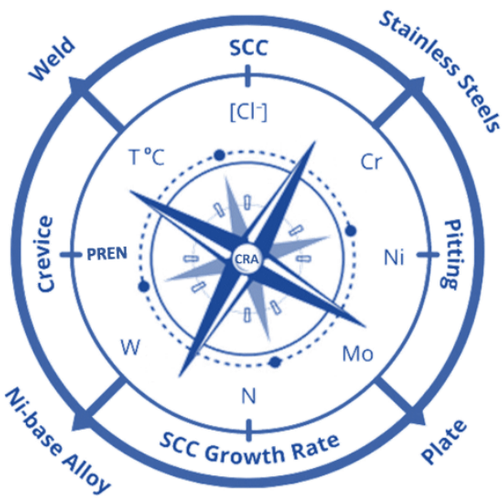


Corrosion Modeling Software and Corrosion Prediction Software Series

CRA-Compass®: Corrosion Modeling and Corrosion Prediction for Corrosion Resistant Alloys

The Threshold Temperature and Chloride Concentration for Pitting, Crevice Corrosion, and SCC

Version 9.3

★ **Performance** ★ **Functionality** ★ **Usability**

Anytime Anywhere Any Device Any OS
No USB dongles No installation No Browser Plug-ins

Contact Us for License Details

Overview of CRA-Compass

CRA-Compass models and predicts the threshold temperature and chloride concentration for pitting, crevice corrosion, and stress corrosion cracking (SCC) of 70 common corrosion resistant alloys used in water systems including natural seawater, chlorinated seawater, brines, produced water, formation water, brackish water, groundwater, fresh water, and potable water. Users can define their own alloys for CRA-Compass to evaluate the application limits for their resistance to pitting, crevice corrosion, and stress corrosion cracking (SCC) under the specified operating conditions. The performance of the CRAs in coastal/marine atmosphere is also included in this software.

Figure 1 below shows the alloy list in the software. Users simply select one of the 70 corrosion resistant alloys from the list or define their own alloy by entering the chemical compositions.

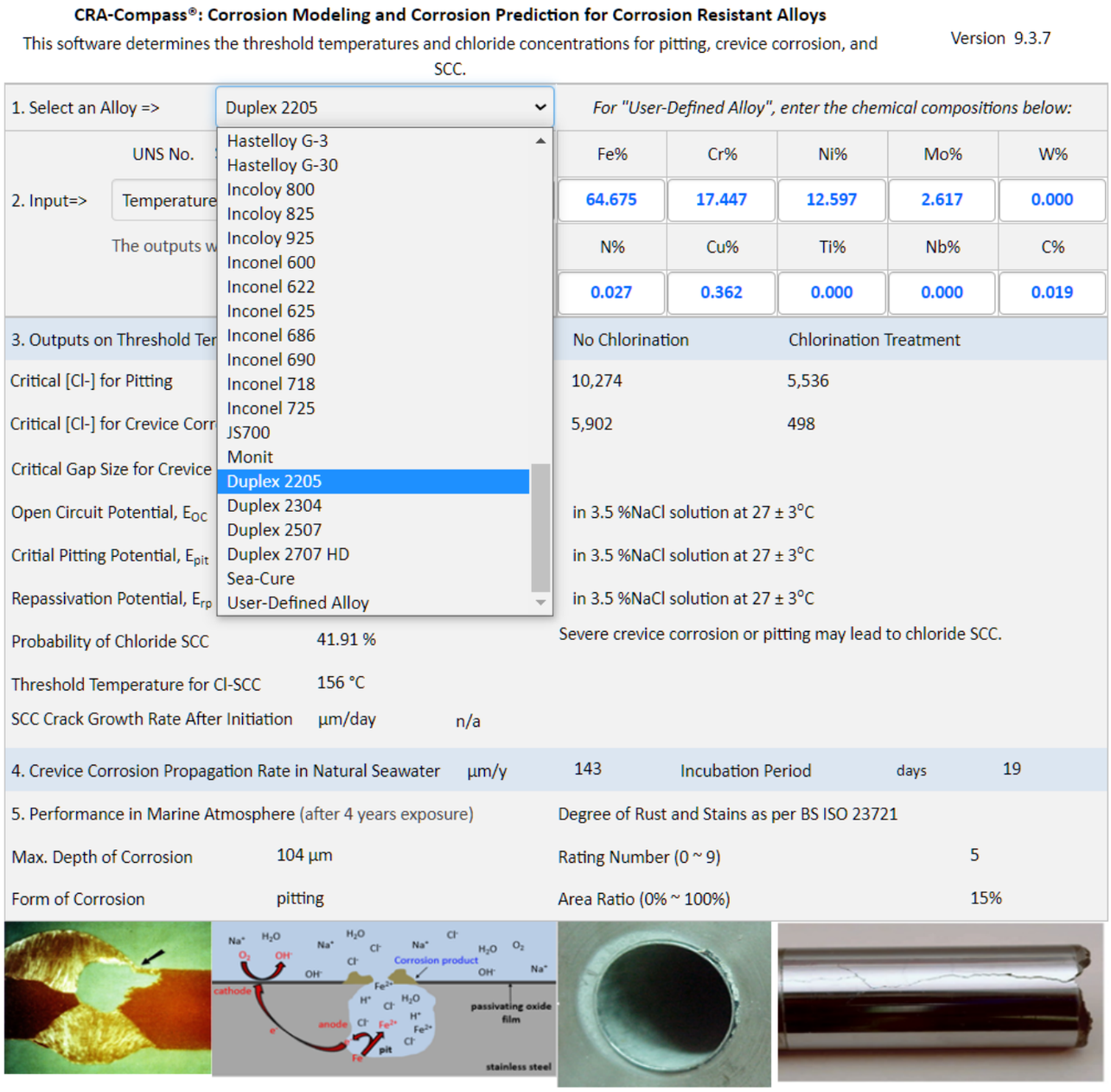


Figure 1 Overview of the CRA-Compass

After selecting or defining the alloy, the pitting resistance equivalent number, PREN, as defined in the International Standard ISO 15156, is calculated and displayed below the selected alloy.

The next step the user needs to do is to select one of the two input parameters, the temperature or the concentration of chloride, both are critical process parameters in many industries. If the user select the temperature as the input parameter (Figure 2), CRA-Compass will determine the threshold temperature or the concentration of chloride for the selected alloy in terms of its resistance to pitting and crevice corrosion for both the plate and weld. The probability of stress corrosion cracking (SCC) and the temperature limit for SCC are also determined. In the application example in Figure 2, for the austenitic stainless steel (AISI Type 347), the PREN is 18 (note that "super"-duplex refers to those with PREN of 40 and above). At the operating temperature of 65°C, the maximum concentration of chloride (for the steel's resistance to pitting and crevice corrosion) is 1,796 ppm and 1202 ppm respectively, in non-chlorinated waters and 158 ppm and 42 ppm in

chlorinated waters. The critical gap size for crevice corrosion is 0.892 µm. The open circuit potential, the critical pitting potential, and the repassivation potential are -74 mV, 86 mV, and -357 mV respectively. The probability of chloride stress corrosion cracking is 98.37% when the temperature exceeds 54oC at a chloride concentration of 1,796 ppm in non-chlorinated waters. The SCC crack growth rate after initiation is 40.174 um/day or 14.663 mm/y. The crevice corrosion propagation rate in natural seawater is 337 µm/y and the crevice incubation period is 1 day. The maximum pit depth is 205 µm after 4 years exposure in coastal/marine atmosphere. The degree of surface rust and stains are rated in accordance with BS ISO 23721 standard, with a RN number of 2 and a rust surface area ratio of 47%.

If the user select the chloride concentration as the input parameter, CRA-Compass will determine the threshold temperature for the selected alloy (Figure 3) in both chlorinated and non-chlorinated waters in terms of its resistance to pitting and crevice corrosion. The probability of stress corrosion cracking (SCC) and the temperature limit for SCC are also determined. If an alloy is susceptible to SCC and the operating temperature is above the threshold temperature, CRA-Compass will predict the crack growth rate of SCC for the selected alloy. The open circuit potential, the critical pitting potential, and the repassivation potential for the selected alloy are computed by CRA-Compass and are displayed under the Output on Threshold Temperature and Chloride Concentration. This predicted values correspond to the measurements in 3.5% NaCl solution at 27°C in the laboratory.

CRA-Compass®: Corrosion Modeling and Corrosion Prediction for Corrosion Resistant Alloys

This software determines the threshold temperatures and chloride concentrations for pitting, crevice corrosion, and SCC.

Version 9.3.7

1. Select an Alloy =>	Type 347			*For "User-Defined Alloy", enter the chemical compositions below:*				
	UNS No.	S34700	PREN (ISO15156)	18	Fe%	Cr%	Ni%	Mo%	W%
2. Input=>	Temperature		°C	65	64.675	17.447	12.597	2.617	0.000
	The outputs will be the threshold concentrations of chloride.				N%	Cu%	Ti%	Nb%	C%
					0.027	0.362	0.000	0.000	0.019

3. Outputs on Threshold Temperature and Chloride Concentration			No Chlorination	Chlorination Treatment
Critical [Cl-] for Pitting	Plate	ppm	1,796	158
Critical [Cl-] for Crevice Corrosion	Plate	ppm	1,202	42
Critical Gap Size for Crevice Corrosion	µm	0.892		
Open Circuit Potential, E_{OC}	-74 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}	86 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}	-357 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	98.37 %		Chloride SCC may initiate when the threshold T°C is exceeded at the critical [Cl-] for pitting OR crevice corrosion.	
Threshold Temperature for Cl-SCC	53 °C			
SCC Crack Growth Rate After Initiation	µm/day	40.174		

4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	337	Incubation Period	days	1

5. Performance in Marine Atmosphere (after 4 years exposure)		Degree of Rust and Stains as per BS ISO 23721	
Max. Depth of Corrosion	205 µm	Rating Number (0 ~ 9)	2
Form of Corrosion	pitting	Area Ratio (0% ~ 100%)	47%

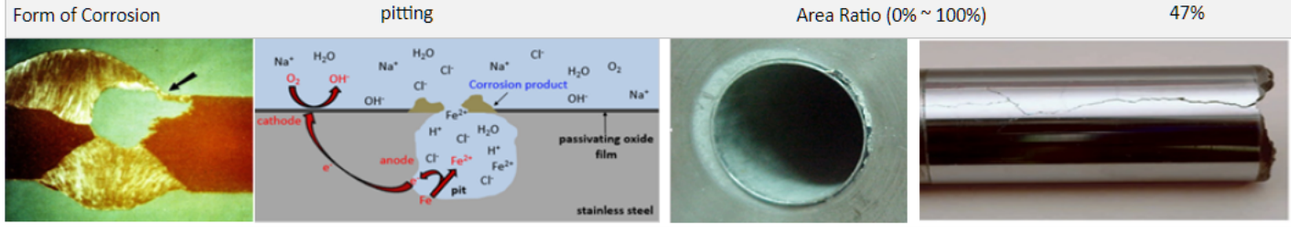


Figure 2

CRA-Compass®: Corrosion Modeling and Corrosion Prediction for Corrosion Resistant Alloys

This software determines the threshold temperatures and chloride concentrations for pitting, crevice corrosion, and SCC.

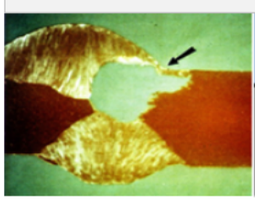
Version 9.3.7

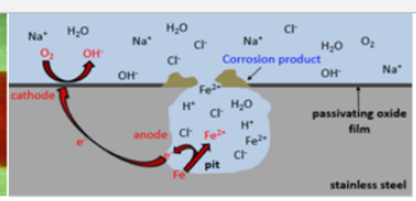
1. Select an Alloy =>	Duplex 2205			*For "User-Defined Alloy", enter the chemical compositions below:*				
UNS No.	S31803	PREN (ISO15156)	34	Fe%	Cr%	Ni%	Mo%	W%
2. Input=>	Chloride Concentration	ppm	1,000	64.675	17.447	12.597	2.617	0.000
	Chloride Concentration / Temperature			N%	Cu%	Ti%	Nb%	C%
	For process fluids with halides, treat the total halides as chloride.			0.027	0.362	0.000	0.000	0.019

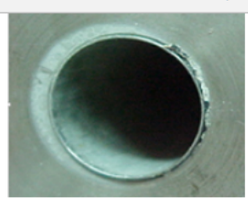
3. Outputs on Threshold Temperature and Chloride Concentration			No Chlorination	Chlorination Treatment
Critical Temperature for Pitting	Plate	°C	150	143
Critical Crevice Temperature	Plate	°C	145	48
Critical Gap Size for Crevice Corrosion	µm	0.248		
Open Circuit Potential, E_{OC}	-46 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}	760 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}	394 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	41.91 %		Severe crevice corrosion or pitting may lead to chloride SCC.	
Threshold Temperature for Cl-SCC	172 °C			
SCC Crack Growth Rate After Initiation	µm/day	n/a		

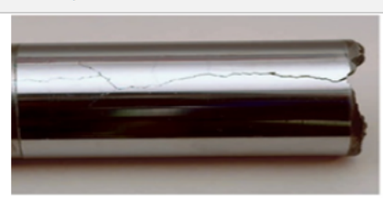
4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	143	Incubation Period	days	19

5. Performance in Marine Atmosphere (after 4 years exposure)		Degree of Rust and Stains as per BS ISO 23721	
Max. Depth of Corrosion	104 µm	Rating Number (0 ~ 9)	5
Form of Corrosion	pitting	Area Ratio (0% ~ 100%)	15%









1. Select an Alloy =>	Duplex 2205			*For "User-Defined Alloy", enter the chemical compositions below:*				
	UNS No.	S31803	PREN (ISO15156)	34	Fe%	Cr%	Ni%	Mo%	W%
2. Input=>	Chloride Concentration		ppm	1,000	64.675	17.447	12.597	2.617	0.000
	The output will be the threshold temperatures.				N%	Cu%	Ti%	Nb%	C%
	For process fluids with halides, treat the total halides as chloride.				0.027	0.362	0.000	0.000	0.019

3. Outputs on Threshold Temperature and Chloride Concentration			No Chlorination	Chlorination Treatment
Critical Temperature for Pitting	Plate	°C	150	143
Critical Crevice Temperature	Plate	°C	145	48
Critical Gap Size for Crevice Corrosion	µm	0.248		
Open Circuit Potential, E_{OC}	-46 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}	760 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}	394 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	41.91 %		Severe crevice corrosion or pitting may lead to chloride SCC.	
Threshold Temperature for Cl-SCC	172 °C			
SCC Crack Growth Rate After Initiation	µm/day	n/a		

4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	143	Incubation Period	days	19
5. Performance in Marine Atmosphere (after 4 years exposure)			Degree of Rust and Stains as per BS ISO 23721		
Max. Depth of Corrosion	104 µm		Rating Number (0 ~ 9)		5
Form of Corrosion	pitting		Area Ratio (0% ~ 100%)		15%

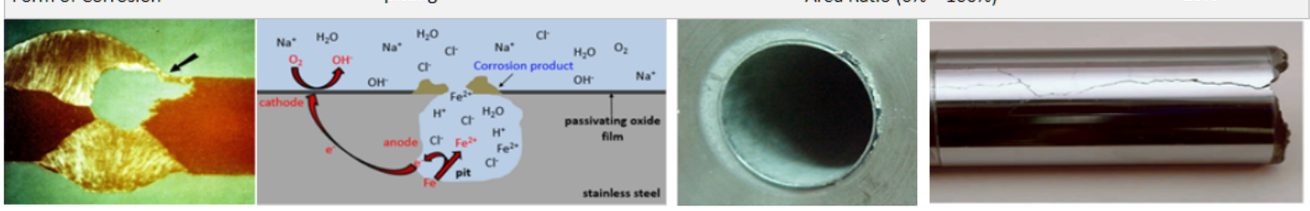


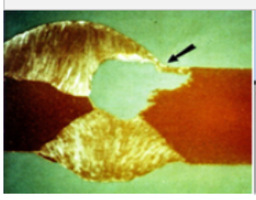
Figure 3

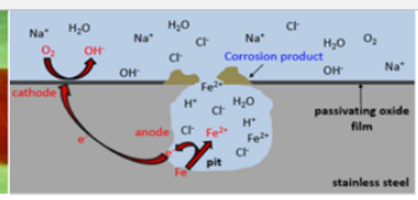
If an alloy is not in the built-in list, the user can select "User-Defined-Alloy" from the list and then enter the chemical compositions in the table as shown in Figure 4 below. The PREN number and all other predictions are then computed accordingly.

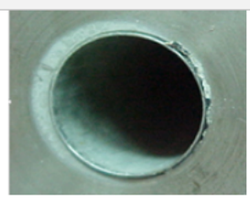
1. Select an Alloy =>	User-Defined Alloy	*For "User-Defined Alloy", enter the chemical compositions below:*				
UNS No.	Hastelloy G-3 Hastelloy G-30 Incoloy 800 Incoloy 825 Incoloy 925 Inconel 600 Inconel 622 Inconel 625 Inconel 686 Inconel 690 Inconel 718 Inconel 725 JS700 Monit Duplex 2205 Duplex 2304 Duplex 2507 Duplex 2707 HD Sea-Cure User-Defined Alloy	Fe%	Cr%	Ni%	Mo%	W%
2. Input=> Temperature		73.920	18.000	8.000	0.000	0.000
The outputs wil		N%	Cu%	Ti%	Nb%	C%
		0.000	0.000	0.000	0.000	0.080

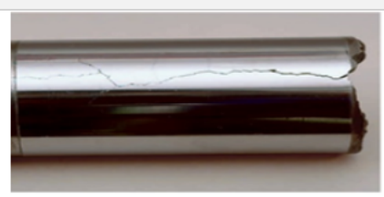
3. Outputs on Threshold Temp			No Chlorination	Chlorination Treatment
Critical [Cl-] for Pitting			1,104	114
Critical [Cl-] for Crevice Corros			758	22
Critical Gap Size for Crevice Co				
Open Circuit Potential, E_{OC}			in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}			in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}			in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	100.00 %		Chloride SCC may initiate when the threshold T°C is exceeded at the critical [Cl-] for pitting OR crevice corrosion.	
Threshold Temperature for Cl-SCC	42 °C			
SCC Crack Growth Rate After Initiation	µm/day	125.425		

4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	345	Incubation Period	days	1
5. Performance in Marine Atmosphere (after 4 years exposure)			Degree of Rust and Stains as per BS ISO 23721		
Max. Depth of Corrosion	205 µm		Rating Number (0 ~ 9)		2
Form of Corrosion	pitting		Area Ratio (0% ~ 100%)		47%









1. Select an Alloy =>	User-Defined Alloy			*For "User-Defined Alloy", enter the chemical compositions below:*				
	UNS No.	N/A	PREN (ISO15156)	18	Fe%	Cr%	Ni%	Mo%	W%
2. Input=>	Chloride Concentration		ppm	1,000	73.920	18.000	8.000	0.000	0.000
	The output will be the threshold temperatures.				N%	Cu%	Ti%	Nb%	C%
	For process fluids with halides, treat the total halides as chloride.				0.000	0.000	0.000	0.000	0.080

3. Outputs on Threshold Temperature and Chloride Concentration			No Chlorination	Chlorination Treatment
Critical Temperature for Pitting	Plate	°C	83	-10
Critical Crevice Temperature	Plate	°C	71	-10
Critical Gap Size for Crevice Corrosion	µm	0.892		
Open Circuit Potential, E_{OC}	-74 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}	86 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}	-357 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	100.00 %		Chloride SCC may initiate when the threshold T°C for SCC is exceeded at the specified 1000 ppm [Cl-].	
Threshold Temperature for Cl-SCC	42 °C			
SCC Crack Growth Rate After Initiation	µm/day	n/a		

4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	345	Incubation Period	days	1

5. Performance in Marine Atmosphere (after 4 years exposure)		Degree of Rust and Stains as per BS ISO 23721	
Max. Depth of Corrosion	205 µm	Rating Number (0 ~ 9)	2
Form of Corrosion	pitting	Area Ratio (0% ~ 100%)	47%

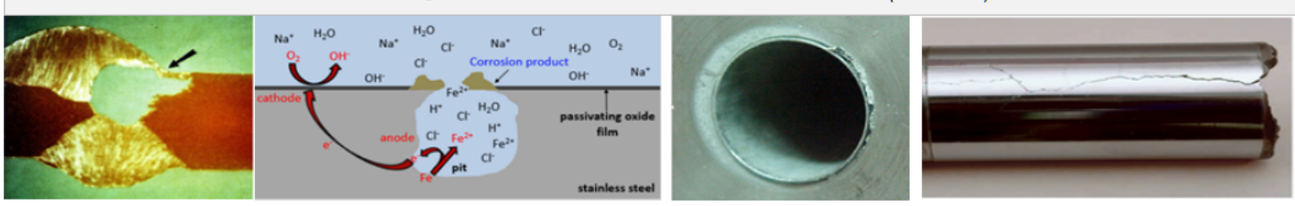


Figure 4 User-Defined-Alloy

Three performance indicators for the selected alloy in the coastal/marine atmosphere are predicted based on the results from 4 years field exposure: (1) the maximum depth of corrosion attack; (2) the form of corrosion (pitting, uniform corrosion, no corrosion); (3) the degree of rust and stains as per BS ISO 23721 standard.

Figures 5a and 5b below show that CRA-Compass models and predict threshold temperature and chloride concentration for both the plate and the weld of CRAs.

1. Select an Alloy =>	User-Defined Alloy			*For "User-Defined Alloy", enter the chemical compositions below:*				
	UNS No.	N/A	PREN (ISO15156)	18	Fe%	Cr%	Ni%	Mo%	W%
2. Input=>	Chloride Concentration		ppm	1,000	73.920	18.000	8.000	0.000	0.000
	The output will be the threshold temperatures.				N%	Cu%	Ti%	Nb%	C%
	For process fluids with halides, treat the total halides as chloride.				0.000	0.000	0.000	0.000	0.080

3. Outputs on Threshold Temperature and Chloride Concentration			No Chlorination	Chlorination Treatment
Critical Temperature for Pitting	Plate	°C	83	-10
Critical Crevice Temperature	Plate	°C	71	-10
Critical Gap Size for Crevice Corrosion	Plate / Weld	0.892		
Open Circuit Potential, E_{OC}	-74 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}	86 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}	-357 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	100.00 %		Chloride SCC may initiate when the threshold T°C for SCC is exceeded at the specified 1000 ppm [Cl-].	
Threshold Temperature for Cl-SCC	42 °C			
SCC Crack Growth Rate After Initiation	µm/day	n/a		

4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	345	Incubation Period	days	1
5. Performance in Marine Atmosphere (after 4 years exposure)			Degree of Rust and Stains as per BS ISO 23721		
Max. Depth of Corrosion	205 µm		Rating Number (0 ~ 9)		2
Form of Corrosion	pitting		Area Ratio (0% ~ 100%)		47%

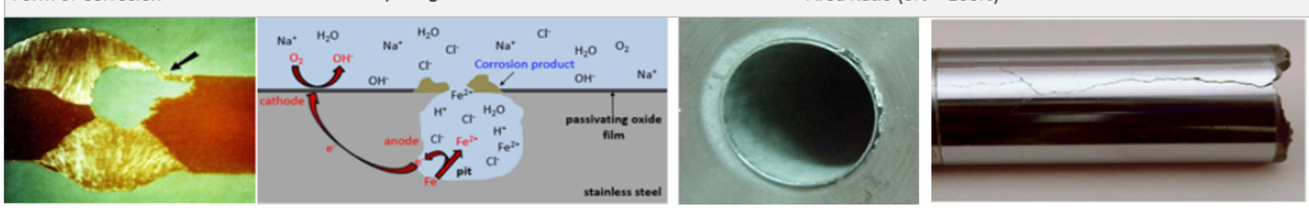


Figure 5a CRA Materials Selection - Comparing the Pitting Resistance of Plate vs Weld

1. Select an Alloy =>	User-Defined Alloy			*For "User-Defined Alloy", enter the chemical compositions below:*				
	UNS No.	N/A	PREN (ISO15156)	18	Fe%	Cr%	Ni%	Mo%	W%
2. Input=>	Chloride Concentration		ppm	1,000	73.920	18.000	8.000	0.000	0.000
	The output will be the threshold temperatures.				N%	Cu%	Ti%	Nb%	C%
	For process fluids with halides, treat the total halides as chloride.				0.000	0.000	0.000	0.000	0.080

3. Outputs on Threshold Temperature and Chloride Concentration			No Chlorination	Chlorination Treatment
Critical Temperature for Pitting	Plate	°C	83	-10
Critical Crevice Temperature	Weld	°C	66	-10
Critical Gap Size for Crevice Corrosion	Plate / Weld	0.892		
Open Circuit Potential, E_{OC}	-74 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Critial Pitting Potential, E_{pit}	86 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Repassivation Potential, E_{rp}	-357 mV (SCE)		in 3.5 %NaCl solution at 27 ± 3°C	
Probability of Chloride SCC	100.00 %		Chloride SCC may initiate when the threshold T°C for SCC is exceeded at the specified 1000 ppm [Cl-].	
Threshold Temperature for Cl-SCC	42 °C			
SCC Crack Growth Rate After Initiation	µm/day	n/a		

4. Crevice Corrosion Propagation Rate in Natural Seawater	µm/y	345	Incubation Period	days	1
5. Performance in Marine Atmosphere (after 4 years exposure)			Degree of Rust and Stains as per BS ISO 23721		
Max. Depth of Corrosion	205 µm		Rating Number (0 ~ 9)		2
Form of Corrosion	pitting		Area Ratio (0% ~ 100%)		47%

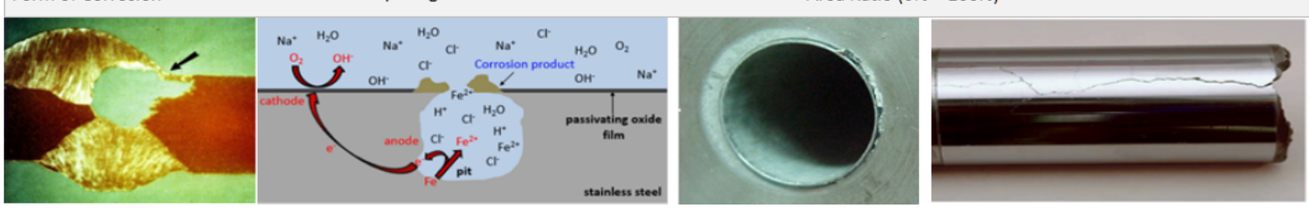


Figure 5b CRA Materials Selection - Comparing the Crevice Corrosion Resistance of Plate vs Weld

List of Alloys Available in CRA-Compass

Type 410

Type 430

Type 444

Type 446

20Cb-3

20Mo-4

20Mo-6

254SMO

654SMO

Type 304

Type 304L

Type 304LN

Type 316

Type 316L

Type 316LN

Type 317

Type 317L

Type 317LMN

Type 321

Type 347

Al-6X

AL-6XN

904L

Alloy 885

Allcorr

Sanicro 28

Nicrofer 3228 NbCe

Nicrofer 2509 Si7

Cronifer 1925 hMo

Nicrofer 5923 hMo

Monel 400

Monel K-500

Inconel 600

Inconel 686

Inconel 690

Ferralium 255

Zeron 100

Alloy 329

7Mo Plus

2RE69

3RE60

44LN

IN-744

Uranus 50

Uranus B66

DP-3W

Hastelloy C

Hastelloy C-2000

Hastelloy C-22

Hastelloy C-276

Hastelloy C-4

Hastelloy G

Hastelloy G-3

Hastelloy G-30

Incoloy 800

Incoloy 825

Incoloy 925

Inconel 622

Inconel 625

Inconel 718

Inconel 725

JS700

Monit

Duplex 2205

Duplex 2304

Duplex 2507

Duplex 2707 HD

Sea-Cure

User-Defined Alloy

Use of CRA-Compass to Establish Integrity Operating Windows in a Gas Processing Plant

Integrity operating windows are established limits for process variables (parameters) that can affect the integrity of the equipment if the process operation deviates from the established limits for a pre-determined length of time (includes critical, standard and informational IOWs). CRA-Compass is a powerful software tool that can help asset owners and operators quickly and accurately determine the IOW limits. CRA-Compass can be used to determine the temperature and chloride IOW limits for a duplex stainless steel used in a gas processing plant.

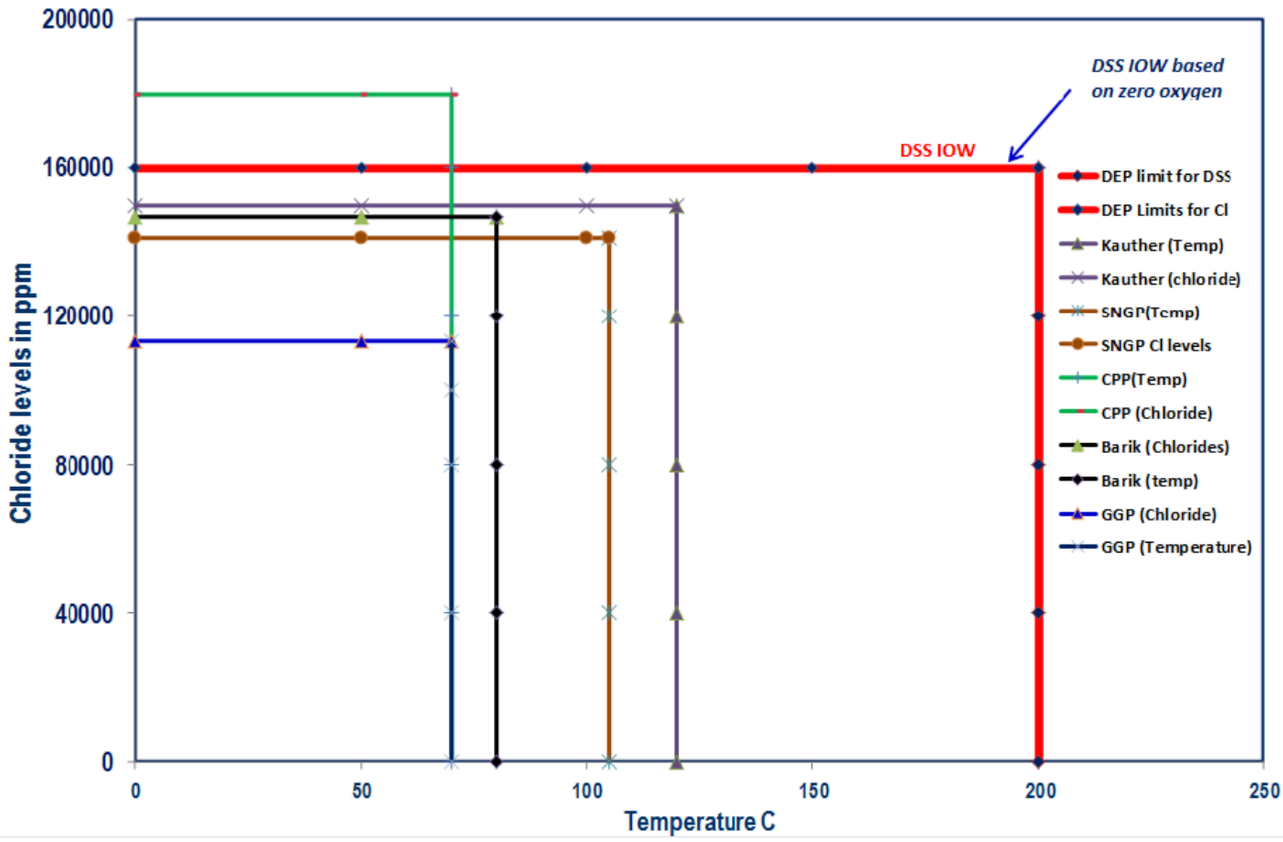


Figure 5c CRA-Compass Software for Determining Integrity Operating Windows (IOWs)

The powerful applications of CRA-Compass are truly unlimited in engineering design, materials selection, process operation, inspection and maintenance, corrosion risk assessment, setting the IOW limits, corrosion modeling and remaining life prediction.

Click here to contact us for licensing details and experience the power of CRA-Compass.

CRA-Compass, giving you the right directions in CRA selection and application.

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