AFGROW 5.02.5.19 up – Pilatus Review of Relevant Changes on Lug Model

Agenda

1. List of changes from V5.02.5.19
2. Change Description
3. Impact on Analyses
4. Changes In Beta Correction
5. Comparison to Pilatus Test Results

2.1 Detailed Change Description Model 1080

- Changes to V5.02.4.19 to V5.02.5.19
  - Various Bug fixes
  - Enhancement: Classic corner crack at a lug model tabular data improvements, see Youtube

    → https://www.youtube.com/watch?v=APRoOQ4Cuk0

- Improved interpolation tables
- Leads to higher, less conservative life

3.1 Impact on Cert Analyses (1)

- Critical Locations of PC-24 cert reports and standard checks

Title	Model Selection	AFGROW Model
LocFr11_ND_CG01	Center Semi-Elliptic Surface Flaw	1010
LocFr11_ND_CG01_2	Center Semi-Elliptic Surface Flaw	1010
LocFr11_v4_ND_CG01	Single Edge Through Crack	2040
LocFr11_v4_ND_CG02	Single Corner Crack At Hole	1030
Pipe1	Part Through Crack In Pipe	1090
Lug2	Single Corner Crack In Lug	1080
Bolt1	Rod	2080
Bolt2	Through Crack In Pipe	2090
GS_Wing_Hinge2_Lug3	Single Corner Crack In Lug	1080
Outbd_Pt-1_Lug-2_Plate	Single Corner Crack At Hole	1030
Inbd_Pt-9_Lug-3	Single Corner Crack In Lug	1080
GS_Wing_Hinge6_LF	Single Corner Crack At Hole	1030
SK03-CG01	Single Corner Crack At Hole	1030
SK03-CG02	WFS - Single Edge Through Crack	4020
CP01-CG01a	Single Edge Corner Crack	1070
CP01-CG01b	Single Edge Through Crack	2040
LocND1_RF_CG01	Single Edge Corner Crack	1070
LocND1_RF_CG02b	Center Through Crack	2010
Loc06-N1	Single Corner Crack At Hole	1030
Loc06-N2	Single Edge Through Crack	2040

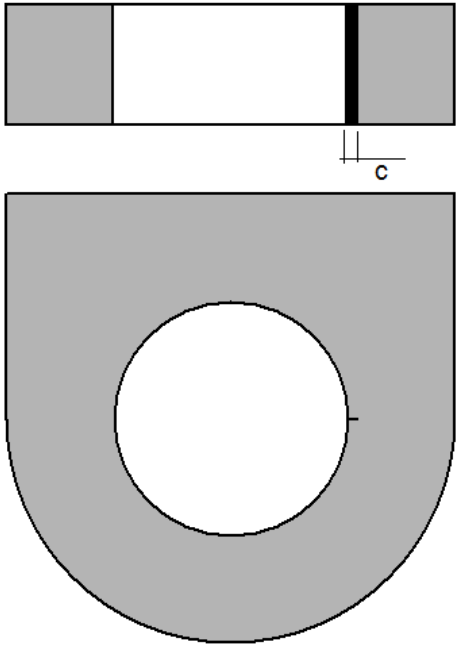
3.1 Impact on Cert Analyses (3)
V5.02 vs V5.03

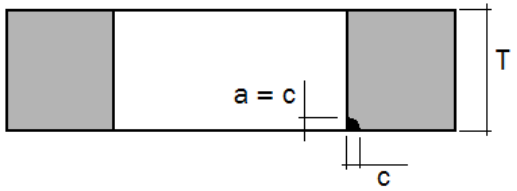
				V5.2.4.19		V5.2.5.19		V5.3.2.22			
	Title	Model Selection	AFGROW Model	Life	Cycles	Life	Cycles	Life	Cycles	Difference to V5.02.4.19	Difference to V5.02.5.19
1	LocFr11_ND_CG01	Center Semi-Elliptic Surface Flaw	1010	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
2	LocFr11_ND_CG01_2	Center Semi-Elliptic Surface Flaw	1010	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
3	LocFr11_v4_ND_CG01	Single Edge Through Crack	2040	**-**	-	**-**	-	**-**	-	**-**	**-**
4	LocFr11_v4_ND_CG02	Single Corner Crack At Hole	1030	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
5	Pipe1	Part Through Crack In Pipe	1090	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
6	Lug2	Single Corner Crack In Lug	1080	**100%**	100%	**100%**	100%	**100%**	100%	**0.01%**	**0.00%**
7	Bolt1	Rod	2080	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
8	Bolt2	Through Crack In Pipe	2090	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
9	GS_Wing_Hinge2_Lug3	Single Corner Crack In Lug	1080	**100%**	100%	**100%**	100%	**100%**	100%	**0.41%**	**0.00%**
10	Outbd_Pt-1_Lug-2_Plate	Single Corner Crack At Hole	1030	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
11	Inbd_Pt-9_Lug-3	Single Corner Crack In Lug	1080	**100%**	100%	**120%**	120%	**120%**	120%	**19.51%**	**0.00%**
12	GS_Wing_Hinge6_LF	Single Corner Crack At Hole	1030	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
13	SK03-CG01	Single Corner Crack At Hole	1030	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
14	SK03-CG02	WFS - Single Edge Through Crack	4020	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
15	CP01-CG01a	Single Edge Corner Crack	1070	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
16	CP01-CG01b	Single Edge Through Crack	2040	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
17	LocND1_RF_CG01	Single Edge Corner Crack	1070	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
18	LocND1_RF_CG02b	Center Through Crack	2010	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
19	Loc06-N1	Single Corner Crack At Hole	1030	**100%**	100%	**100%**	100%	**100%**	100%	**0.00%**	**0.00%**
20	Loc06-N2	Single Edge Through Crack	2040	**-**	-	**-**	-	**-**	-	**-**	**-**

4.1 Changes in Beta Correction Factors (1)
Geometry & Boundary Conditions

- Geometry:

- Boundary Conditions
  - Default
  - Spring



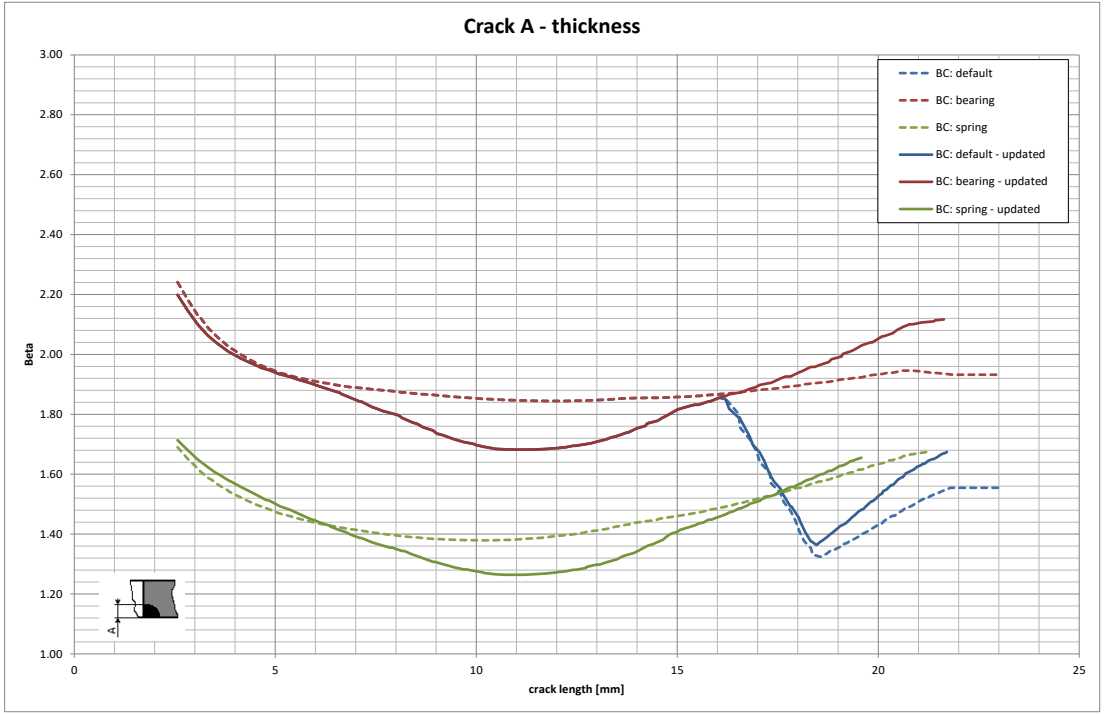


a=c = 2.57mm

W = 86 mm
D = 45 mm
T = 23 mm

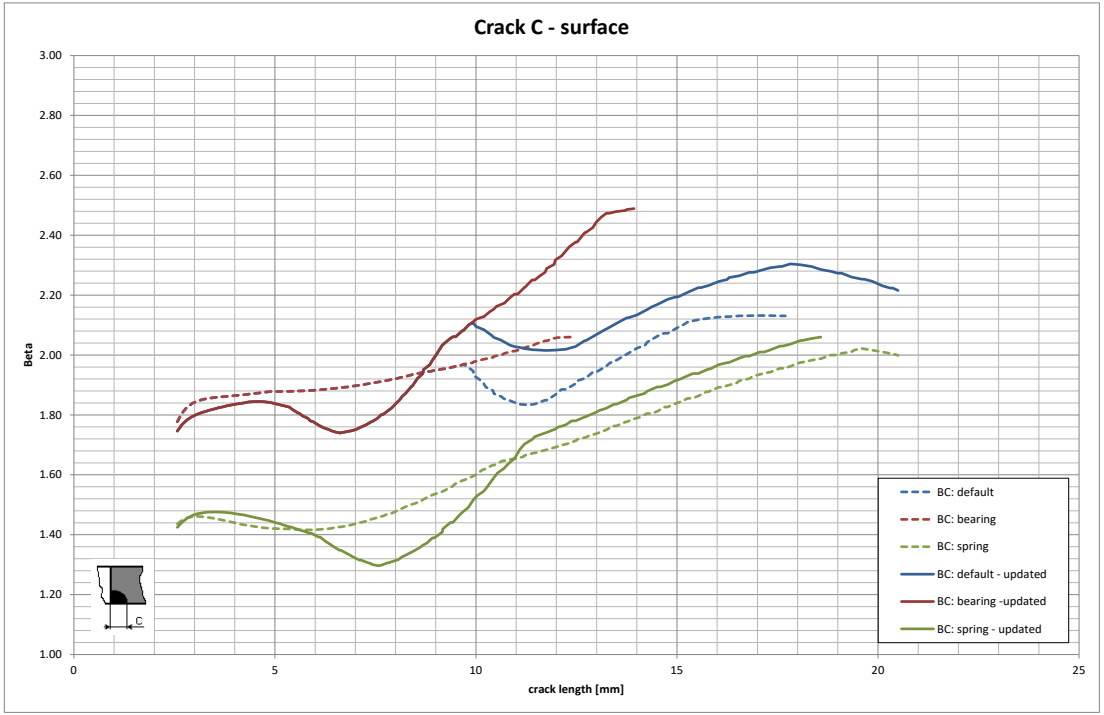
4.1 Changes in Beta Correction Factors
A crack direction

- Significant changes for medium crack sizes
- How can the differences be explained?



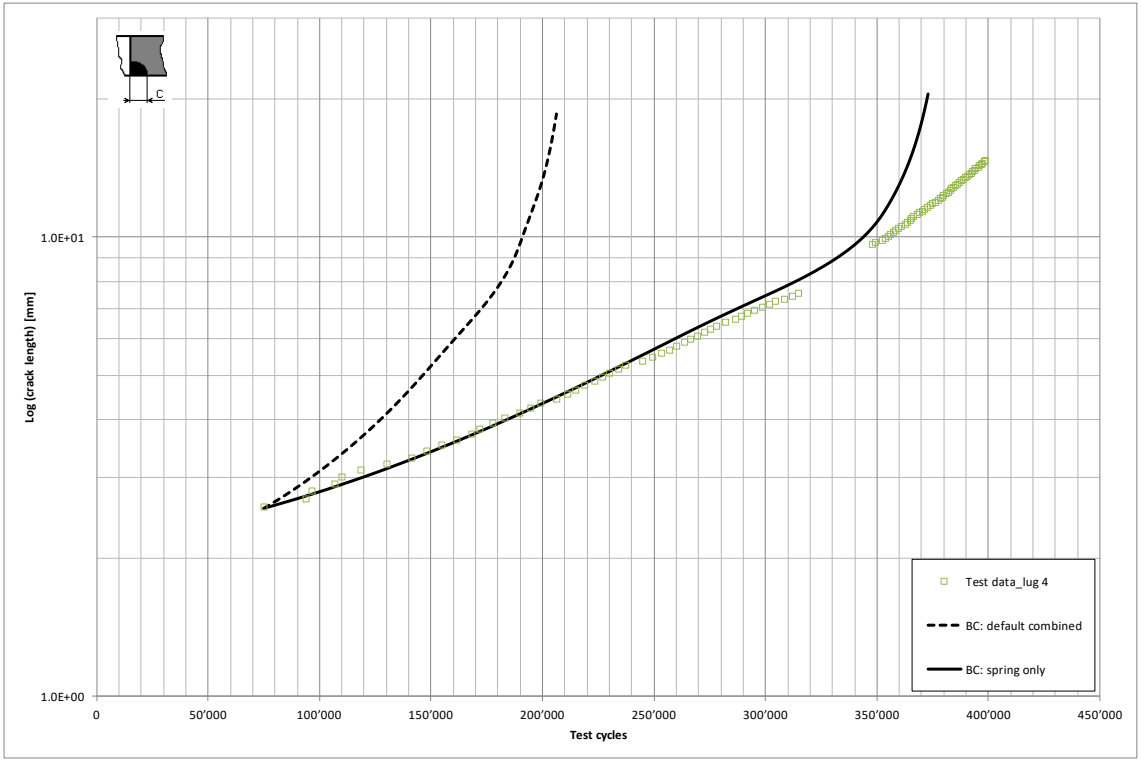
4.1 Changes in Beta Correction Factors
C crack direction

- Significant changes for small to medium crack sizes
- General offset with crossing at medium crack size
- How can the differences be explained?



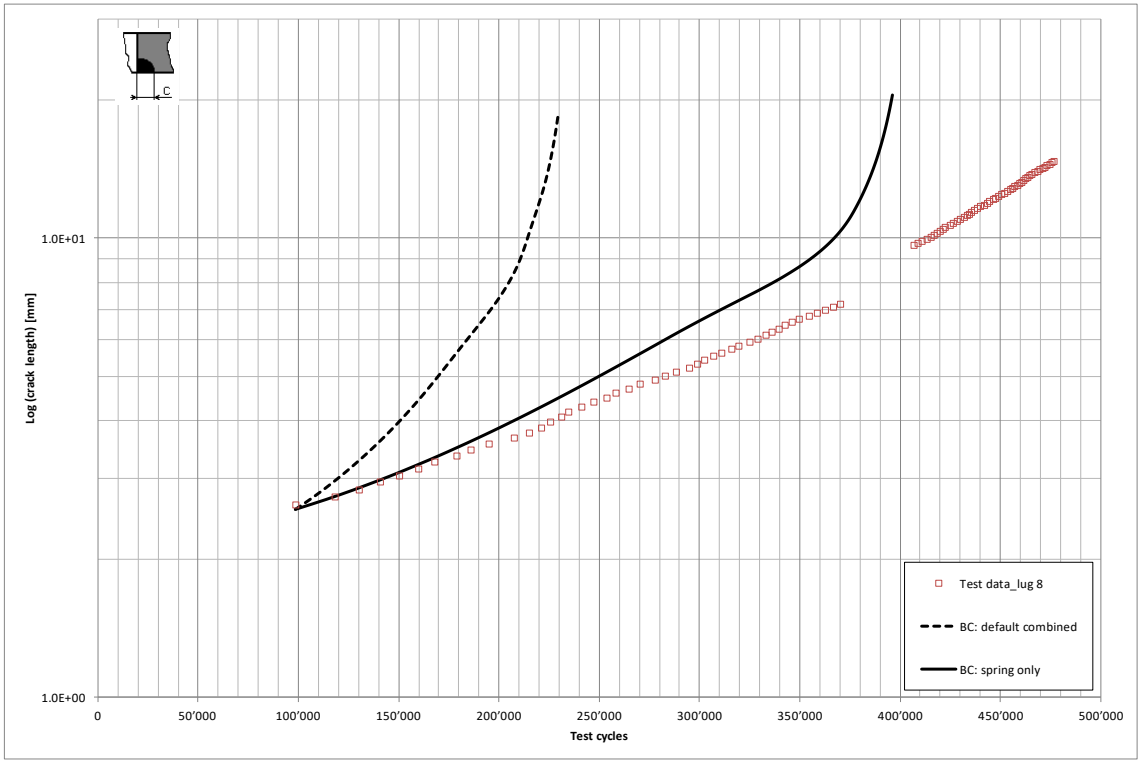
5.1 Comparison to Pilatus Test Results Lug 4

- C Crack Direction
- Conservative lug model for combined condition



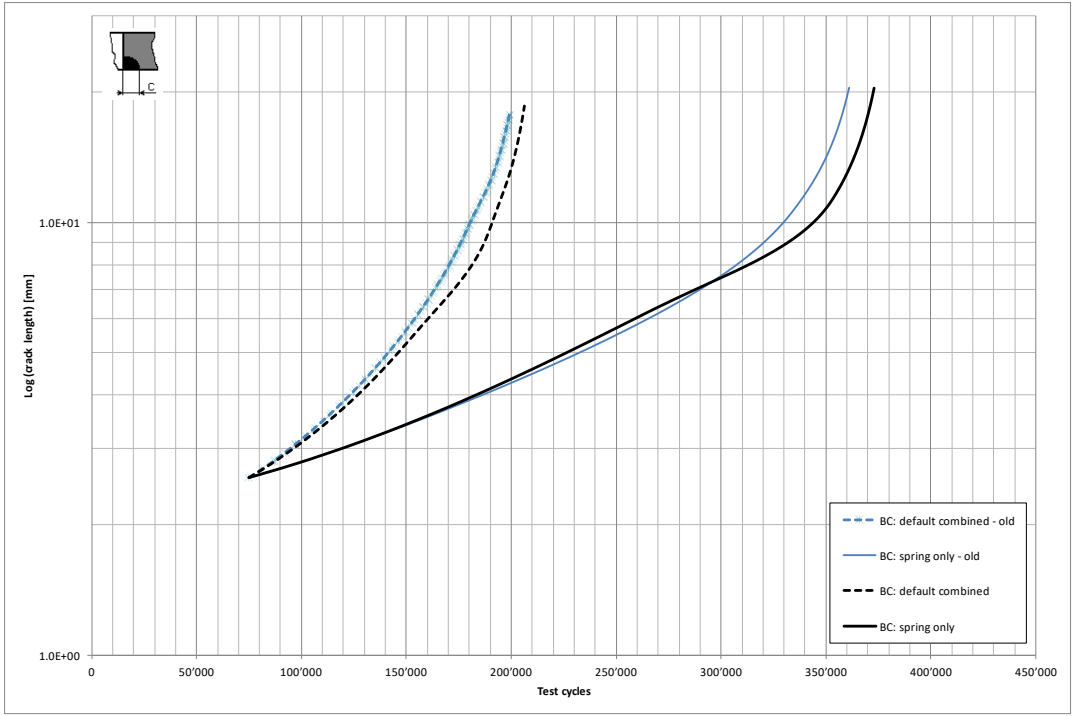
5.1 Comparison to Pilatus Test Results Lug 8

- C Crack Direction
- Conservative lug model for combined condition



5.2 Changes from V5.02.4.18 for Test Lug Geometry

- For combined --:
  - Longer lives for all crack lengths
- For spring -:
  - Similar lives for small to medium crack lengths
  - Longer lives for big cracks



6.1 Conclusion

- No substantial changes identified for critical locations
- Conservatism of model still present
- Closer to Lug NASGRO solution
- Closer to Pilatus test results

6.2 Questions

- The inaccuracy was identified in V5.02.4.18? How about the previous analyses?
- Were the changes and implications on various lug models under different loading histories assessed?
- What are the explanations for the beta differences?
- Are there publicly available sanity checks / parameter studies where new models are validated?

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Questions?