LMS Engineering Services

SAE FD&E Weld Challenge 3A

Exhaust Hanger Example for SAE FD&E Weld Challenge

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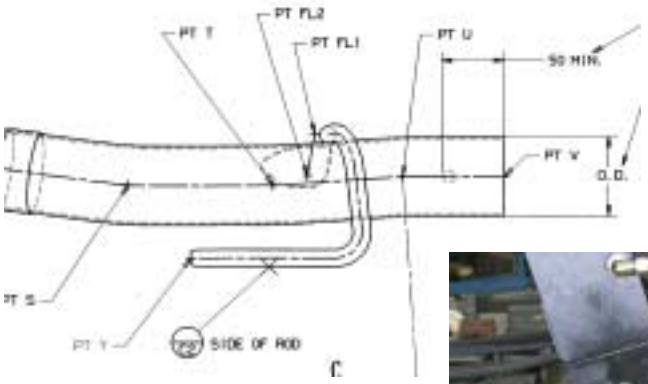
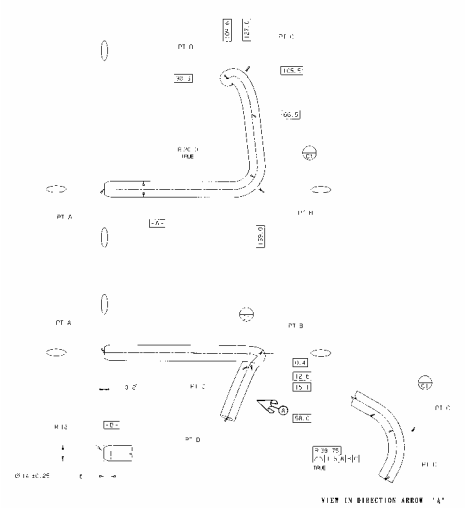
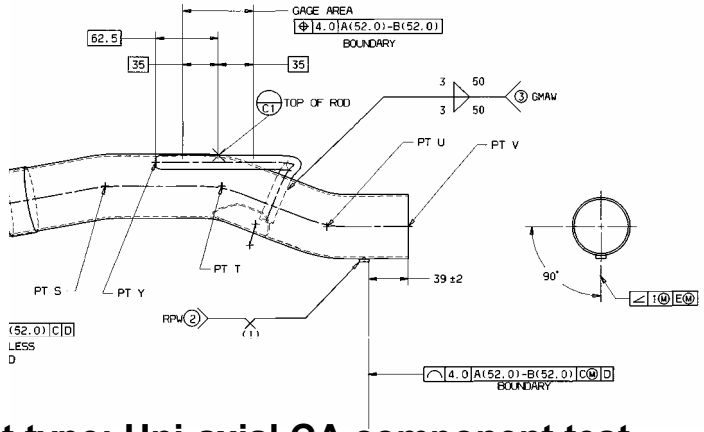
Test Setup

Input:



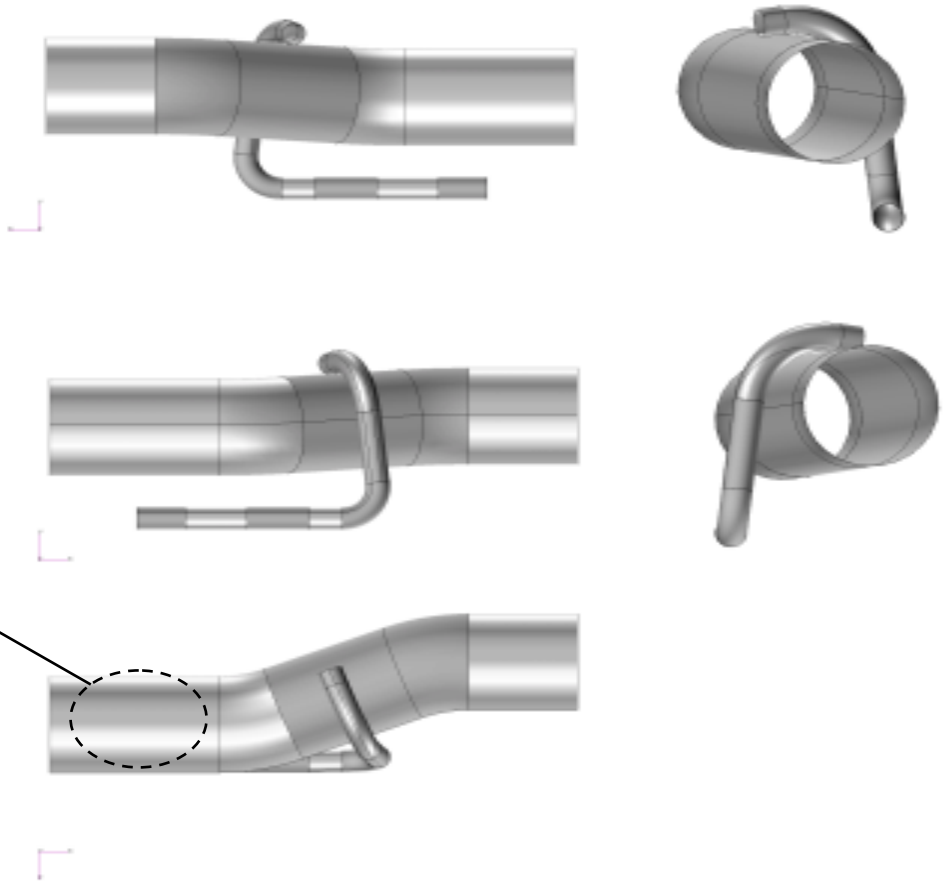




- **Test type: Uni-axial CA component test**
- **4 Load amplitudes: 1023, 845, 689, 578 N**
- **Mean force = zero**
- **Material: 409 stainless (tube), 1008/10 steel (rod)**
- **Failure = detected crack at least 6 mm long**

Comment: Imprecise definition of failure, contains macroscopic crack growth. Available SN data will only approximate this criterion.

CAD geometry of specimen:



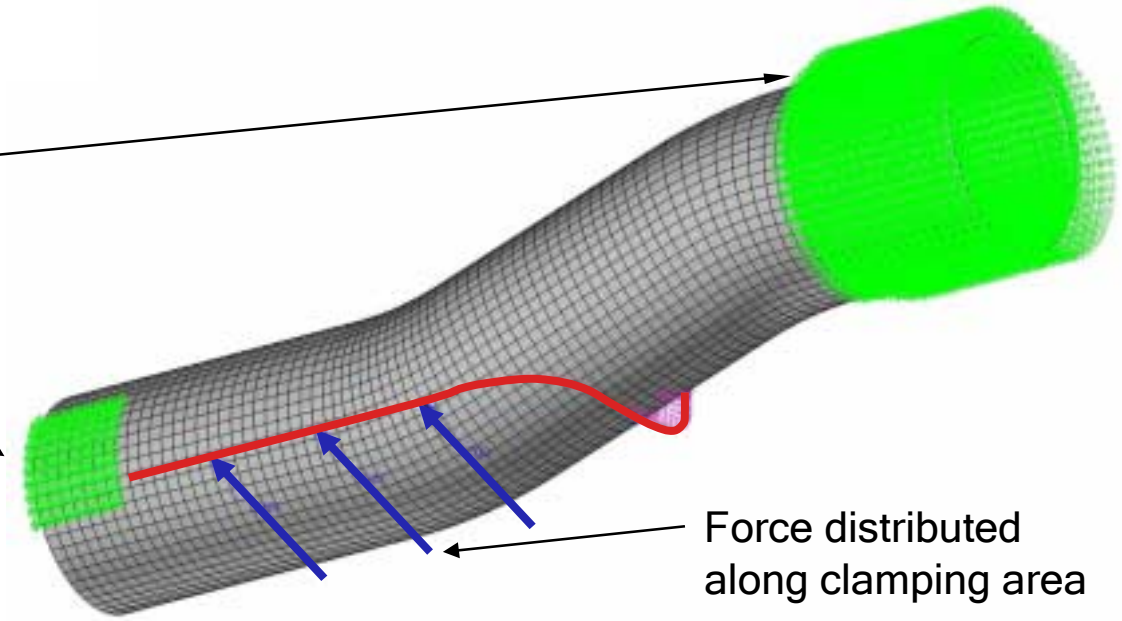
Simplification 1:
Flattened region not modeled

FE Model:

- FE Code: MSC.Nastran
- Component modeled by 4080 QUAD4 elements
- Element size: b = h = 2*t = 3.8 mm
- Rod modeled with CBAR beam elements
- Rigidly fixed at both ends of component:

Rear clamp: all 6 DOFs fixed

Shoe clamp: DOFs 123 fixed in specified area

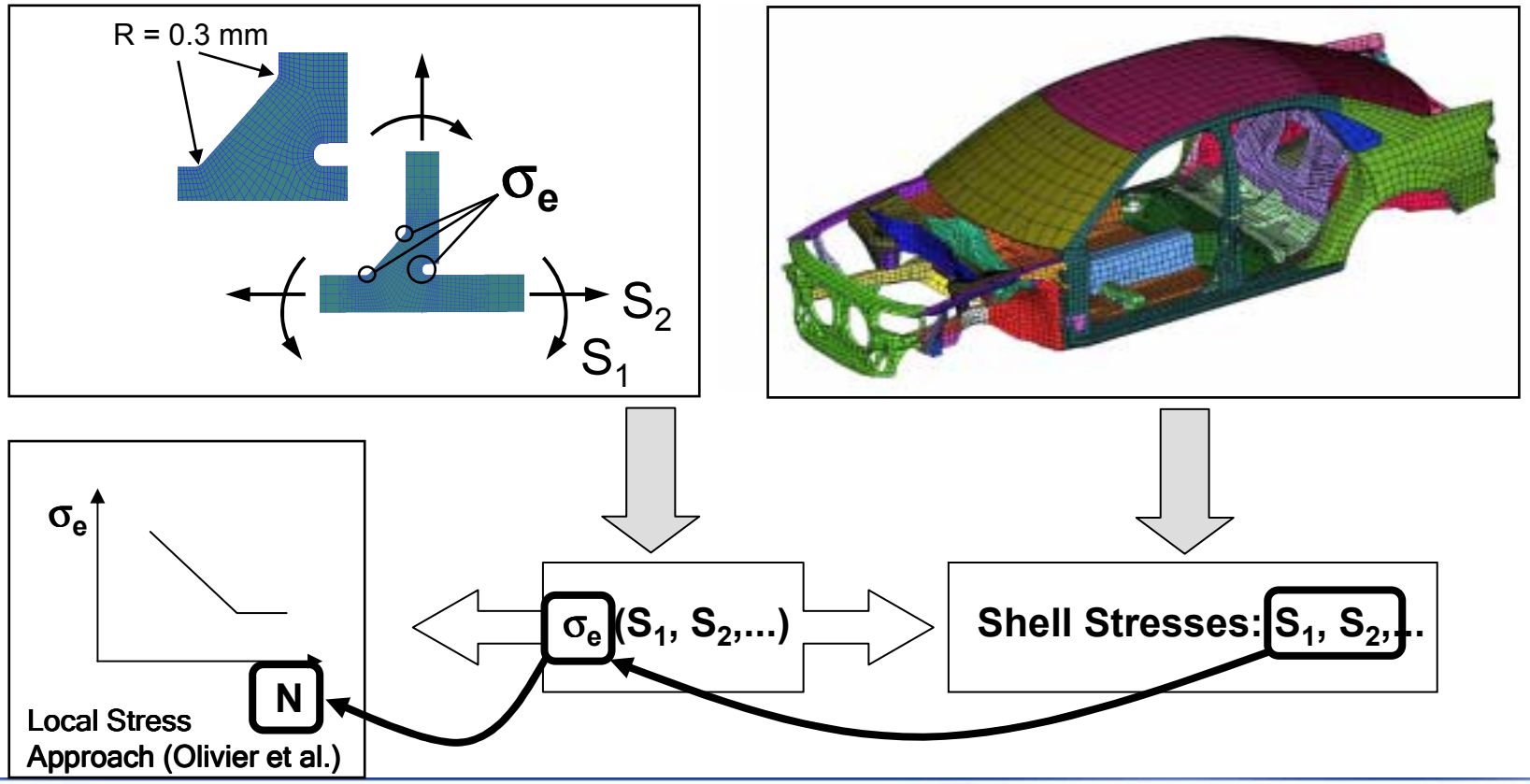


Force distributed along clamping area

Simplification 2:
Fixed areas not precisely defined

Weld Fatigue Life Analysis Approach

Used Approach: Hybrid structural / local stress approach



Weld Fatigue Life Analysis Approach

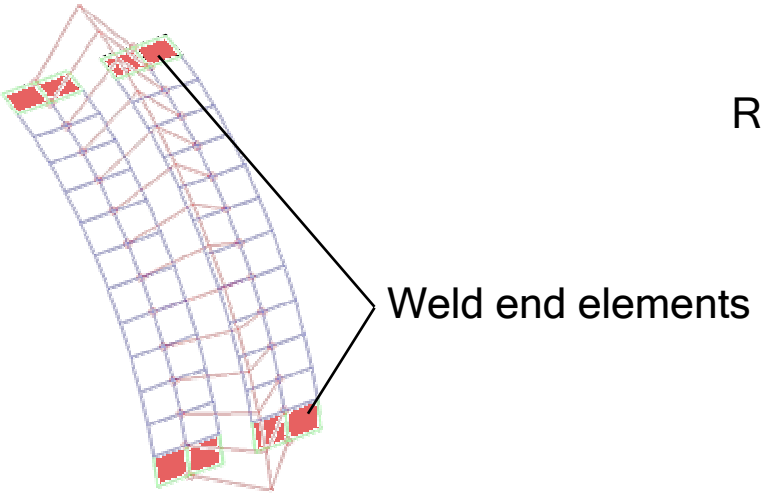
Used Approach: Hybrid structural / local stress approach

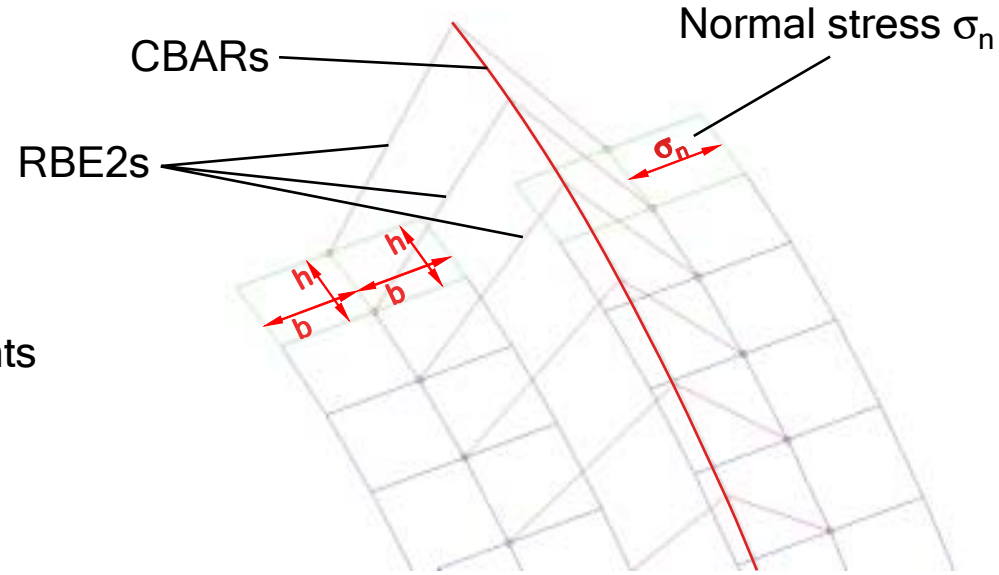
- Motivation: (Nodal) force based approach numerical difficulties at weld ends
- Hybrid approach validated for certain types of welds and joints
- Requires modeling guidelines for structural FE mesh (see next slide)
- Effectively uses a conservative shell stress-life curve applied to normal component of CENTER stress of weld elements (see next slide)

Weld Fatigue Life Analysis Approach

Used Approach: Hybrid structural / local stress approach

- Seam weld modeled by rigid RBE2 connections (all DOFs coupled)
- Element size of QUAD4s: b = h = 2*t = 3.8 mm
- Normal stress component (CENTER) used for fatigue life prediction

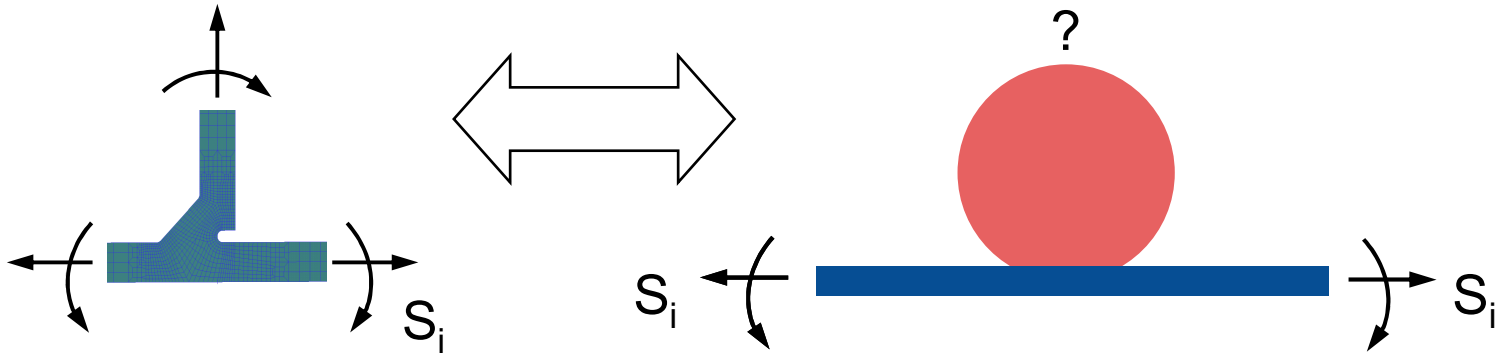




Weld Fatigue Life Analysis Approach

Major challenge: “exotic” joint type rod / sheet

- No proper definition of sectional forces/moments:



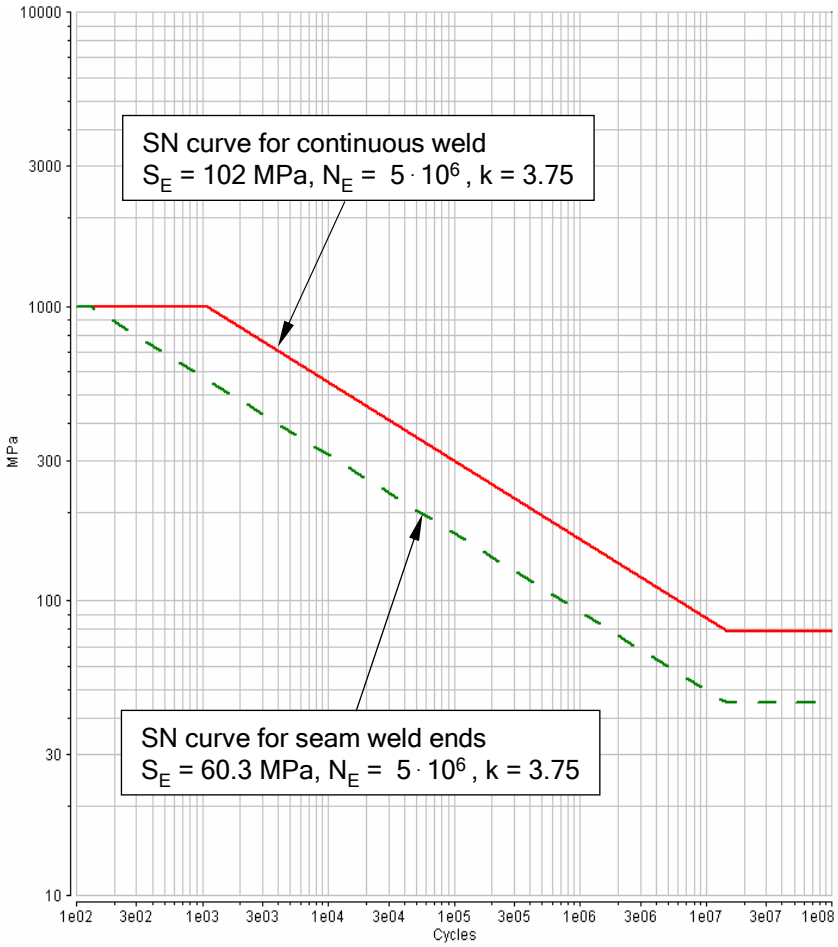
- Effective notch factor at weld end unknown

Weld Fatigue Life Analysis Approach

- Decisions made:
  - Rod to be modeled by CBARs
  - Only shell stresses of tube to be assessed, no stress indicator for rod itself
  - Due to lack of specific rod/sheet SN data: SN data derived as interpolation of existing T-joint and lap joint data
- Weld ends:
  - Assessed separately by lowered SN data
  - Scaling factor < 1 derived from specimen tests

Weld Fatigue Life Analysis Approach

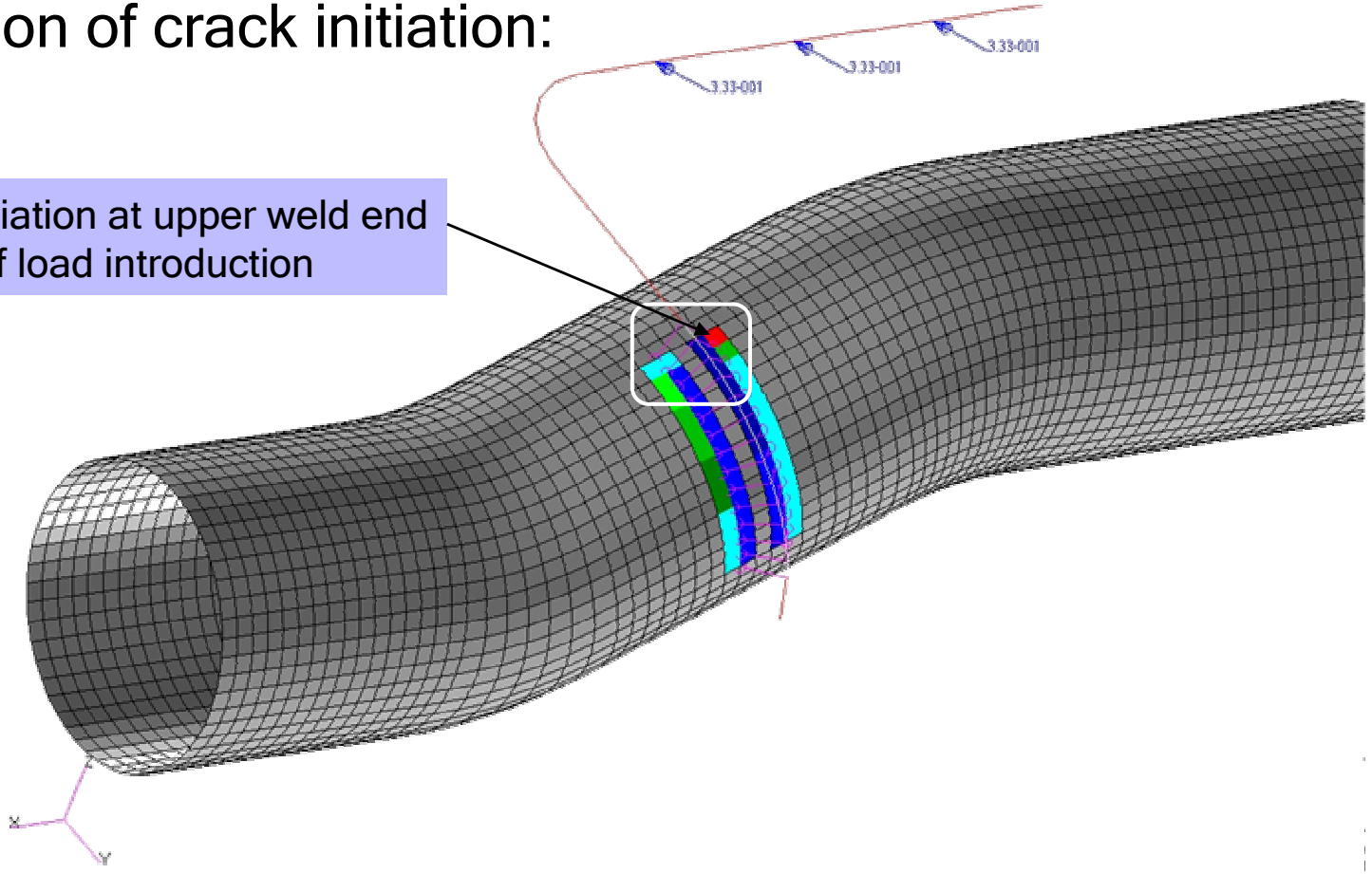
- SN data:
  - Data derived from mild steel weld specimens
  - Failure criterion: crack of ≈ 5mm
  - Influence of deviating target material not considered
- Other FLA parameters:
  - Stress based approach
  - No mean stress influence



Weld Fatigue Life Analysis Results

A: Location of crack initiation:

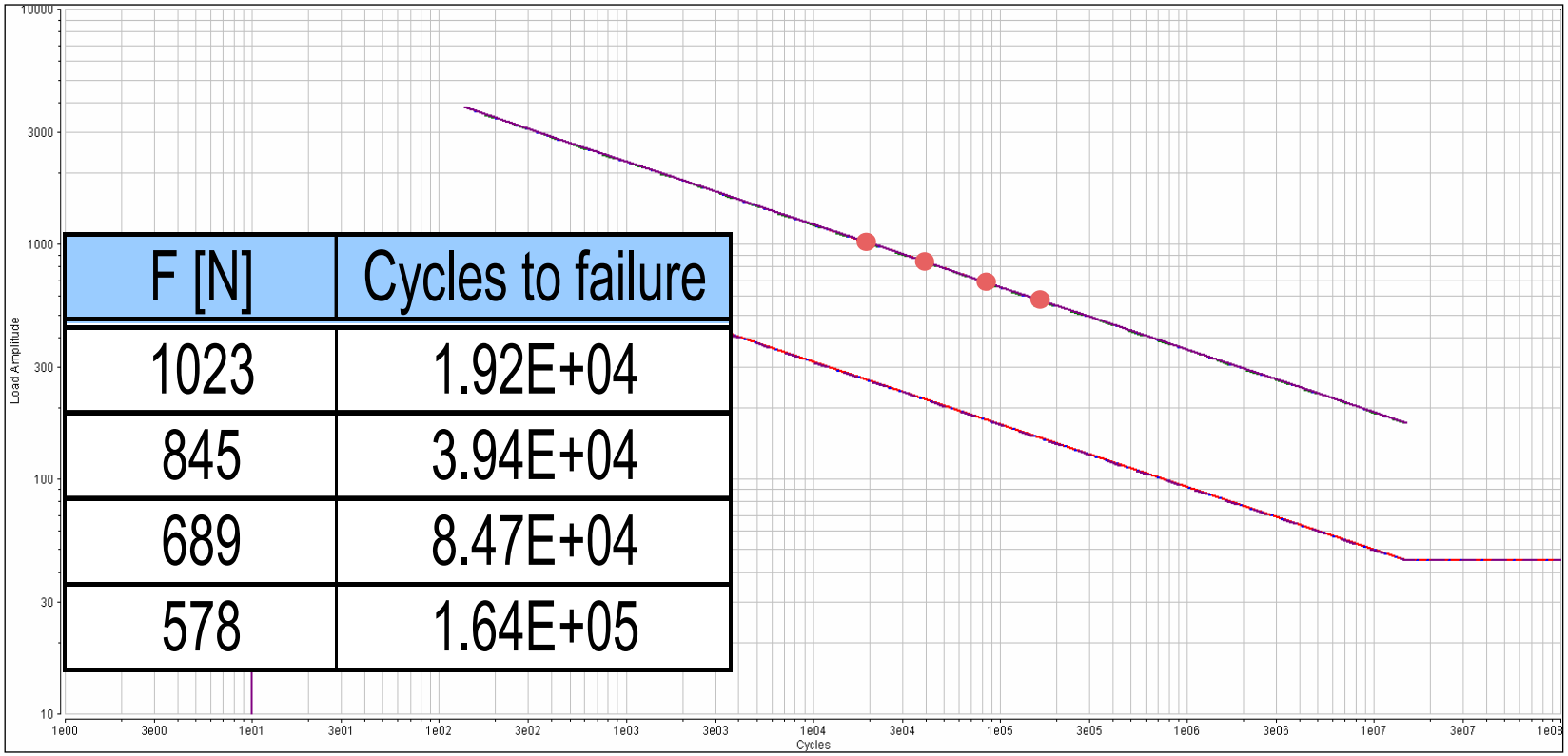
Crack initiation at upper weld end on side of load introduction



Weld Fatigue Life Analysis Results

B: Predicted Lifetime at different load levels:

F [N]	Cycles to failure
1023	1.92E+04
845	3.94E+04
689	8.47E+04
578	1.64E+05



Summary

- Major challenge: Non-standard type of joint (rod – sheet)
- FE Simplifications:
  - Boundary conditions
  - Geometry of tube
  - Rod modeled by CBARs
- FLA Approach: LMS hybrid structural / local stress approach, effectively leads to shell stress based life prediction
  - Fatigue solver: LMS Virtual.Lab Durability (FALANCS)
- Modeling guideline for element size at seam weld: b = h = 2 * t
- CENTER stress normal to welding direction used for fatigue life prediction
- Seam weld ends assessed by lowered SN curve

