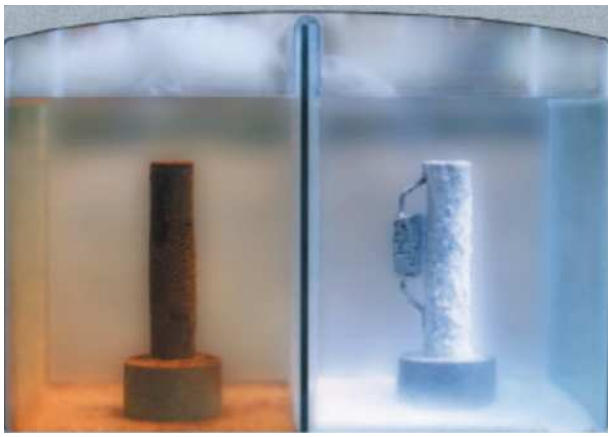
Then, all corrosion cells and all batteries contain four parts : an anode, a cathode, an external circuit, and an electrolyte (soil, water).

# 3. CATHODIC PROTECTION SYSTEM

Therefore, cathodic protection consists of impressing an electromotive force on a protected structure in such a way as to make the entire structure a cathode with respect to the adjacent electrolyte (soil, water).

This can be accomplished by using either auxiliary anodes to impress an EMF (electromotive force) from an outside source on the protected structure or by the sacrificial anode principle.

This manner of corrosion protection system to prevent steel structures from corrosion is called "Cathodic Protection System"



**Experimentation of cathodic protection**

## ■ Advantages of Cathodic Protection

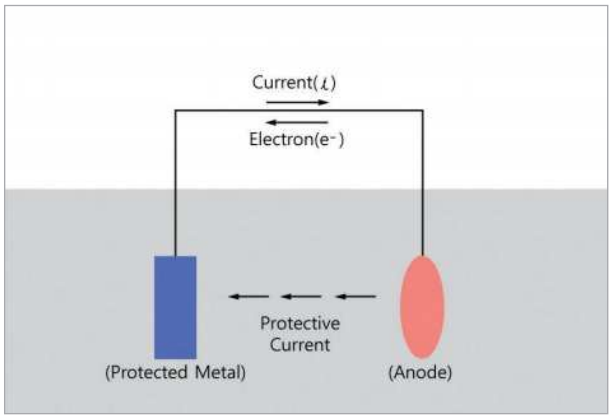
- Cathodic protection can provide larger anti-corrosion effect with less cost than other anti-corrosion methods such as painting and coating.
- As protective current can be supplied into such areas where coating is impossible or areas areas that are too finite, it can provide a complete anti-corrosion effect to the subject system.
- When cathodic protection method is applied to a system in which a certain degree of corrosion has been already progressed, it can prohibit further corrosion.

## Sacrificial Anode Cathodic Protection

In the sacrificial anode method, the protected structure to be placed under cathodic protection is metallically coupled to a metal less noble (more negative) than itself (the protected steel structure).

A galvanic cell is thereby established in which the protected structure becomes the cathode and the less noble metal, the sacrificial anode.

Current flows through the electrolyte (water, soil) from the anode to the cathode.




**Concept of SACP**

The system is designed so that sufficient current will flow from the anode to suppress all local action current on the surface of the protected structure.

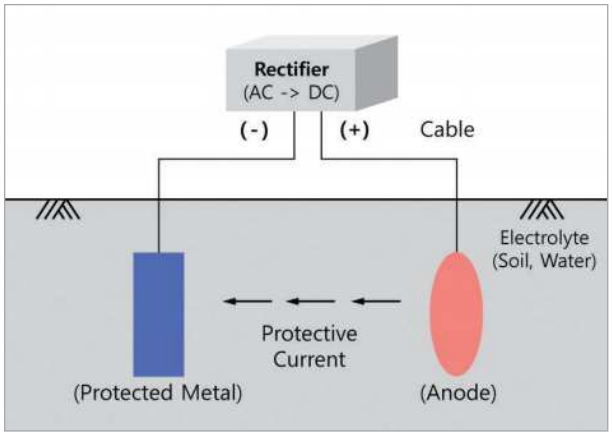
### ■ Properties of Sacrificial Anode System

- It is independent of any source of electric power
- It is less likely to affect any neighboring structures because the output at any point is low
- Cost for maintenance is very low
- Protective current distribution to the structure is uniform and good
- Its output cannot be controlled but there is a tendency for its current to be self-adjusting

## Impressed Current Cathodic Protection

In the impressed current method of cathodic protection, the anodes may consist of any conducting material found suitable for the purpose. Any available source of direct current, provided that it is continuous may be used.

Rectifiers are generally used for this purpose. The direct current enters the electrolyte (soil, water) from the anodes, flows to the protected structure, and is drained back to the current source through a metallic circuit.




Concept of ICCP

### ■ Properties of Impressed Current System

- Requires an external power source to impress DC current
- It can be applied to a wide range of structures
- Use is less restricted by the resistivity of the soil or water

# 4. ANODES

## Sacrificial Anodes

### Magnesium Anode

### ■ General

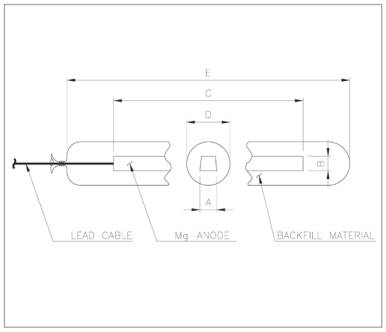
Magnesium anode is the most widely used metal in sacrificial anodes for underground structures and certain aqueous environments. Mg anode has the highest driving potential of sacrificial anodes. It is used for most direct U/G applications and in higher resistivity, aqueous electrolytes. They are available in a wide variety of forms and weights for many kinds of applications.

### ■ Product Properties

| Open Circuit Potential Cu/$CuSO_4$ [-mV] | Theoretical Current Capacity [A • hr/Kg] | Effective Current Capacity [A • hr/Kg] | Current Efficiency [%] | Consumption Rate [Kg/A•yr] | Specific Gravity |
|---|---|---|---|---|---|
| 1,650 | 2,200 | 1,100 | 50 | 8 | 1.80 |

### ■ Dimension and Weight

| Type | Dimension[mm] | | | | | Weight[Kg] | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | Bare | Package |
| 1.47R | 20 | | 1,000 | 200 | 1,200 | 0.66 | 45.5 |
| 9D2 | 70 | 76 | 550 | 152 | 787 | 4.08 | 15.9 |
| 14D2 | 70 | 76 | 850 | 152 | 1,168 | 6.35 | 22.7 |
| 17D3 | 90 | 96 | 642 | 165 | 736 | 7.71 | 20.4 |
| 32D5 | 133 | 142 | 500 | 195 | 700 | 14.5 | 30.0 |
| 60R | 175 | | 635 | 285 | 900 | 27.2 | 77.7 |



## ■ Chemical Composition

| Element | Backfill material |
|---|---|
| Al : 0.01% Max<br>Mn : 0.5~1.3%<br>Cu : 0.02% Max<br>Ni : 0.001% Max<br>Fe : 0.03% Max<br>Others : 0.3% Max<br>Mg : Balance | Gypsum : 75%<br>Bentonite : 20%<br>Sodium Sulfate : 5% |

## ■ Guidelines for Installation

- When installing Mg anode underground, surrounding area of anode should be filled with fine soil without stones or gravels.
- If possible, anodes should maintain at least 30cm distance from the subject to be protected.

# Aluminum Anode

## ■ General

Al anode makes an attractive sacrificial anode material, especially in low resistivity applications such as seawater and produced brines. Al anode has lower driving potential than Mg anode and higher current capacity than Zn anode, and these are important traits for its use in long life saline system.

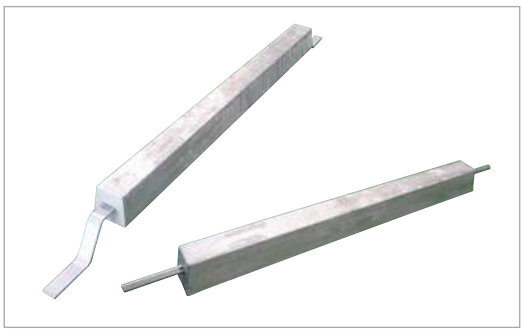
## ■ Product Properties

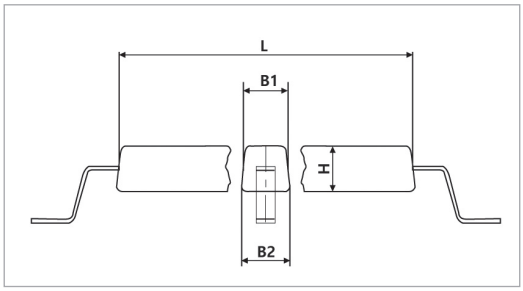
| Open Circuit Potential Cu/$CuSO_4$ [-mV] | Theoretical Current Capacity [A • hr/Kg] | Effective Current Capacity [A • hr/Kg] | Current Efficiency [%] | Consump-tionRate [Kg/A•yr] | Specific Gravity |
|---|---|---|---|---|---|
| 1,100 | 2,890 | 2,600 | 90 | 3.37 | 2.7 |

# 4. ANODES

## ■ Al Anode (Off-shore Type) Dimension and Weight

| Type | Dimension [mm] (B1 + B2) X H X L | Weight [Kg] | | Output current [A] ρ=30[ohm.cm] | Design life [Year] | Remarks |
|---|---|---|---|---|---|---|
| | | Net | Gross | | | |
| A1 | (170+150)x145x335 | 20.7 | 23.2 | 1.0 | 10 | |
| A2 | (170+135)x130x585 | 30.8 | 33.9 | 1.5 | 10 | |
| A3 | (160+125)x125x875 | 41.4 | 45.1 | 2.0 | 10 | |
| A4 | (155+115)x120x1,195 | 50.8 | 57.5 | 2.5 | 10 | |
| A5 | (155+120)x110x1,555 | 61.6 | 69.6 | 3.0 | 10 | |
| B1 | (235+200)x230x300 | 40.2 | 44.2 | 1.0 | 20 | |
| B2 | (225+190)x205x510 | 58.0 | 62.7 | 1.5 | 20 | |
| B3 | (220+180)x190x765 | 77.6 | 83.2 | 2.0 | 20 | |
| B4 | (200+170)x190x1,035 | 97.0 | 103.6 | 2.5 | 20 | |
| B5 | (195+165)x180x1,340 | 115.6 | 123.3 | 3.0 | 20 | |





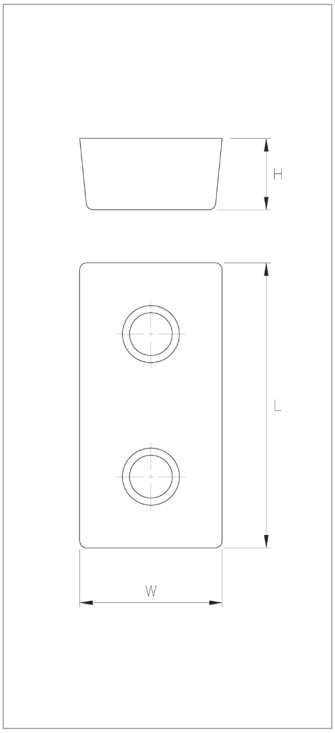
## ■ Al Anode (Stand-off Type) Dimension and Weight

| Type | Dimension [mm] | Weight [Kg] | | Remarks |
|---|---|---|---|---|
| | (B1+B2)xHxL | Net | Gross | |
| DPA-J10-1 | (145+120)x140x380 | 18.6 | 22.1 | |
| DPA-J10-2 | (140+110)x130x620 | 26.7 | 30.6 | |
| DPA-J10-3 | (150+125)x140x690 | 35.3 | 39.3 | |
| DPA-J10-4 | (130+105)x115x1,230 | 44.0 | 48.8 | |
| DPA-J10-5 | (125+100)x110x1,610 | 52.8 | 58.2 | |
| DPA-J10-6 | (125+100)x110x1,950 | 63.9 | 69.8 | |
| DPA-J15-1 | (180+155) x175x330 | 25.8 | 29.4 | |
| DPA-J15-2 | (170+145)x160x600 | 40.3 | 44.3 | |
| DPA-J15-3U | (160+140)x150x850 | 51.0 | 55.4 | |
| DPA-J15-4 | (160+135)x140x1,150 | 63.3 | 68.1 | |
| DPA-J15-5 | (150+125)x140x1,480 | 76.0 | 81.4 | |
| DPA-J20-1 | (215+190)x210x400 | 45.5 | 49.3 | |
| DPA-J20-2 | (205+170)x190x550 | 52.4 | 56.4 | |
| DPA-J20-3U | (270+210)x235x450 | 68.1 | 71.9 | |
| DPA-J20-4 | (225+195)x230x660 | 85.5 | 89.7 | |
| DPA-J20-5 | (180+150)x165x1,390 | 101.3 | 106.6 | |
| DPA-J20-6 | (175+140)x170x1,690 | 121.1 | 126.9 | |
| DPA-J30-1T | (295+265)x280x490 | 103.1 | 108.7 | |
| DPA-J30-2U | (295+265)x280x610 | 128.4 | 134.3 | |
| DPA-J30-3 | (295+265)x280x730 | 153.7 | 159.8 | |
| DPA-J30-4 | (225+195)x230x1,370 | 177.4 | 185.0 | |
| DPA-YX-1 | (210+200)x220x1,600 | 181.0 | 190.0 | |
| DPA-YX-2 | (240+220)x230x2,300 | 294.0 | 310.0 | |

# 4. ANODES

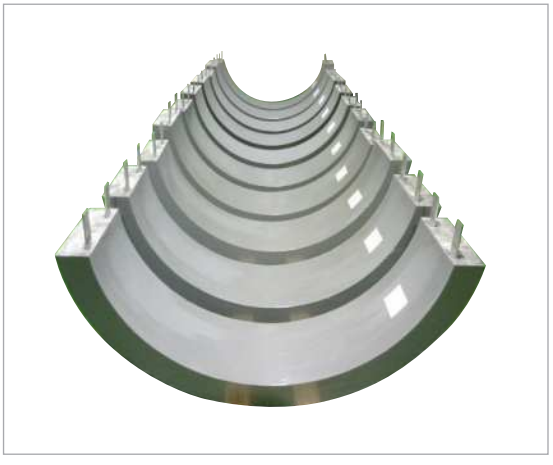
## ■ Al Anode (Plate Type) Dimension and Weight

| Type | Dimension [mm] | Weight [Kg] | Remarks |
|---|---|---|---|
| | L x W x H | | |
| DPA-B150-1 | 150 x 150 x 30 | 1.7 | |
| DPA-B150-2 | 150 x 150 x 50 | 2.9 | |
| DPA-B200-1 | 200 x 100 x 20 | 1.0 | |
| DPA-B200-2 | 200 x 100 x 30 | 1.5 | |
| DPA-B200-3 | 200 x 100 x 40 | 1.9 | |
| DPA-B200-4 | 200 x 100 x 100 | 4.8 | |
| DPA-B300-1 | 300 x 150 x 20 | 2.7 | |
| DPA-B300-2 | 300 x 150 x 25 | 3.2 | |
| DPA-B300-3 | 300 x 150 x 30 | 3.6 | |
| DPA-B300-4 | 300 x 150 x 40 | 4.4 | |
| DPA-B300-5 | 300 x 150 x 50 | 5.6 | |
| DPA-B300-6 | 300 x 150 x 60 | 6.4 | |




## ■ Al Anode (Bracelet Type) Dimension and Weight

- Anodes can be manufactured in various sizes according to the offshore pipe diameter.



## ■ Chemical Composition

| Element | DYCE | Alloy III | DNV |
|---|---|---|---|
| Zn | 1.0~5.0 | 2.8~3.5 | 2.5~5.75 |
| Sn | 0.01~0.15 | - | - |
| In | 0.005~0.03 | 0.01~0.02 | 0.015~0.040 |
| Mg | 1.0~3.0 | - | - |
| Fe | 1.0 Max | 0.12 Max | 0.09 Max |
| Si | - | 0.08~0.20 | 0.12 Max |
| Cu | - | 0.01 Max | 0.003 Max |
| Cd | - | - | 0.002 Max |
| Al | Balance | Balance | Balance |

* The chemical composition according to the international specification standard can be adjusted.

## ■ Application

- Platform, Dock, Barge, Steel pile, Pier, Tank and Vessel internal, Condenser, Heat Exchanger, Ship Ballast Tank, Offshore Pipeline, etc.

# 4. ANODES

## Zinc Anode

### ■ General

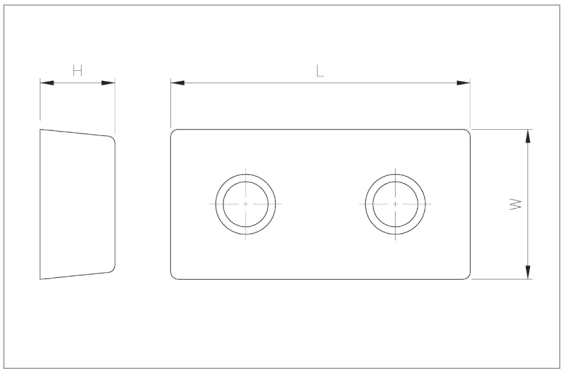
Zinc has the longest history of use in sacrificial cathodic protection methods. Zinc has been widely used for decades for both marine and soil applications. Zinc anodes are usually applied in low resistivity soils below 1,000 ohm-cm and in seawater or produced brines. Zinc is excellent when used as electrical grounds and special 99.99% pure Zinc is used as permanent reference electrodes under tank bottoms and inside vessels.

### ■ Product Properties

| Open Circuit Potential Cu/$CuSO_4$ [-mV] | Theoretical Current Capacity [A • hr/Kg] | Effective Current Capacity [A • hr/Kg] | Current Efficiency [%] | Consump-tion Rate [Kg/A•yr] | Specific Gravity |
|---|---|---|---|---|---|
| 1,100 | 820 | 780 | 95 | 11.23 | 7.1 |

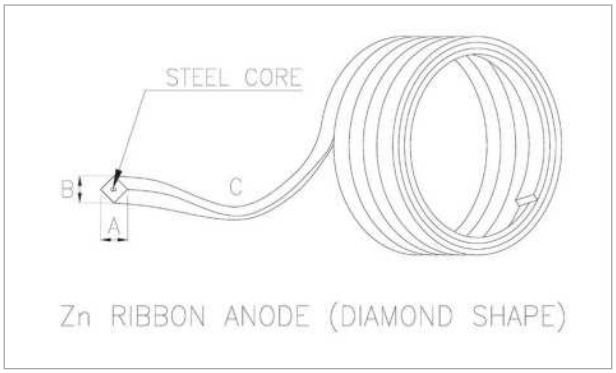
### ■ Zn Anode (Plate Type) Nominal Dimension and Weight

| Type | Dimension [mm] | Weight [Kg] | Remarks |
|---|---|---|---|
| | L x W x H | | |
| B1 B TYPE | 100 x 100 x 50 | 3.0 | |
| B2 B TYPE | 200 x 100 x 20 | 2.4 | |
| B3 B TYPE | 200 x 100 x 30 | 3.6 | |
| B4 B TYPE | 200 x 100 x 50 | 6.4 | |
| B5 B TYPE | 300 x 150 x 50 | 14.8 | |



## ■ Zn Anode (Ribbon Type) Nominal Dimension and Weight

| Type | Dimension [mm] | | | | Weight [Kg/m] | Remarks |
|---|---|---|---|---|---|---|
| | A [mm] | B [mm] | C [m/Drum] | Dia. of Steel Core [mm] | | |
| Small | 8.73 | 11.91 | 305 | 2.92 | 0.37 | |
| Standard | 12.7 | 14.29 | 250 | 3.30 | 0.89 | |
| Plus | 15.88 | 22.23 | 180 | 3.43 | 1.78 | |
| Super | 25.4 | 31.75 | 30.5 | 4.70 | 3.57 | |




## ■ Chemical Composition

| Element | DYCE | MILL SPEC. A-18001K | ASTM B418 TYPE I | ASTM B418 TYPE II |
|---|---|---|---|---|
| Al | 0.1~0.5% | 0.1~0.5% | 0.1~0.5% | 0.005 Max |
| Cd | 0.05~0.3% | 0.025~0.07% | 0.025~0.07% | 0.003 Max |
| Pb | - | 0.006 Max | 0.006 Max | 0.003 Max |
| Cu | - | 0.005 Max | 0.005 Max | 0.002 Max |
| Fe | - | 0.005 Max | 0.005 Max | 0.0014 Max |
| Si | - | 0.125 Max | | |

* The chemical composition according to the international specification standard can be adjusted.

## ■ Application

- Condenser, Hull, Ballast tank, Pier, Pile, Off-shore pipeline, Heat exchanger, Grounding cell, etc.

# 4. ANODES

## Impressed Current Anodes

### MMO-Ti Anode

#### ■ General

Mixed Metal Oxide (MMO)-Ti has been designed for use in all cathodic protection applications. These anodes are coated with MMO and is suitable for use in soils, carbonaceous backfill, fresh and brackish water, seawater and concrete.
MMO-Ti anodes have an extremely low consumption rate and high current capacity.



#### ■ MMO-Ti Tubular Anode

MMO-Ti tubular anodes are manufactured using titanium which meets ASTM B338 Grade 1 or 2 Standards.

| Environment | Anode Size [mm] | Output Current [A] | Lifetime [Years] |
|---|---|---|---|
| Calcined Petroleum Coke & Freshwater | Ø 19 x 1,220 | 7 | 20 |
| | Ø 25 × 500 | 4 | 20 |
| | Ø 25 × 1000 | 8 | 20 |
| | Ø 32 × 1220 | 12 | 20 |
| Seawater | Ø 19 x 1,220 | 45 | 20 |
| | Ø 25 × 500 | 25 | 20 |
| | Ø 25 × 1000 | 50 | 20 |
| | Ø 32 × 1220 | 75 | 20 |

∗ It is possible to achieve longer life by increasing coating density or reducing anode current density.

**[ Application ]**

U/G piping, U/G pipeline, U/G storage tank external, Water storage tank internal, Sheet pile, Steel pile

## ■ MMO-Ti Ribbon Anode

MMO-Ti ribbon anodes are manufactured using solid titanium, which meets ASTM B265 Grade 1 or 2 Standards.

| | |
|---|---|
| **Coating** | Iridium based mixed metal oxide |
| **Nominal Dimension** | 0.25"(6.35mm) Width x 0.025" (0.63mm) Thickness |

* It is possible to achieve longer life by increasing coating density or reducing anode current density.

**[ Application ]**

Tank bottom external, U/G tank external

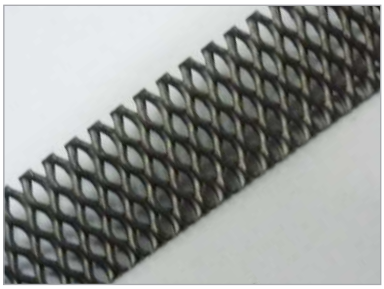
## ■ MMO-Ti Ribbon Mesh Anode

MMO-Ti ribbon mesh anodes are manufactured using titanium expanded mesh substrate, which meets ASTM B265 Grade 1 or 2 Standards.

| | | | |
|---|---|---|---|
| **Width [mm]** | 10 | 13 | 19 |
| **Thickness [mm]** | 1.3 | | |
| **Material** | Grade 1 or 2 ASTM B265 | | |
| **Current Rating [mA/m]** @ 110 [mA/m²] | 2.8 | 3.5 | 5.25 |

**[ Application ]**

Concrete rebar



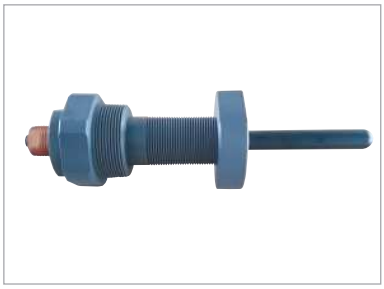
# 4. ANODES

## ■ MMO-Ti Rod Anode

MMO-Ti Rod Anodes are manufactured using titanium, which meets ASTM B348 Grade 1 or 2 standards.

| Environment | Max. Current Density [A/m²] | Lifetime [Years] |
|---|---|---|
| Seawater | 600 | 20 |

* The length of the anode can be made according to design and customer's requirement and anode diameters are 1/8"(3.18mm), 1/4"(6.4mm), 1/2"(12.7mm) and 3/4"(19mm).



**[ Application ]**

Tank internal, Pump, Condenser, Heat Exchanger, Pipe internal, Jetty steel Pile, Intake structure

## ■ Liner Anode(Flexible Type)

Liner anode are flexible and can be assembled using MMO-Ti wire anode connected anode cable. The liner anode is packed in a fabric sleeve that is filled using coke breeze.

| | | | | |
|---|---|---|---|---|
| Wire Anode | Diameter [mm] | 1.0 | 1.5 | 3.0 |
| | Material | Grade 1 or 2 ASTM B863 | | |
| | Coating | Mixed Metal Oxide | | |
| Current Output for 20Years [mA/m] | | 67 | 89 | 195 |
| Sock Diameter [mm] | | 38 | | |

* It is possible to achieve longer life by increasing coating density or reducing anode current density.

**[ Application ]**

U/G piping, U/G storage tank external

# High Silicon Cast Iron Anode

## ■ General

High Silicon Cast Iron Anodes have been used successfully in the cathodic protection industry for decades. The HSCI anodes with chromium alloy has been used extensively in many countries and conforms to ASTM A518 Grade3.

For reliable operation in earth installation, HSCI anodes has been used with coke breeze to surround them completely.

**• Solid Type**

| Dimension [Inches] | | Weight [lbs] |
|---|---|---|
| Diameter | Length | |
| 1 1/2 | 60 | 26 |
| 2 | 60 | 44 |
| 3 | 60 | 110 |
| 1.1 | 9 | 1.1 |
| 1 1/2 | 24 | 11 |

**• Tubular Type**

| Dimension [Inches] | | Weight [lbs] |
|---|---|---|
| Diameter | Length | |
| 2.2 | 60 | 36 |
| 2.2 | 84 | 50 |
| 2.6 | 60 | 50 |
| 3.8 | 84 | 95 |
| 4.8 | 84 | 122 |

## ■ Chemical Composition

| ASTM A518 Grade 3 |
|---|
| Si : 14.20~14.75 |
| Cr : 3.25~5.00 |
| C : 0.70~1.10 |
| Mn : 1.50 Max |
| Cu : 0.50 Max |
| Mo : 0.20 Max |

| Consumption Rate [lbs/ A •yr] |
|---|
| 0.3~1.1 |

# 4. ANODES

## Pb-Ag Anode, Pt-Ti Anode, Pt-Nb Anode

### ■ General

There are various anodes used as impressed current anodes which include Pb-Ag, Pt-Ti, Pt-Nb, etc. Consumption rates of these anodes are very small and current outputs are very high.

| Anode Material | Consumption Rate [kg/A•yr] | Current Density [A/m$^2$] | Max. Voltage [V] |
|---|---|---|---|
| Pb-Ag | 0.014~0.027 | 300 | 60 |
| Pt-Ti | 1x10$^{-5}$ Max | 1,000 | 8 |
| Pt-Nb | 1x10$^{-5}$ Max | 1,000 | 60 |

Pb-Ag Anode

Pt-Ti Anode

**[ Application ]**

Large condenser and heat exchanger used in power plants, A/G pipe internal, etc.

# 5. TR/RECTIFIER/REMOTE MONITORING & CONTROL SYSTEM

## TR/Rectifier

### ■ General

In application of impressed current method, the most commonly used DC power source is the rectifier which converts alternating current (AC) to full-wave direct current (DC). It is a DC power supply equipment which is used to provide a required protective current from anode to protected structure through electrolyte. The rectifiers are classified into manual and automatic types, depending upon the control method of the rectifier to maintain the proper protective potential.

| Description | Manual Type | Automatic Type |
|---|---|---|
| Control Method | Manually controls voltage and current by changing relevant taps, based upon the measured protective potential | Voltage and current are automatically controlled by presented potential |
| Application | Appropriate for the use when there are almost no environmental changes and facilities which may affect the cathodic protection system in the vicinity. | Appropriate for the use when there are a lot of environmental changes and facilities which may affect the cathodic protection system in the vicinity. |

### ■ How to Order

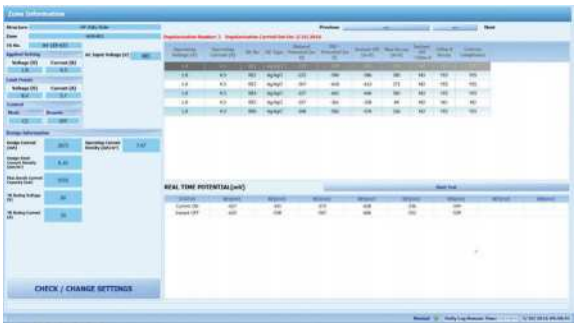
- Input voltage, phase, Hz
- DC output voltage and current
- Control type
- Analog or digital
- Optional features (Cooling method, enclosure, etc.)

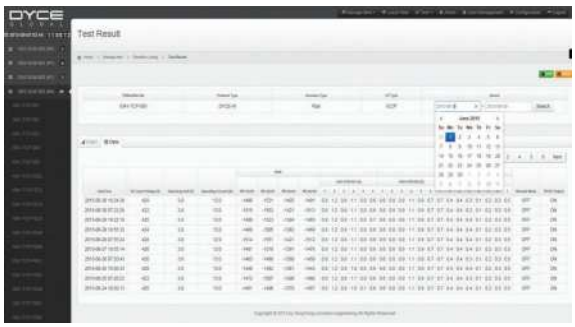
# 5. TR/RECTIFIER/REMOTE MONITORING & CONTROL SYSTEM

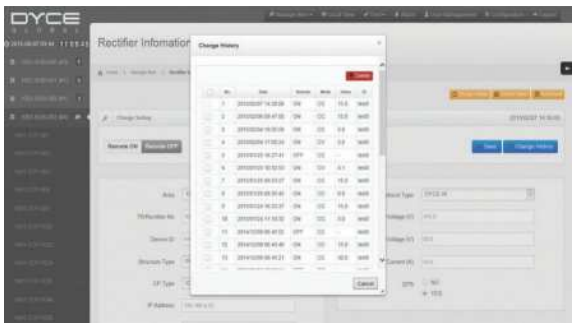
## Remote Monitoring & Control System

### ■ General

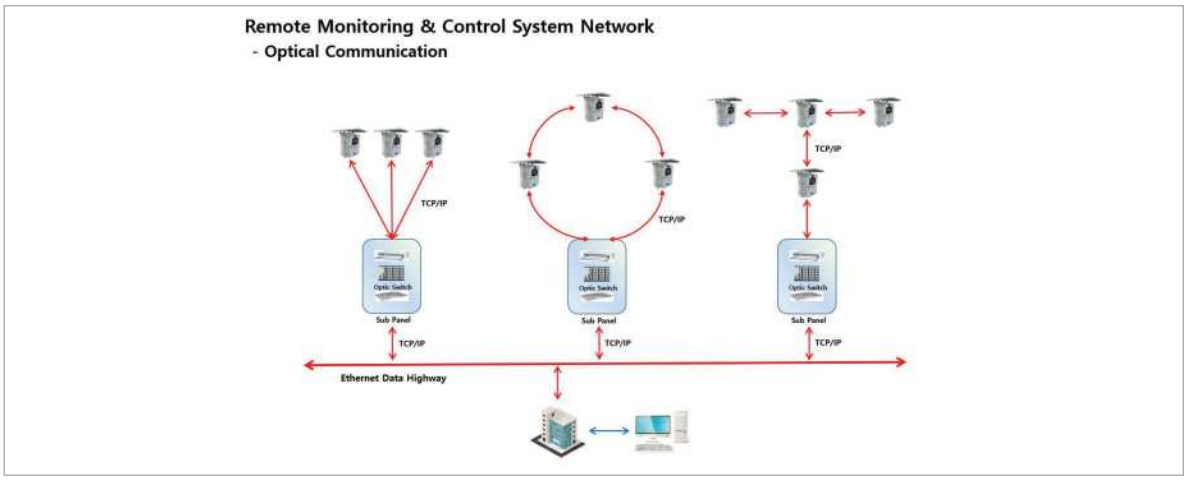
A Remote Monitoring and Control System for Cathodic Protection provides users with the ability to control and monitor the status, potential and rectifier output of the Cathodic Protection system using workstations and the monitoring devices provided.

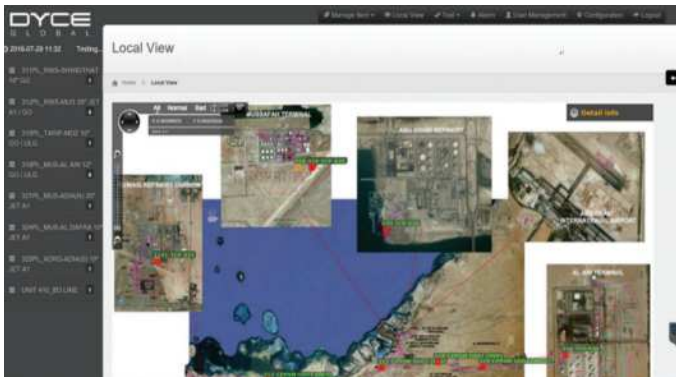

### ■ Remote Monitoring & Control System Network Diagram



## ■ Remote Monitoring & Control System Software

Using the software, it is possible to confirm the operational status of all cathodic protection equipment at every location. The user interface can be tailored to meet your specific needs.

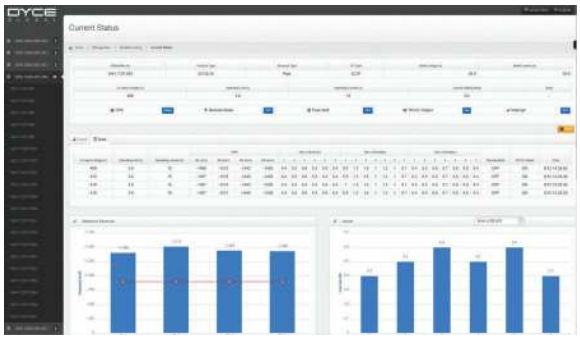
In addition, we provide continuous technical support including on-site evaluations and updates.

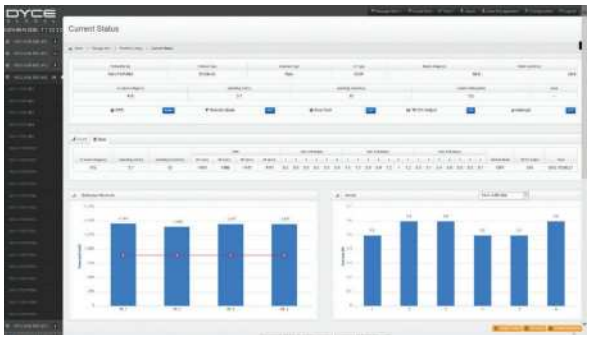




**Software Features**

- Zoom in / Zoom out function
- Rectifier location Search
- Control & monitoring of DC output Voltage & Current
- Monitoring of anode current & potential
- Monitoring of AC input voltage & operating mode
- Measurement of instant off Potential

1) Monitoring in real time
   - The current status of rectifier can be checked in real time.





# 5. TR/RECTIFIER/REMOTE MONITORING & CONTROL SYSTEM

2) Interrupt Result (Instant on & off potential)
- The user can test the interrupt at the desired date and time.
- GPS module in each TR/Rectifier can be synchronized.



## ■ Wireless Type (WatchCat)

Our wireless version of the RMCS can be installed in remote areas where wired connections are not available. It can be installed in new and existing Transformer Rectifiers regardless of its type or manufacturer.


1) Monitoring and controlling in real time


2) Mobile optimized frontend


- For new and existing systems
- Real-time information
- Wireless communication
- Secure data transfer
- Platform independent software
- Redundant data storage
- Current interruption facility
- GPS time synchronized
- Coupon measurements
- Customizable alarm system
- Controlling abilities
- Auxiliary inputs/ouputs
- Mobile device access

# 6. OTHER MATERIALS

## Box

The test stations are installed at selected locations along the protected structure to test, monitor and control the performance of cathodic protection.
The each box type can be produced according to the usage environment and purpose.

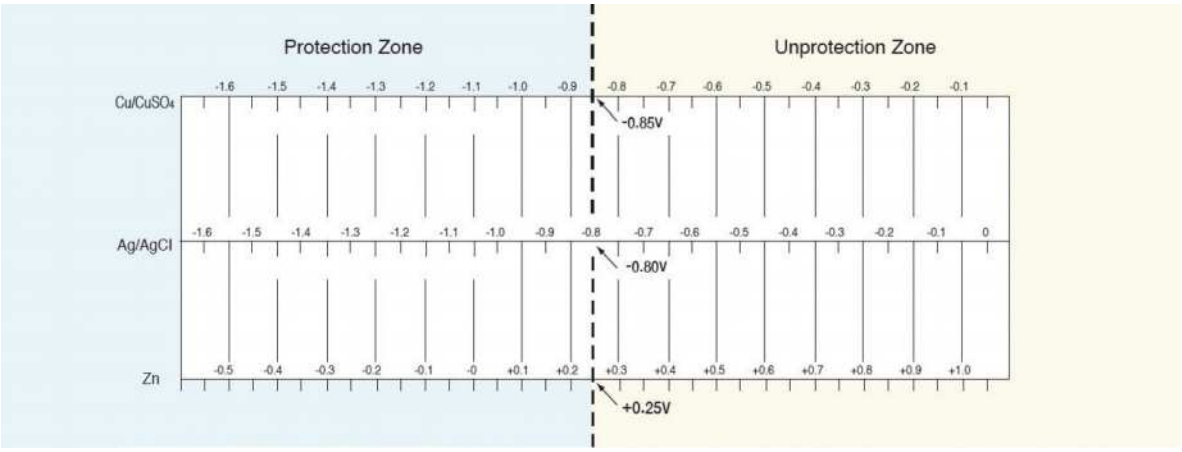



## Reference Electrode

After the completion of installation by a sacrificial anode method or an impressed current method, protection effect should be verified against corrosive subject which is to be protected, and this can be determined by the measurement of subject's potential (mV).

The value of potential appeared at this time varies by the different reference electrode being used, and protective reference value also will be changed accordingly.

### ■ Criteria of Protection Potential




Comparision of reference electrodes

Zn Ref. Electrode


Cu/$CuSO_4$ Ref. Electrode


Ag/AgCl Ref. Electrode

## Cable

The cables mentioned below are applicable for cathodic protection system.

- 0.6/1KV Cu/HMWPE (High Molecular Weight Polyethylene)
- 0.6/1KV Cu/KYNAR/HMWPE
- 0.6/1KV Cu/XLPE/FR-PVC
- 0.6/1KV Cu/XLPE/XLPE
- 0.6/1KV Cu/XLPE/PVC/AWA/FR-PVC
- 0.6/1KV Cu//XLPE/LS/PVC/AWA/FR-PVC

## Anode Backfill

Anode backfill material are placed in a hole to fill the space around the anode.

| Element | Loresco SC-3 / SC-2 | Remarks |
|---|---|---|
| Fixed Carbon | 99.35% Min | |
| Ash | 0.6% Max | |
| Moisture | 0.05% | |
| Volatiles | 0% (950°C) | |

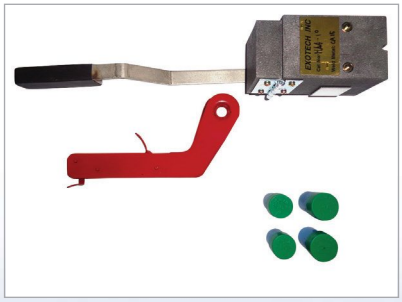
# 6. OTHER MATERIALS

## Accessories

- CP Coupon
- Splice Kit
- Cadweld Package
- Spark Gap
- Polarization Cell

CP Coupon

Splice Kit



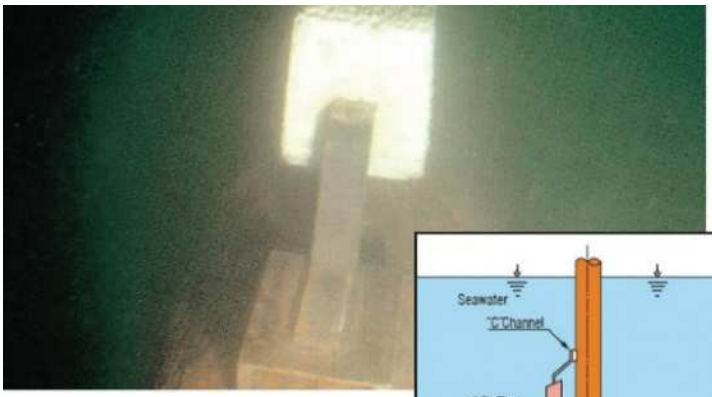
Cadweld Package

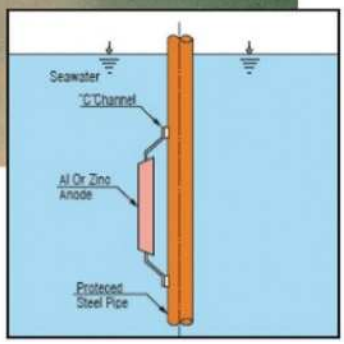
Spark Gap

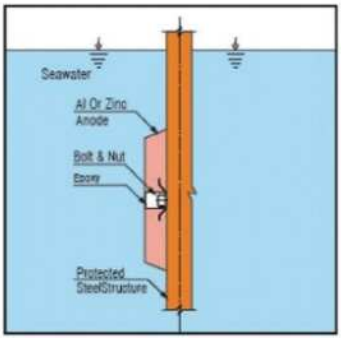
Polarization Cell

# 7. INSTALLATION

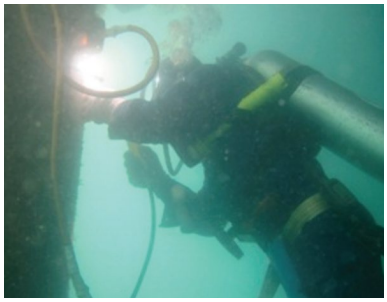
## Installation of SACP






Installation of Al anode for offshore steel pile



Installation of Al anode for intake structures

# 7. INSTALLATION

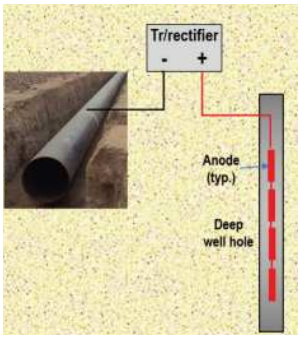
Installation of Mg anode for U/G piping

Installation of test station

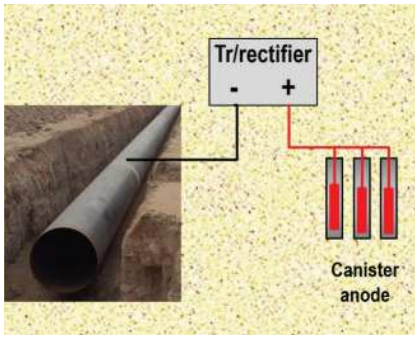
Cadwelding & epoxy recoating

Installation of Al anode for tank internal

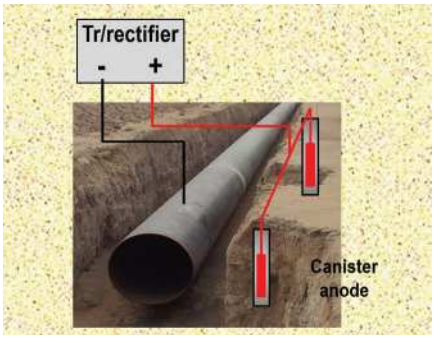
## Installation of ICCP




Deep well bed type




Shallow bed type




Distribution type

Installation of canister anode

Installation of MMO-Ti anode

Installation of MMO-Ti anode and
ref. electrode for intake structures

Installation of Pt-Ti anode and
ref. electrode for condenser

# 7. INSTALLATION

Installation of liner anode for U/G piping

Installation of MMO-Ti ribbon anode for tank bottom

Installation of HSCI anode for tank internal

Installation of MMO-Ti ribbon mesh anode for concrete rebar


Installation of Tr/rectifier and box

Installation of boxes

# 8. DA(DCVG & CIPS)

Direct Assessment is an inspection technology for pipelines where in-line inspection is not practical. Direct Assessment consists of four primary steps, which are Pre-Assessment (Step1), Indirect Inspection (Step 2), Direct Examination (Step 3), and Post Assessment (Step 4). DYCE Integrity Team (DGIT) has experience in performing all 4 steps regarding ECDA, LP-ICDA, DG-ICDA, WG-ICDA, and SCCDA with the NACE standard documentation and CFR 49 Part 192 regulations.

The most important key parameter for the success of ICDA process is to understand pipeline flow since ICDA was developed based on pipeline flow concepts. DGIT has a very strong background in pipeline multiphase flow and corrosion. DYCE also provides training workshops regarding "Determination of multiphase flow in onshore and offshore pipelines" upon client request.

- ECDA (External Corrosion Direct Assessment, NACE Standard SP0502)
- LP - ICDA (Liquid Petroleum Pipeline Internal Corrosion Direct Assessment, NACE Standard SP0208)
- DG - ICDA (Dry Gas Internal Corrosion Direct Assessment, NACE Standard SP0206)
- WG - ICDA (Wet Gas Internal Corrosion Direct Assessment, NACE Standard SP0110)
- SCCDA (Stress Corrosion Cracking Direct Assessment, NACE Standard SP0204)

External Corrosion Direct Assessment (ECDA) is a structured process that is intended to improve safety by assessing and reducing the impact of external corrosion on pipeline.

ECDA is a continuous improvement process. Operator should be able to identify and address defect locations at which corrosion activity has occurred, is occurring, or may occur.

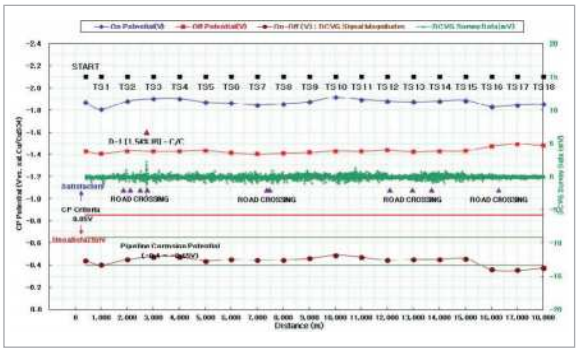
# 8. DA(DCVG & CIPS)

## ■ Step 1. Pre-Assessment

Data collection, to determine whether ECDA is feasible and to select indirect inspection tool, to identify ECDA region

## ■ Step 2. Indirect Inspection

Pipeline Route Survey, Direct Current Voltage Gradient (DCVG), Close Interval Potential Survey (CIPS), GPS, Soil Resistivity Survey



## ■ Step 3. Direct Examination

- Selection of sites for excavation and pipe surface evaluation
- Assess the impact of external corrosion on the pipe
- Non Destructive Test (LRUT, UT)
- Recoating (High Build Epoxy or Tape coating)

## ■ Step 4. Post Assessment

- Data analysis
- Assessment of ECDA effectiveness
- Determination of reassessment interval

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