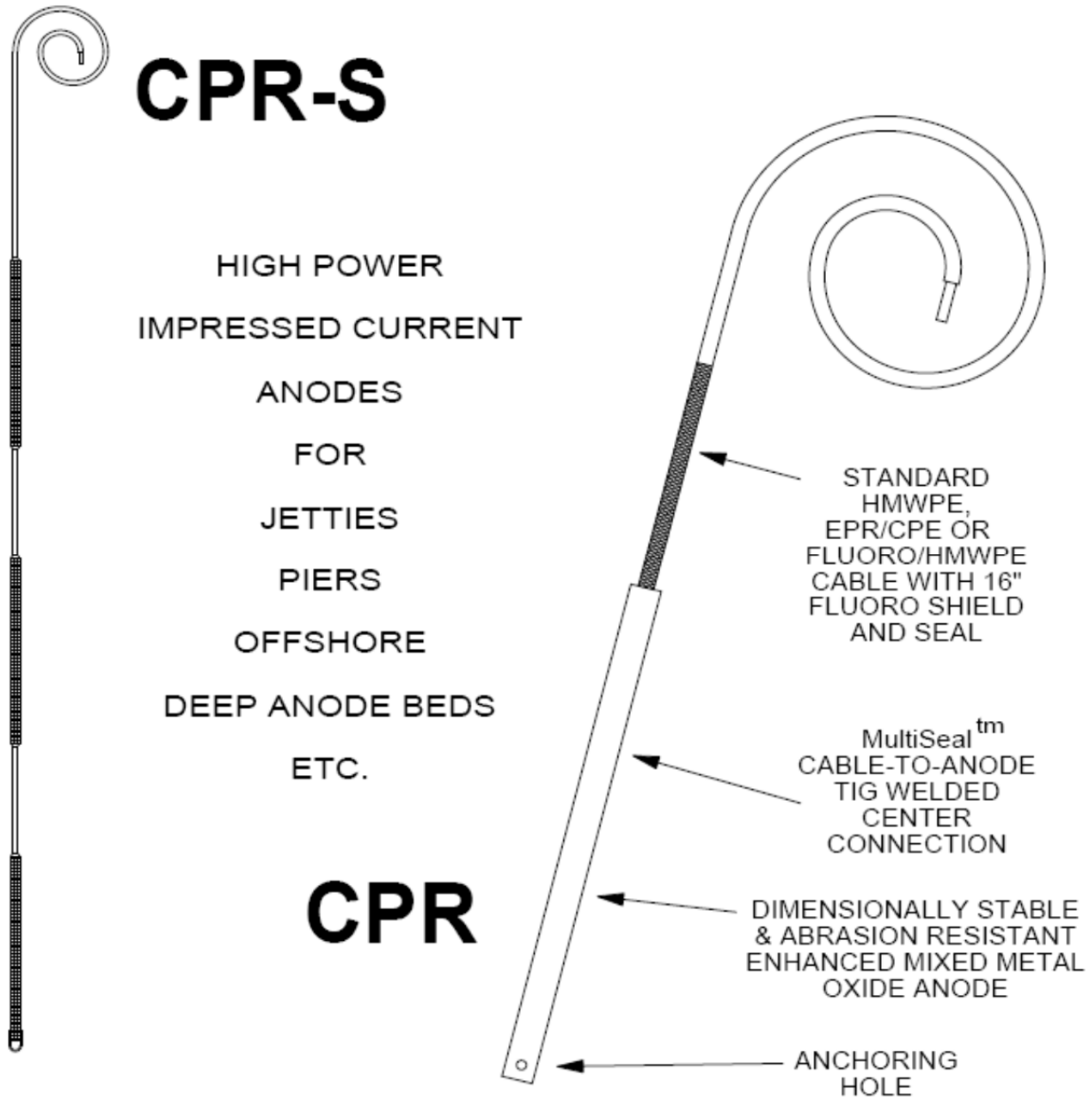


CerAnode EMMO TUBULAR POWER RODS and STRINGS



**Enhanced Mixed Metal Oxide Tubular Anodes
CerAnode-Power-RodTM (CPRTM)
and CPR-String (CPR-STM)**

A Robust Anode with a Track Record

- Arc Plasma Spray Processed MMO Coating
- Anode String Burnout Protection
- A History of Reliability
- CerAnode 7 Year Warranty

The CPRTM and CPR-STM are manufactured using the same special arc-plasma spray processing developed by CerAnode in the mid 80's. The EMMO (**enhanced** mixed metal oxide) coating is a truly unique surface architecture providing an abrasion resistant surface protecting it from damage during handling and installation. They are specifically designed for the demands of deep anode ground beds. They are also an excellent choice for shallow beds, horizontal beds, offshore and other CP applications. By means of a very special cable-to-anode connection, CerAnode has uniquely combined the features of this enhanced version with well established CP cable materials such as HMWPE, Dual Extruded cables with Halar^R, Kynar^R, etc.

CPRTM - ONE ANODE PER CABLE --- a single anode power tube at the end of a standard HMWPE or Dual Extruded CP cable. The CPRTM is used where anodes with individual leads are desired for maximum anode bed system integrity. This traditional ground bed approach allows individual anode current and depth control.

CPR-STM - MULTIPLE ANODES PER CABLE --- a string version of the CPRTM consisting of a number of anode power tubes on a single HMWPE or Dual Extruded cable. The CPR-STM has a very unique power feed-through arrangement for feeding power from one anode to the next on the string. This provides anode string burnout protection. The end result is anode string integrity never before realized!

The CPRTM and CPR-STM anode design not only makes cost effective installation possible, but has added a new magnitude of anode reliability. A truly Hi Tech CP Anode has finally surfaced. It is definitely a Robust Anode with a Track Record!

UNIQUE FEATURES

1) ARC PLASMA SPRAY PROCESSED MMO COATING.

All CPR™ and CPR-S™ anodes feature unique CerAnode Arc Plasma Spray Processing resulting in a state-of-the-art abrasion resistant EMMO (enhanced mixed metal oxide) coating with the following advantages.

- a) Superior abrasion resistance is “one-of-a-kind” among many MMO technologies available in the market place today. Coating is durable enough to handle the demanding environment of field installations without being damaged by contact with sharp metal objects.
- b) MMO anodes in general are considered to be dimensionally stable, the EMMO coating is even more so. The EMMO material deposited onto the titanium substrate is more tightly bound than standard MMO coatings.

2) HIGH POWERED ACTIVATED TITANIUM ANODE.

CerAnode's very thin anode coating in combination with its ductile titanium substrate is extremely durable. The particular mixed metal oxide ceramic is custom formulated for each CPR™ and CPR-S™ and is tested at extremely high current densities to insure consistent product quality. It consists of precious metal/metal oxides in sufficient quantities and ratios to provide long life expectancies. This provides the conservatism in anode design needed to assure a long life even in harsh environments such as deep anode beds and offshore applications. Since this ceramic material will support the evolution of both oxygen and chlorine, it is the choice for fresh water, sea water, mud, brackish water and coke/soil environments.

3) STANDARD HMWPE OR DUAL EXTRUDED CABLE.

The CPR™ and CPR-S™ use cable that has been an industry standard for many decades, a proven reliable choice. The cable choices have withstood the test of time. HMWPE is the most popular, but Kynar^R/HMWPE or Halar^R/HMWPE are available for more demanding applications where chlorides or other harsh environments are involved. Other cable choices such as EPR/CSPE are also available for some applications.

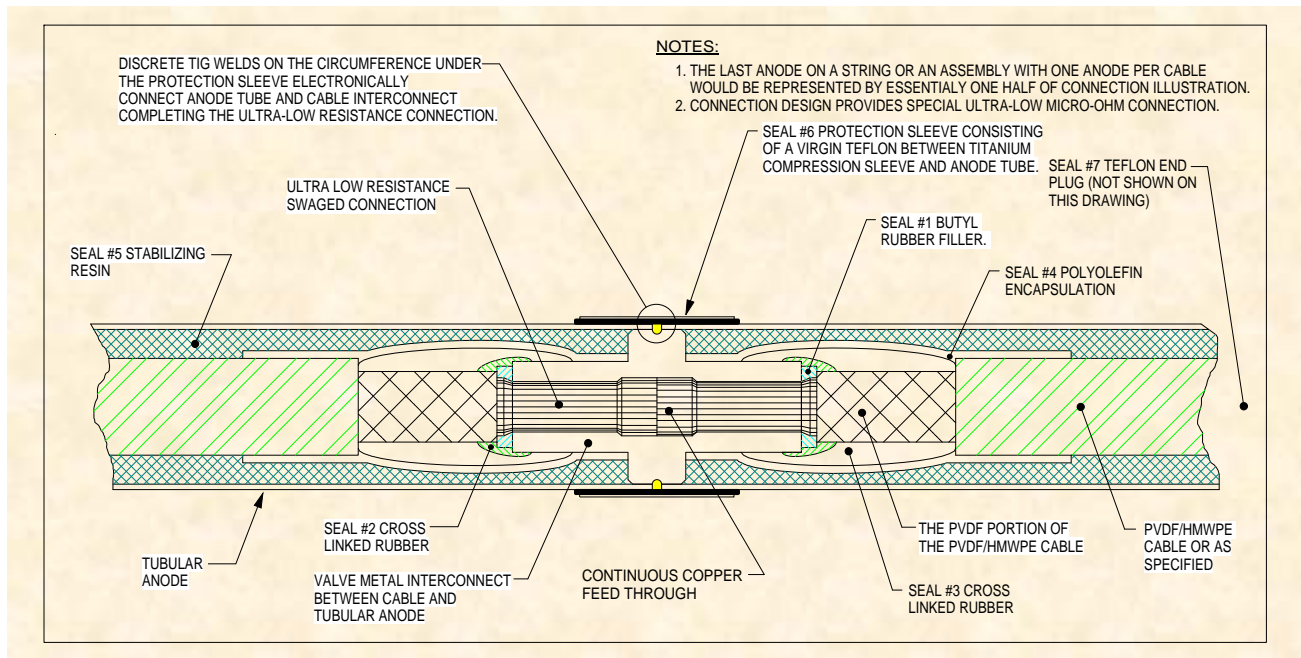
4) ANODE STRING BURNOUT PROTECTION.

The electrical feed-through connection between the tubular anode and the cable is unique. No copper metal exists directly under the exposed Power-Rod tubular anode. Therefore, (a) if any one anode tube on the anode string should ever receive a puncture due to arcing or a microscopic flaw in the titanium tube, it will continue to operate since there is no copper under

the tube wall. And, (b) if, by reason of the characteristics of a particular deep anode bed stratum, the anode tube at that stratum should ever become exhausted prematurely due to unanticipated excessive current, the remainder of the anode string will continue to operate. Why? Because the electrical current passing through the center of any anode tube on the anode string to the next anode tube on that string, is not dependent on the condition or presence of any other anode tube on that string.

5) MOISTURE PROOF CORROSION RESISTANT CONNECTION.

The CerAnode MultiSeal™, consisting of 7 distinct seals per single anode tube (14 per string tube) assures a moisture proof connection and excellent resistance against acids & chlorine gas sometimes associated with a deep anode environment. The string also has inherent "water block" integrity at every anode tube. This means that the CP cable jacket and tubes cannot act as one continuous siphon from the bottom of a deep anode bed to the surface.



6) ULTRA LOW ELECTRICAL CONNECTION RESISTANCE.

The special TIG Weld-Swage has resulted in an ultra low resistance electrical connection. The cable-to-titanium tube connection resistance is ultra-low having a mean copper-to-titanium resistance of <100 micro-ohms as measured with a 4-wire Kelvin type resistance bridge capable of resolving 5×10^{-5} ohms.

7) MAXIMUM MECHANICAL STRENGTH.

The cable-to-anode connection is achieved by means of a proprietary copper to titanium valve metal swage process. The connection is so strong that the cable breaks before the connection.

GENERAL INFORMATION

The CPR™ and CPR-S™ are available in many sizes, 50cm (~20"), 61cm (~24"), 100cm (~40"), 125cm (~48"), 150cm (~60"), 229cm (~90") and 300cm (~120"). Some of the longer anodes provide a more direct alternative to the silicon iron and graphite anodes in terms of geometry, current density and cost while maintaining the advantages of light weight, dimensional stability and ease of handling and installation. APS has adjusted the coating density, mixture ratio, type of precious & refractory metal oxides and the dielectric materials to accommodate different electrolytes & environments. CerAnode processing is compatible with ASTM B338, CP Titanium Grade 1 or 2. Unless otherwise specified, CerAnode standard product is supplied with the best of both grades, i.e. Grade 1 chemical properties and Grade 2 physical properties resulting in high purity and superior mechanical strength.

Single or Multiple Power-Rod tubes may be specified per anode cable (string) to obtain total anode bed current required. The environment (coke/soil or sea water) and cable (gage size) resistance must be considered when specifying the number of anodes/cables and their spacing. This is for consideration of not only the cable's current capacity but also the cable-to-coke/earth and anode-to-coke-to-earth attenuation. When in doubt, consult CerAnode.

Use a 20 mil (0.5 mm) thick fluoro-insulation for deep anode beds where chlorine gas may be generated or where other aggressive chemicals might be present. For open hole applications specify a 40 mil (1mm) fluoropolymer. CerAnode will supply the most available and economical fluoropolymer (Halar, Tefzel or Kynar) unless otherwise specified. EPR/CPE and HMWPE are not acceptable as a primary insulation in groundbeds where chlorine is present. All CerAnode Tubular singles and strings are manufactured with a FluoroShield™ but these shields are not designed to replace the need for fluoropolymer cable in deep anode applications where chlorine is present. A chlorine gas resistant FluoroShield™ can be used with EPR/CPE & HMWPE in sea water (chloride) applications where the chloride gas is continually washed away.

The CPR™ and the CPR-S™ are easy to install but must be installed by qualified personnel. It is important that a high quality Calcined Fluid Petroleum Coke Backfill (low resistivity--98-99% carbon, high density and small particle size) be used. (Design suggestions: Conservative current densities at the coke-to-earth interface should be <0.15 Amp/ft², preferably lower. Conservative coke column attenuation between anodes should also be considered in light of the coke to earth interface current density.) Vent pipes must be used in deep and shallow anode beds and arranged 1" from anode. To prevent the entry of silt, sediment or fine coke particles the slots should be no larger than 0.006"-0.008". Centralizers (CerAnode Ventrolizers) must be used in groundbeds to assure proper current distribution from the anode.

Standard CerAnode TYPICAL ANODE SIZES

Consult CerAnode for other size and amp rating options

Anode Type	Anode Length in. (cm)	Anode Dia. in. (cm)	Anode Weight lbs/kg	Amps Per Tube
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COKE¹ - SOIL & FRESH WATER with 20yr design life

2.5C/FW20YR	20 (51)	3/4 (1.9)	2 (0.9)	2.5
4C/FW20YR	24 (61)	3/4 (1.9)	2 (0.9)	4
5C/FW20YR	40 (101)	3/4 (1.9)	3 (1.3)	5
8C/FW20YR	48 (122)	3/4 (1.9)	3 (1.3)	8
4C/FW20YR	20 (51)	1 (2.5)	2 (0.9)	4
5C/FW20YR	60 (152)	1 (2.5)	5 (2.3)	5
8C/FW20YR	90 (228)	1 (2.5)	6 (2.7)	8
8C/FW20YR	40 (101)	1 (2.5)	4 (1.8)	8
10C/FW20YR	120 (304)	1 (2.5)	8 (3.6)	10
13C/FW20YR	40 (101)	1 (2.5)	4 (1.8)	13
8C/FW20YR	60 (152)	1.25 (3.2)	8 (3.6)	8

SEA WATER² with 20 year design life

8SW20YR	20 (51)	3/4 (1.9)	2 (0.9)	8**
15SW20YR	40 (101)	3/4 (1.9)	3 (1.3)	15**
10SW20YR	20 (51)	1 (2.5)	2 (0.9)	10**
20SW20YR	40 (101)	1 (2.5)	4 (1.8)	20**
33SW20YR	40 (101)	1 (2.5)	4 (1.8)	33**
50SW20YR	48 (122)	1.25 (3.2)	6 (2.7)	50**

MUD with 20 year design life

2M/20YR	24 (61)	3/4 (1.9)	2 (0.9)	2
4M/20YR	48 (122)	3/4 (1.9)	3 (1.3)	4
2M/20YR	20 (51)	1 (2.5)	2 (0.9)	2
7M/20YR	40 (101)	1 (2.5)	4 (1.8)	7
10M/20YR	48 (122)	1.25 (3.2)	6 (2.7)	10

Contact CerAnode for additional Tubular Anode sizes

NOTES

- * Reduce current 50% for operation below 5 degrees C. Impurities may also affect rating.
- ** Reduce current 50% for operation below 10 degrees C. Impurities may also affect rating.

1) The backfill chosen must be high grade of fluid calcined petroleum coke with low electronic resistivity and a low contact resistance from particle to particle as well as between the anode and the coke particles (Loresco[®] SC-3 or equal). A vent pipe (Loresco[®] AllVent or equal) and centralizers must be used.

2) This current rating applies when the anode is totally immersed in water.

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"RECOGNIZED WORLD WIDE"

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See back of catalog for CerAnode's 7-Year
Anode Warranty Details

CABLE FOR CerAnode TUBULAR

HMWPE INSULATION

8 AWG (8.4 mm ²)	HMWPE	0.087 lb/ft (0.130kg/m)
6 AWG (13.3 mm ²)	HMWPE	0.122 lb/ft (0.182kg/m)
4 AWG (21.2 mm ²)	HMWPE	0.175 lb/ft (0.260kg/m)
2 AWG (33.6 mm ²)	HMWPE	0.260 lb/ft (0.387kg/m)
1/0 AWG (53.5 mm ²)	HMWPE	0.405 lb/ft (0.603kg/m)

FLUOROPOLYMER INSULATION

(Choose Kynar®, Halar® or "Fluoro". "Fluoro" = either Halar or Kynar)

8 AWG (8.4 mm ²)	Fluoro/HMWPE	0.083 lb/ft (0.124kg/m)
6 AWG (13.3 mm ²)	Fluoro/HMWPE	0.120 lb/ft (0.179kg/m)
4 AWG (21.2 mm ²)	Fluoro/HMWPE	0.177 lb/ft (0.263kg/m)
2 AWG (33.6 mm ²)	Fluoro/HMWPE	0.260 lb/ft (0.387kg/m)
1/0 AWG (53.5 mm ²)	Fluoro/HMWPE	0.395 lb/ft (0.588kg/m)

EPR/CPE INSULATION

6 AWG (13.3 mm ²)	EPR/CPE	0.150 lb/ft (0.223kg/m)
4 AWG (21.2 mm ²)	EPR/CPE	0.220 lb/ft (0.327kg/m)
2 AWG (33.6 mm ²)	EPR/CPE	0.265 lb/ft (0.394kg/m)
1/0 AWG (53.5 mm ²)	EPR/CPE	0.510 lb/ft (0.759kg/m)

Consult CerAnode for many other Cable options.

