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AFGROW Workshop 2023

Overview of the Implementation of API 579 Stress Intensity Factor Solution for Cylinders in AFGROW

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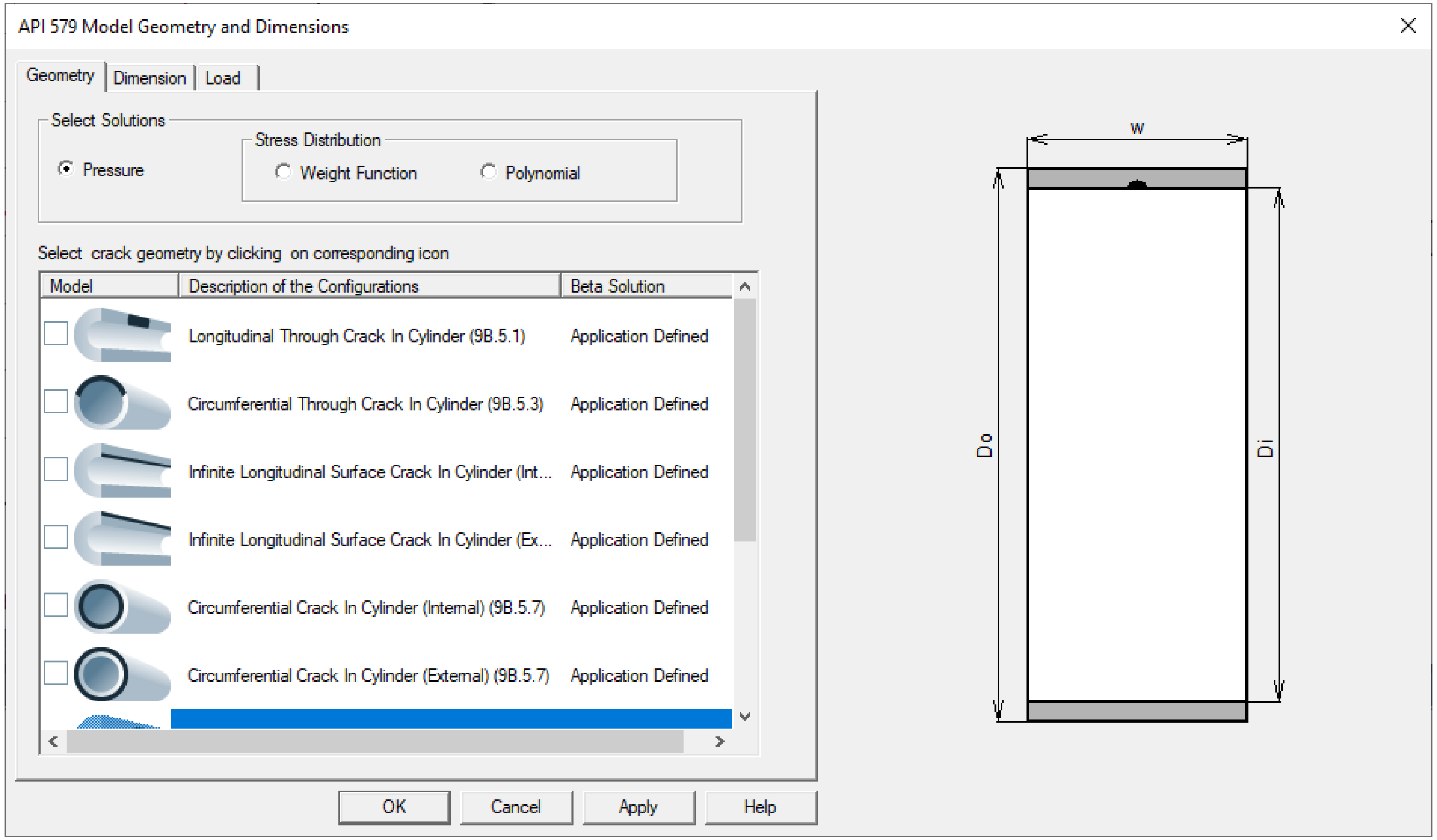
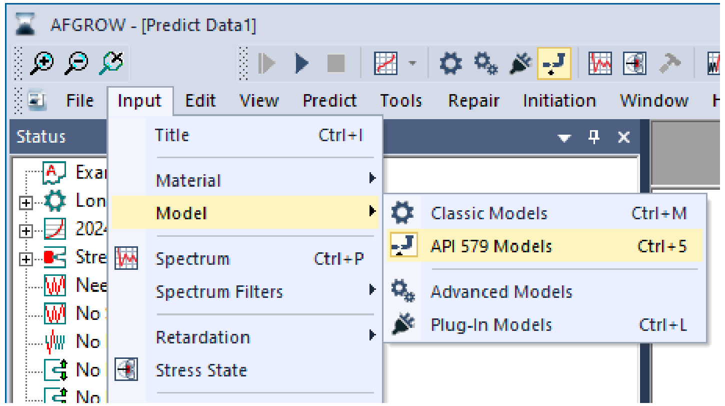
API 579-1 Pipeline Crack Solutions

API 579-1, Part 9 (Annex 9B) stress intensity solutions have been implemented in AFGROW for several cracked pipe geometries.





- API 579-1 solutions are divided into three loading categories: pressure, stress based weight functions and polynomial based weight functions.
- 22 total solutions were added
- All solutions have an infinite width. If the width is a part of dimension parameters it is used only as a crack limit.

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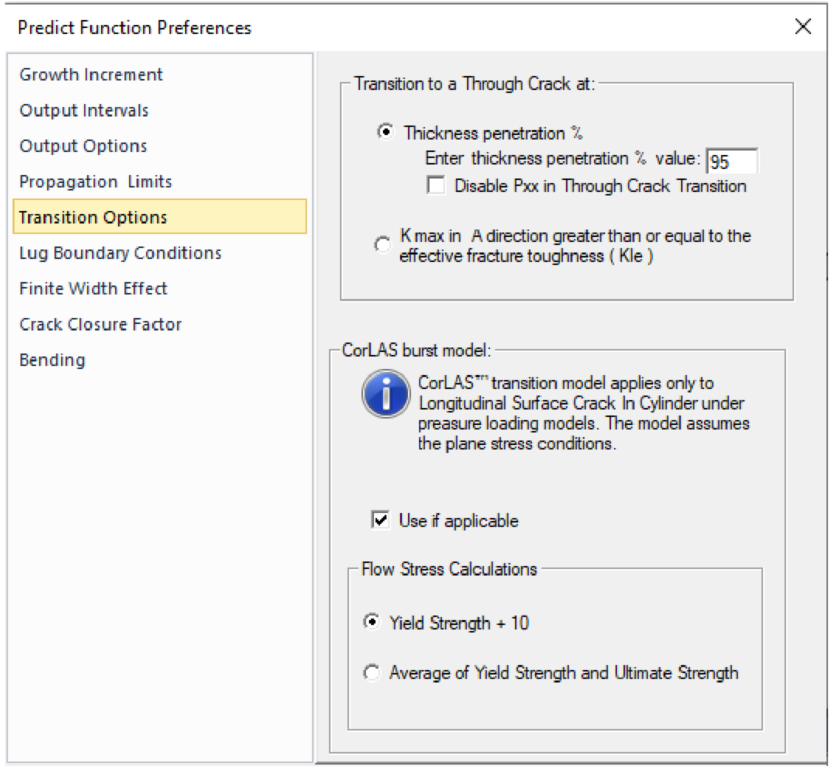
API 579-1 Implementation Notes

Internal and external Longitudinal Surface Crack in Cylinder pressure loaded models can use a new transition criteria (CorLAS tm burst model)



First time AFGROW has the part-through crack solutions that do not transition to a through crack solutions

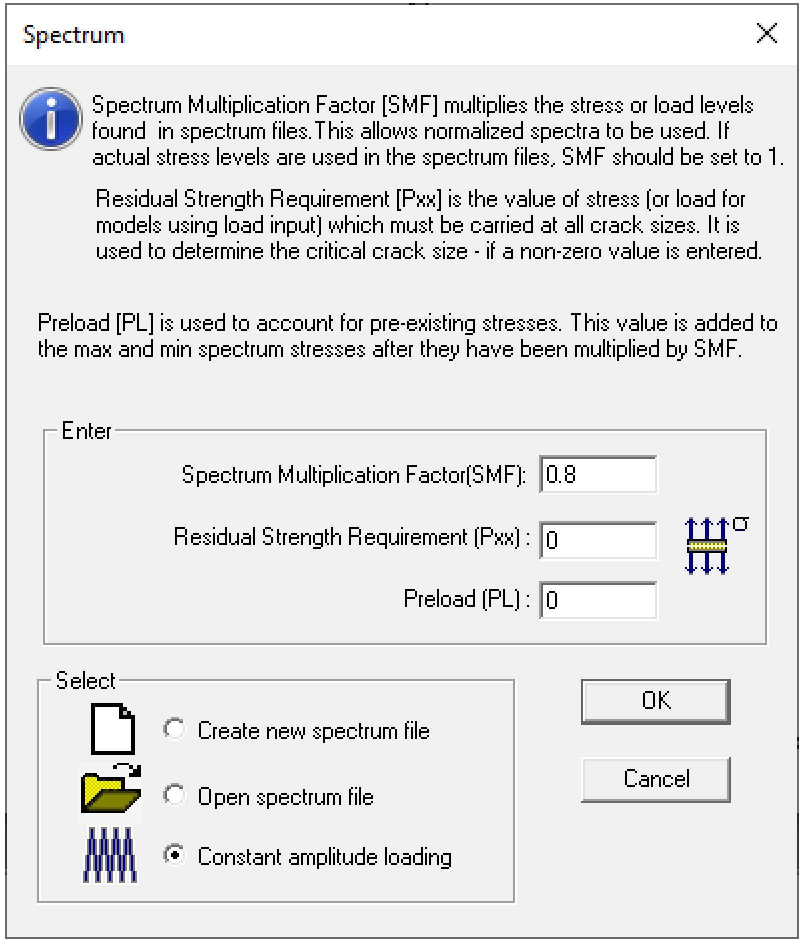
Longitudinal Surface Crack In Cylinder (Internal) (9B.5.12)	Weight Function
Longitudinal Surface Crack In Cylinder (External) (9B.5.12)	Weight Function
Longitudinal Surface Crack In Cylinder (Internal) (9B.5.11)	Polynomial Stress
Longitudinal Surface Crack In Cylinder (External) (9B.5.11)	Polynomial Stress
Circumferential Surface Crack In Cylinder (Internal) (9B.5....	Polynomial Stress
Circumferential Surface Crack In Cylinder (External) (9B.5...	Polynomial Stress

First time AFGROW has the part-through crack solutions that do transition to a part-through crack solutions

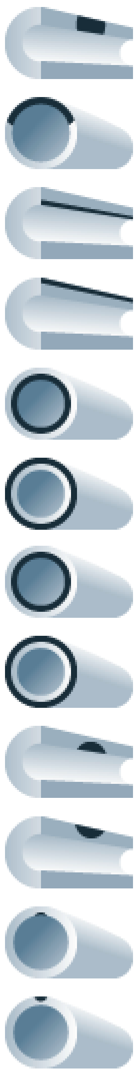
Longitudinal Full-Elliptic Embedded Crack in Cylinder (9B....	Polynomial Stress
Full-Elliptic Embedded Crack in Cylinder (9B.5.19)	Polynomial Stress

API-579 Pressure Based Solutions

All pipeline pressure-based models require the input loading spectrum in terms of internal pipe pressure. In US customary systems units, pressure is given in Ksi and in the Metric system, pressure is expected in MPa.



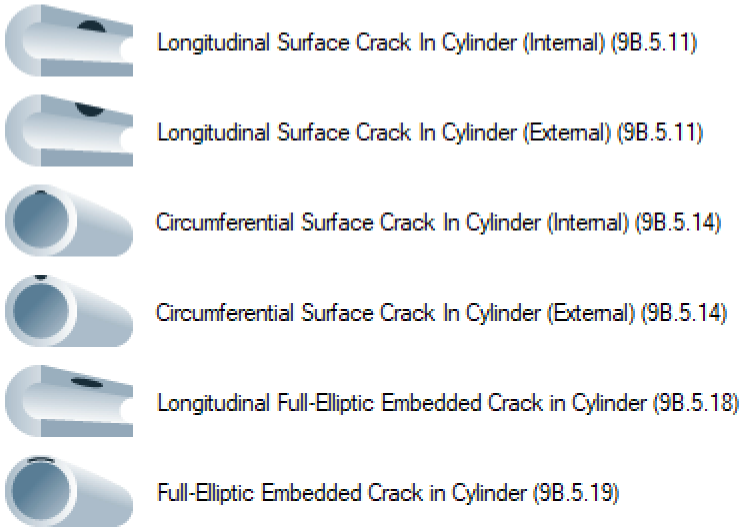
All user input values in the Spectrum Dialog will be related to internal pipe pressure when any of the pipeline pressure-based models are selected. The Spectrum Multiplication Factor (SMF) is a scaling factor applied to the maximum and minimum values in the input spectrum. The resulting values will reflect internal maximum and minimum internal pressure values. The Residual Strength Requirement and Preload values are assumed to be internal pressure values and are not scaled by the SMF.

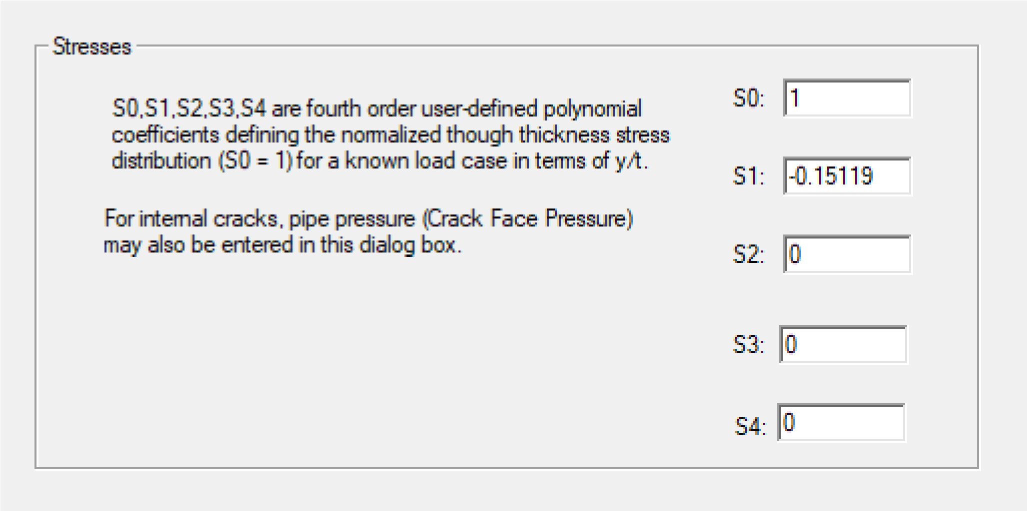


- Longitudinal Through Crack In Cylinder (9B.5.1)
- Circumferential Through Crack In Cylinder (9B.5.3)
- Infinite Longitudinal Surface Crack In Cylinder (Internal) (9B.5.4)
- Infinite Longitudinal Surface Crack In Cylinder (External) (9B.5.4)
- Circumferential Crack In Cylinder (Internal) (9B.5.7)
- Circumferential Crack In Cylinder (External) (9B.5.7)
- Circumferential Crack In Cylinder (Internal) (9B.5.7)
- Circumferential Crack In Cylinder (External) (9B.5.7)
- Longitudinal Surface Crack In Cylinder (Internal) (9B.5.10)
- Longitudinal Surface Crack In Cylinder (External) (9B.5.10)
- Circumferential Surface Crack In Cylinder (Internal) (9B.5.13)
- Circumferential Surface Crack In Cylinder (External) (9B.5.13)

API-579 Polynomial K-Solutions

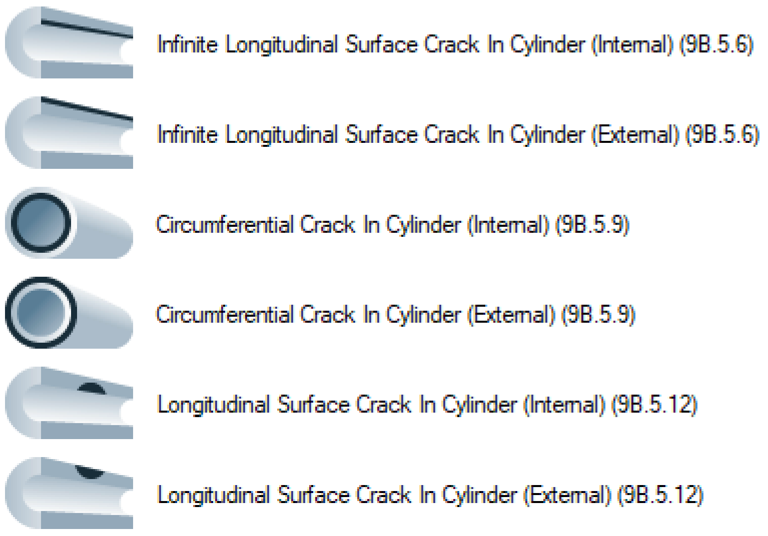
- All pipeline polynomial K-solution models require the input loading spectrum in terms of the stress at the crack origin. In US customary systems units, stress is given in Ksi and in the Metric system, stress is expected in MPa.
- The fourth order polynomial representation of the stress distribution in the thickness direction acting at the crack plane are expected to start at the crack origin and is a function of the normalized distance from the crack origin in the pipe thickness direction (y/t). The polynomial coefficients (S0 – S4) are entered in the Polynomial Stresses dialog as shown. In the case of internal cracks, internal pipe pressure (crack face pressure) should be entered in the dialog. The pressure entered will be scaled by the spectrum maximum and minimum values after they are scaled by the SMF. This can be simplified using a normalized input spectrum where the highest maximum value is 1.0.
- All user input values in the Spectrum Dialog will be related to the stress normal to the crack plane at the crack origin when any of the pipeline polynomial-based models are selected. The Spectrum Multiplication Factor (SMF) is a scaling factor applied to the maximum and minimum values in the input spectrum. The resulting values will reflect maximum and minimum stress values at the crack origin. The Residual Strength Requirement and Preload values are assumed to be normal stress values normal to the crack origin and are not scaled by the SMF.





API-579 Weight Function Models

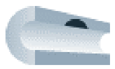
- All pipeline weight function K-solution models require the input loading spectrum in terms of the stress at the crack origin. In US customary systems units, stress is given in Ksi and in the Metric system, stress is expected in MPa.
- These models are used when there is a known unflawed stress distribution through the pipe thickness at the proposed crack location.
- The stress distribution in the crack plane is entered in the thickness direction starting at the crack origin. It is highly recommended that the distribution be normalized to 1.0 at the crack origin since the input spectrum is expected to represent the stress at the crack origin. If the stress distribution and input spectrum are normalized, the SMF value in the Spectrum dialog will represent the stress at the crack origin for the spectrum value that has been normalized to 1.0.
- All user input values in the Spectrum Dialog will be related to the stress normal to the crack plane at the crack origin when any of the pipeline weight function based models are selected. The Spectrum Multiplication Factor (SMF) is a scaling factor applied to the maximum and minimum values in the input spectrum. The resulting values will reflect maximum and minimum stress values at the crack origin. The Residual Strength Requirement and Preload values are assumed to be normal stress values normal to the crack origin and are not scaled by the SMF.



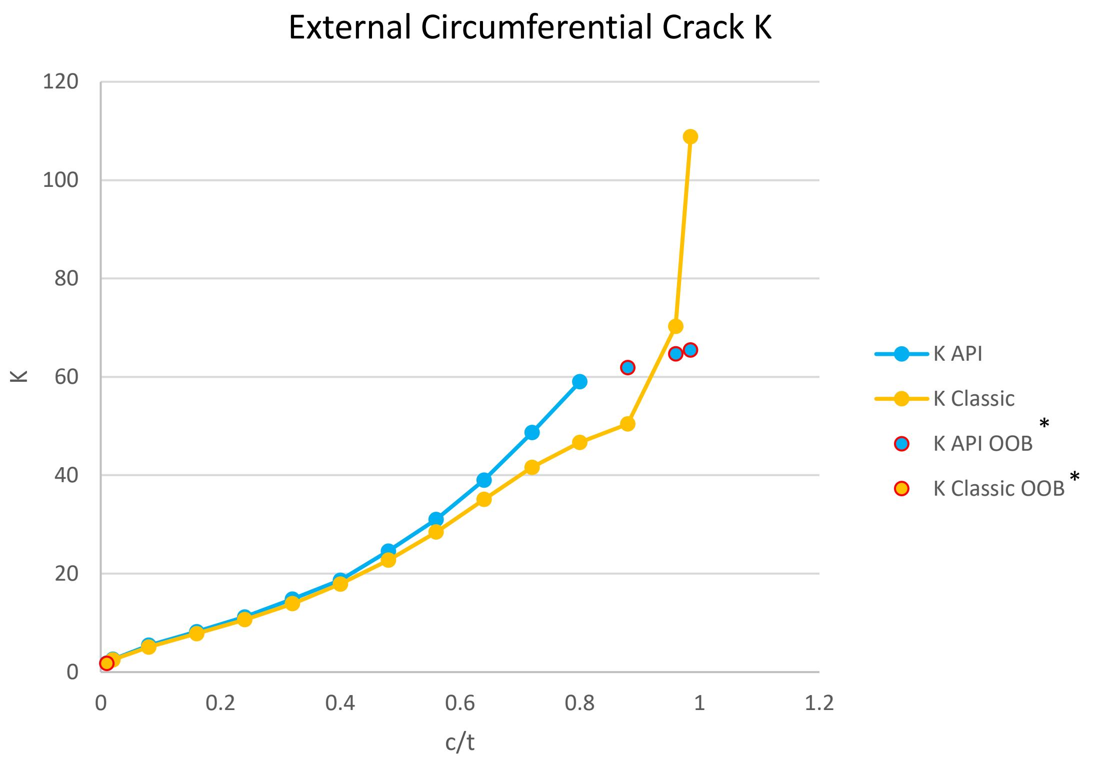
Comparison between API-579 and Classic Solutions

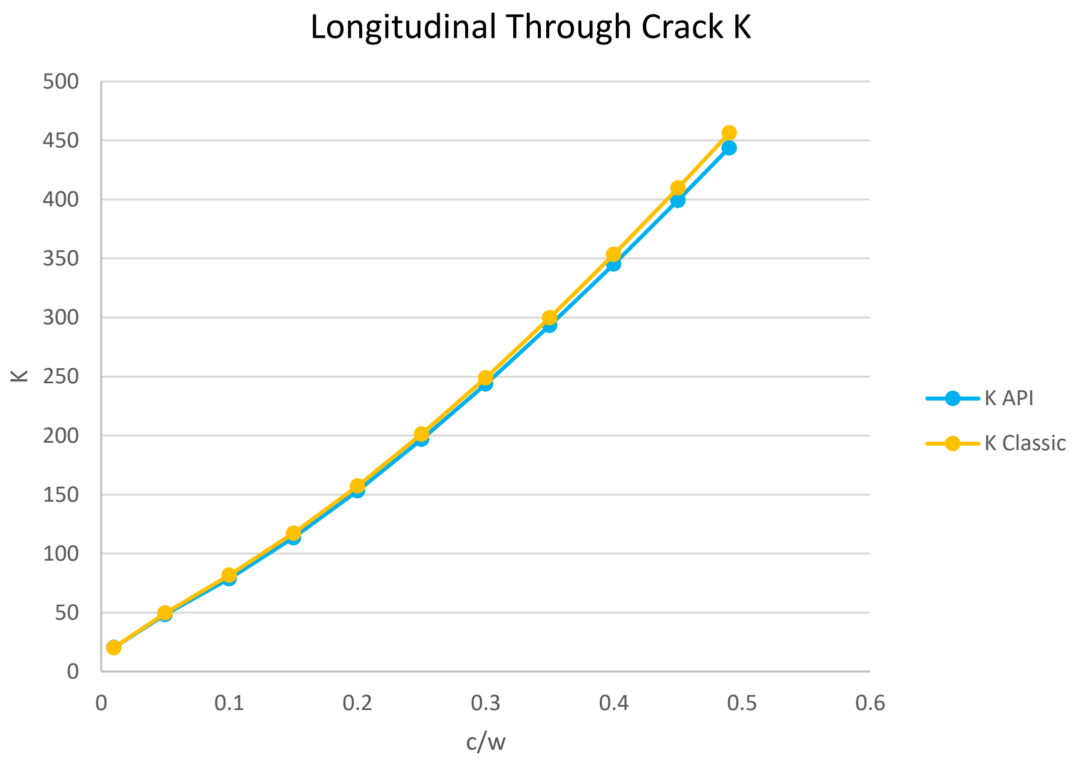
ID	Name	Load	Stress Distribution	Classic Model Equivalent
5010	Longitudinal Through Crack In Cylinder (9B.5.1)	Pressure		2098
5030	Circumferential Through Crack In Cylinder (9B.5.3)	Pressure		2090
5040	Infinite Longitudinal Surface Crack In Cylinder (Internal) (9B.5.4)	Stress	Polynomial	
5041	Infinite Longitudinal Surface Crack In Cylinder (External) (9B.5.4)	Stress	Polynomial	
5060	Infinite Longitudinal Surface Crack In Cylinder (Internal) (9B.5.6)	Stress	WF	
5061	Infinite Longitudinal Surface Crack In Cylinder (External) (9B.5.6)	Stress	WF	
5070	Circumferential Crack In Cylinder (Internal) (9B.5.7)	Pressure		2096
5071	Circumferential Crack In Cylinder (External) (9B.5.7)	Pressure		2095
5090	Circumferential Crack In Cylinder (Internal) (9B.5.9)	Stress	WF	
5091	Circumferential Crack In Cylinder (External) (9B.5.9)	Stress	WF	
5100	Longitudinal Surface Crack In Cylinder (Internal) (9B.5.10)	Pressure		1091
5101	Longitudinal Surface Crack In Cylinder (External) (9B.5.10)	Pressure		1092
5110	Longitudinal Surface Crack In Cylinder (Internal) (9B.5.11)	Stress	Polynomial	
5111	Longitudinal Surface Crack In Cylinder (External) (9B.5.11)	Stress	Polynomial	
5120	Longitudinal Surface Crack In Cylinder (Internal) (9B.5.12)	Stress	WF	3030
5121	Longitudinal Surface Crack In Cylinder (External) (9B.5.12)	Stress	WF	3040
5130	Circumferential Surface Crack In Cylinder (Internal) (9B.5.13)	Pressure		
5131	Circumferential Surface Crack In Cylinder (External) (9B.5.13)	Pressure		1090
5140	Circumferential Surface Crack In Cylinder (Internal) (9B.5.14)	Stress	Polynomial	
5141	Circumferential Surface Crack In Cylinder (External) (9B.5.14)	Stress	Polynomial	
5180	Longitudinal Full-Elliptic Embedded Crack in Cylinder (9B.5.18)	Stress	Polynomial	
5190	Full-Elliptic Embedded Crack in Cylinder (9B.5.19)		Polynomial	

Applicability Limits of API-579 and Classic Solutions

					classic				API 579			
	Id	Load	Type	Classic Model Id	C/T	A/T	A/C	t/R	C/T	A/T	A/C	t/R
	5010	Pressure		2098				<= 0.25				[0.01 ; 1]
	5030	Pressure		2090								[0.01 ; 1]
	5070	Pressure		2096	[0.02 ,0.985]			[0.005;9]	[0.0 ; 0.8]			[0.001 ; 1.0]
	5071	Pressure		2095	[0.02 ,0.985]			[0.005;9]	[0.0 ; 0.8]			[0.001 ; 1.0]
	5100	Pressure		1091		[0.0 ; 0.8]	[0.2;1.0]	<= 0.25		[0.0 ; 0.8]	[0.03125 ; 2.0]	[0.0 ; 1.0]
	5101	Pressure		1092		[0.0 ; 0.8]	[0.2;1.0]	<= 0.25		[0.0 ; 0.8]	[0.03125 ; 2.0]	[0.0 ; 1.0]
	5120	Stress	WF	3030		[0.0 ; 0.8]	[0.2;1.0]	[0.1;1.0]		[0.0 ; 0.8]	[0.03125 ; 2.0]	[0.0 ; 1.0]
	5121	Stress	WF	3040		[0.0 ; 0.8]	[0.2;1.0]	[0.1;1.0]		[0.0 ; 0.8]	[0.03125 ; 2.0]	[0.0 ; 1.0]
	5131	Pressure		1090		[0.2 ; 0.8]	[0.6; 1.0]	[0.1;1.0]		[0.0 ; 0.8]	[0.03125 ; 2.0]	[0.0 ; 1.0]

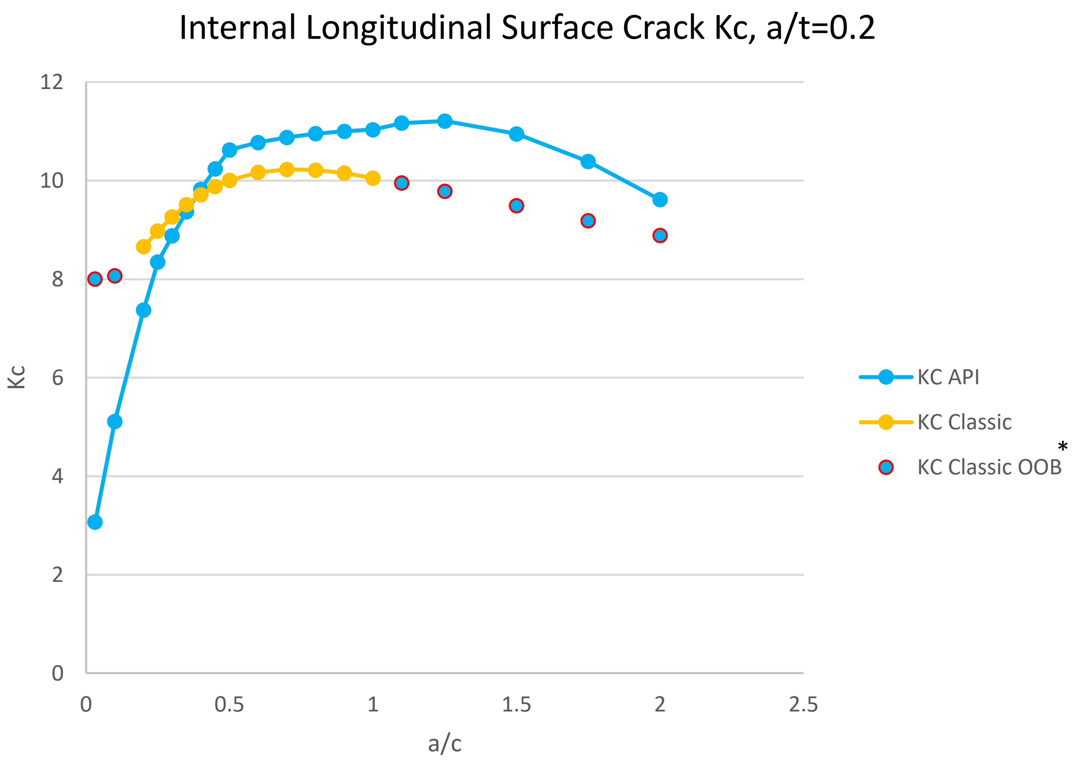
Observations

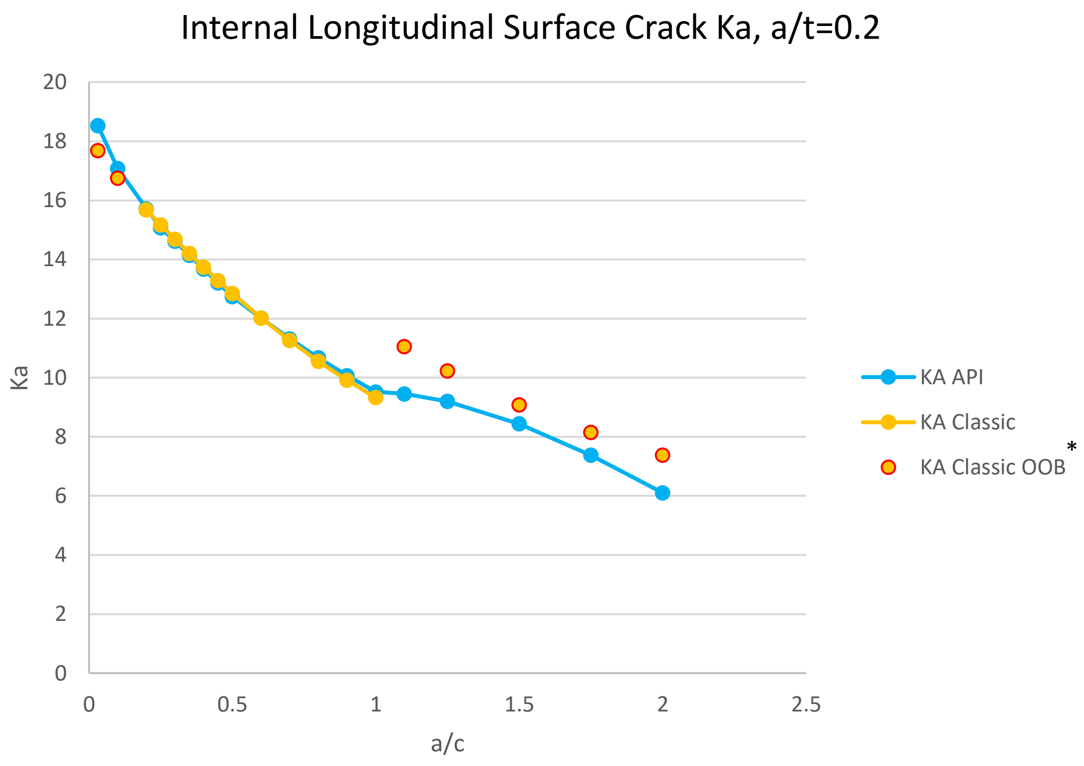




* - Out of bounds

Observations





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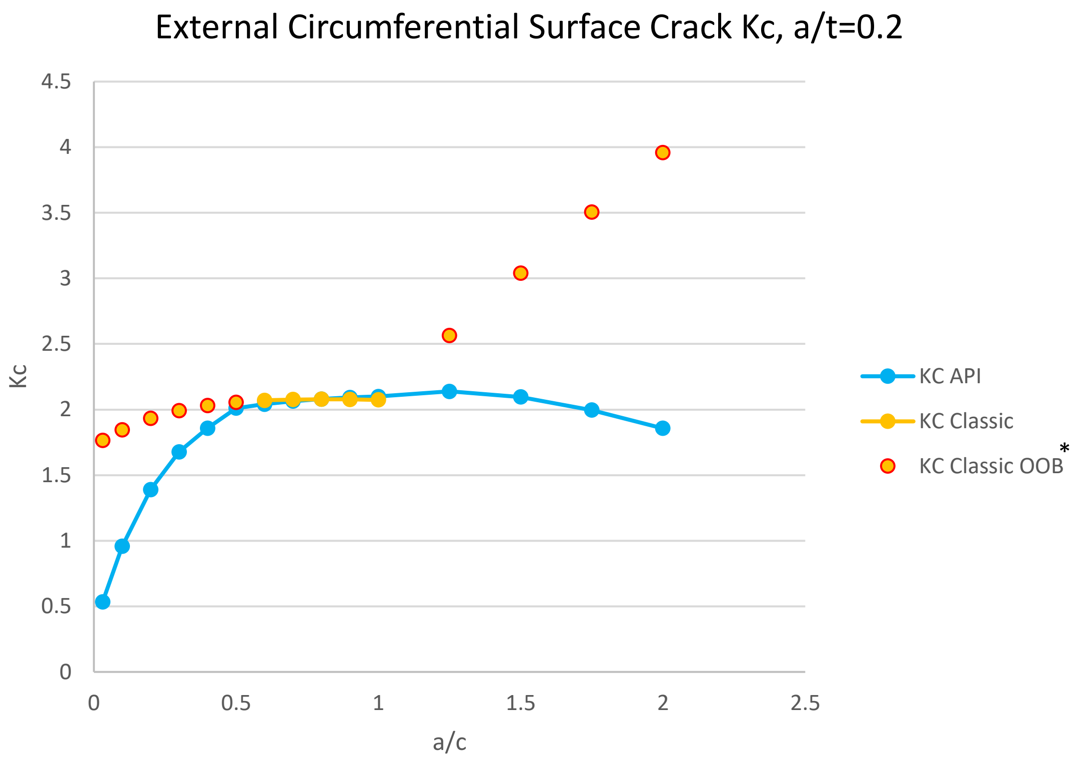

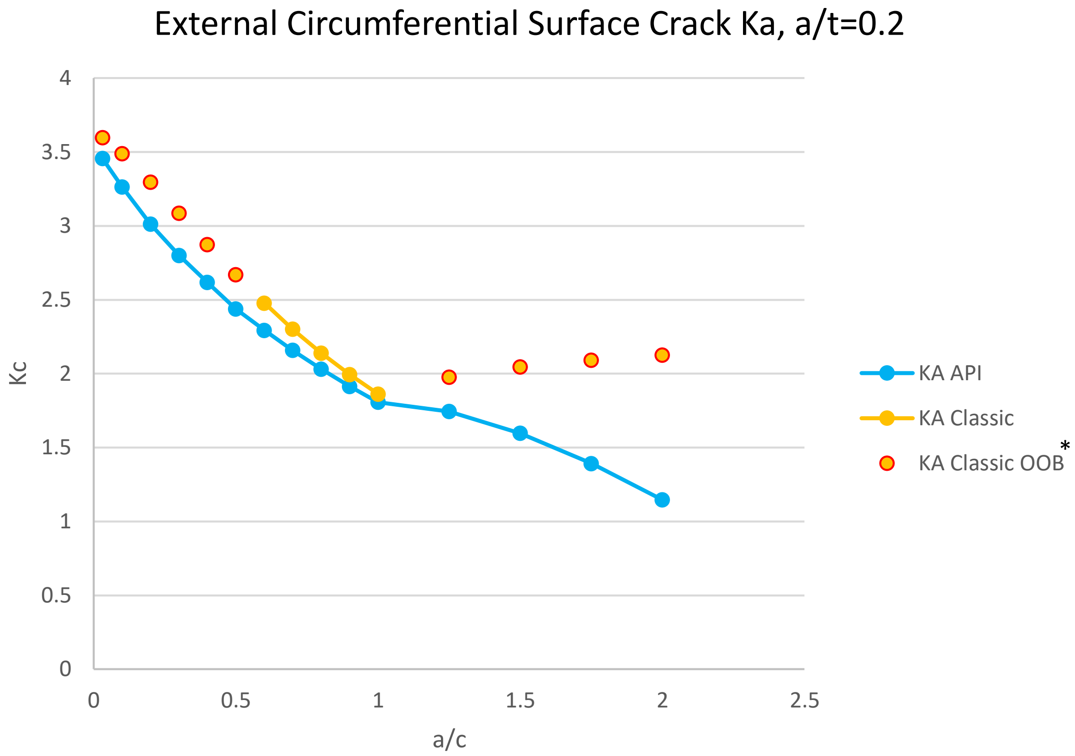

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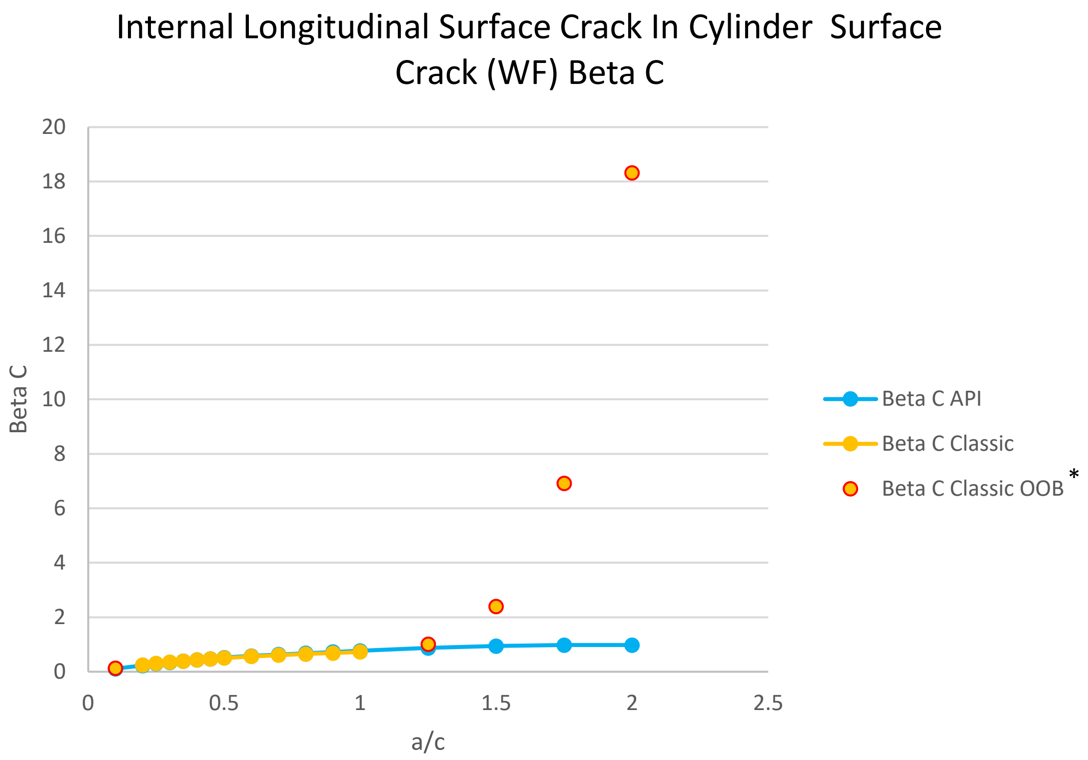

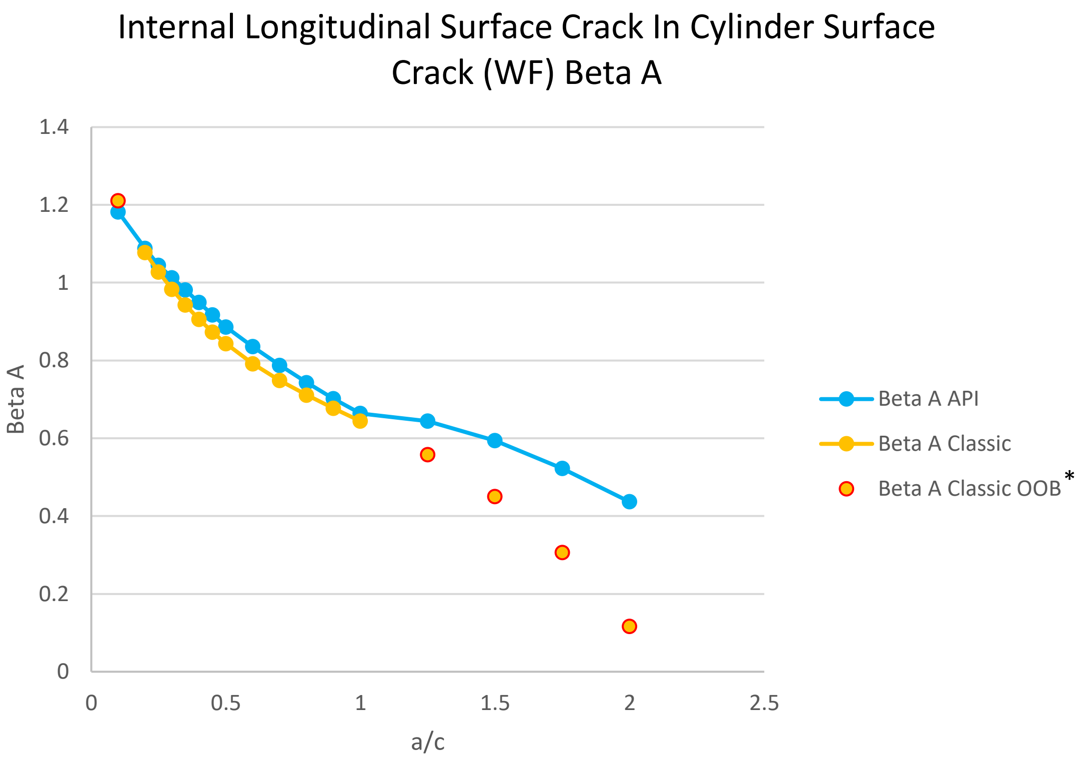

* - Out of bounds

Acknowledgements

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