AFGROW Calculation

Zurich University of Applied Sciences
School of Engineering
ZAV Center for Aviation

Project Ageing Aircraft: Pilatus P3

(Design life of 2'500 FH
Fleet leader approximately 4'300 FH)

Crack Growth Analysis for a Lug (H-Tail Attachment)

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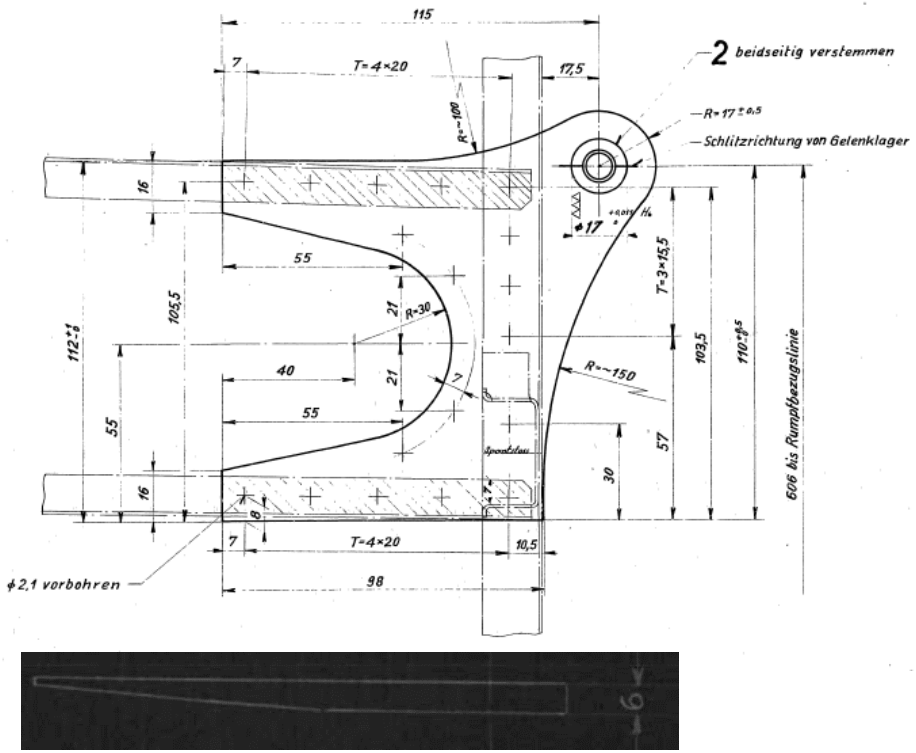
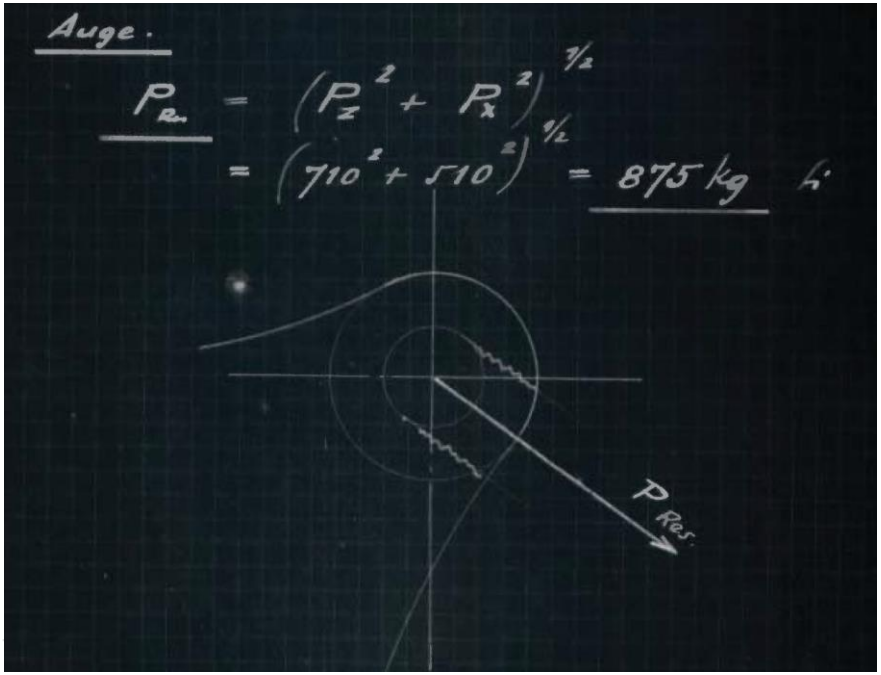
Configuration Fuselage
H-Tail Support





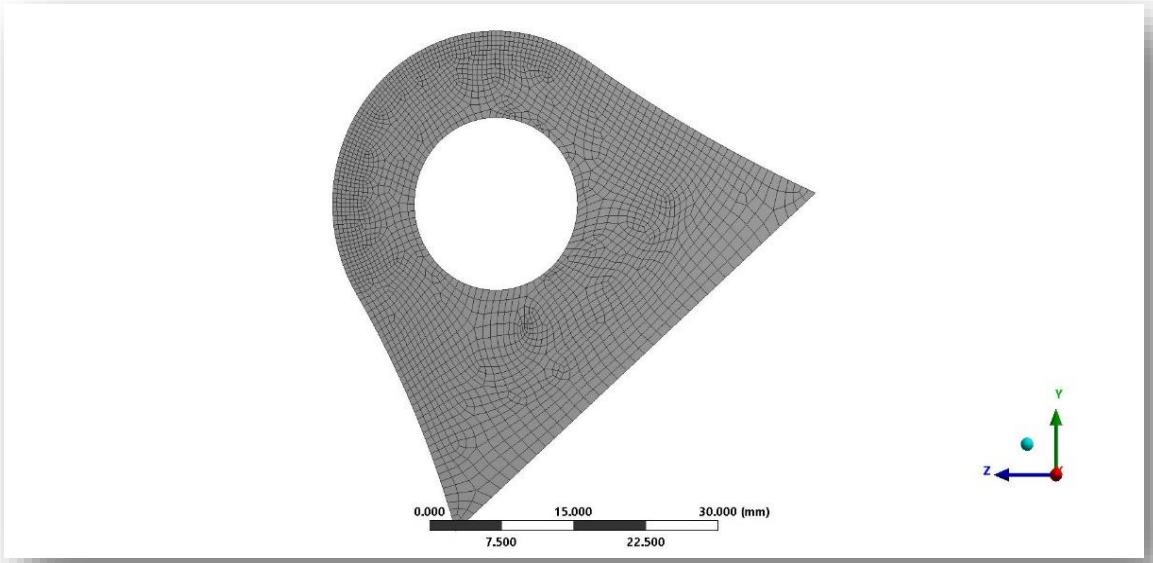
Drawing: P3.03-201.452
Thickness of 6 mm for H-Tail Support

P-3 F.R.-3.100 Fuselage Static Strength Report, Page 450
Material Aluminium 746.6 aquivalent to 2014-T6 (FWN2055)
$\sigma_{0.2}$ = 280 MPa, σ_B = 420 MPa

Ansys 16.1 Workbench

Real model

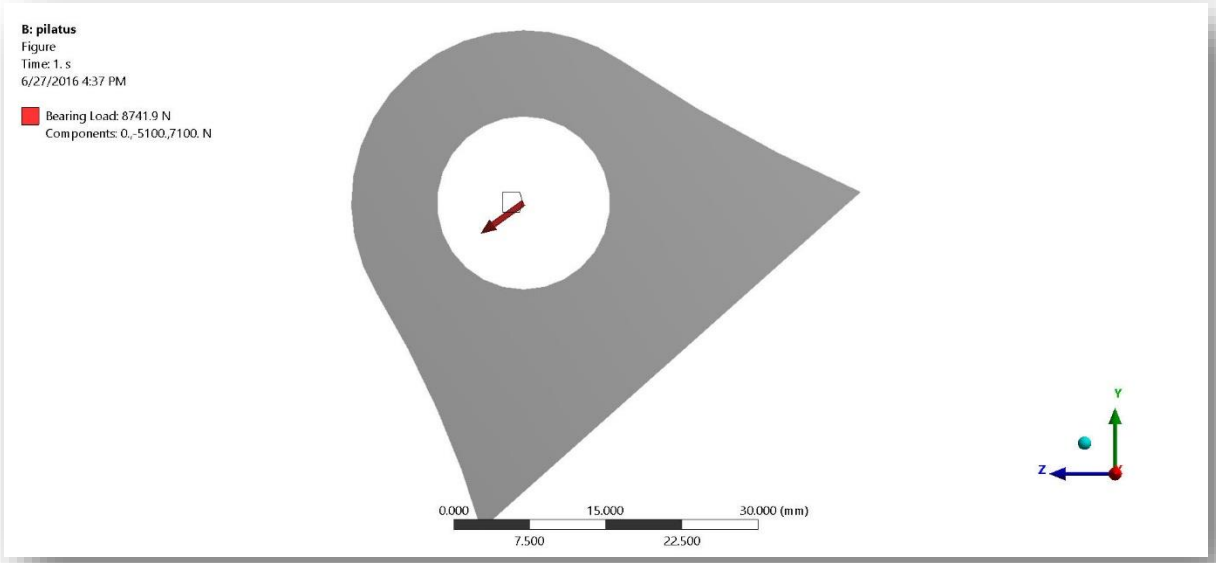
Mesh



Nodes: 165434
Elements: 37800

Real model

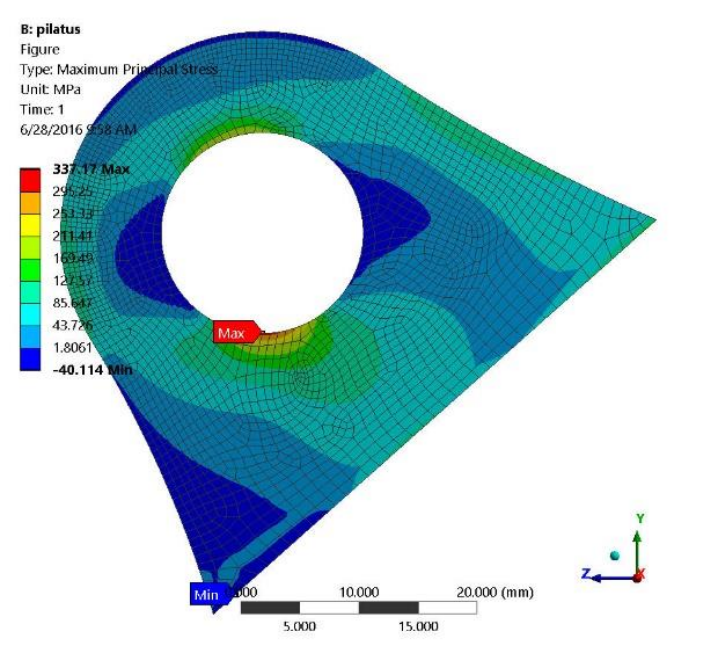
Load

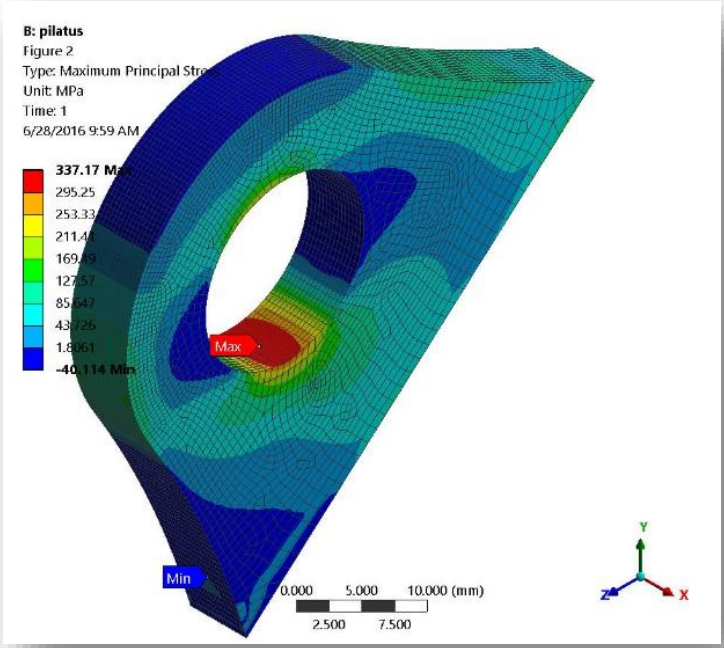


Bearing load:
F=(0 N, -5100N, 7100N)

Real model

Maximum principal stress

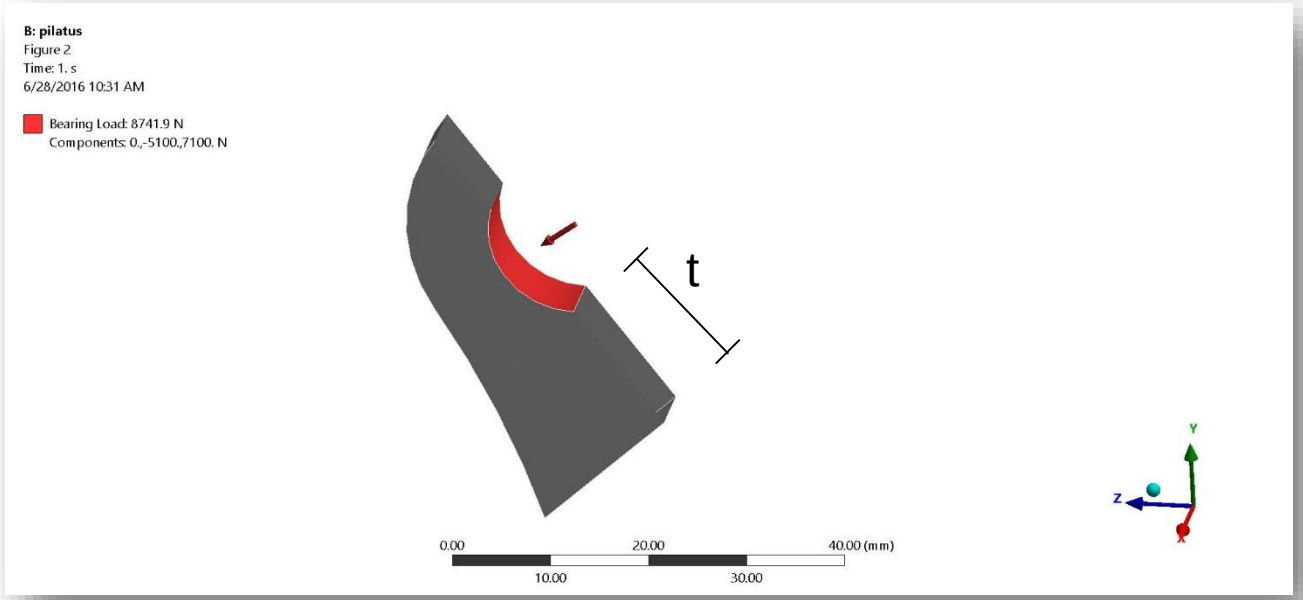




σ_{max_real}= 337 MPa

Real model

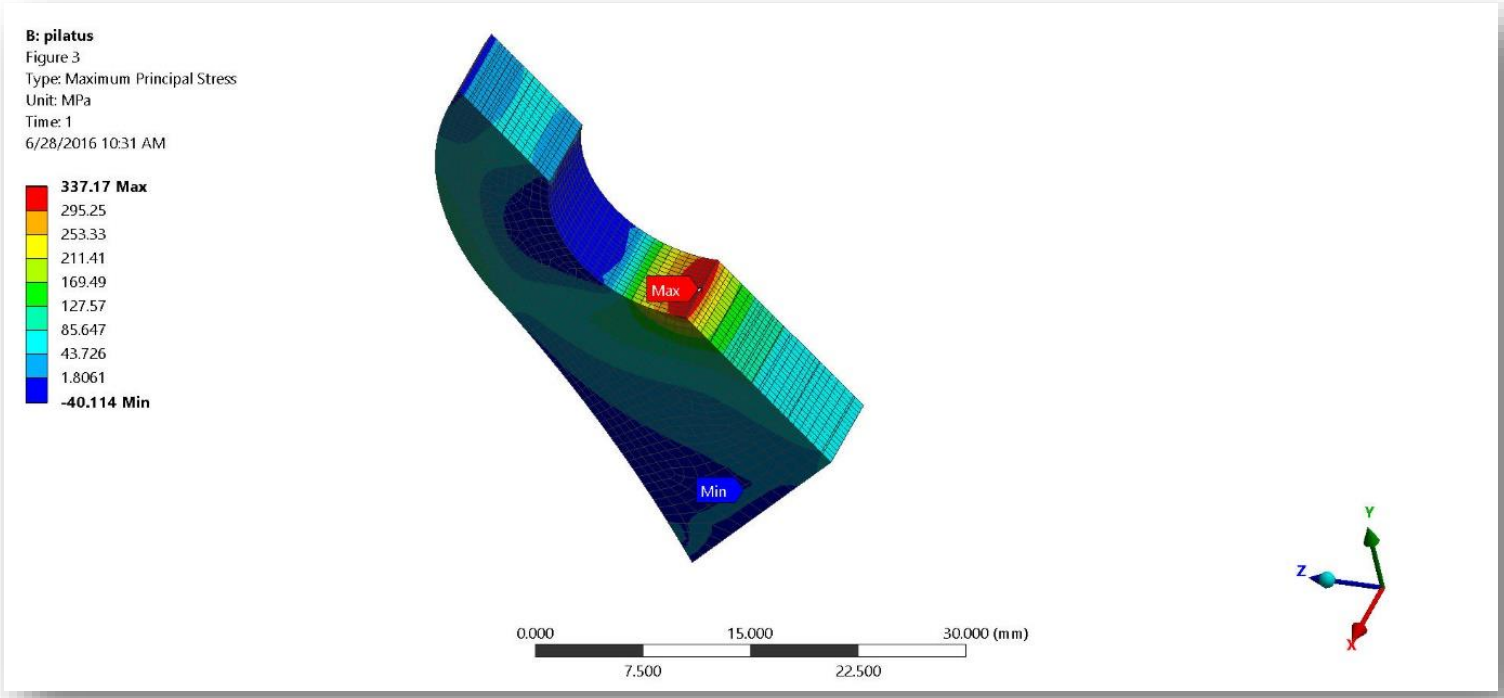
Maximum principal stress



In order to use an ideal model for the fatigue life of the body, it is necessary to find a reference dimension, *t*: perpendicular to the load and in correspondence to the maximum stress.

Real model

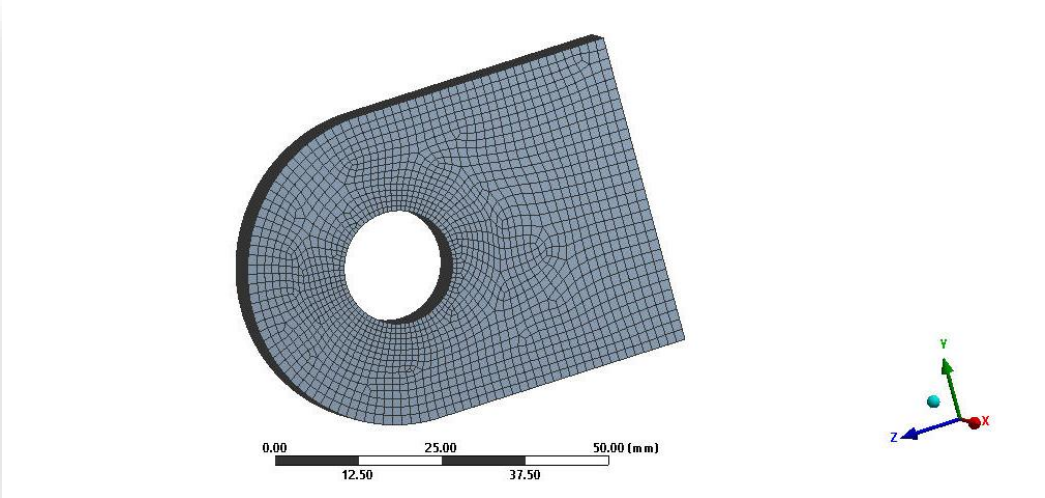
Maximum principal stress



Reference dimension:
t =15.15 mm

Ideal model

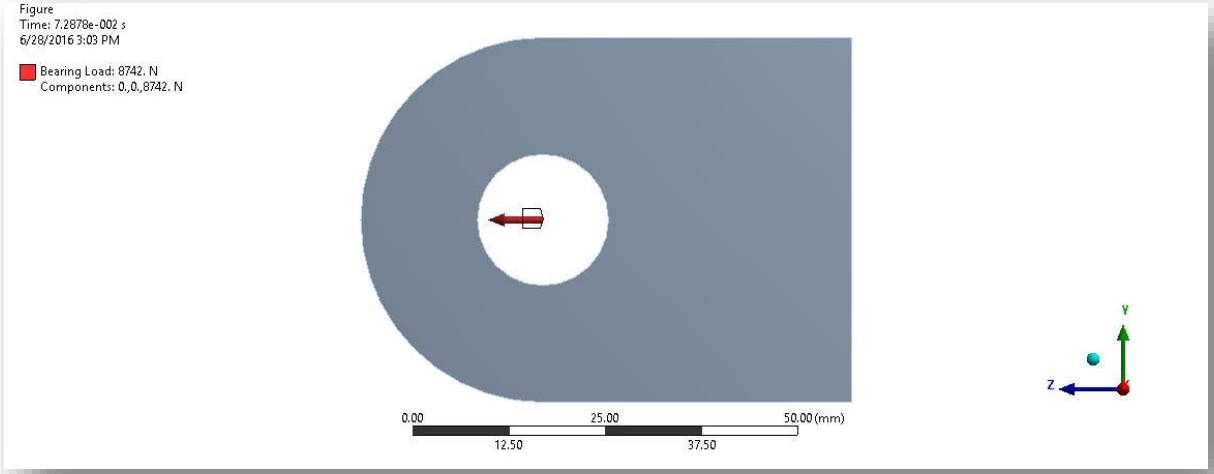
Mesh



Nodes: 113420
Elements: 25785

Ideal model

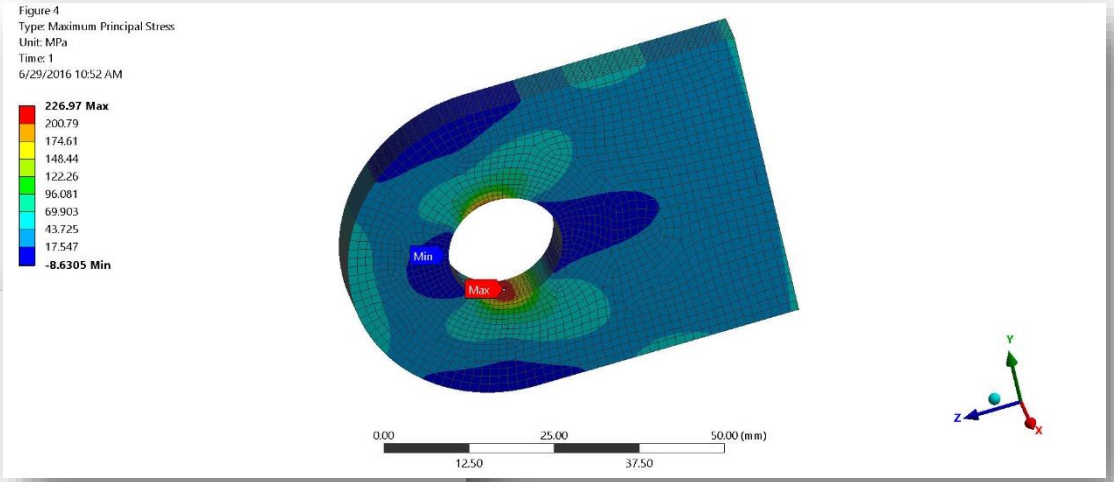
Load

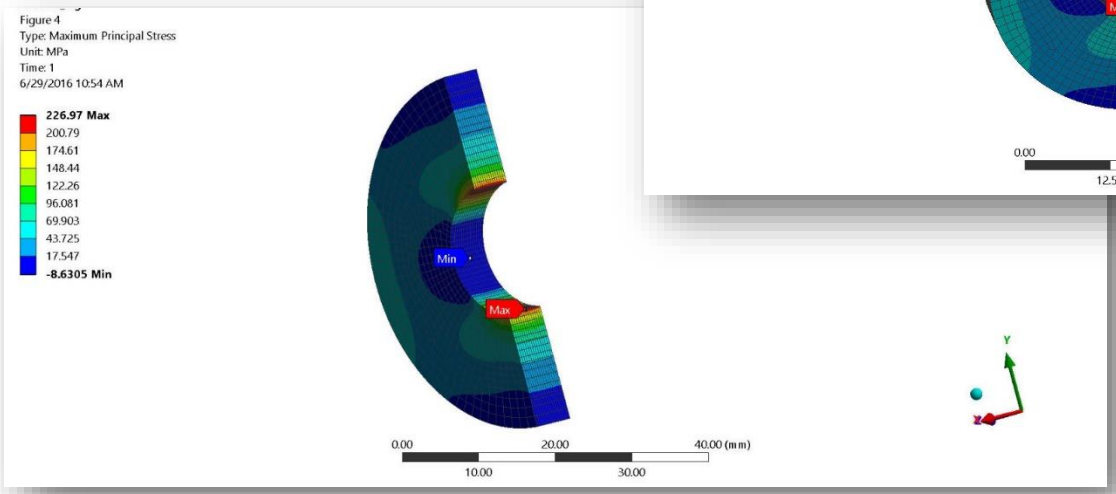


Bearing load:
F=(0 N, 0N, 8742N)

Ideal model

Maximum principal stress





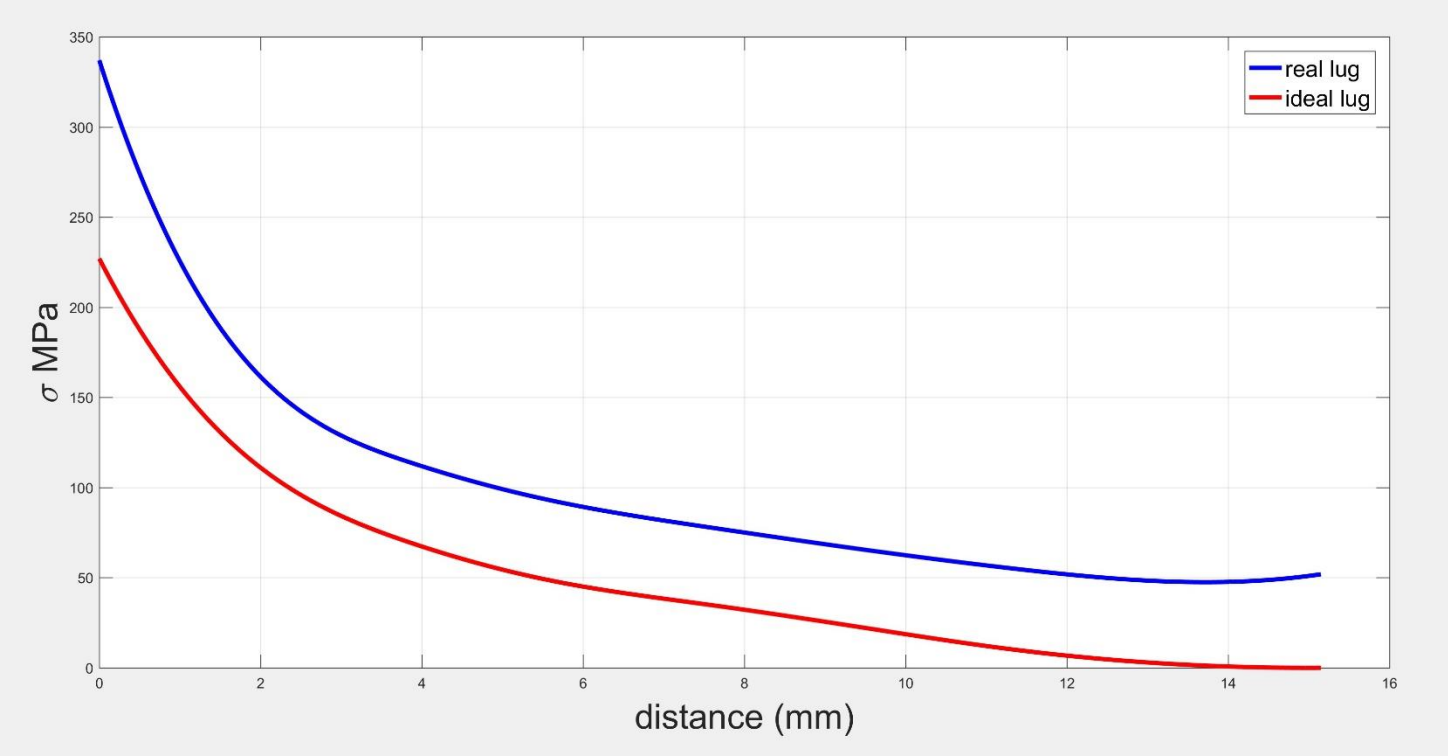
σ_{max_ideal}= 226.97 MPa

Comparison

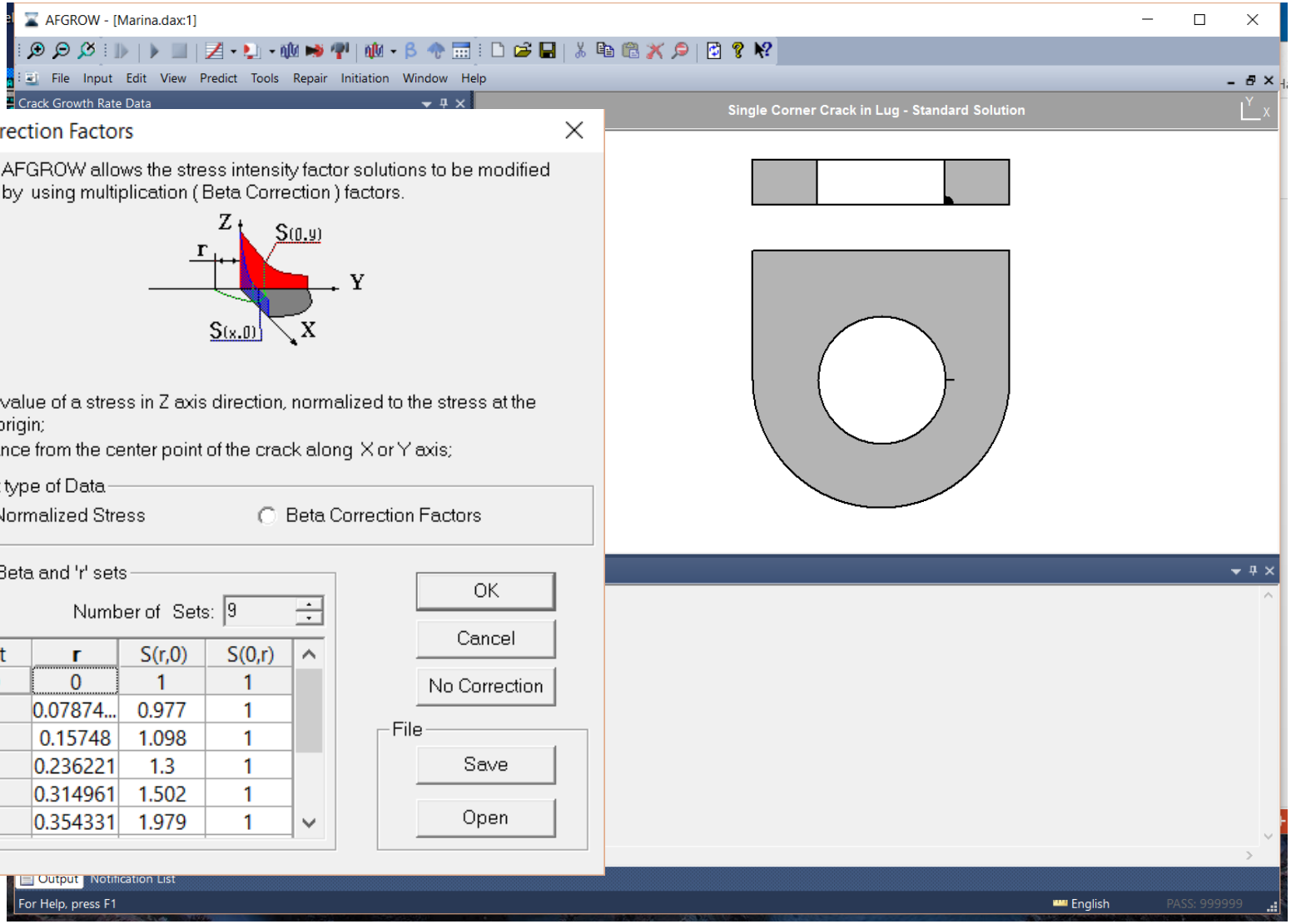
AFGROW

Distance (mm)	Real stress (MPa)	Ideal stress (MPa)	Ratio	Normalized
0	337	226.97	1.485	1
1.89	166.68	114.94	1.45	0.976
3.79	114.89	70.451	1.63	1.098
5.68	92.103	47.701	1.93	1.300
7.57	77.884	34.923	2.23	1.502
9.47	65.628	22.33	2.94	1.979
11.37	54.877	9.9475	5.52	3.715
13.26	47.882	2.2556	21.23	14.245
14.2	41.837	0.767	54.55	36.731
15.15	51.901	0.025	2076.04	1398.007

Comparison for Stress Gradient



Beta Correction Table

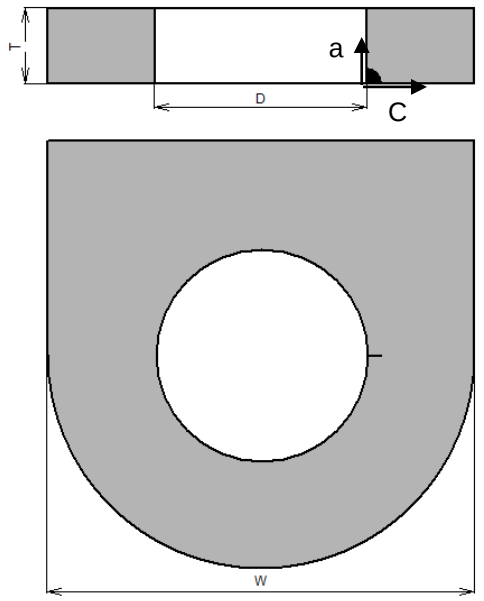


AFGROW Input & Result (Version 5.02.05.19, US Units)
Bem: 13.359 Ksi x 1.485 = 19.838 Ksi

Status

- Example Problem
- Single Corner Crack in Lug - Standard Solution
  - Load
  - Crack length (C) =0.05
  - Crack length (A) =0.05
  - Width (W) =1.339
  - Thickness (T) =0.236
  - Hole Diameter (D)=0.669
- 1000-9000 series aluminum, 2014-T6 Al, [Plt & sht; L-T] (NASGRO Equation)
- Stress State
- Spectrum File - 'P3.sp3'
  - M:\05_Akquisition\Ageing Airplane\P-3\Höhenleitwerk\P3.sp3
  - SMF=19.838000
  - Pxx=23.806000
  - SPL=0.000000
- No Spectrum Filters
- No Retardation
- No K-Solution Filters
- No Residual Stresses
- Beta Correction Factors 10 sets

Single Corner Crack in Lug - Standard Solution

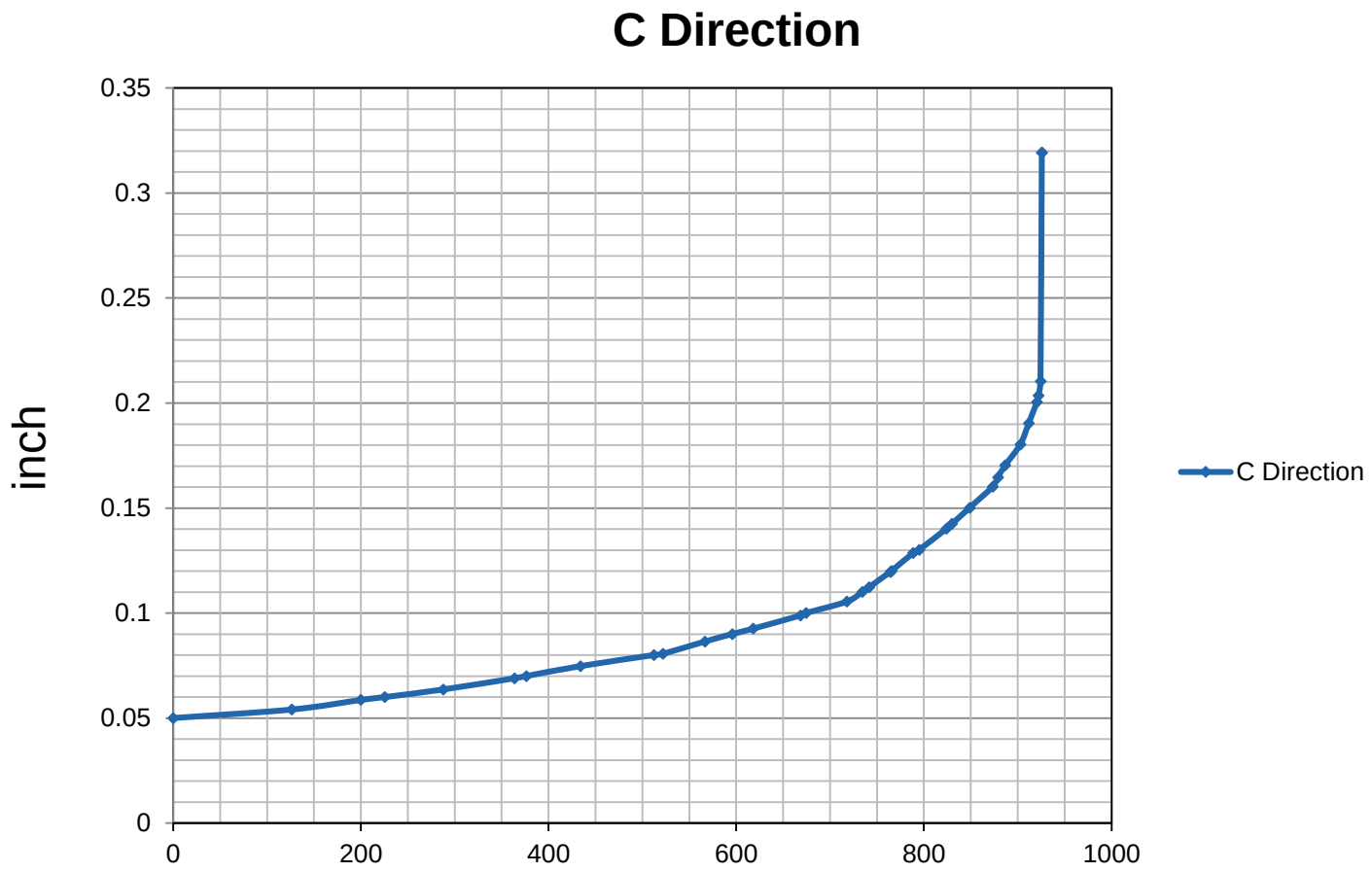


Output

```
A  Crack size=  0.20949  Beta Tension= 1.6130 Beta Compression= 1.6130  R(k)= 0.5015  R(final)= 0.5015   Delta k=4.3091e+000  D()/DN=1.2955e-006
A/t  ratio=  0.88766  A/C ratio=  1.0454
Max stress =    6.606  r = 0.50     82763  Cycles     Label:        5  Pass:   5

C  Crack size=  0.20355  Beta Tension= 2.4969 Beta Compression= 2.4969  R(k)= 0.7986  R(final)= 0.7000   Delta k=3.3272e+000  D()/DN=8.7239e-007
A  Crack size=  0.21013  Beta Tension= 1.6130 Beta Compression= 1.6130  R(k)= 0.7986  R(final)= 0.7000   Delta k=2.1838e+000  D()/DN=1.9871e-007
A/t  ratio=  0.89036  A/C ratio=  1.0323
Max stress =    8.272  r = 0.80     82925  Cycles     Label:        5  Pass:   5

C  Crack size=  0.21041  Beta Tension= 2.5756 Beta Compression= 2.5756  R(k)= 0.3320  R(final)= 0.3320   Delta k=6.9374e+000  D()/DN=4.3322e-006
A  Crack size=  0.21128  Beta Tension= 1.6545 Beta Compression= 1.6545  R(k)= 0.3320  R(final)= 0.3320   Delta k=4.4657e+000  D()/DN=9.8962e-007
A/t  ratio=  0.89526  A/C ratio=  1.0042
Max stress =    4.960  r = 0.33     83112  Cycles     Label:        5  Pass:   5

Transitioned to a thru-crack based on 'Kmax' Criteria
C  Crack size=  0.31915  Beta Tension= 2.0122 Beta Compression= 2.0122  R(k)= 0.7153  R(final)= 0.7000   Delta k=6.6352e+000  D()/DN=1.1512e-005
A  Crack size=  0.21258  Beta Tension= 2.0123 Beta Compression= 2.0123  R(k)= 0.7153  R(final)= 0.7000   Delta k=5.4154e+000  D()/DN=5.0631e-006
A/t  ratio=  0.90075  A/C ratio=  0.66607
Max stress =   11.566  r = 0.72     83242  Cycles     Label:        5  Pass:   5

**********Fracture based on ' Kmax' Criteria (current maximum stress)
C  Crack size=  0.31915  Beta Tension= 4.2779 Beta Compression= 4.2779  R(k)= 0.7153  R(final)= 0.7000   Delta k=1.4106e+001  D()/DN=1.0000e-001
Max stress =   11.566  r = 0.72     83242  Cycles     Label:        5  Pass:   5

Stress State in the 'C' direction (PSC): 3.01824
Fracture has occurred- run time:  0 hour(s)  0 minute(s)  0 second(s)
925.8369 hours have passed
```

Crack Growth Life = 925 Flights

AFGROW: Crack Growth Curve (c direction)



Crack Growth Life = 925 Flights