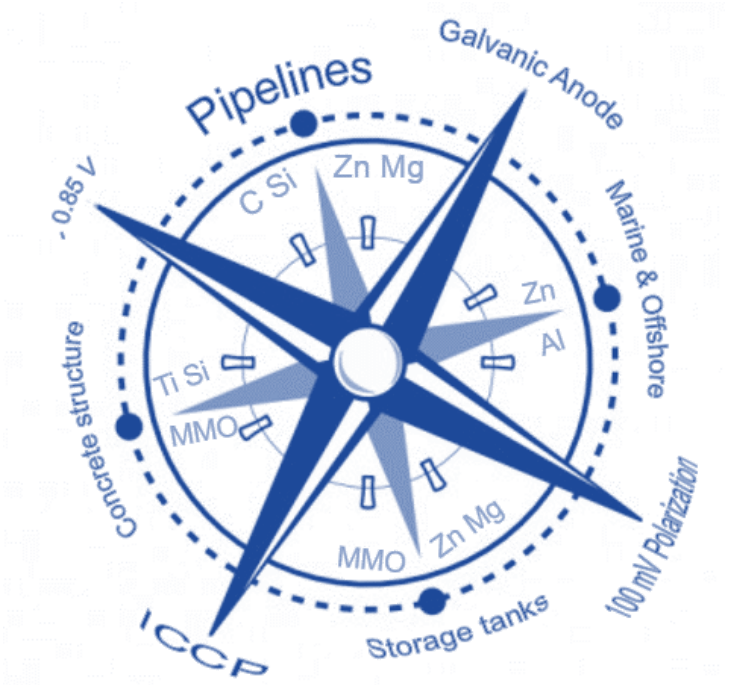


CP-Compass®: Cathodic Protection Design, Verification & Assessment

Version 9.20

☆ **Performance** ☆ **Functionality** ☆ **Usability**

Anytime Anywhere Any Device Any OS

No USB dongles No installation No Browser Plug-ins

CP-Compass has the following standalone modules:

- **CP-Compass-Underground pipeline**
- **CP-Compass-Submarine pipeline**
- **CP-Compass-Platform**
- **CP-Compass-FPSO**
- **CP-Compass-Well casing**
- **CP-Compass-Jetty pile**
- **CP-Compass-Storage tanks**
- **CP-Compass-Concrete structure**
- **CP-Compass-Condensers & heat exchanger**
- **CP-Compass-Customized for special need**

Design calculations in CP-Compass modules are in compliance with internationally accepted codes and standards: AS 2239; AS 2832; BS EN ISO 12696; BS EN 12473; BS ISO 15589; DNV-RP-B401; DNV-RP-F103; NACE SP0169; NACE SP0176.

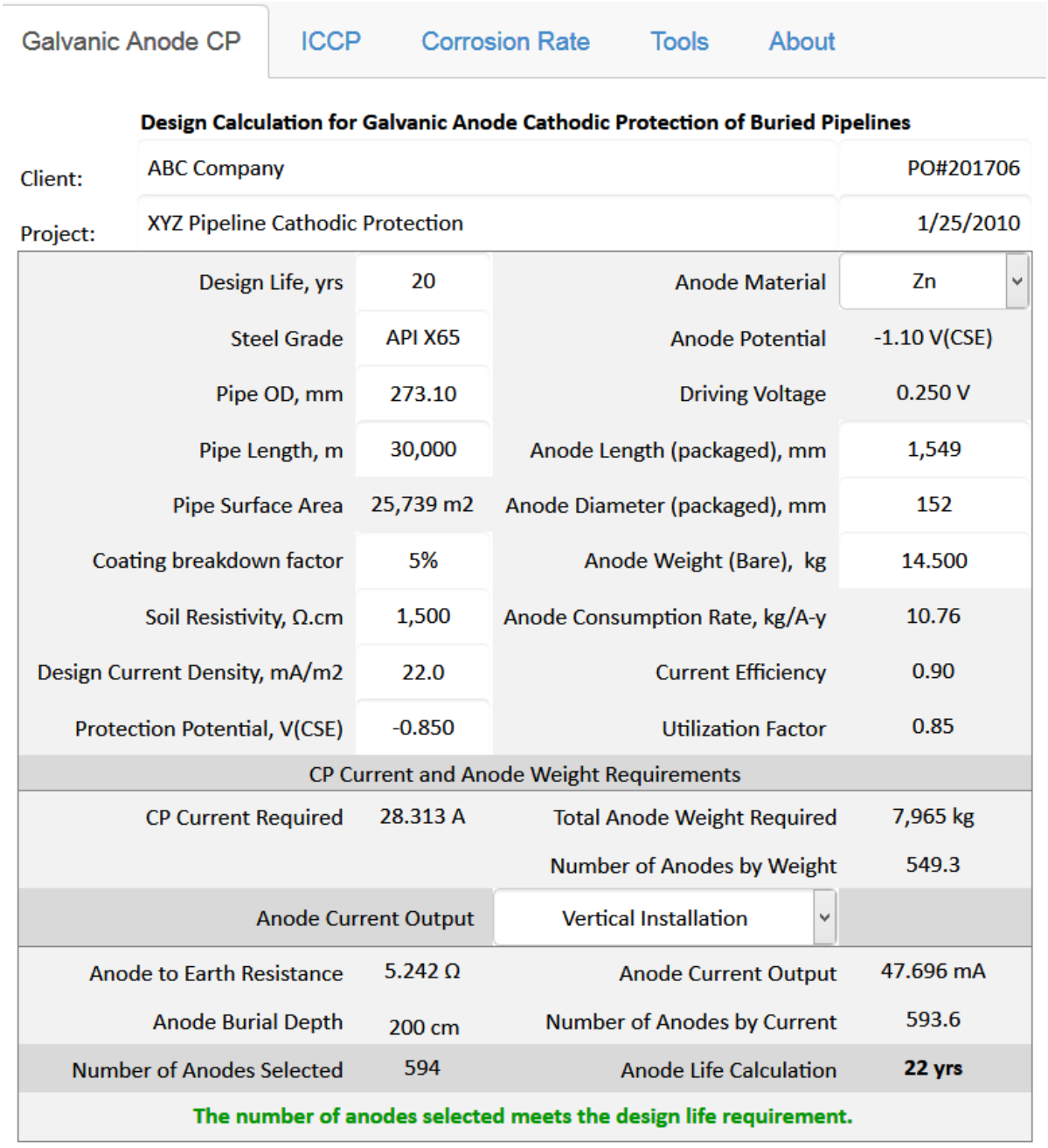
Our NACE certified Corrosion Specialist will review and endorse all CP designs based on CP-Compass at no charge to licensed users.

Unparalleled Functionality: CP-Compass is not just for CP design and verification of CP design calculations by 3rd party contractors, it also gives you tools to predict the corrosion rate of the structure WHEN CP IS ON! Refer to the screen shot below for details.

Unmatched Usability: CP-Compass was designed with the user in mind. Experience the industry's first cross-platform and device-independent Cathodic Protection Design, Verification

and Assessment application on your iPads, tablets, smart phones, notebooks and desktops, at any time and anywhere, in the office or in the field. No installation files to download, no browser plug-ins required, no USB dongles to carry around, and no license keys to transfer from one PC to another. **CP-Compass simply works on any device running any OS**. All you need is an internet browser.

A Brief Overview of CP-Compass-Underground pipeline



Galvanic Anode CP | ICCP | Corrosion Rate | Tools | About

Design Calculation for Galvanic Anode Cathodic Protection of Buried Pipelines

Client:	ABC Company		PO#201706
Project:	XYZ Pipeline Cathodic Protection		1/25/2010
Design Life, yrs	20	Anode Material	Zn
Steel Grade	API X65	Anode Potential	-1.10 V(CSE)
Pipe OD, mm	273.10	Driving Voltage	0.250 V
Pipe Length, m	30,000	Anode Length (packaged), mm	1,549
Pipe Surface Area	25,739 m2	Anode Diameter (packaged), mm	152
Coating breakdown factor	5%	Anode Weight (Bare), kg	14.500
Soil Resistivity, Ω.cm	1,500	Anode Consumption Rate, kg/A-y	10.76
Design Current Density, mA/m2	22.0	Current Efficiency	0.90
Protection Potential, V(CSE)	-0.850	Utilization Factor	0.85
CP Current and Anode Weight Requirements			
CP Current Required	28.313 A	Total Anode Weight Required	7,965 kg
		Number of Anodes by Weight	549.3
Anode Current Output		Vertical Installation	
Anode to Earth Resistance	5.242 Ω	Anode Current Output	47.696 mA
Anode Burial Depth	200 cm	Number of Anodes by Current	593.6
Number of Anodes Selected	594	Anode Life Calculation	**22 yrs**
The number of anodes selected meets the design life requirement.			

Galvanic Anode CP Design and Verification

With CP-Compass, designing a galvanic anode CP system or verifying a CP design by a 3rd party contractor is as easy as 1-2-3:

1. Enter the design parameters (items in the above screen shot).
2. Choose the anode from the dropdown list.
3. The number of anode required, the the anode life, and system design life are automatically determined and verified.

Impressed Current CP Design and Verification

Impressed Current CP design and verification are shown in the screen shot below:

Galvanic Anode CP | ICCP | Corrosion Rate | Tools | About

Design Calculation for Impressed Current Cathodic Protection of Buried Pipelines

Client:	ABC Oil and Gas Company		PO#201706
Project:	XYZ Oil and Gas Pipeline Cathodic Protection		1/25/2010

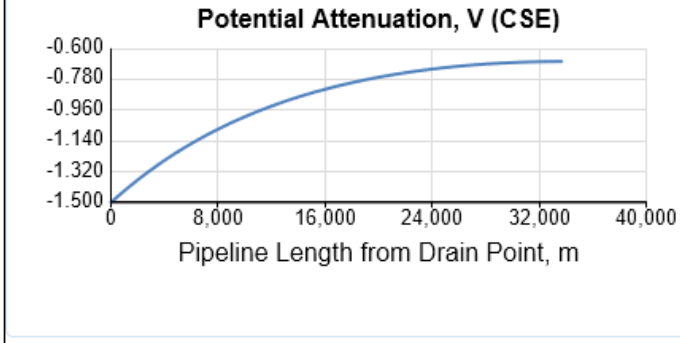
Design Life, yrs	20	Soil Resistivity, Ω.cm	1,500	Natural Corrosion Potential, V(CSE)	-0.500
Pipe Steel Grade	API X65	Coating Type	FBE	Minimum Protection Potential, V(CSE)	-0.850
Steel Resistivity, Ω.m	1.850e-007	Coating Resistance, Ω.m2	4,000	Maximum Protection Potential, V(CSE)	-1.500
Pipeline Length, km	1,070.000	Coating Breakdown Factor	1.0%	Attenuation constant	7.211e-5 /m
Pipe OD, m	0.762	Design Current Density, mA/m2	0.100	Current from E-Logl Test?	Yes
Pipe Wall Thickness, mm	9.00	Total Surface Area	2,561,466 m2	Enter current (A) if Yes	36.000
Pipe Linear Resistance	8.689e-6 Ω/m	CP Current Required	256.147 A	This option can be used for what-if senarios	
1. Total CP Current Based on the Specified Design Current Density			256 A	CP Current per Station	15 A

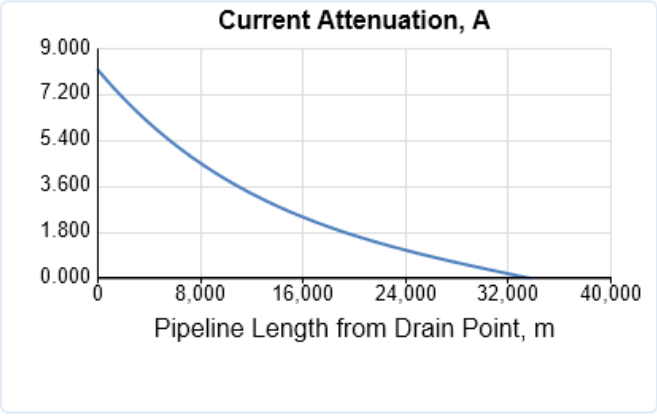
2. Calculation of Protection Current Requirement Based on Attenuation

One Way of An Infinite Pipeline			One Way To A Mid-Point Between 2 Drain Points		
Protected Length One Side	m	23,724	Protected Length One Side	m	33,674
Protection Current One Side	A	7.774	Protection Current One Side	A	8.171
Resulting Current Density	mA/m2	0.137	Resulting Current Density	mA/m2	0.101

3. Number of Stations and Spacing Between Stations

No of Stations Required	2	Located at	23,700 m	from pipe end		Current per Station	16 A
No of Stations Required	15	Spaced at	63,700 m	along the pipeline		Current per Station	16 A
Total No of Stations	17	One Way To Mid-Point Between 2 Drain Points				Total Current Required	272 A





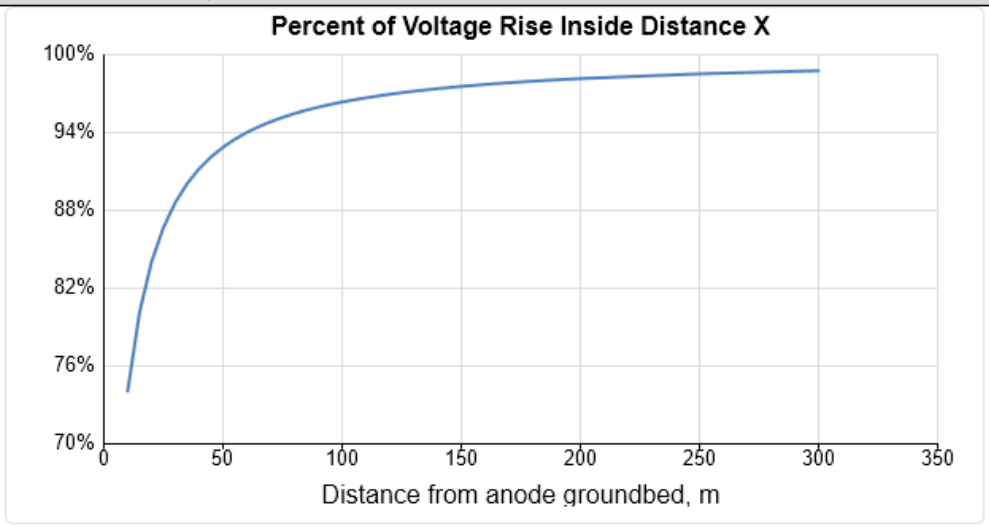
4. Selection of CP Current (per station) Based on:	Attenuation	16 A	Extra Capacity:	%	0%

5. Anode Selection and Groundbed Design

Design Life	yrs	20	**Anode Material Selected**		HSCI
Total Capacity Required	A-y	320.000	*Net Weight of Single Anode*	*kg*	14.300
Single Anode Output	A	5.000	*Anodes Consumption Rate*	*kg/A-y*	0.227
Single Anode Capacity	A-y	47.247	*Anode Utilization Factor*		0.75
If not known, enter data on the right to calculate =>			*Single Anode Capacity*	*A-y*	47.247
Number of Anode Required	6.77		**The number of anodes selected meets the design life requirement.**		
Number of Anodes Selected:	7	Current Output: 16.536 A	System Life: 21 yrs		

Shallow Anode Groundbed Design		Vertical	Deep Well Anode Groundbed Design		
Anode Length (incl. backfill)	cm	243.84	**Groundbed Diameter**	cm	20.00
Anode Diameter (incl. backfill)	cm	30.48	**Coke Consumption Rate**	kg/A-y	0.9988
Anode Spacing	cm	500.00	**Coke Utilization Factor**		0.50
Anode Burial Depth	cm	200.00	Coke Length by Consumption	m	20.35
Single Anode Resistance	Ω	3.093	Coke Length by Current Limit	m	16.45
Groundbed Resistance	Ω	0.650	Coke Column Length Selected	m	21
Pipe Resistance to Earth	Ω	0.061	Anode Spacing	cm	300
Cable Resistance per km	Ω/km	0.833	Groundbed Drilling Depth	m	41
Cable Length	m	150	Pipe Resistance to Earth	Ω	0.061
Cable Resistance	Ω	0.125	Groundbed Resistance	Ω	0.652
Total Circuit Resistance	Ω	0.836	Total Circuit Resistance	Ω	0.838
Rectifier Output Rating			Rectifier Output Rating		
Back Voltage	V	2.000	Back Voltage	V	2.000
TR Voltage Output Rating	V	16	TR Voltage Output Rating	V	16
TR Current Output Rating	A	17	TR Current Output Rating	A	17

6. Separation Distance of Anode Groundbed from Pipeline

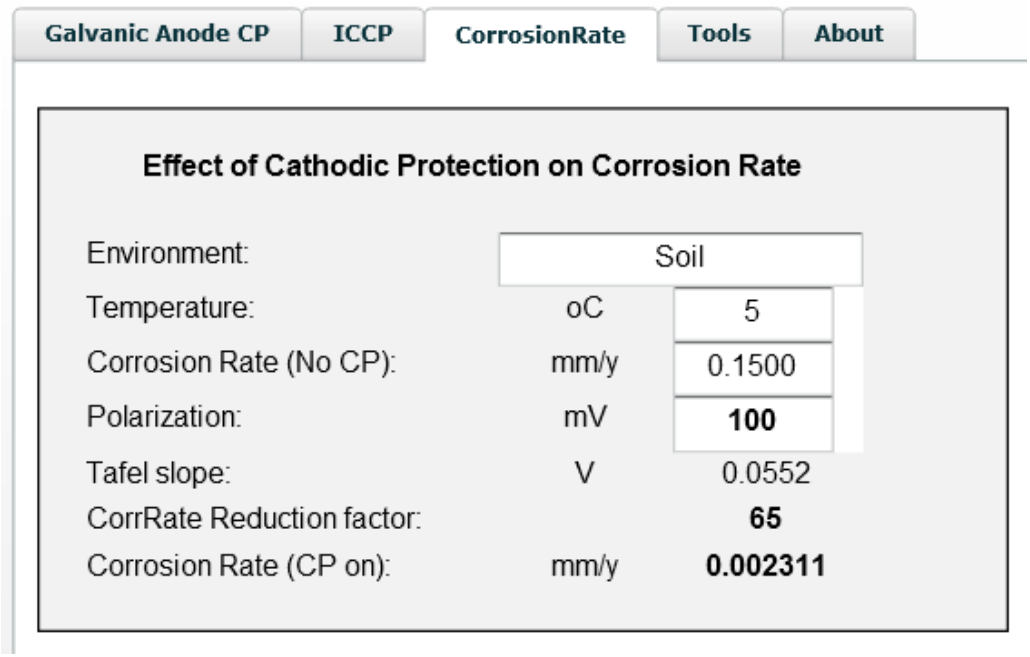


Distance from the Anode Groundbed	X	m	50	This is the minimum
Voltage Drop at Distance X from anode	Vx	V	0.238	separation distance for
Voltage drop over 1 m at Xmin from anode	Vd	mV	5.000	the groundbed to be
Min Distance of Anode to Pipeline	X_{min}	m	87.404	electrically "remote".
Recommended Separation Distance of Anode Groundbed from Pipeline			90 m	

Current and potential attenuation are calculated automatically to give you the most realistic estimation of the number of anode groundbeds required (see plots under Section 3 above).

The separation distance between the anode groundbed and the structure is automatically optimized based on the user specified acceptable voltage drop (see plot under Section 6).

The corrosion rate of the structure when CP is on can be calculated based on the polarization measurements, as shown in the screen shot below:



This unique function not found in any other CP design software allows users of CP-Compass to assess the degree of CP protection on an existing structure based on the CP survey results (the polarization data). It also allows the designer to set the CP criteria (e.g., 100 mV or 150 mV) to meet the corrosion rate target when CP is on.

The "Tools" menu in CP-Compass allows users to perform design calculations for any CP system for any structure.

Relative Values of Typical Reference Electrodes to Copper-Copper Sulfate Reference Electrode

Electrode (Half - Cell)	Name	Potential (Volts)
Copper - Copper Sulfate (Cu-Cu SO4)	CSE	0
Silver - Silver Chloride (Saturated)	Ag-AgCl	-0.05
Saturated Calomel	SCE	-0.07
Zinc (Pure Zinc)	Zn	-1.1

Sacrificial Anode Efficiency and Utilization Factor

Magnesium :

$$L_M = \frac{C_a * W * E * U_F}{I}$$

Ca = Electrochemical Capacity (A-y/kg)	Ca =	0.250
W = Weight of Anode (kg)	W =	109.000
E = Current Efficiency	E =	0.5
U_F = Utilization Factor	U_F =	0.85
I = Total Protection Current (amps)	I =	2.000
L_M = Life of Magnesium Anode (yrs)	L_M =	**5.791 yrs**

CP-Compass, giving you the right directions in the design and operation of cathodic protection.

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