Common Pitfalls During Subsea Cathodic Protection Design

For most offshore facilities and subsea components such as trees and manifolds, carbon steel is a common material of construction. Effective external corrosion control is essential for the longevity and safe operation of these components.

For long-term external corrosion protection of subsea steel components, cathodic protection (CP) along with corrosion coatings are commonly used. As the offshore environment moves into deeper waters, the cost of interventions subsequently increases. Therefore, the engineer is challenged with balancing a highly reliable CP system, sometimes achieved with excess anode mass, with CAPEX and weight restrictions. The optimal CP system will need to minimize weight and cost and maximize reliability.

CP Design Consideration

Common pitfalls during CP design include electrical continuity, current drain, hydrogen embrittlement of susceptible alloys, anode placement, anode chemistry, and test point placement.

Electrical Continuity

As stated above, corrosion cannot occur if an electrical path is absent. For a component to be able to receive CP, it must be in the same electrical circuit as the anodes. This is easily verified and cheap to rectify onshore, but impractical to rectify once installed. See Figure 1 for examples of the consequences of lack of continuity.

Current Drain

Another common mistake is an unaccounted drain of current from the CP system. A drain consists of exposed surface areas which received protection such as:

- Suction piles, stability piles, anchoring chains or cables.
- Under protected adjacent electrically continuous components.

Hydrogen Embrittlement

For deepwater conditions, CP is usually provided by aluminum alloy sacrificial anodes which reduce the potential of the cathode mitigating corrosion. While effective for carbon steel, the induced potentials can have negative effects on certain corrosion resistant alloys (CRAs). This can lead to hydrogen embrittlement of the CRA. In order for hydrogen embrittlement to occur the following conditions must exist:

- A hydrogen source - such as welding, corrosion of the material or CP.
- An applied stress above a critical value - Even if the material is saturated with hydrogen, it will not fail unless the critical minimum applied stress is exceeded.
- A material strength above a critical value - Even under plastic deformation, a failure will only occur when the yield strength of the material is exceeded.

Besides selection of appropriate materials, a number of alternatives can be used to mitigate hydrogen embrittlement. These include coatings, anode placement, electrical isolation, under protection, minimization of material strength, minimization of applied stress, solution anneal before thermal hardening and post weld heat treatment.

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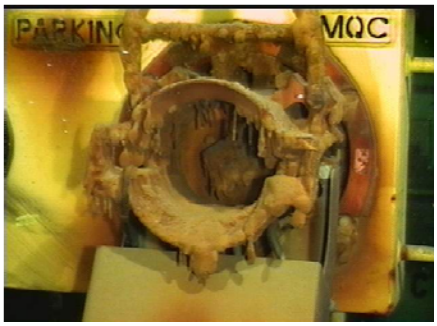


Figure 1: Consequences of Lack of Continuity

Anode Chemistry

The cold temperatures associated with deepwater locations drives the selection of tighter anode chemistry limits than shallower waters. This is to ensure correct anode interaction.

Al-Zn-In Alloy		
Element	**Min (wt%)**	**Max (wt%)**
Fe	-	0.060
Zn	4.75	5.75
Cu	-	0.0030
Si	0.08	0.12
In	0.016	0.020
Cd	-	0.0020
Each	-	0.020
Total	-	0.050
Al	93.99	95.15

Anode Placement

When designing anode placement, the following should be considered:

- The exposed anode should be one foot from the structure to avoid reduction in current output.
- Anode spacing to avoid current interference.
- Impact on center of gravity.
- Anode placement to achieve even current distribution.

Figure 2: Even Anode Distribution

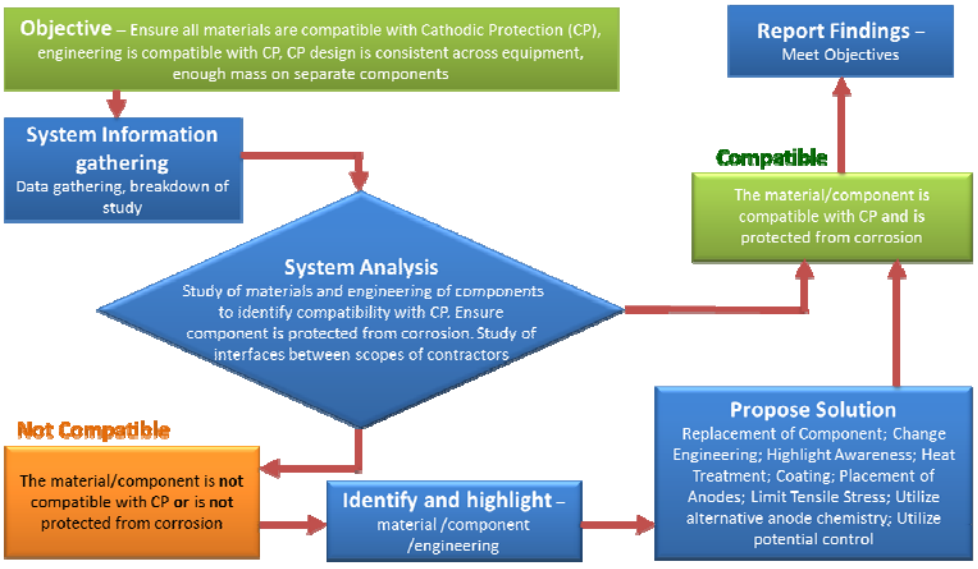
Test Points

Test points provide an easy way to take potential measurements with a tip contact probe.

- CP test points should be placed away from anodes.
- One test point is recommended per independent CP system.
- The probe tip used should be contact friendly.
- Test points should be included in approved for construction drawings.
- Special consideration should be made for those test points needed near the mudline.

Conclusion

Careful consideration should be given when considering the electrical continuity, current drain, anode placement, anode chemistry and test points of a CP design. Over design of the CP system should be avoided and ways to maximize the reliability of the CP of the structure while minimizing weight should be utilized.



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