

SAE FD&E Weld Challenge 3

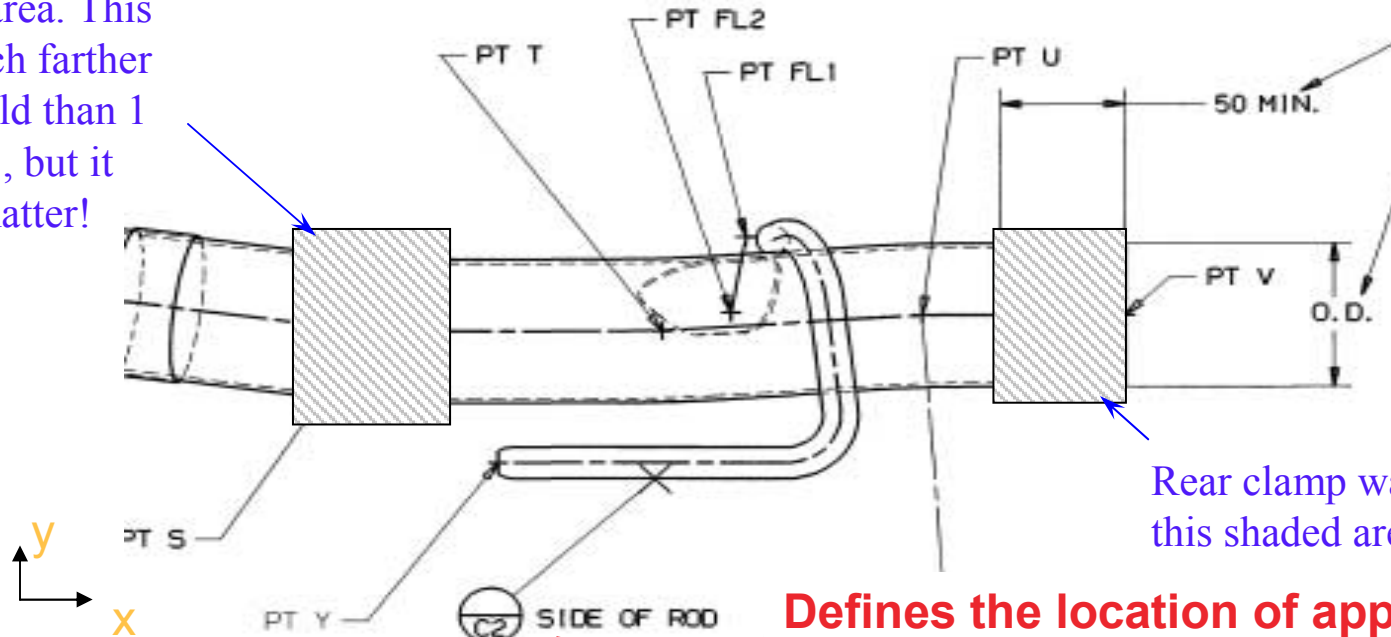


**ENGINEERING CENTER STEYR
GmbH & Co KG**

Helmut Dannbauer, Magna Steyr, helmut.dannbauer@ecs.steyr.com
Gerald Schwarz, Magna Steyr, femfat.usa@magnasteyr.com

Exhaust Hanger SAE FD&E Weld Challenge 3A

Forward clamp was near this shaded area. This was much farther from weld than 1 pipe dia., but it didn't matter!

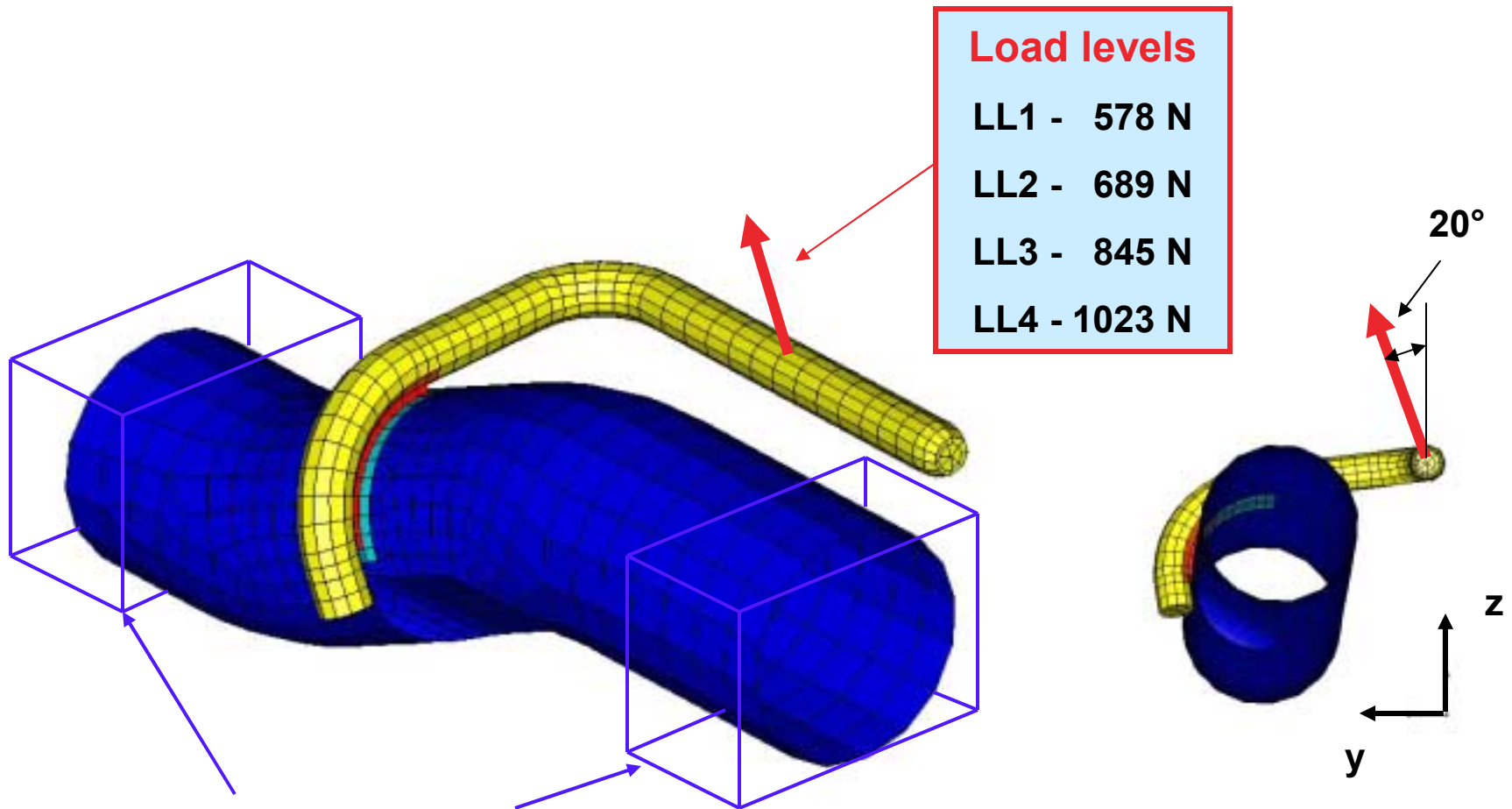


Rear clamp was near this shaded area.

Defines the location of applied force in the test

- **Force amplitude**
1023 / 845 / 689 / 578 N
- **Mean force = 0**

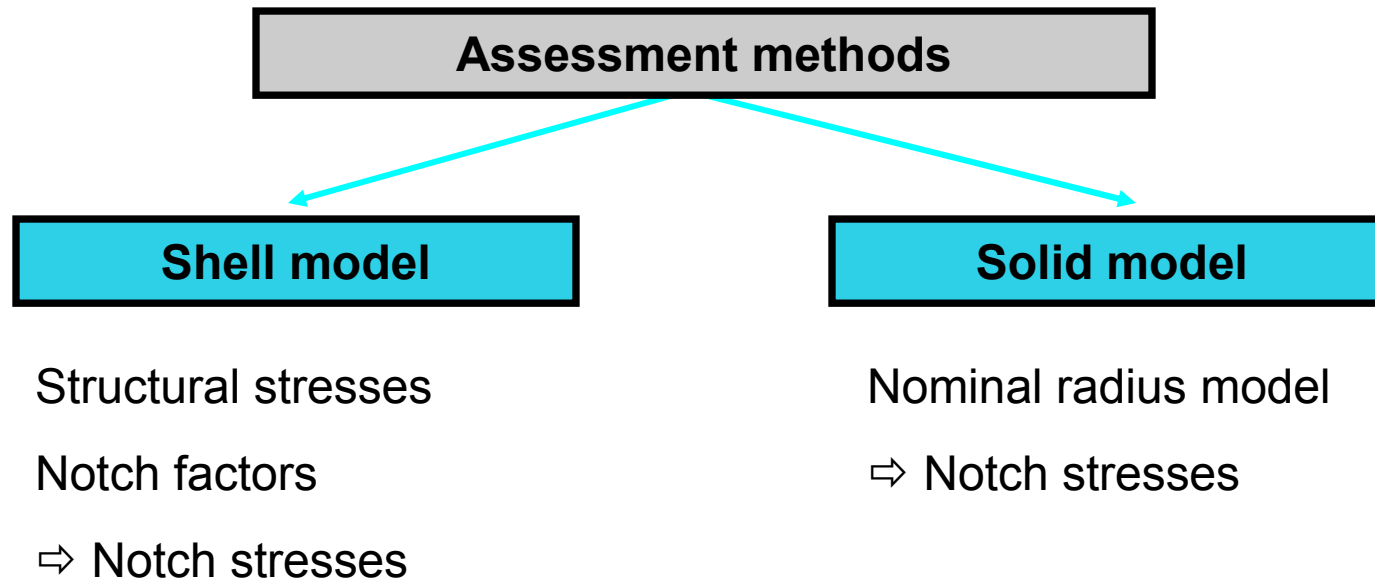
Exhaust Hanger SAE FD&E Weld Challenge 3A



Boundary conditions
6 DOF = 0

All linear static analysis was solved with
NASTRAN 2004

Exhaust Hanger SAE FD&E Weld Challenge 3A

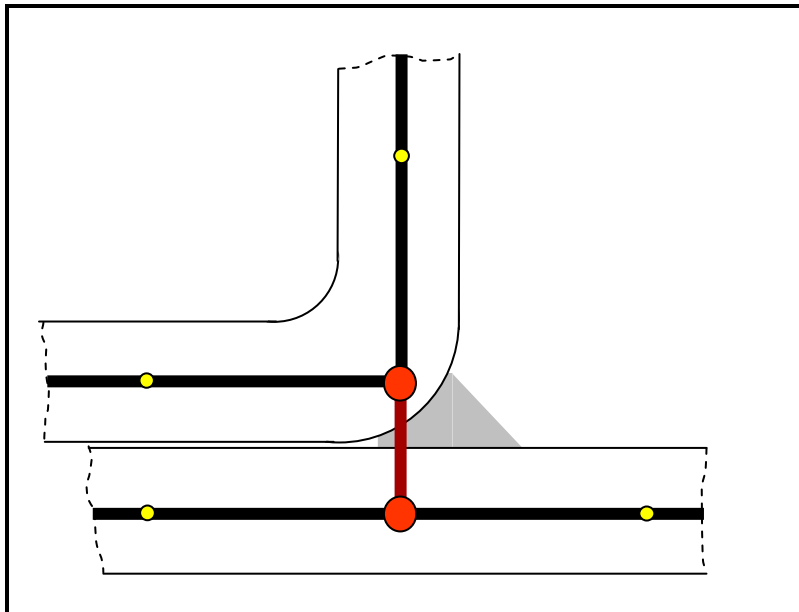


Exhaust Hanger SAE FD&E Weld Challenge 3A

FEMFAT WELD database – 2 choices

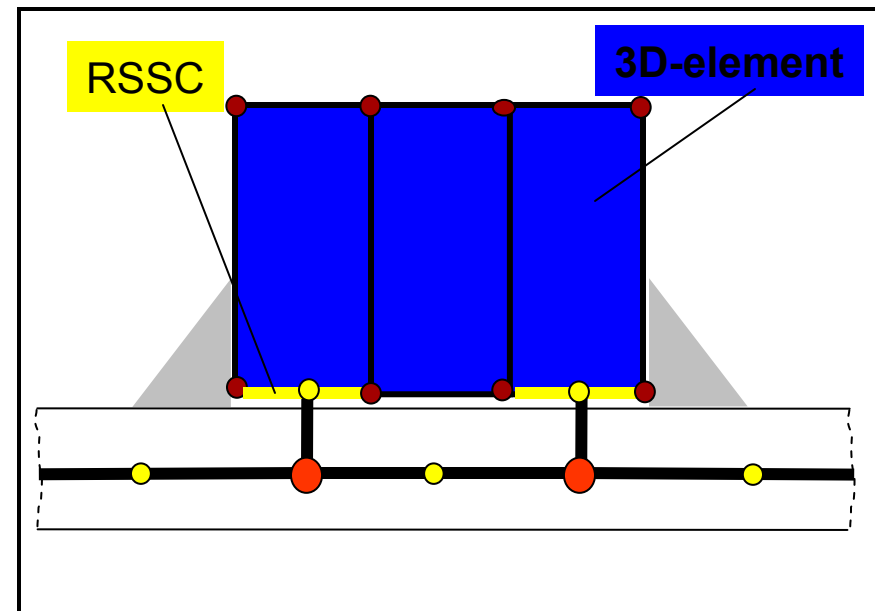
Flared joint

fillet seam



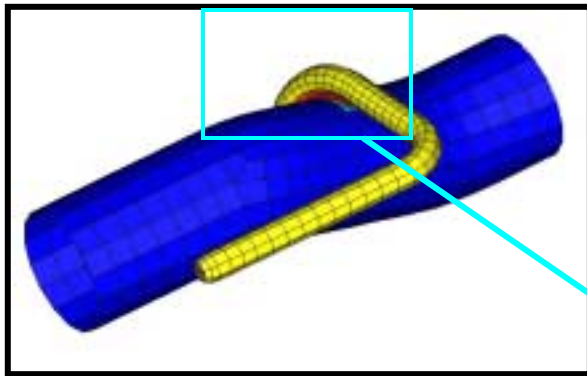
T-joint

double sided fillet seam
(shell-solid connection)

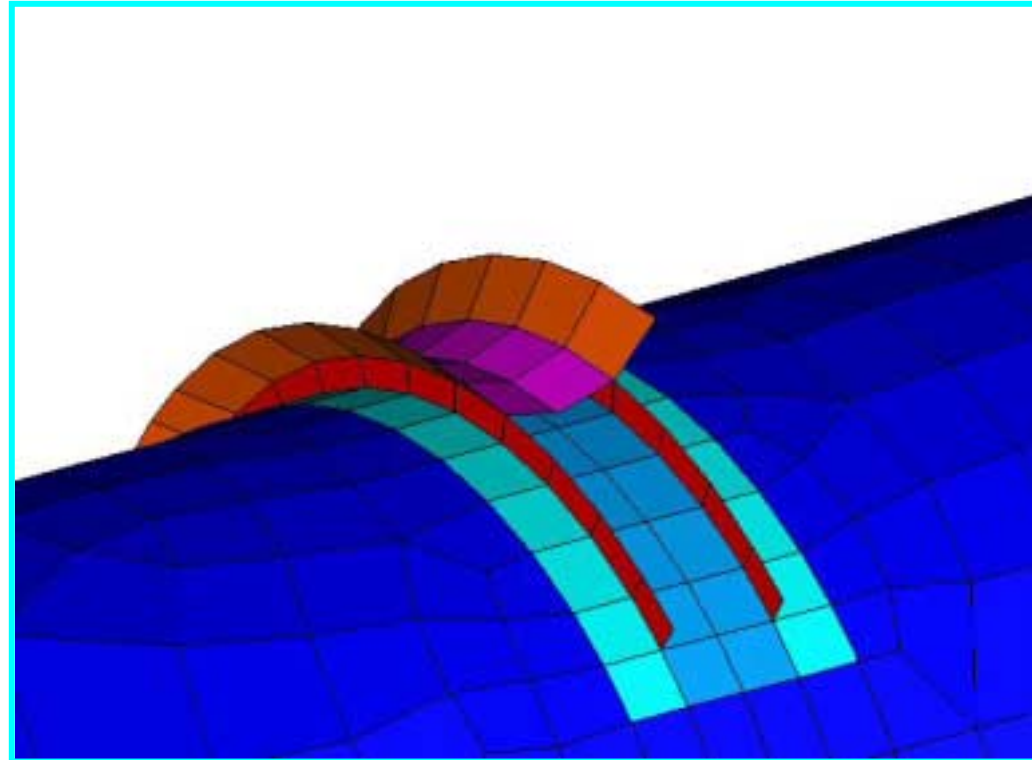


Exhaust Hanger SAE FD&E Weld Challenge 3A

Flared joint
fillet seam



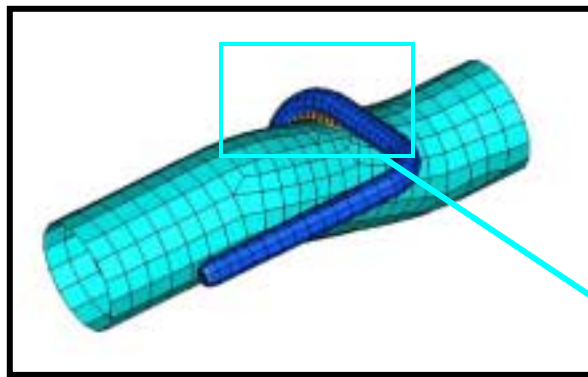
FE-mesh shell-shell



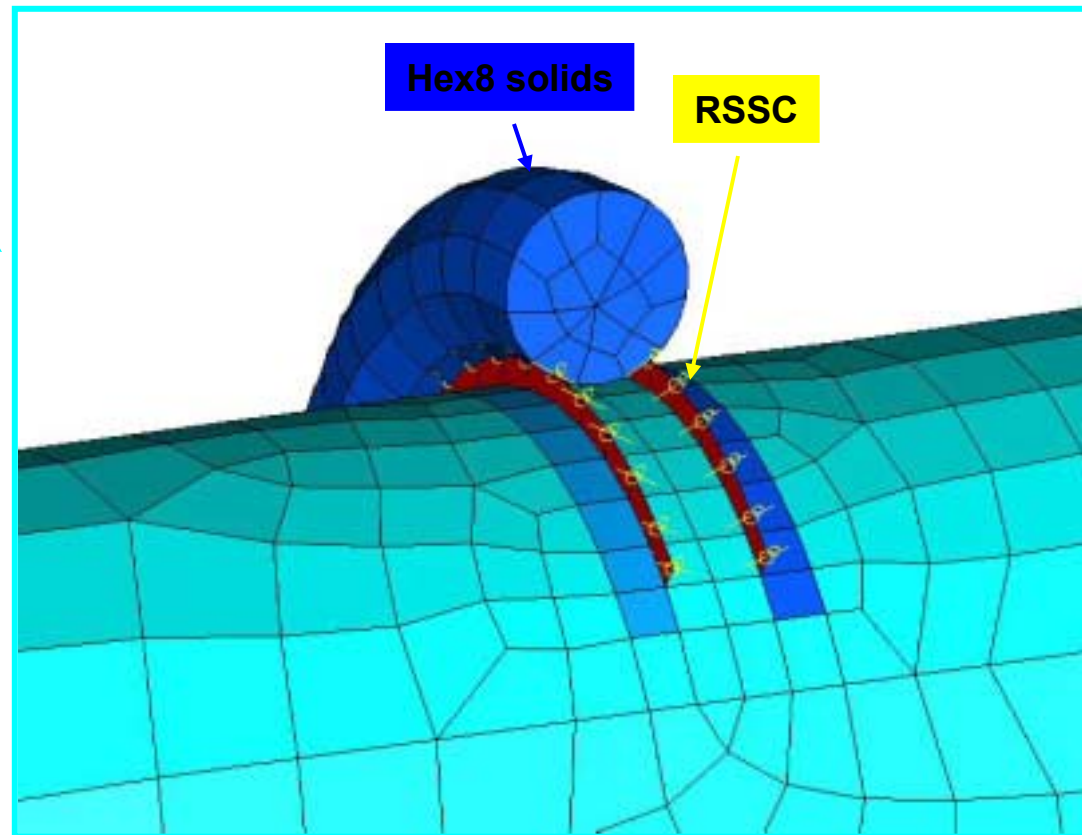
Exhaust Hanger SAE FD&E Weld Challenge 3A

T-joint

double sided fillet seam (shell-solid connection)

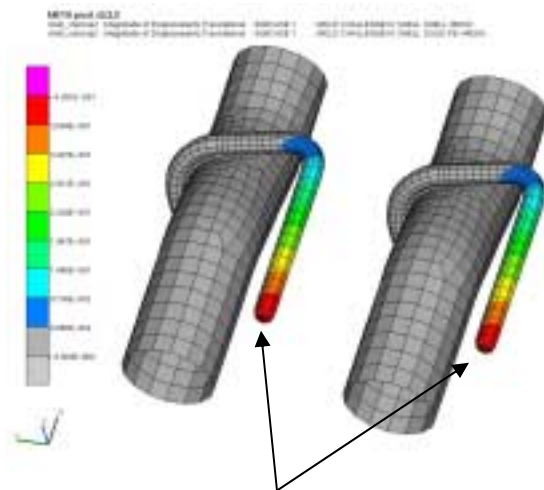
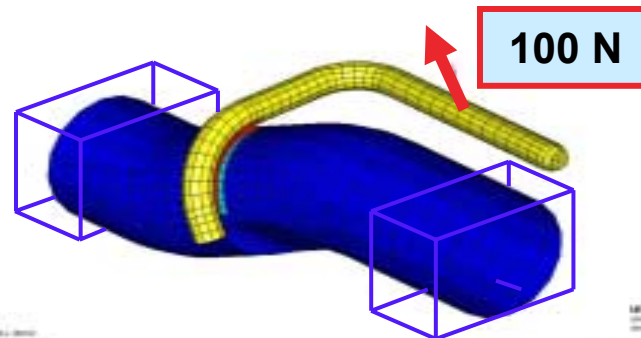


FE-mesh shell-solid



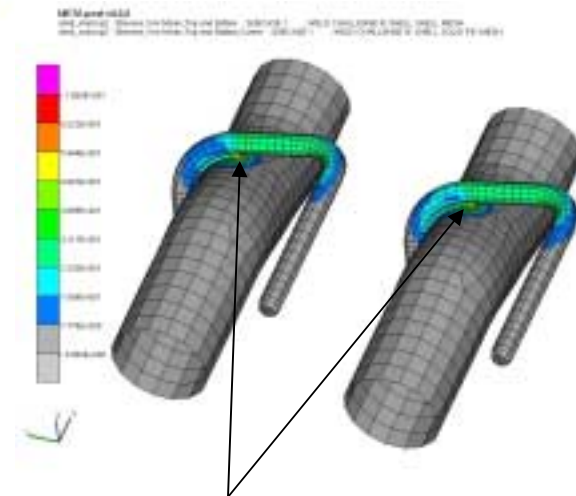
Exhaust Hanger SAE FD&E Weld Challenge 3A

FE-model comparison for shell-shell / shell-solid



Displacements

- Right side – shell-shell mesh
- Left side – shell-solid mesh



V. Mises stress (unaveraged element)

- Right side – shell-shell mesh
- Left side – shell-solid mesh

Exhaust Hanger SAE FD&E Weld Challenge 3A

FE-model comparison for shell-shell / shell-solid

Displacement at end of rod	Shell-shell mesh	Shell-solid mesh
	[mm]	[mm]
x	0.007	0.007
y	0.124	0.120
z	0.414	0.417
magn.	0.432	0.434

V. Mises stress at weld tip	Shell-shell mesh	Shell-solid mesh
	[MPa]	[MPa]
unaveraged element stress	60.0	57.0

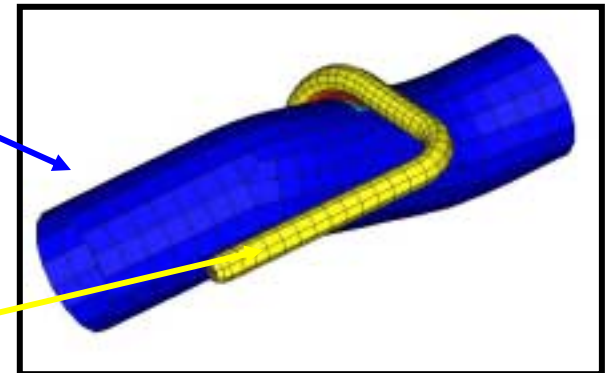
Exhaust Hanger SAE FD&E Weld Challenge 3A

Material properties

409 Stainless / used - NiCr20Co18Ti	Ultimate strength	Yield strength	Pulsating strength	Alternating strength
	[MPa]	[MPa]	[MPa]	[MPa]
Tension	1250	820	1110	563
Compression	1250	820	x	563
Bending	1496	1037	1356	595
Shear	744	473	710	325

pipe

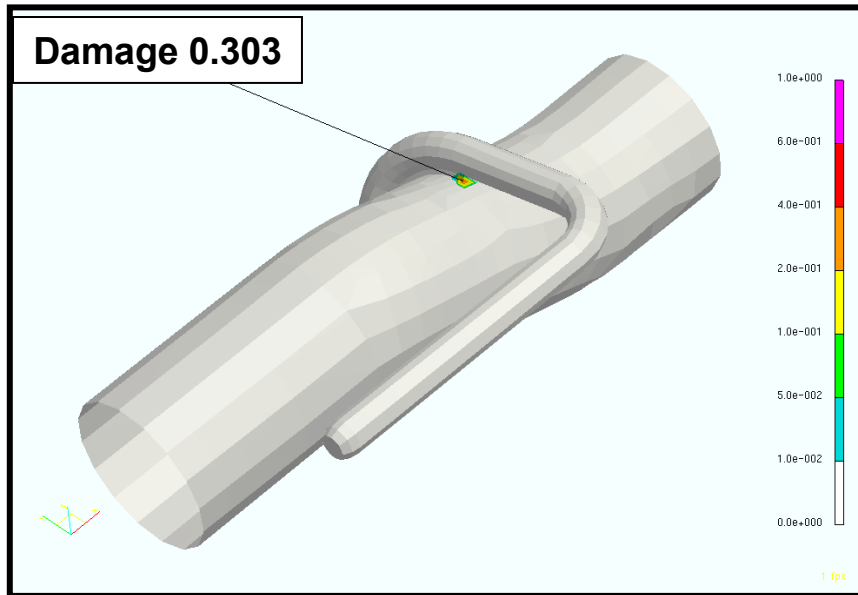
rod



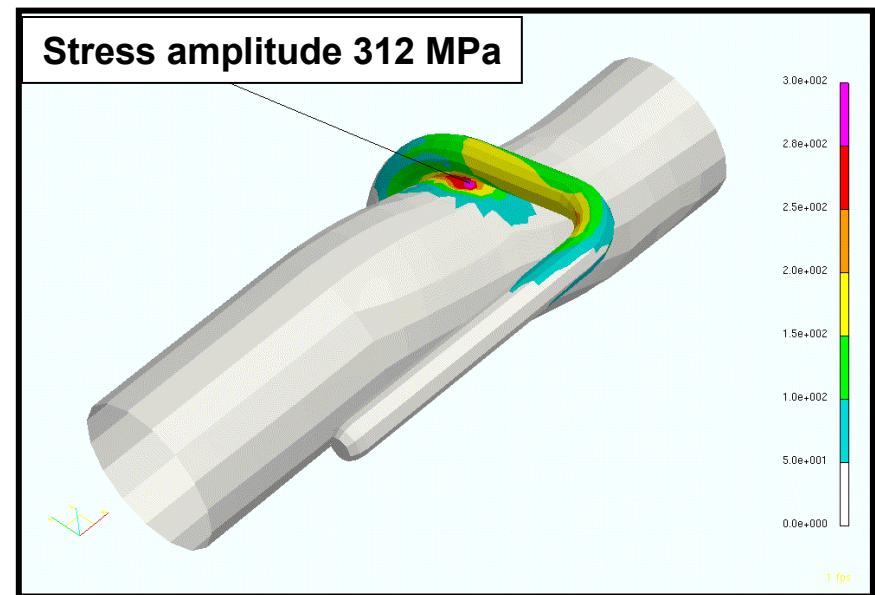
Cold-rolled steel ~ 1008-1010 / used - ST34-2	Ultimate strength	Yield strength	Pulsating strength	Alternating strength
	[MPa]	[MPa]	[MPa]	[MPa]
Tension	490	295	434	221
Compression	490	295	x	221
Bending	587	373	530	245
Shear	283	170	278	128

Exhaust Hanger SAE FD&E Weld Challenge 3A

Flared joint
fillet seam

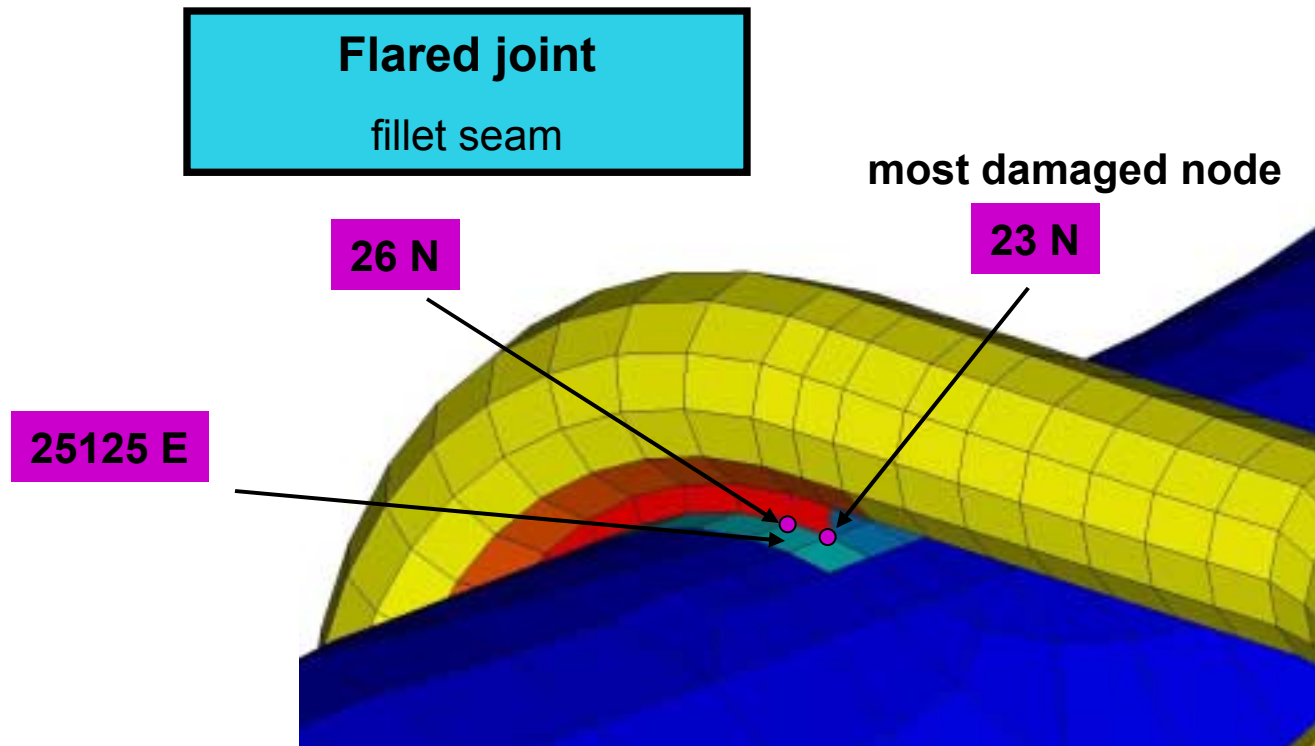


Damage for 1000 load cycles
Load level 1 – $F = 578 \text{ N}$



Stress amplitude
Load level 1 – $F = 578 \text{ N}$

Exhaust Hanger SAE FD&E Weld Challenge 3A

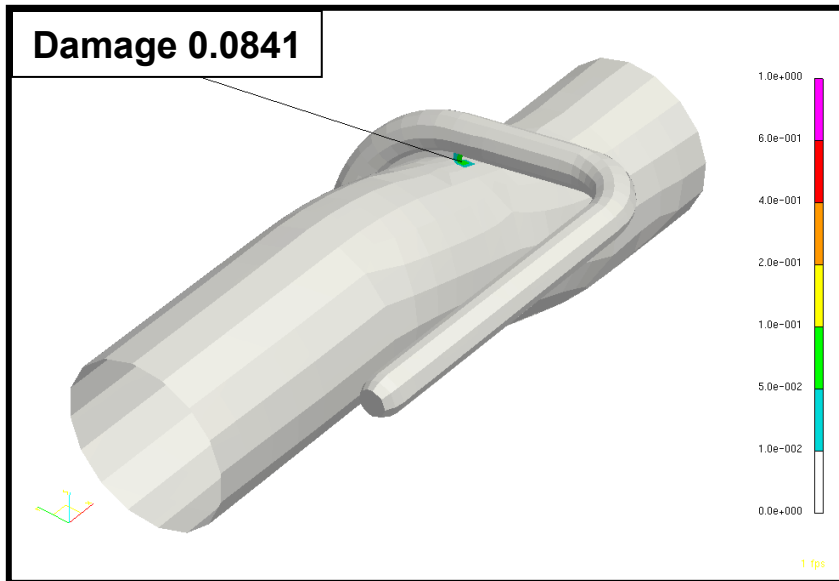


Node-label	Damage factor	Relevant weld element	Position	Notch factor
23	0.303	25125	EUETOP	2.52

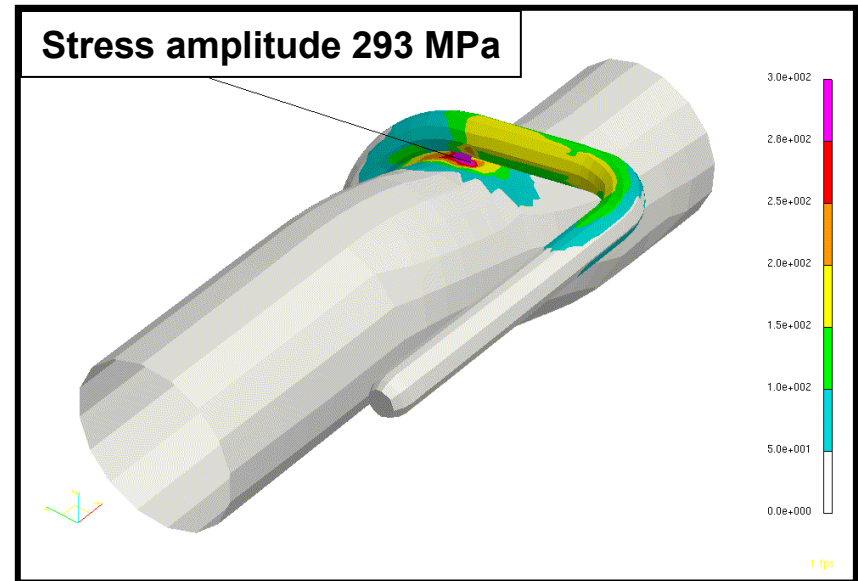

EUETOP – Weld toe on the shell TOP of element 25125

Exhaust Hanger SAE FD&E Weld Challenge 3A

T-joint
double sided fillet seam (shell-solid connection)



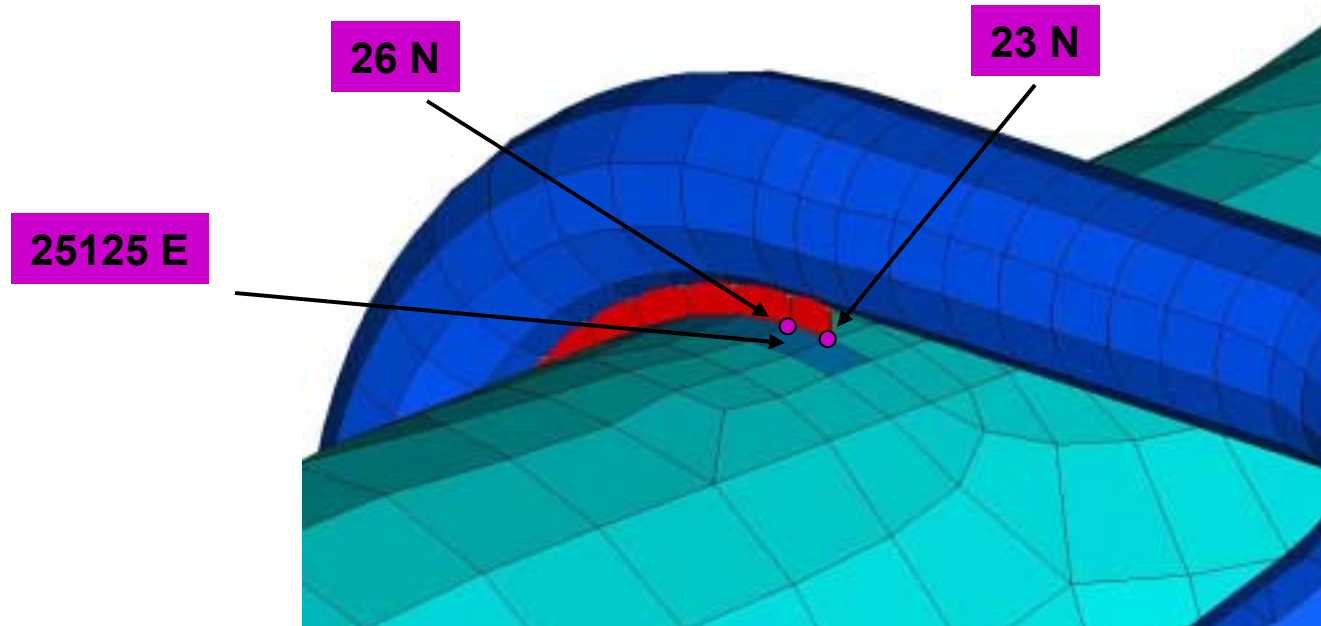
Damage for 1000 load cycles
Load level 1 – F = 578 N



Stress amplitude
Load level 1 – F = 578 N

Exhaust Hanger SAE FD&E Weld Challenge 3A

T-joint
double sided fillet seam (shell-solid connection)

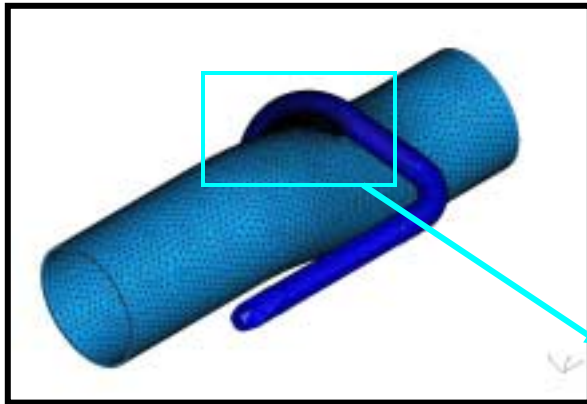


Node-label	Damage factor	Relevant weld element	Position	Notch factor
23	0.0841	25125	EUETOP	1.76

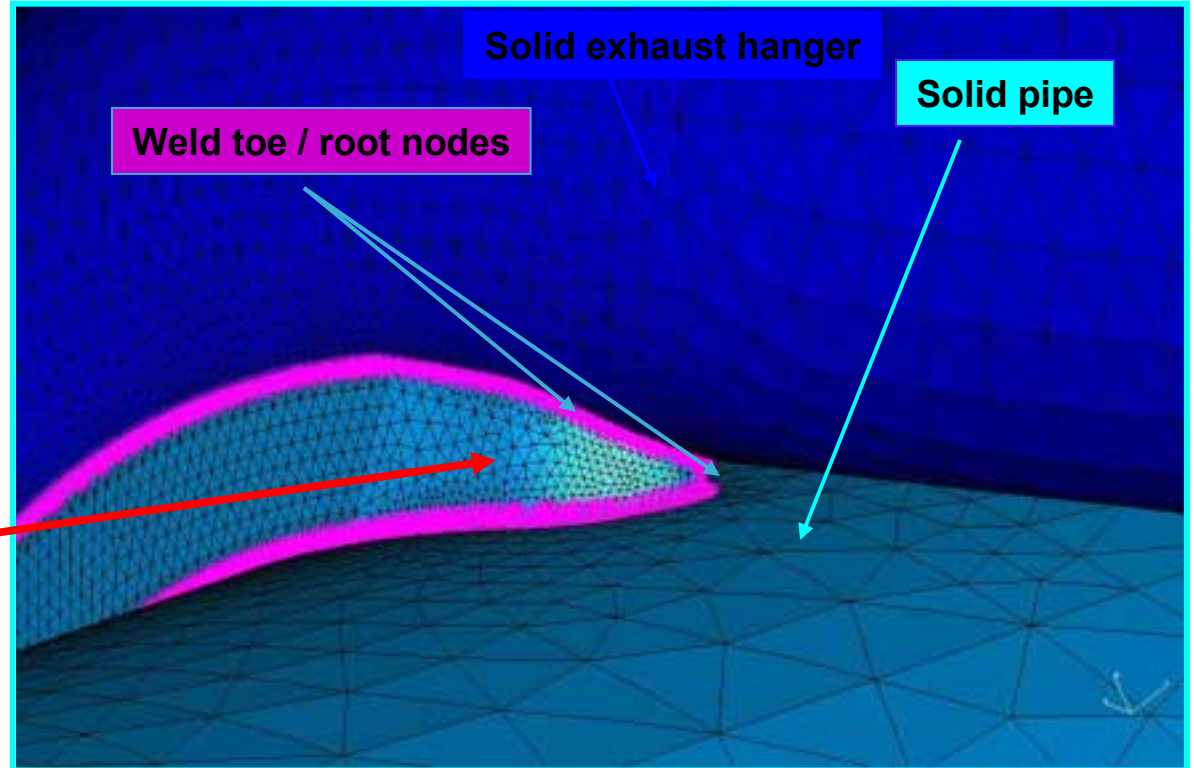
EUETOP – Weld toe on the shell TOP of element 25125

Exhaust Hanger SAE FD&E Weld Challenge 3A

Solid Tet10 model R0.3



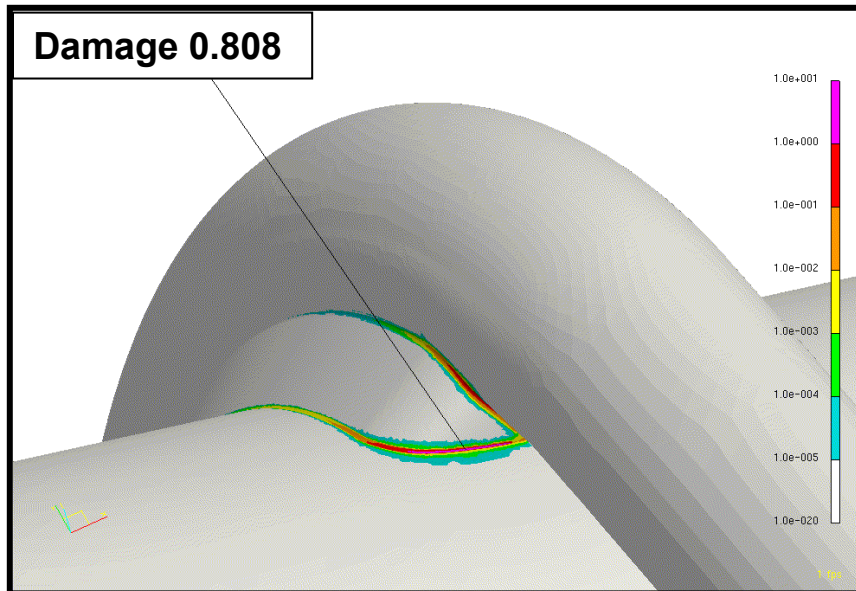
FE-mesh solid model



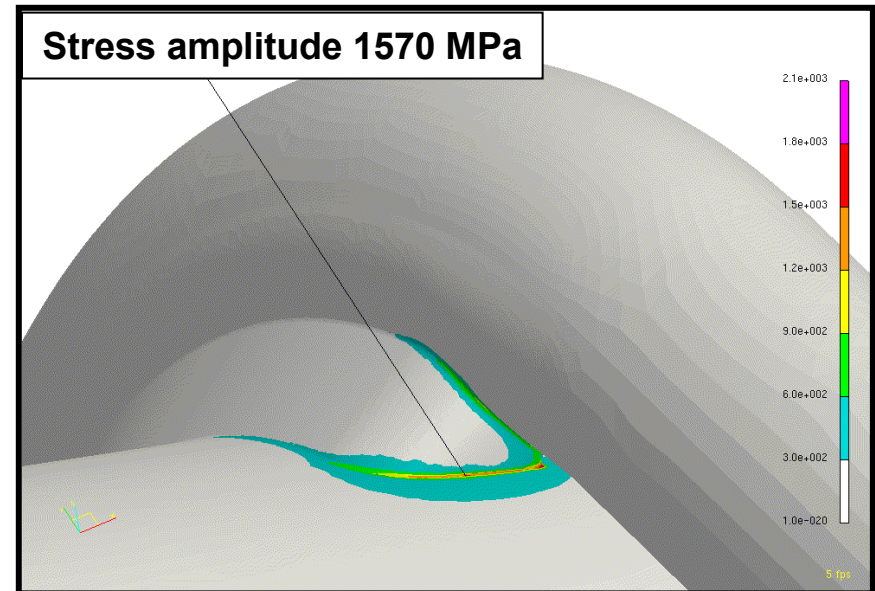
Meshing error
Welding 7 mm too short !

Exhaust Hanger SAE FD&E Weld Challenge 3A

Solid Tet10 model R0.3



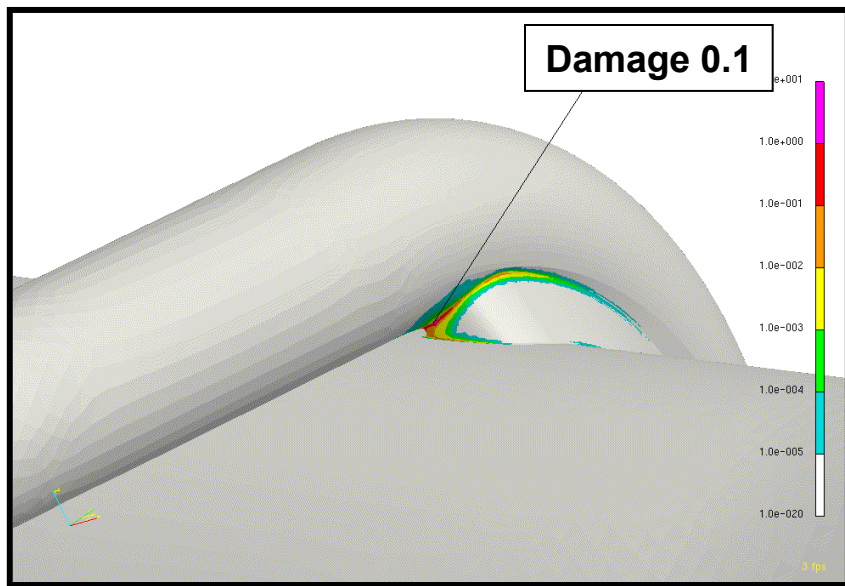
Damage for 1000 load cycles
Load level 1 – F = 578 N



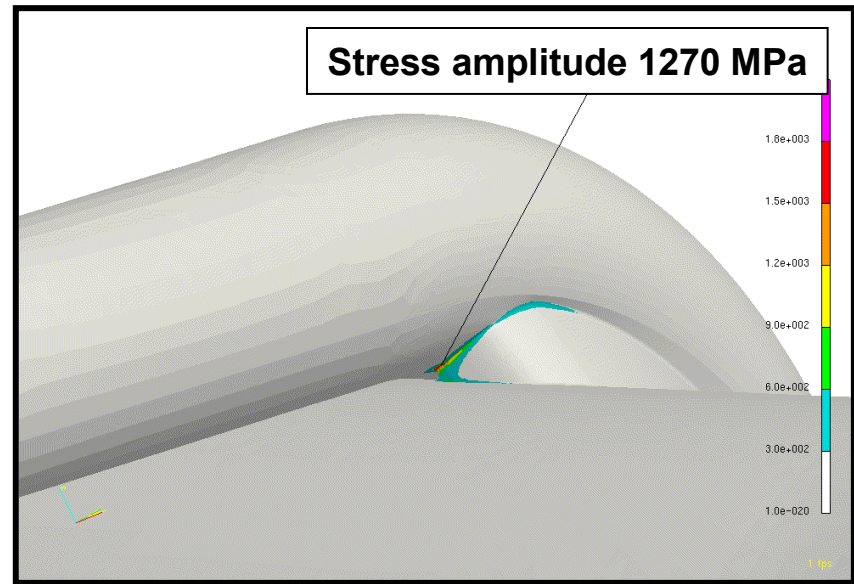
Stress amplitude
Load level 1 – F = 578 N

Exhaust Hanger SAE FD&E Weld Challenge 3A

Solid Tet10 model R0.3



Damage for 1000 load cycles
Load level 1 – F = 578 N



Stress amplitude
Load level 1 – F = 578 N

Exhaust Hanger SAE FD&E Weld Challenge 3A

Force amplitude	FE-mesh (shell-shell) / flared Joint		FE-mesh (shell-solid) / T-joint		FE-mesh solid Tet10	
	Damage	Fatigue life	Damage	Fatigue life	Damage	Fatigue life
578	0.30	3300	0.08	11891	0.81	1238
689	0.67	1497	0.21	4878	2.12	472
845	1.67	599	0.56	1779	5.66	177
1023	3.95	253	1.46	684	14.75	68

S/N curve parameters

Flared joint

$\sigma = 225 \text{ Mpa}$
 $N = 1.8 \cdot 10^6$
 $k = 4.5$

T-joint

$\sigma = 225 \text{ Mpa}$
 $N = 1.8 \cdot 10^6$
 $k = 5$

Solid Model

$\sigma = 370 \text{ Mpa}$
 $N = 1.8 \cdot 10^6$
 $k = 5$

