



Corrosion Prediction and Corrosion Modeling Software

### EVS-Compass®: Extreme Value Statistics for Corrosion Modeling and Corrosion Life Prediction

Version 9.20

★ Performance ★ Functionality ★ Usability



Anytime Anywhere Any Device Any OS

No USB dongles No installation No Browser Plug-ins

Why WebCorr | Performance Guarantee | Unparalleled Functionality | Unmatched Usability | Any Device Any OS | Free Training & Support

#### Overview and Application Examples of EVS-Compass - Extreme Value Statistics for Corrosion Modeling and Corrosion Life Prediction

Extreme value statistics (EVS) has been used since the 1950s for extrapolating corrosion damages (maximum pit depth, crevice depth, crack depth etc.) from small lab samples, field coupons, or partial coverage inspection blocks to larger area of structures and assets at present or future times. WebCorr's EVS-Compass is the only device and OS independent EVS software on the market for corrosion modeling and life prediction of corrodible structures. Designers, OEM engineers, consultants, operation personnel, maintenance and inspection engineers, and government regulators can quickly and accurately determine:



1. the time to first leak or perforation;
2. the number of leaks or perforation at any given time;
3. the time to **N**th leak or perforation for any given number of **N**;
4. the area of perforation holes;
5. the depth of the largest pit at any given time;
6. the depth of the **N**th largest pit at any given time;
7. the number of pits exceeding a given depth **D** at any given time;
8. the time required for **N** pits to exceed the depth of **D**;
9. the probability of failure (POF) at a given time and a given wall thickness;
10. the service life for a given wall thickness at a given POF threshold;

11. the maximum surface area for EVS extrapolation in partial coverage inspection;
12. the recommended area for lab coupons or inspection blocks for EVS extrapolation in space and in time;
13. the recommended number of lab coupons or inspection blocks for EVS extrapolation in space and in time;
14. the charts showing (a) pit depth vs service life; (b) pit depth vs area; (c) probability of failure vs service life; (d) probability of failure vs area; (e) probability of failure vs wall thickness.

The probability of failure (POF) is an important factor in API 580 Risk-Based Inspection and API 581 Risk-Based Inspection Methodology. EVS-Compass is a powerful EVS software tool that goes beyond the prediction of the probability of failure (POF) in time (POF vs service life) and in space (POF vs area, POF vs wall-thickness), it predicts **the time to FIRST leak or perforation, the number of leaks at any given time, the depth of corrosion and the number of pits exceeding the specified depth at any future time**. For partial coverage inspection, EVS-Compass determines both the size and number of inspection blocks to minimize uncertainties. The unique capabilities of EVS-Compass help assets owners, operators, and government regulators make quantitative risk-based decisions pertaining to the future conditions and operations of structures and assets.

EVS-Compass is a cloud-based software that works on any device running any OS without the need for users to install or download anything. Figure 1 below shows an overview of the user interface of EVS-Compass.

Structure ID		Type 316L stainless steel coupons in chloride solution at 50oC					
Material of construction	Stainless Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Chemicals						
Remaining wall thickness, d	mm						12.700
Area of coupons or inspection blocks, A <sub>c</sub>	m <sup>2</sup>						0.00258
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						0.0929
Service life or exposure time for each dataset	Days		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	3		2.063	6.007	15.771	18.885	22.000
Prediction of Leaks or Perforations			0.640	1.011	1.135	1.552	1.389
Service life or exposure time for prediction, t	Days	4015.000	0.775	1.011	1.273	1.651	1.397
Time to first leak or perforation, t <sub>1</sub>	Days	882		1.011	1.344	1.857	1.443
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	675		1.036	1.379	1.857	1.461
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	8871		1.054	1.506	2.030	1.542
	N =	100		1.118	1.613	2.030	1.577
Area of perforation holes, A <sub>H</sub>	% total	9.955%		1.326	1.641	2.101	1.588
Prediction of Maximum Depth of Pits							1.595
Depth of the largest pit at time t, D <sub>t</sub>	mm	24.532					1.669
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.999					1.676
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	2318					1.694
	D (mm) =	0.500					1.715
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	5					1.768
Probability of Failure (POF)							1.776
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		100.000%					
Service life for wall thickness d, t <sub>d</sub>	Days	170					
	at the user defined POF threshold of	5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		2.010					
Maximum Pit Depth, mm		Max Pit Depth vs Time					

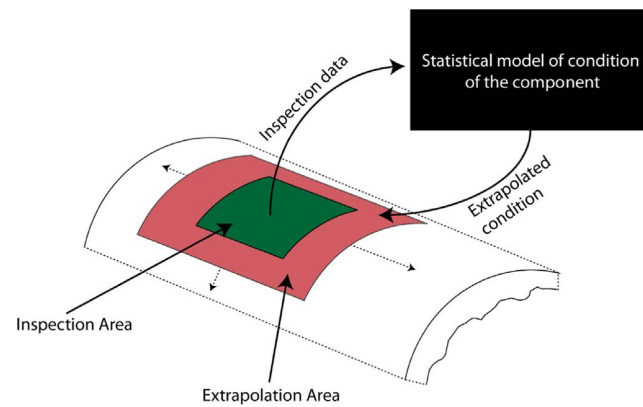
Figure 1 EVS-Compass: Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets.

**EVS-Compass Application Example No.1**

**Prediction of Pitting Corrosion in Type 316L Stainless Steel: EVS Extrapolation in Space and in Time**

In Figure 1 above, type 316L stainless steel coupons of 2" by 2" ( $4 \text{ in}^2 = 0.00258 \text{ m}^2$ ) with a thickness of 0.5" (12.7 mm) were immersed in chloride solution at 50°C for durations ranging from 49.50 hours to 528 hours (2.063 to 22 days) in the laboratory. For each exposure duration, a number of identical coupons (from 3 to 15) were used. The maximum pit depth on each coupon was measured and entered in EVS-Compass. The 5 exposure durations produced 5 datasets. For a surface area of 1 ft<sup>2</sup> (12"x12"=144 in<sup>2</sup>=0.0929 m<sup>2</sup>), EVS-Compass predicts that:

- (1) the time to first leak or perforation of the 12.7 mm plate is 882 days;
- (2) after 11 years (4015 days), the number of leaks or perforation holes is 63 ( $675 \times 0.0929 = 63$ );
- (3) the time to **100**th leak or perforation is 8871 days (24.3 years);
- (4) the hole area at 11 years is 9.955% of the total surface area;
- (5) the depth of the largest pit at 11 years is 24.532 mm;
- (6) the depth of the **100**th largest pit at 11 years is 8.999 mm;
- (7) the number of pits exceeding 0.5 mm at 11 years is 215 ( $2318 \times 0.0929 = 215$ );
- (8) the time for the first 100 pits to exceed 0.5 mm is 5 days;
- (9) the probability of failure at 11 years for wall thickness of 12.7 mm is 100%;
- (10) the service life for wall thickness of 12.7 mm at 5% probability of failure is 170 days;
- (11) For partial coverage inspection (PCI), the maximum area of EVS extrapolation under the current settings is 2.01 m<sup>2</sup>.



EVS-Compass is designed with end-users in mind without the usual learning curve associated with a new software. Users simply enter the basic information such as material, service environment, area of coupons or inspection blocks, total surface area of the structure, exposure time and durations, and the maximum pit depth for each coupon or inspection block at each exposure duration. Figures 2-5 show the options for materials, service environments, exposure time, and type of charts to display.

Structure ID		Type 316L stainless steel coupons in chloride solution at 50oC					
Material of construction	Carbon Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Carbon Steels						
Remaining wall thickness, d	12.700						
Area of coupons or inspection blocks, A <sub>C</sub>	0.00258						
Total surface area of the structure, A <sub>T</sub>	100.0000						
Service life or exposure time for each dataset	Days	2.063	6.007	15.771	18.885	22.000	
Number of datasets used for analysis and prediction	3	0.531	0.930	0.902	1.478	1.181	
Prediction of Leaks or Perforations		0.640	1.011	1.135	1.552	1.389	
Service life or exposure time for prediction, t	Days	365.000	0.775	1.011	1.273	1.651	1.397
Time to first leak or perforation, t <sub>1</sub>	Days	787		1.011	1.344	1.857	1.443
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0		1.036	1.379	1.857	1.461
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	814		1.054	1.506	2.030	1.542
	N =	100		1.118	1.613	2.030	1.577
Area of perforation holes, A <sub>H</sub>	% total	0.000%		1.326	1.641	2.101	1.588
Prediction of Maximum Depth of Pits						1.595	
Depth of the largest pit at time t, D <sub>t</sub>	mm	9.095				1.669	
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.963				1.676	
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0				1.694	
	D (mm) =	0.500				1.715	
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	0				1.768	

Figure 2 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: option for Material of Construction

Structure ID		Type 316L stainless steel coupons in chloride solution at 50oC					
Material of construction	Carbon Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Chemicals						
Remaining wall thickness, d	12.700						
Area of coupons or inspection blocks, A <sub>C</sub>	0.00258						
Total surface area of the structure, A <sub>T</sub>	100.0000						
Service life or exposure time for each dataset	Days	2.063	6.007	15.771	18.885	22.000	
Number of datasets used for analysis and prediction	3	0.531	0.930	0.902	1.478	1.181	
Prediction of Leaks or Perforations		0.640	1.011	1.135	1.552	1.389	
Service life or exposure time for prediction, t	Days	365.000	0.775	1.011	1.273	1.651	1.397
Time to first leak or perforation, t <sub>1</sub>	Days	787		1.011	1.344	1.857	1.443
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0		1.036	1.379	1.857	1.461
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	814		1.054	1.506	2.030	1.542
	N =	100		1.118	1.613	2.030	1.577
Area of perforation holes, A <sub>H</sub>	% total	0.000%		1.326	1.641	2.101	1.588
Prediction of Maximum Depth of Pits						1.595	
Depth of the largest pit at time t, D <sub>t</sub>	mm	9.095				1.669	
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.963				1.676	
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0				1.694	
	D (mm) =	0.500				1.715	
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	0				1.768	

Figure 3 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: option for Service Environment.

Structure ID	Type 316L stainless steel coupons in chloride solution at 50oC			
Material of construction	Stainless Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.		
Service environment	Chemicals			
Remaining wall thickness, d	mm	12.700		
Area of coupons or inspection blocks, A <sub>C</sub>	m <sup>2</sup>	0.00258		
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>	100.0000	Dataset 1	Dataset 2
Service life or exposure time for each dataset	Days		2.063	6.007
Number of datasets used for analysis and prediction	Hours		0.531	0.930
	Days		0.640	1.011
Prediction of Leaks or Perforations	Weeks		1.135	1.552
	Months		1.552	1.389
Service life or exposure time for prediction, t	Days		0.775	1.011
Time to first leak or perforation, t <sub>1</sub>	Days	787		1.011
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0		1.036
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	814		1.054
Area of perforation holes, A <sub>H</sub>	% total	N = 100		1.118
				1.613
		0.000%		1.326
Prediction of Maximum Depth of Pits				1.641
Depth of the largest pit at time t, D <sub>t</sub>	mm	9.095		2.101
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.963		1.588
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0		1.595
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	D (mm) = 0.500		1.669
				1.676
		0		1.694
				1.715
				1.768

Figure 4 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: option for Exposure Time.

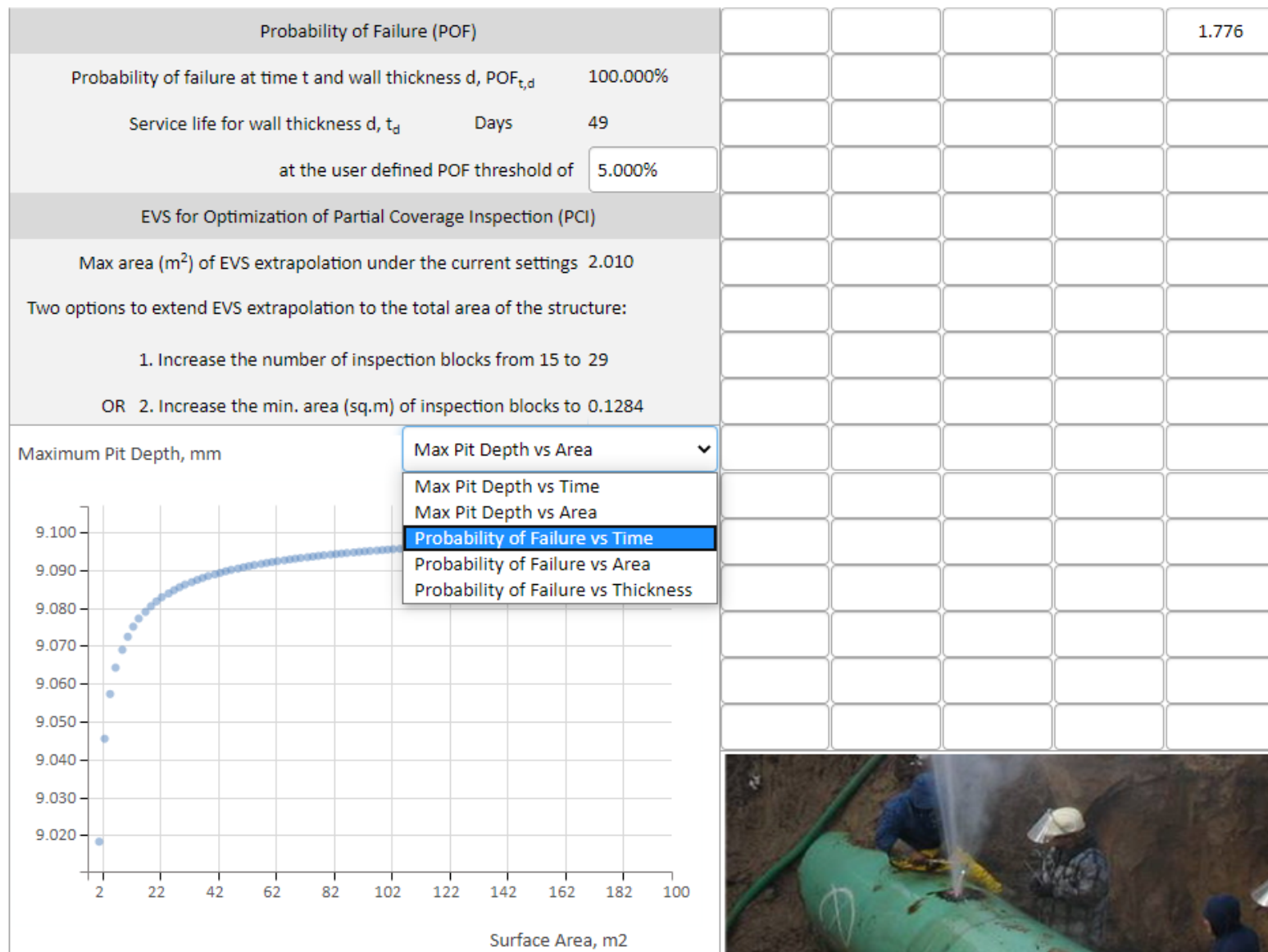


Figure 5 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: option for different types of plots.

**EVS extrapolation in space and in time:** The surface area of coupons used in laboratory tests was 4 in<sup>2</sup> (0.00258 m<sup>2</sup>) for a maximum duration of 22 days. Figure 6 shows prediction results by EVS-Compass when the surface area is extrapolated to 2.58 m<sup>2</sup> (1000 times) and the exposure time to 365 days. The time to first leak or perforation is 800 days, the time to **100**th leak or perforation is 1028 days. For partial coverage inspection (PCI), EVS-Compass determines that the maximum surface area for extrapolation is 2.02 m<sup>2</sup>. EVS-Compass recommends two options to extend the extrapolation to the total surface area of the structure: (1) by increasing the number of inspection blocks from the current 15 to 16; or by increasing the minimum surface area of the inspection blocks from the current 0.00258 m<sup>2</sup> to 0.0033 m<sup>2</sup>. The probability of failure vs. service life is selected in Figure 6. In Figure 7, the probability of failure vs. surface area is selected. Figure 8 show the plot of the probability of failure vs. wall thickness.

Structure ID		Type 316L stainless steel coupons in chloride solution at 50oC					
Material of construction	Stainless Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Chemicals						
Remaining wall thickness, d	mm						12.700
Area of coupons or inspection blocks, A <sub>c</sub>	m <sup>2</sup>						0.00258
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						2.5800
Service life or exposure time for each dataset	Days		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	3		2.063	6.007	15.771	18.885	22.000
Prediction of Leaks or Perforations			0.640	1.011	1.135	1.552	1.389
Service life or exposure time for prediction, t	Days	365.000	0.775	1.011	1.273	1.651	1.397
Time to first leak or perforation, t <sub>1</sub>	Days	800		1.011	1.344	1.857	1.443
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0		1.036	1.379	1.857	1.461
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	1028		1.054	1.506	2.030	1.542
	N =	100		1.118	1.613	2.030	1.577
Area of perforation holes, A <sub>H</sub>	% total	0.000%		1.326	1.641	2.101	1.588
Prediction of Maximum Depth of Pits							1.595
Depth of the largest pit at time t, D <sub>t</sub>	mm	9.029					1.669
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.099					1.676
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0					1.694
	D (mm) =	0.500					1.715
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	1					1.768
Probability of Failure (POF)							1.776
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		100.000%					
Service life for wall thickness d, t <sub>d</sub>	Days	86					
	at the user defined POF threshold of	5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings			2.010				
Two options to extend EVS extrapolation to the total area of the structure:							
1. Increase the number of inspection blocks from 15 to 16							
OR 2. Increase the min. area (sq.m) of inspection blocks to 0.0033							
Probability of Failure		Probability of Failure vs Time					

Figure 6 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: Probability of Failure vs. Service Life.



Structure ID		Type 316L stainless steel coupons in chloride solution at 50oC					
Material of construction	Stainless Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Chemicals						
Remaining wall thickness, d	mm						12.700
Area of coupons or inspection blocks, A <sub>c</sub>	m <sup>2</sup>						0.00258
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						50.0000
Service life or exposure time for each dataset	Days		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	3		2.063	6.007	15.771	18.885	22.000
Prediction of Leaks or Perforations			0.640	1.011	1.135	1.552	1.389
Service life or exposure time for prediction, t	Days	365.000	0.775	1.011	1.273	1.651	1.397
Time to first leak or perforation, t <sub>1</sub>	Days	788		1.011	1.344	1.857	1.443
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0		1.036	1.379	1.857	1.461
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	828		1.054	1.506	2.030	1.542
	N =	100		1.118	1.613	2.030	1.577
Area of perforation holes, A <sub>H</sub>	% total	0.000%		1.326	1.641	2.101	1.588
Prediction of Maximum Depth of Pits							1.595
Depth of the largest pit at time t, D <sub>t</sub>	mm	9.090					1.669
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.899					1.676
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0					1.694
	D (mm) =	0.500					1.715
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	0					1.768
Probability of Failure (POF)							1.776
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		100.000%					
Service life for wall thickness d, t <sub>d</sub>	Days	54					
	at the user defined POF threshold of	5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		2.010					
Two options to extend EVS extrapolation to the total area of the structure:							
1. Increase the number of inspection blocks from 15 to 26							
OR 2. Increase the min. area (sq.m) of inspection blocks to 0.0642							
Probability of Failure	Probability of Failure vs Area						

Figure 7 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: Probability of Failure vs. Surface Area.

Structure ID		Type 316L stainless steel coupons in chloride solution at 50oC					
Material of construction	Stainless Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Chemicals						
Remaining wall thickness, d	mm						25.000
Area of coupons or inspection blocks, A <sub>c</sub>	m <sup>2</sup>						0.00258
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						2.5800
Service life or exposure time for each dataset	Days		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	3		2.063	6.007	15.771	18.885	22.000
Prediction of Leaks or Perforations			0.531	0.930	0.902	1.478	1.181
Service life or exposure time for prediction, t	Days	365.000	0.640	1.011	1.135	1.552	1.389
Time to first leak or perforation, t <sub>1</sub>	Days	3803	0.775	1.011	1.273	1.651	1.397
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0		1.011	1.344	1.857	1.443
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	4885		1.036	1.379	1.857	1.461
	N =	100		1.054	1.506	2.030	1.542
Area of perforation holes, A <sub>H</sub>	% total	0.000%		1.118	1.613	2.030	1.577
Prediction of Maximum Depth of Pits				1.326	1.641	2.101	1.588
Depth of the largest pit at time t, D <sub>t</sub>	mm	9.029					1.595
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	8.099					1.669
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0					1.676
	D (mm) =	0.500					1.694
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	1					1.715
Probability of Failure (POF)							1.768
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		2.617%					1.776
Service life for wall thickness d, t <sub>d</sub>	Days	409					
	at the user defined POF threshold of	5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		2.010					
Two options to extend EVS extrapolation to the total area of the structure:							
1. Increase the number of inspection blocks from 15 to 16							
OR 2. Increase the min. area (sq.m) of inspection blocks to 0.0033							
Probability of Failure		Probability of Failure vs Thickness					

Figure 8 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: Probability of Failure vs. Wall Thickness.

**EVS-Compass Application Example No.2**

**Prediction of Pitting Corrosion in Aluminum Alloy: EVS Extrapolation in Space and in Time**

Figures 9 and 10 show another application example of EVS-Compass in corrosion modeling and life prediction. Aluminum alloy Alcan 2S-O coupons of 129 cm<sup>2</sup> were immersed in Kingston tap water at 25°C for various durations from 7 to 365 days. Maximum pit depth on each coupon at 5 exposure durations is entered into EVS-Compass as shown in Figure 9 below. For a large structure with an area of 1000 m<sup>2</sup> (that is 77,519 times of the area of coupons) and a wall thickness of 2.54 mm, EVS-Compass predicts that:

- (1) the time to first leak or perforation is 991 days;
- (2) the number of leaks or perforation after 5 years (1825 days) is 24/m<sup>2</sup>;
- (3) the time to the **100**th leak or perforation is 997 days;
- (4) the hole area after 5 years exposure is 21% of the total surface area;
- (5) the depth of the largest pit on the 1000 m<sup>2</sup> surface area after 5 years is 3.09 mm;
- (6) the number pits exceeding 1.27 mm after 5 years is 108/m<sup>2</sup>;
- (7) the time required for the first 100 pits to exceed 1.27 mm is 98 days;
- (8) the probability of failure at 5 years for the wall thickness of 2.54 mm on the 1000 m<sup>2</sup> surface is 100%;
- (9) the service life for the wall thickness of 2.54 mm in the 1000 m<sup>2</sup> surface is 3 days at the POF of 5%;
- (10) for partial coverage inspection, the maximum area of extrapolation is 0.809 m<sup>2</sup>;
- (11) EVS-Compass recommends two options to extend EVS extrapolation to the entire surface area of the structure: (a) by increasing the number of coupons or inspection blocks from the current 10 to 32; (b) by increasing the area of coupons or inspection blocks to 15.9438 m<sup>2</sup> (shown in Figure 10 below);
- (12) the maximum pit depth vs. service life is plotted in Figure 9.

Structure ID		Alcan 2S-O coupons immersed in Kingston tap water at 25oC					
Material of construction	Aluminum Alloys	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Water Immersion						
Remaining wall thickness, d	mm						2.540
Area of coupons or inspection blocks, A <sub>C</sub>	m <sup>2</sup>						0.01290
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						1000.0000
Service life or exposure time for each dataset	Days		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	5		7.000	30.000	90.000	180.000	365.000
Prediction of Leaks or Perforations			0.266	0.500	0.578	0.620	0.680
Service life or exposure time for prediction, t	Days	1825.000	0.290	0.510	0.610	0.620	0.700
Time to first leak or perforation, t <sub>1</sub>	Days	991	0.306	0.580	0.610	0.680	0.760
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	24	0.334	0.580	0.610	0.680	0.800
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	997	0.340	0.640	0.660	0.720	0.810
		N = 100	0.340	0.654	0.690	0.740	0.820
Area of perforation holes, A <sub>H</sub>	% total	21.081%	0.410	0.680	0.718	0.740	0.840
Prediction of Maximum Depth of Pits			0.410	0.692	0.760	0.760	0.840
Depth of the largest pit at time t, D <sub>t</sub>	mm	3.050	0.545	0.692	0.798	0.760	0.900
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	3.044					
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	108					
		D (mm) = 1.270					
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	98					
Probability of Failure (POF)							
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		100.000%					
Service life for wall thickness d, t <sub>d</sub>	Days	3					
		at the user defined POF threshold of 5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		0.809					
Two options to extend EVS extrapolation to the total area of the structure:							
1. Increase the number of inspection blocks from 10 to 32							
OR 2. Increase the min. area (sq.m) of inspection blocks to 15.9438							
Maximum Pit Depth, mm	Max Pit Depth vs Time						

Figure 9 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: aluminum alloy in Kingston tap water.

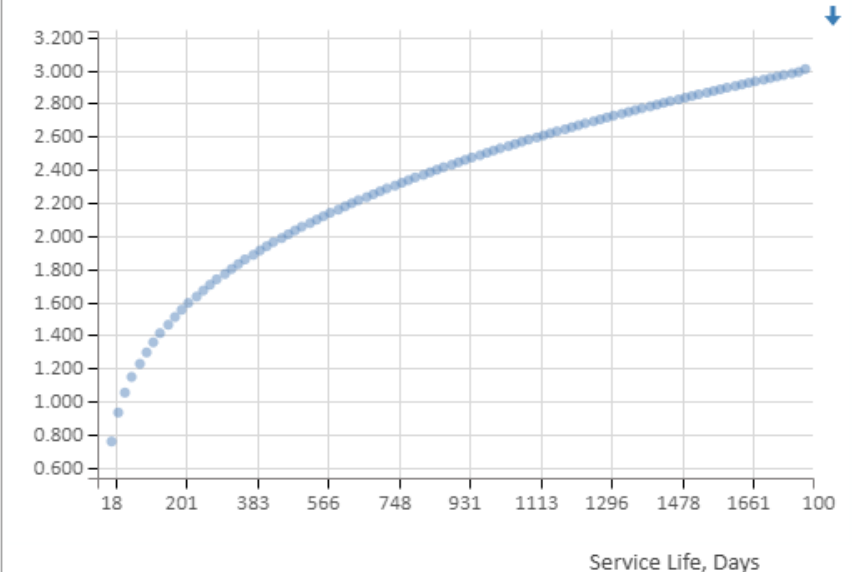

Structure ID		Alcan 2S-O coupons immersed in Kingston tap water at 25oC					
Material of construction	Aluminum Alloys	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Water Immersion						
Remaining wall thickness, d	mm						2.540
Area of coupons or inspection blocks, A <sub>c</sub>	m <sup>2</sup>						15.94380
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						1000.0000
Service life or exposure time for each dataset	Days		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	5		7.000	30.000	90.000	180.000	365.000
Prediction of Leaks or Perforations			0.266	0.500	0.578	0.620	0.680
Service life or exposure time for prediction, t	Days	1825.000	0.290	0.510	0.610	0.620	0.700
Time to first leak or perforation, t <sub>1</sub>	Days	1038	0.306	0.580	0.610	0.680	0.760
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	0	0.334	0.580	0.610	0.680	0.800
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Days	32853	0.340	0.640	0.660	0.720	0.810
	N =	100	0.340	0.654	0.690	0.740	0.820
Area of perforation holes, A <sub>H</sub>	% total	0.017%	0.410	0.680	0.718	0.740	0.840
Prediction of Maximum Depth of Pits			0.410	0.692	0.760	0.760	0.840
Depth of the largest pit at time t, D <sub>t</sub>	mm	3.007	0.545	0.692	0.798	0.760	0.900
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	1.069					
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	0					
	D (mm) =	1.270					
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Days	3245					
Probability of Failure (POF)							
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		100.000%					
Service life for wall thickness d, t <sub>d</sub>	Days	22					
	at the user defined POF threshold of	5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		1000.003					
Maximum Pit Depth, mm		Max Pit Depth vs Time					
							
							

Figure 10 Extreme Value Statistics software for corrosion modeling and corrosion life prediction of structures and assets: Optimization of Partial Inspection Coverage

**EVS-Compass Application Example No.3**

**Partial Coverage Inspection of Pitting Corrosion in Oil Tank Bottom Plate: EVS Extrapolation in Space**

Inspection of a large oil tank carbon steel base plate of 6 mm in thickness was carried out to determine the maximum pit depth distribution. The whole surface area of the oil tank plate was 1040 m<sup>2</sup>. Due to time,

cost, and accessibility considerations, partial coverage inspection using 10 blocks of 1.85 m<sup>2</sup> each was randomly selected for pit depth measurements. The maximum pit depth on each of the inspection blocks was entered into EVS-Compass (one block showed no pitting and is not included in the data entry). Based on the maximum pit depth data measured using small inspection blocks of 1.85 m<sup>2</sup>, EVS-Compass predicts that the maximum pit depth in the 1040 m<sup>2</sup> base plate is 4.297 mm (Figure 11). The chart in Figure 11 shows the pit depth vs. surface area of the base plate. Other time-based predictions are not applicable in this application example for EVS extrapolation in space that has only one dataset available. For EVS extrapolation in time or in time and in space, at least two datasets collected at two different exposure times are required (Figures 1-10 above).

Structure ID		Pitting in Oil Tank Bottom Plate					
Material of construction	Carbon Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m <sup>2</sup> . 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.					
Service environment	Water Immersion						
Remaining wall thickness, d	mm						6.000
Area of coupons or inspection blocks, A <sub>C</sub>	m <sup>2</sup>						1.85000
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						1040.0000
Service life or exposure time for each dataset	Years		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
Number of datasets used for analysis and prediction	1		5.000	0.000	0.000	0.000	0.000
Prediction of Leaks or Perforations			0.500				
Service life or exposure time for prediction, t	Years	5.000	0.500				
Time to first leak or perforation, t <sub>1</sub>	Years	n/a	1.000				
Number of leaks or perforations at time t, N <sub>t</sub>	No./m <sup>2</sup>	n/a	1.000				
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>	Years	n/a	1.000				
		N = 100	1.500				
Area of perforation holes, A <sub>H</sub>	% total	n/a	1.500				
Prediction of Maximum Depth of Pits			3.000				
Depth of the largest pit at time t, D <sub>t</sub>	mm	4.297					
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>	mm	n/a					
No. of pits exceeding depth D at time t, N <sub>Dt</sub>	No./m <sup>2</sup>	n/a					
		D (mm) = 0.500					
Time Required for N pits to Exceed D mm, t <sub>ND</sub>	Years	1					
Probability of Failure (POF)							
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		1.849%					
Service life for wall thickness d, t <sub>d</sub>	Years	6					
		at the user defined POF threshold of 5.000%					
EVS for Optimization of Partial Coverage Inspection (PCI)							
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		4.283					
Two options to extend EVS extrapolation to the total area of the structure:							
1. Increase the number of inspection blocks from 9 to 74							
OR 2. Increase the min. area (sq.m) of inspection blocks to 449.2028							
Maximum Pit Depth, mm	Max Pit Depth vs Area						

Figure 11 EVS-Compass predicts pitting depth in a large oil tank base plate of 1040 sq.m surface based on the partial coverage inspection.

**EVS-Compass Application Example No.4**

**Pitting Corrosion of Carbon Steel in Natural Seawater: EVS Extrapolation in Space and in Time**

Carbon steel coupons of 75 mm x 50 mm were immersed in natural seawater for durations of 1.0, 1.5, 2.0, 3.0 and 4.0 years. Maximum pit depth for each coupon at each exposure duration is entered into EVS-

Compass (Figure 12). Note that the surface area of a coupon (with 2 sides) is  $0.0075 \text{ m}^2$  ( $75 \text{ cm}^2$ ). EVS

Extrapolation of the pit depth to a surface area of  $75 \text{ m}^2$  (10000 times of the coupon area) and the a future time of 10 years produces the following results:

- (1) the time to first leak or perforation is 9.084 years;
- (2) the number of leaks or perforation at 10 years is 2772 ( $75 \times 36.954$ );
- (3) the time to 100th leak or perforation is 9.122 years;
- (4) the hole area at 10 years is 8.762%;
- (5) the time required for 100 pits to exceed 3 mm depth is 5.311 years;
- (6) the depth of the largest pit at 10 years is 6.786 mm;
- (7) the depth of the 100th largest pit is 6.75 mm;
- (8) the number of pits exceeding 3 mm depth at 10 years is 15358 ( $75 \times 204.773$ );
- (9) the probability of failure at 10 years and 6mm thickness is 100%;
- (10) the service life for wall thickness of 6 mm at POF of 5% is 2.658 years



Structure ID		Carbon Steel Coupons Immersed in Natural Seawater at 20oC						
Material of construction	Carbon Steels	Note on Data Entry 1. Enter the actual remaining wall thickness in mm. 2. Enter the surface area of the coupon or inspection block in m2. 3. Enter the exposure time in <b>ascending order</b> from dataset 1. 4. Enter the maximum pit depth in mm in <b>ascending order</b> . 5. Each dataset consists of a number of coupons or inspection blocks.						
Service environment	Water Immersion							
Remaining wall thickness, d	mm						6.000	
Area of coupons or inspection blocks, A <sub>c</sub>	m <sup>2</sup>						0.00750	
Total surface area of the structure, A <sub>T</sub>	m <sup>2</sup>						75.0000	
Service life or exposure time for each dataset	Years		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5	
Number of datasets used for analysis and prediction	5		1.000	1.500	2.000	3.000	4.000	
Prediction of Leaks or Perforations			0.046	0.239	0.259	0.200	0.320	
Service life or exposure time for prediction, t		Years	10.000	0.049	0.302	0.311	0.201	0.472
Time to first leak or perforation, t <sub>1</sub>		Years	9.084	0.097	0.324	0.380	0.228	0.571
Number of leaks or perforations at time t, N <sub>t</sub>		No./m <sup>2</sup>	36.954	0.098	0.326	0.447	0.350	0.637
Time to N <sup>th</sup> leak or perforation, t <sub>N</sub>		Years	9.122	0.169	0.394	0.559	0.427	0.693
Area of perforation holes, A <sub>H</sub>		% total	8.762%	0.233	0.523	0.638	0.472	0.702
		N =	100	0.244	0.540	0.648	0.541	0.759
Prediction of Maximum Depth of Pits				0.341	0.600	0.851	0.546	0.816
Depth of the largest pit at time t, D <sub>t</sub>		mm	6.786	0.359	0.669	0.876	0.558	0.822
Depth of the N <sup>th</sup> largest pit at time t, D <sub>N</sub>		mm	6.750	0.501	0.700	0.885	0.560	1.048
No. of pits exceeding depth D at time t, N <sub>Dt</sub>		No./m <sup>2</sup>	204.773	0.504	0.717	0.901	0.602	1.080
		D (mm) =	3.000	0.532	0.772	0.938	0.624	1.117
Time Required for N pits to Exceed D mm, t <sub>ND</sub>		Years	5.311	0.556	0.823	1.117	0.674	1.133
Probability of Failure (POF)				0.626	0.909	1.235	0.746	1.441
Probability of failure at time t and wall thickness d, POF <sub>t,d</sub>		100.000%			0.982	1.534	0.895	1.631
Service life for wall thickness d, t <sub>d</sub>		Years	2.658		1.038		0.943	2.208
at the user defined POF threshold of		5.000%					1.081	
EVS for Optimization of Partial Coverage Inspection (PCI)							1.963	
Max area (m <sup>2</sup> ) of EVS extrapolation under the current settings		0.107						
Two options to extend EVS extrapolation to the total area of the structure:								
1. Increase the number of inspection blocks from 18 to 220								
OR 2. Increase the min. area (sq.m) of inspection blocks to 5.2695								
Maximum Pit Depth, mm		Max Pit Depth vs Area						

Figure 12 EVS-Compass predicts pitting corrosion of carbon steel in natural seawater with EVS extrapolation in space and in time.

The powerful applications of EVS-Compass are truly unlimited in engineering design, materials selection, process operation, inspection and maintenance, corrosion modeling and corrosion life prediction of structures and plant assets.

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