

“PSD Based Weld Fatigue Analysis and Correlation For Commercial Vehicle Exhaust System Using FEMFAT Spectral ”

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- TATA MOTORS LTD.

ECS Simulation Conference 2023

10th – 11th May 2023



- **Company Profile**
- **Exhaust System**
- **Problem Statement**
- **Analysis Work Flow**
- **CAE Results & Failure Correlation**
- **Design Modifications**
- **Results Discussion**
- **Acknowledgment**
- **Reference**

Company Profile and Product Portfolio

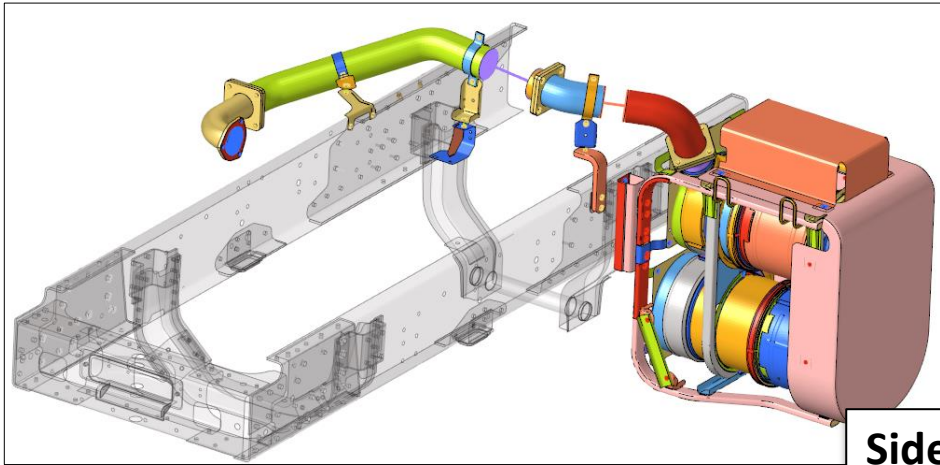
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We bring your dreams to life by engineering the best in design, connectivity, and safety.

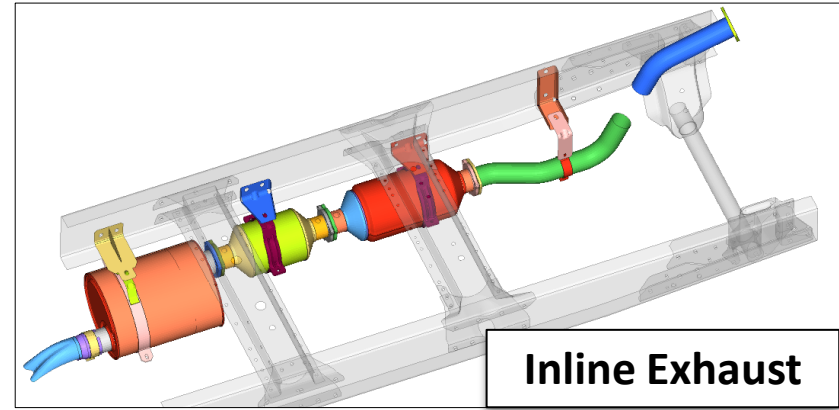


- Tata Motors Limited is India's largest Automobile Company established in 1945.
- Tata Motors Limited, a USD 45 billion organization
- Leader in commercial vehicles in each segment, and among the top in passenger vehicles.
- Tata Motors is committed to improve the quality of life of communities by working on four thrust areas -employability, education, health and environment.

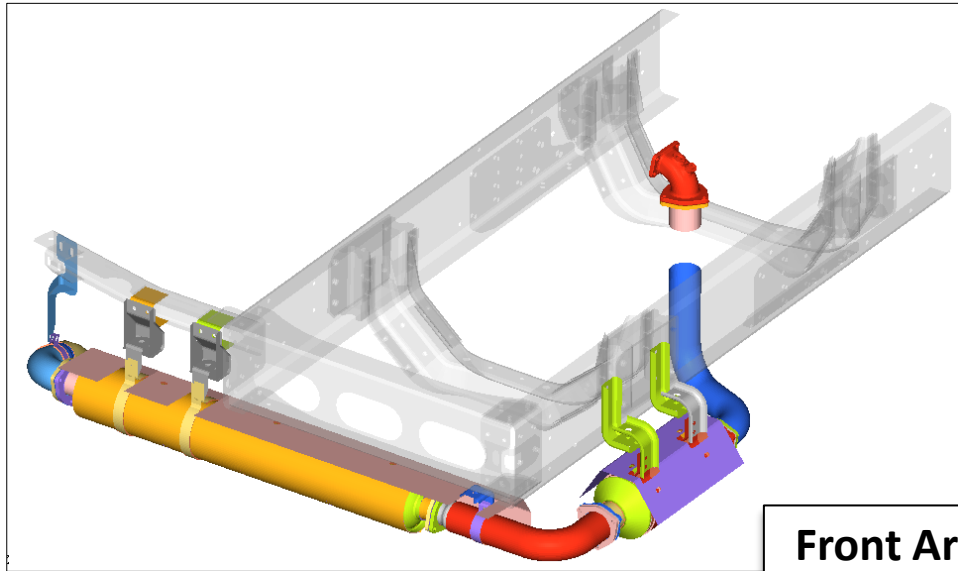
Exhaust System : Types of CV Exhaust Systems



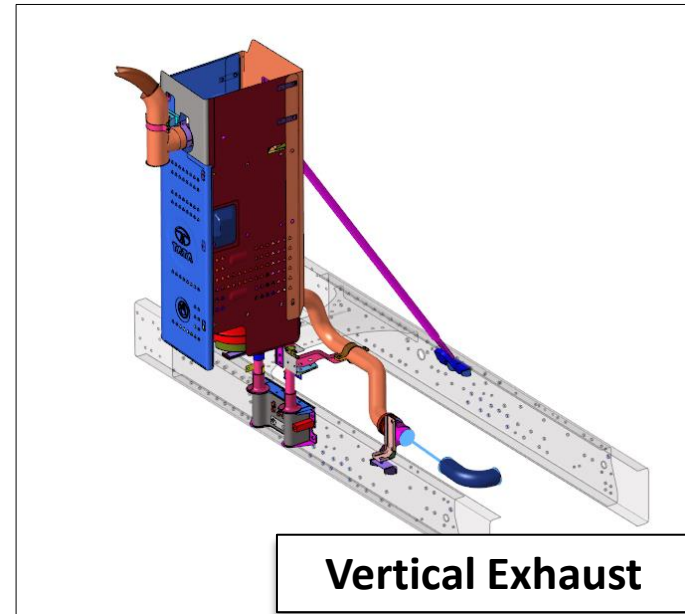
Side Module Exhaust



Inline Exhaust



Front Architecture Exhaust

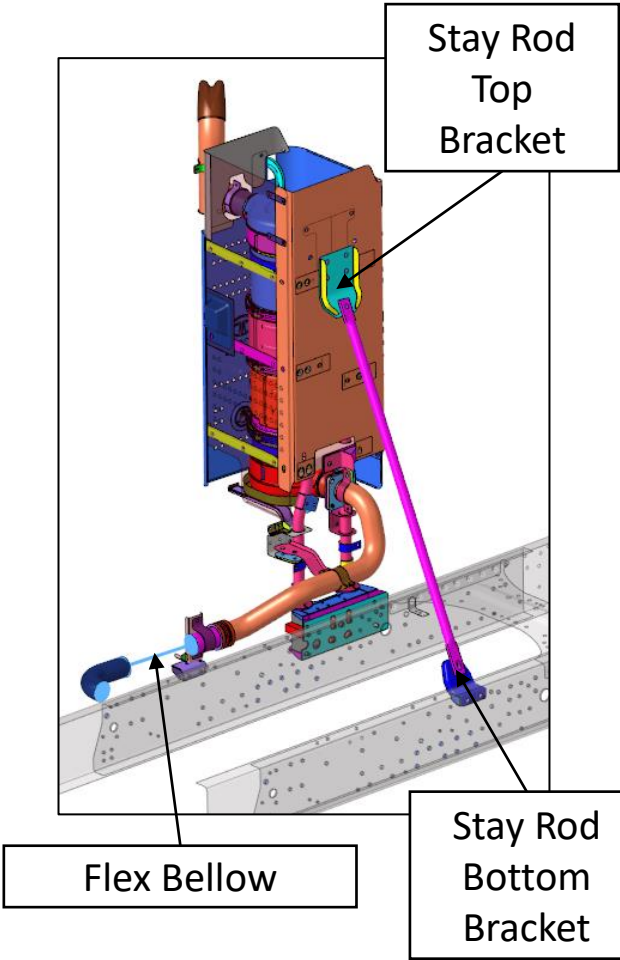
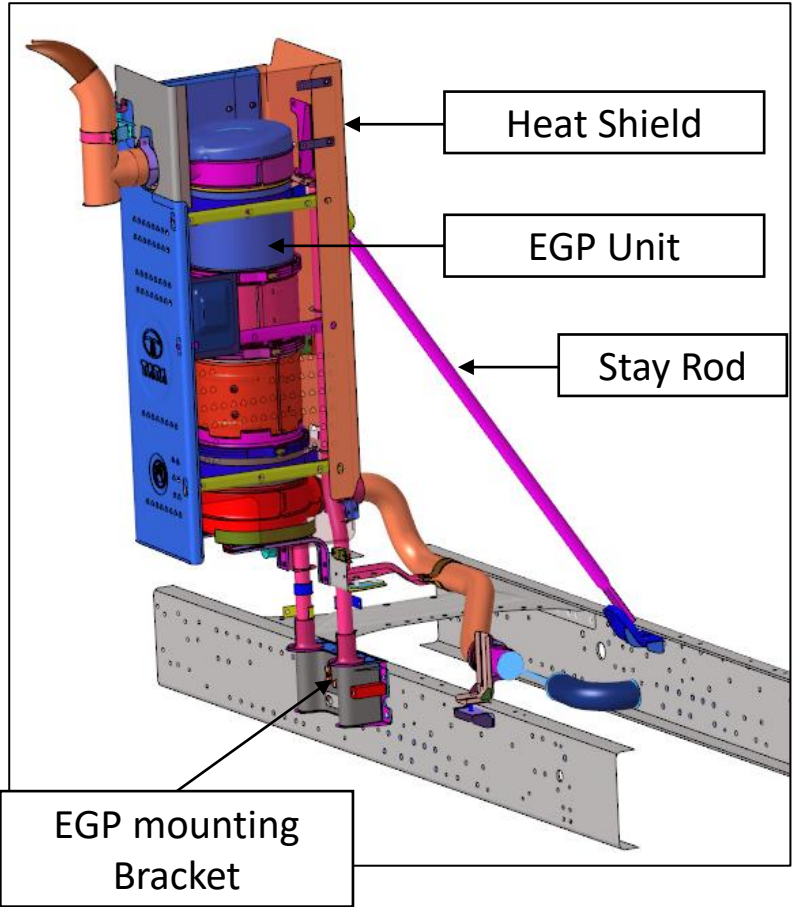


Vertical Exhaust

Exhaust System Details : About Vertical Exhaust



Vertical Exhaust on Vehicle

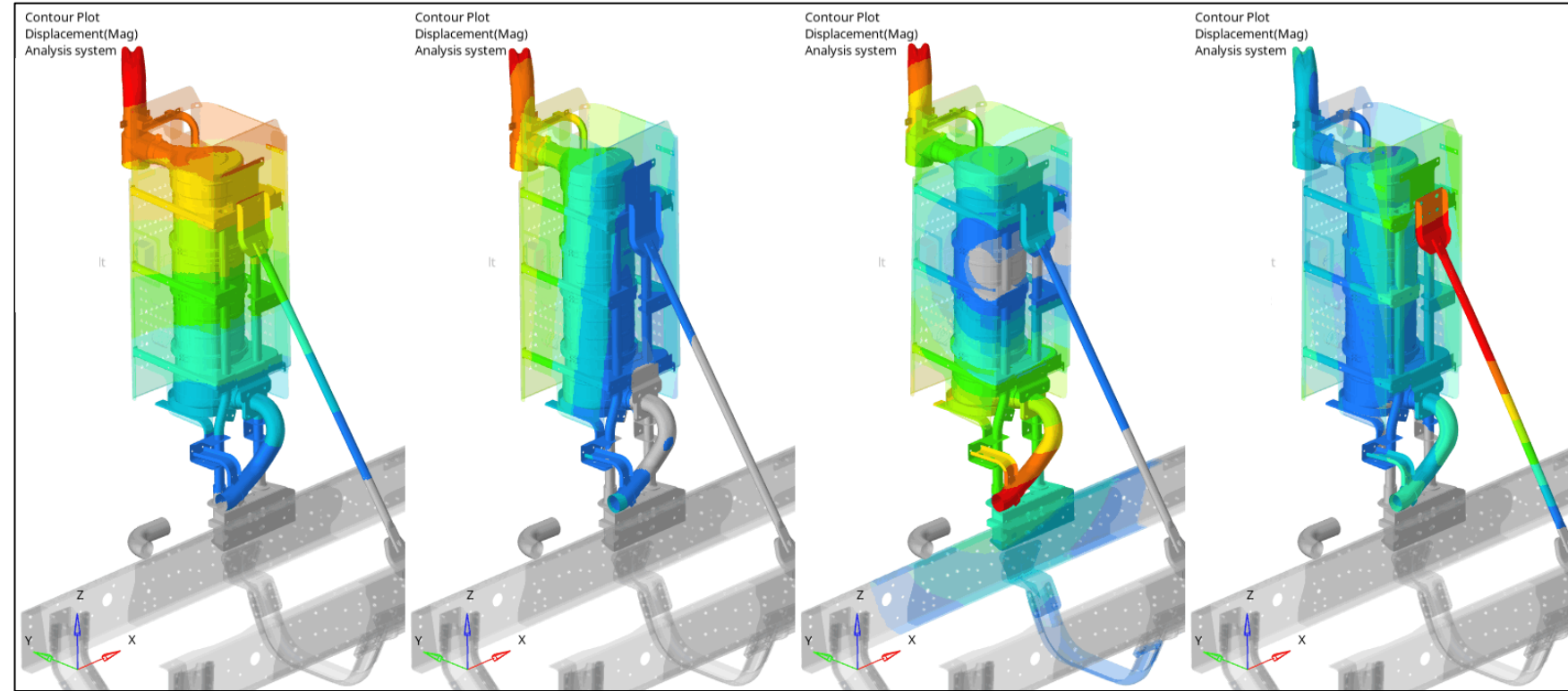


Vertical Exhaust Major Aggregates

Exhaust System Details : DVP

- Modal Analysis
- Frequency Response Analysis
- Static Strength Analysis
- RLD Fatigue

Mode Shapes



Translational Mode

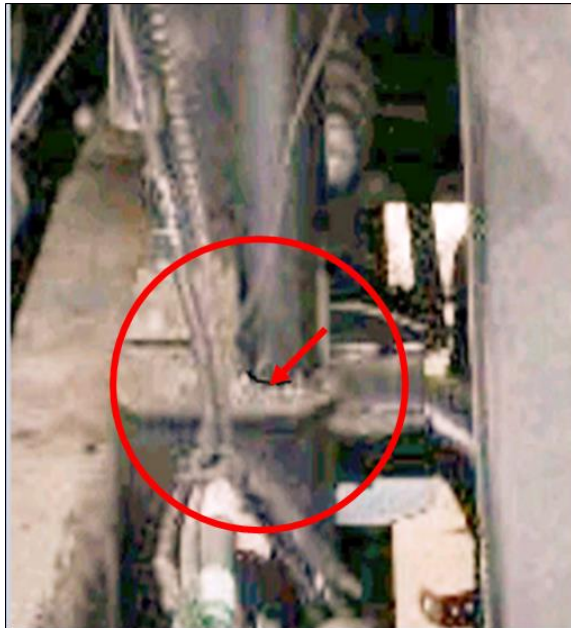
Translational Mode

Rotational Mode

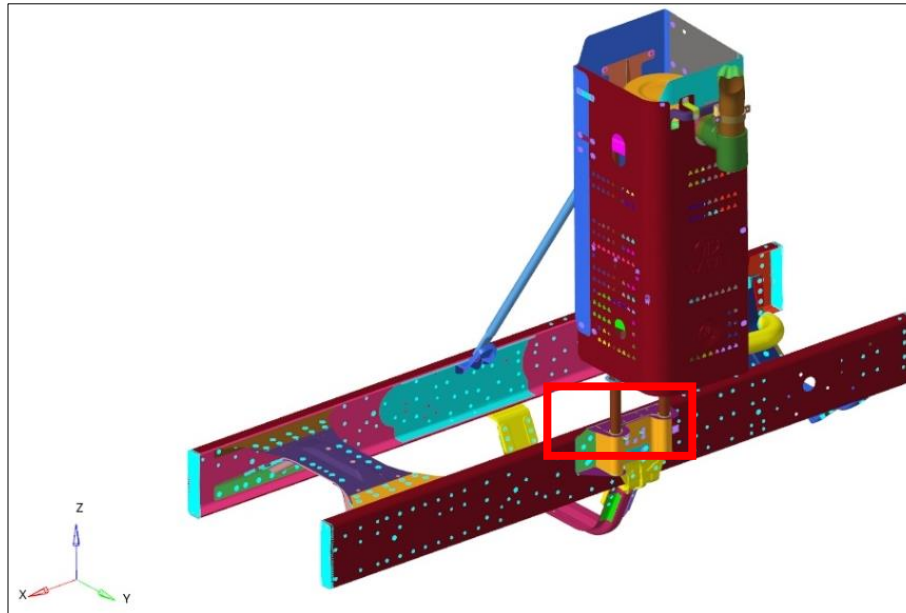
Rotational Mode

Problem Statement

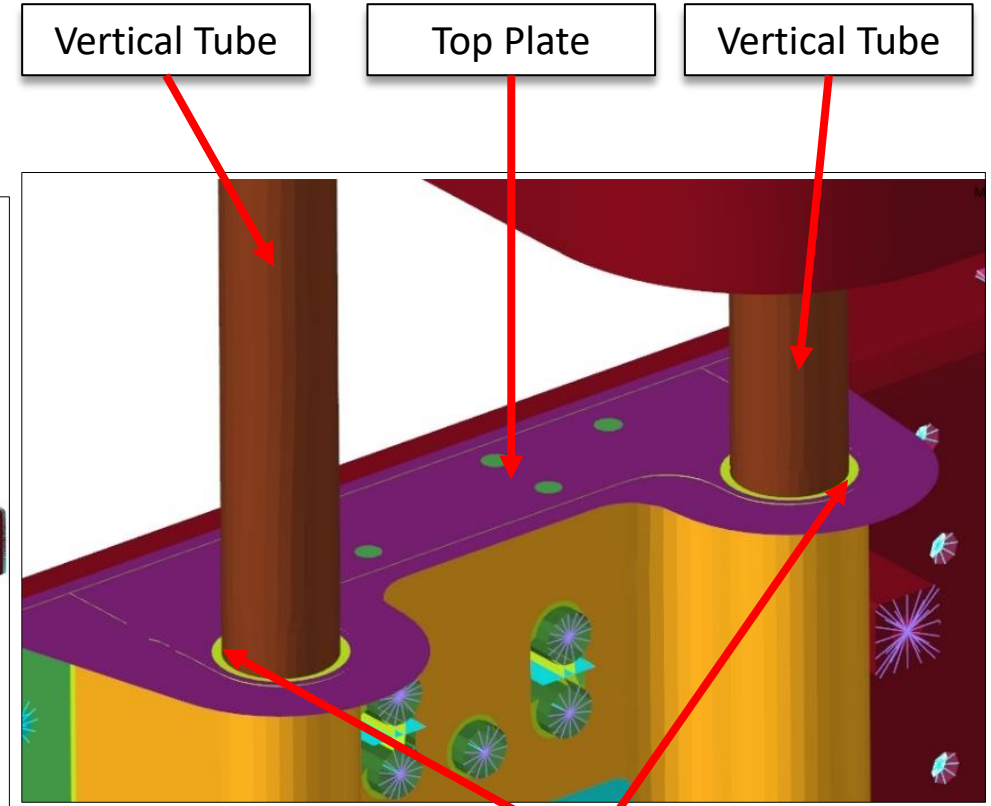
- Failure is reported in tipper test vehicle in exhaust system.
- Cracked between Top Plate and Vertical Tubes.



Failure Zone

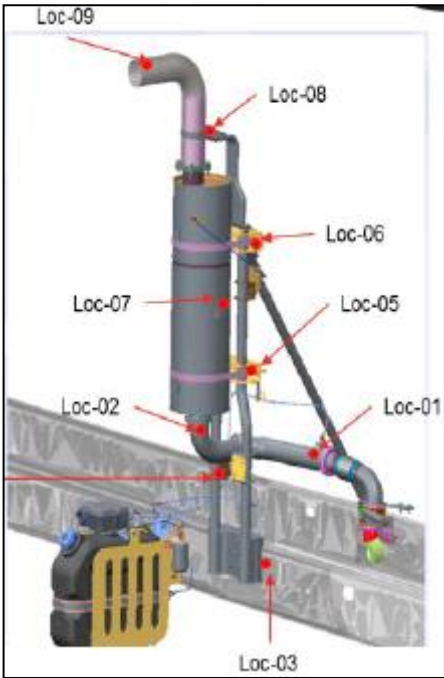


Failure Location w.r.to Exhaust Assembly

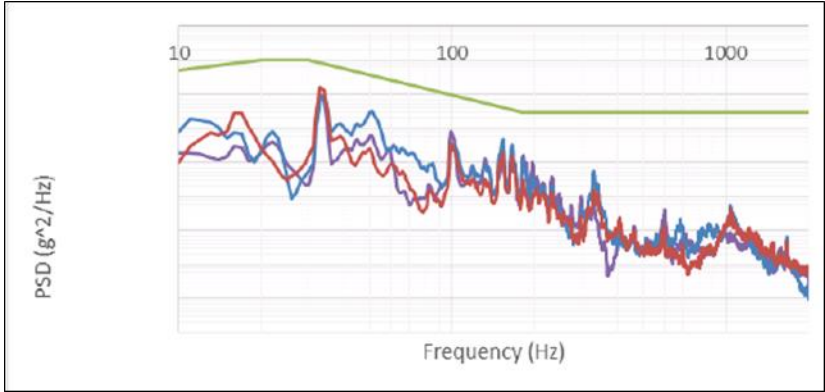


Failure Zone

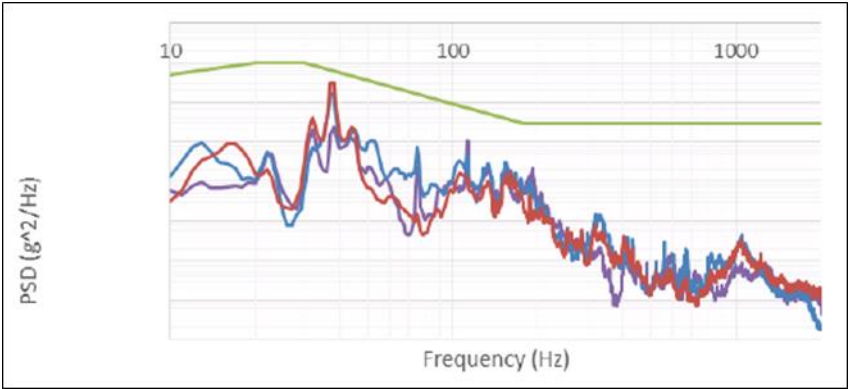
Problem Statement : RLDA Measurement



Torture Track Condition			
Sr.No.	Track	Vehicle Speed	No.of repeats
1	Track-1	xx	xx
2	Track-2	xx	xx
3	Track-3	xx	xx
4	Track-4	xx	xx



Proto-2



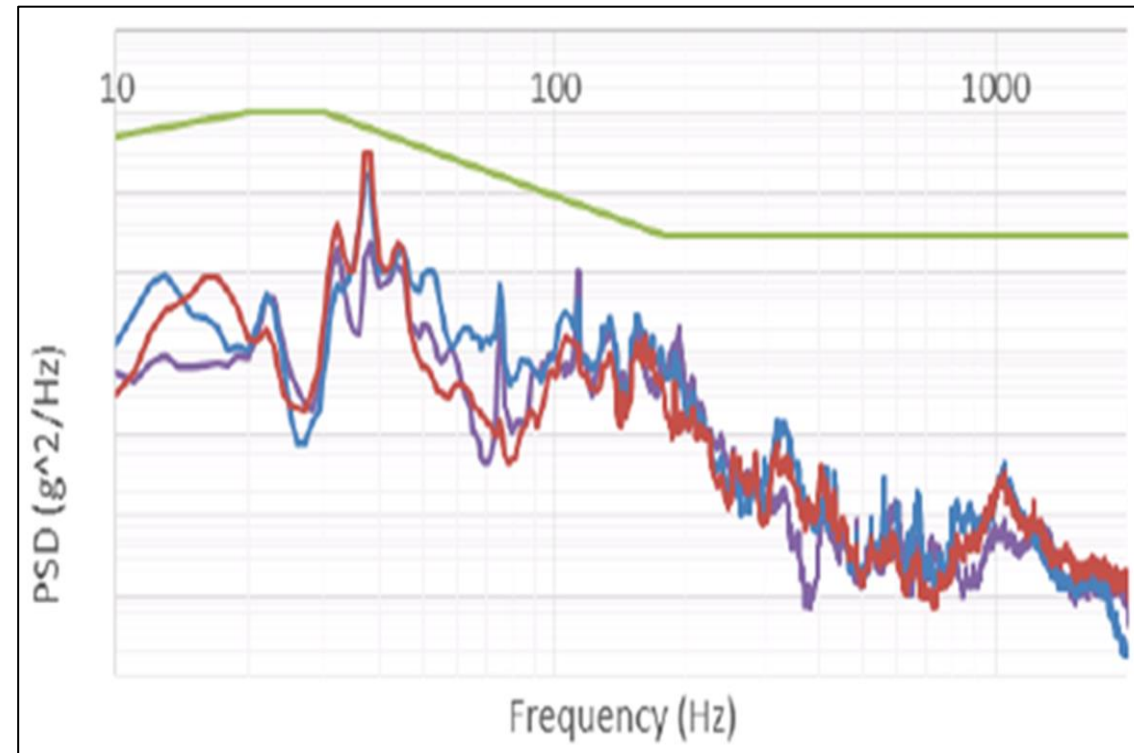
Proto-1

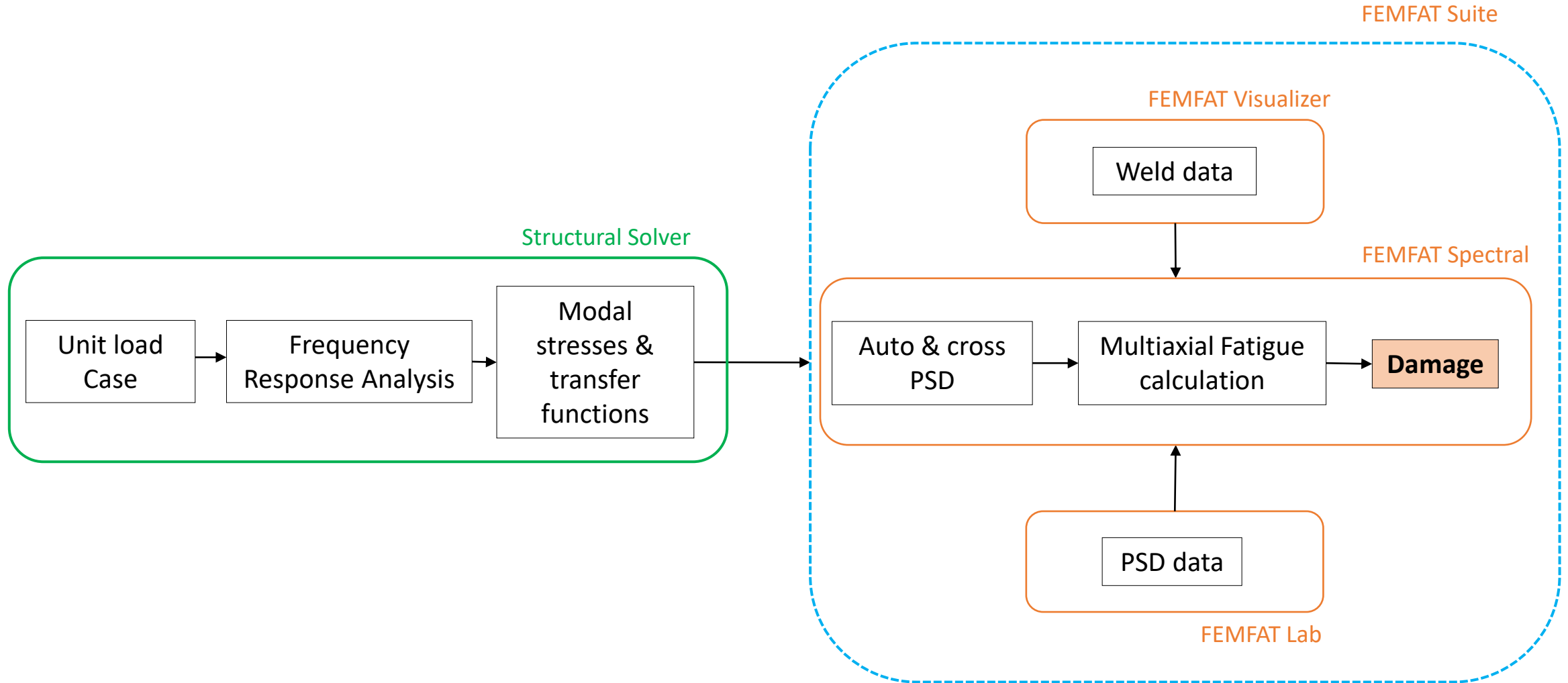
RLDA to PSD
conversion using
FEMFAT Lab

Problem Statement : About PSD

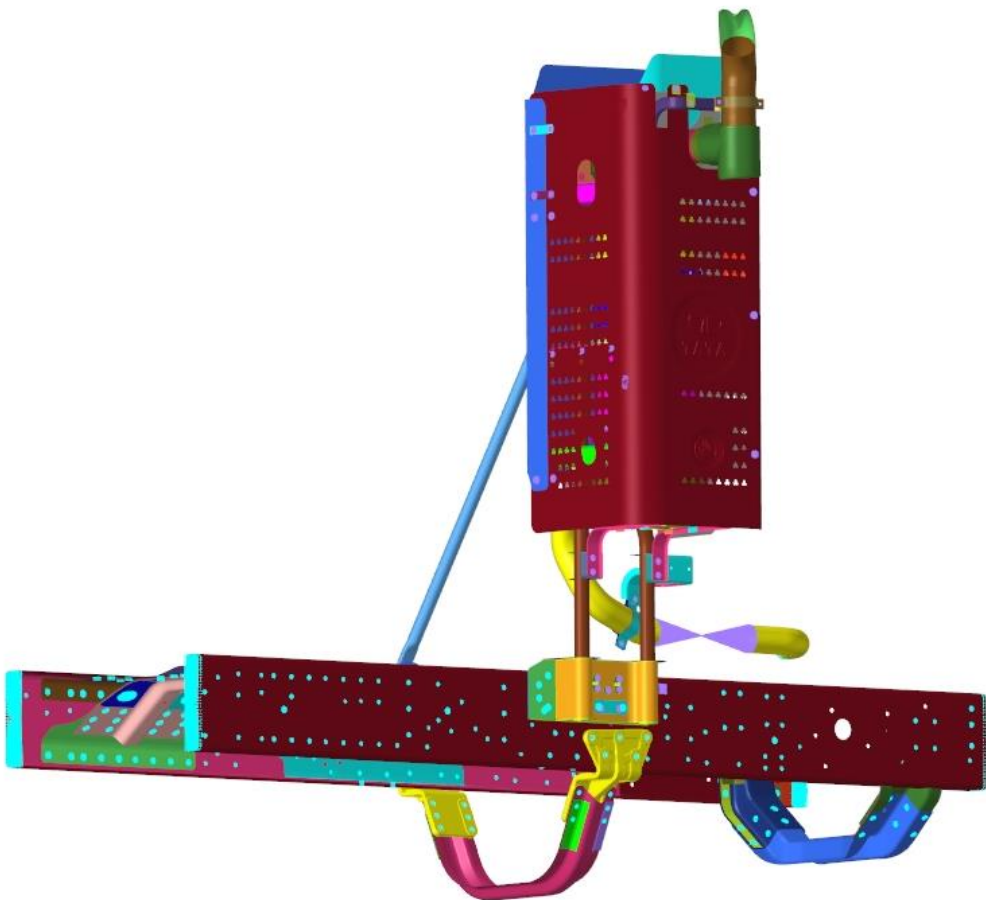
Generic PSD profile

- What is PSD ?
- Why PSD?
- Advantage of PSD
- Generic PSD profile

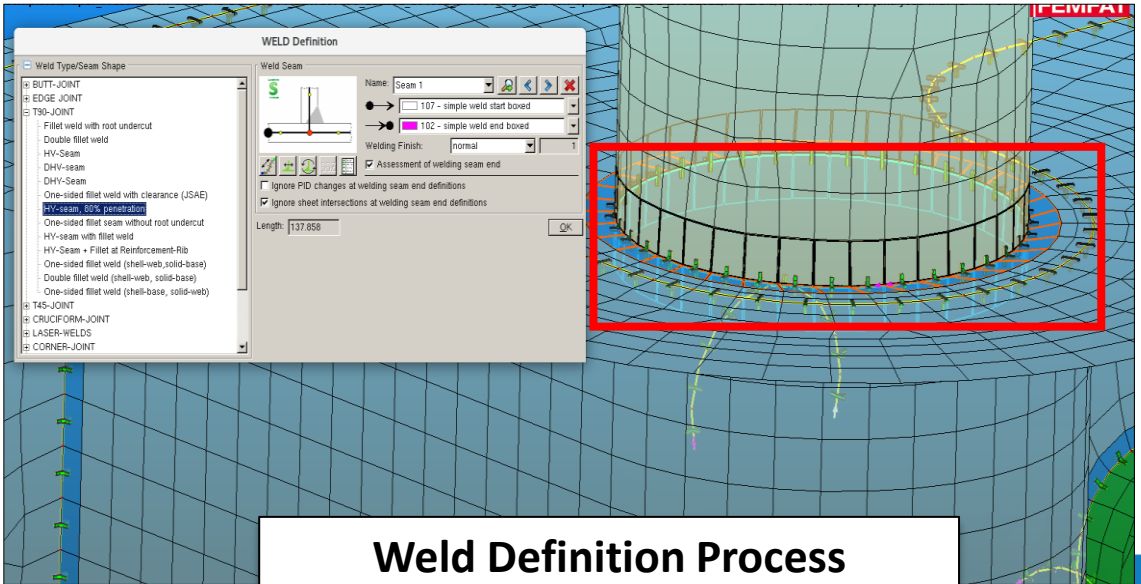
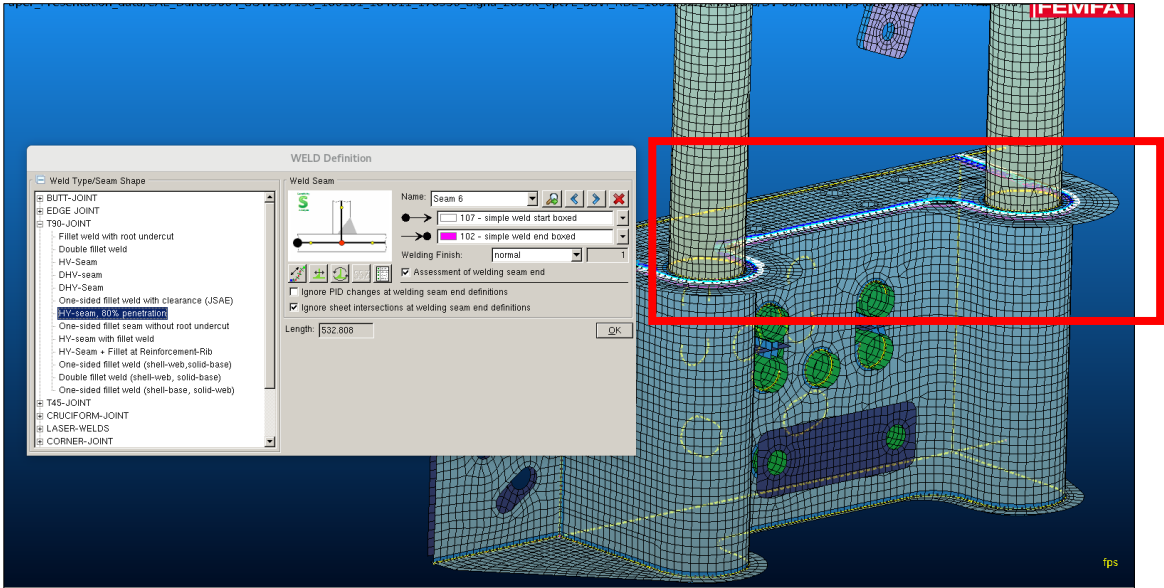




Analysis Work Flow : Model Setup & Weld Definition

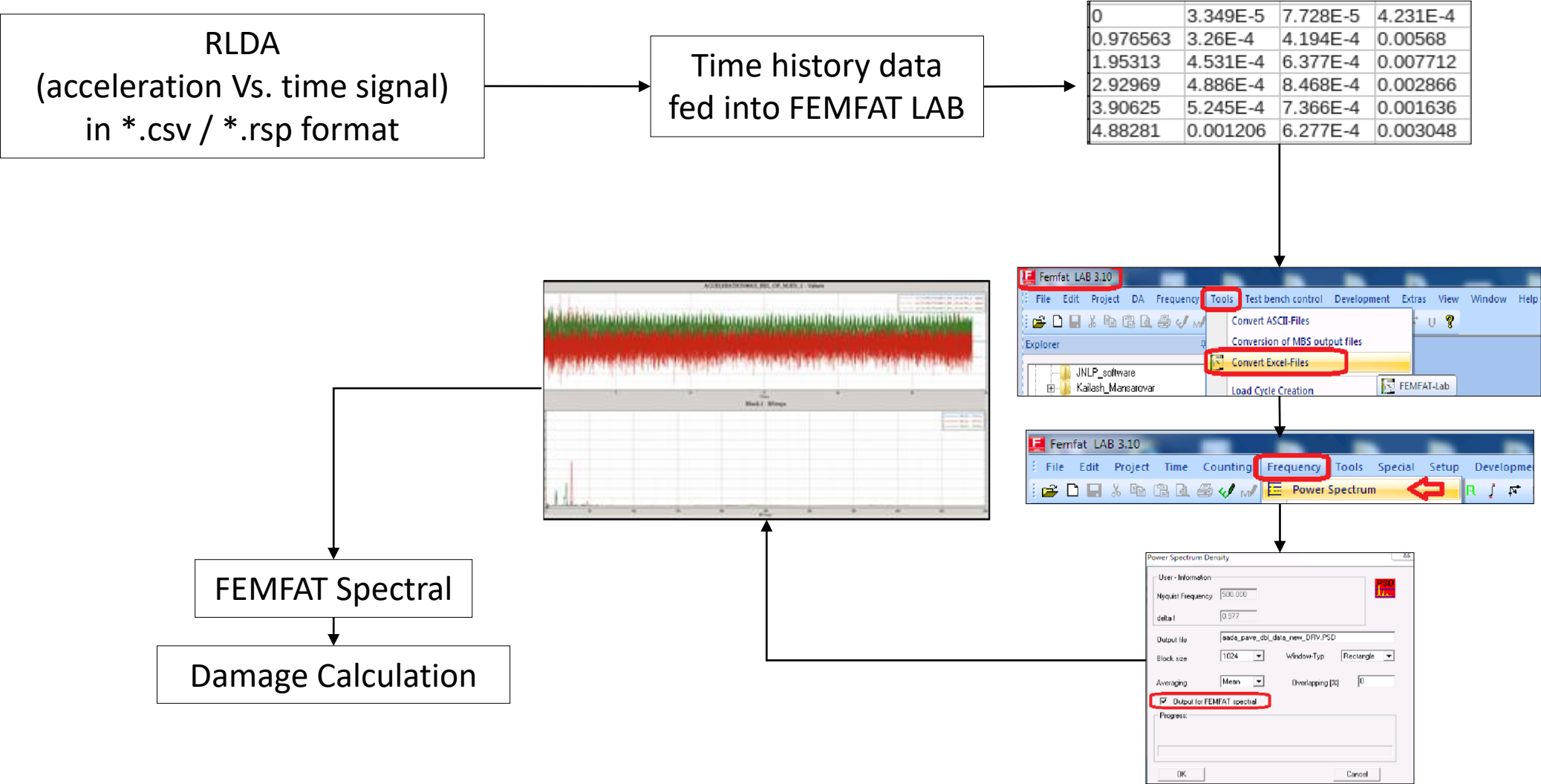


FE Model



Weld Definition Process

Analysis Work Flow : RLDA to PSD Through FEMFAT Lab



Analysis Work Flow : FEMFAT Spectral Process

Model Definition

FE Entities

Groups

Stress/Spectral Data

Material Data

Node Characteristics

Influence Factors

Analysis Parameters

Scratch Setting

Output

Report

Analyze

Visualization

File Format: NASTRAN Bulk

File Name: result weld_DV0.wdf

Directory: /s

Open

File name: open

Files of type: Cancel

WELD Definition

Modify Dimension

Length Unit Multiplication Factor: 1.00000 Multiply

1998.901 [mm]

1145.108 [mm]

1743.875 [mm]

Shell Thickness Min: 0.800 [mm]

Max: 7.800 [mm]

BASIC

ChannelMAX

TransMAX

HEAT Sehitoglu

SPECTRAL

SPOT Remeshing

STRAIN Calc

Results Manager

Stress History Import

FE Definition

PSD Definition

FE Definition

Input File

NASTRAN OP2

xx_xxxx_BSxx_xxx_DR1.op2

Scan Mode

Mode Limitation

Number of Modes: 109

Lower Limit: 1

Upper Limit: 109

Transfer Functions

Input File

NASTRAN PUNCH

xx_xxxx_BSxx_xxx_DR1.pch

Statistics

Number of Unit Load Cases: 3

Number of Spectral Lines: 601

Constant Stress

File Format

File Name

Load Case

Factor

OP2 NASTRAN

1.00000

BASIC

ChannelMAX

TransMAX

HEAT Sehitoglu

SPECTRAL

SPOT Remeshing

STRAIN Calc

Results Manager

PSD Definition

FE Definition

PSD Definition

PSD Definition

Auto PSD Definition

Number of Unit Load Cases: 3

Current Auto PSD: 1

Plot

Auto Fill Anchor

Unit Load Label: 0

Last

Label

File Format

File Name

Col

Factor

1

CSV lin.interp.

PSD_Profile_EGP.csv

2

1.00000

2

CSV lin.interp.

PSD_Profile_EGP.csv

3

1.00000

3

CSV lin.interp.

PSD_Profile_EGP.csv

4

1.00000

Cross PSD Definition

Auto Fill

Current Cross PSD:

Row/Col: 1 / 1

Plot

File Format

File Name

Col

CSV lin.interp.

PSD_Profile_EGP.csv

2

LC1

LC2

LC3

LC1

2

5

9

LC2

3

7

LC3

4

PSD XYZ

Calculation Setting

Load duration: 115200 [sec]

Read PSDs

BASIC

ChannelMAX

TransMAX

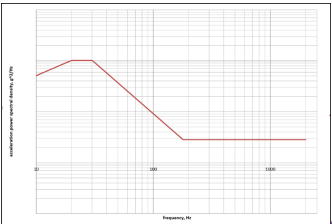
HEAT Sehitoglu

SPECTRAL

SPOT Remeshing

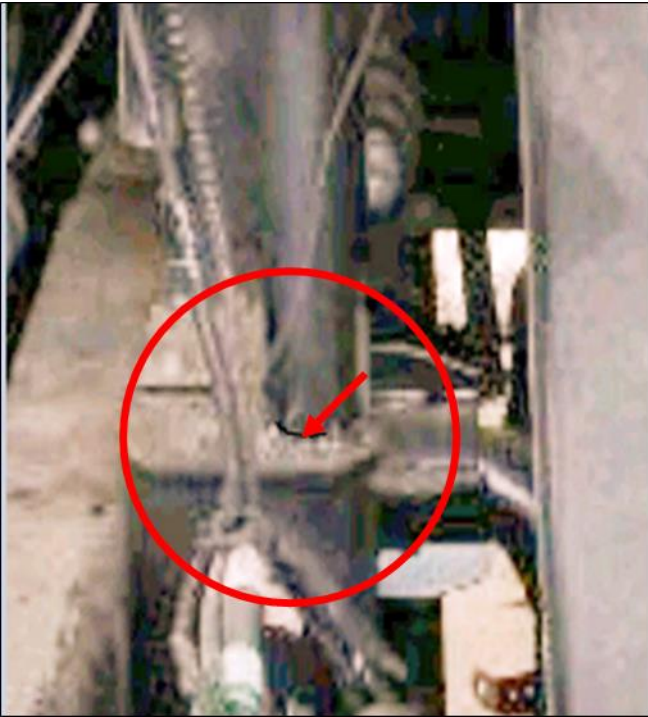
STRAIN Calc

Results Manager

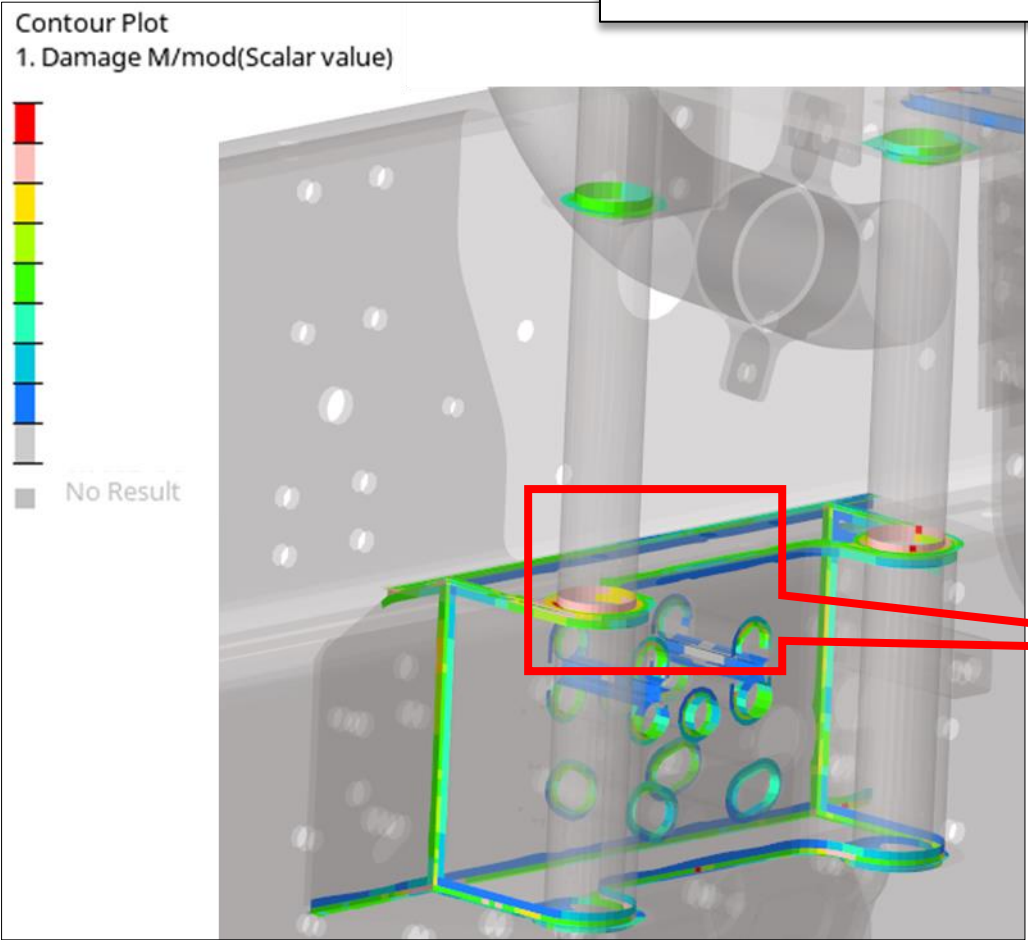


CAE Result & Failure Correlation - RLDA

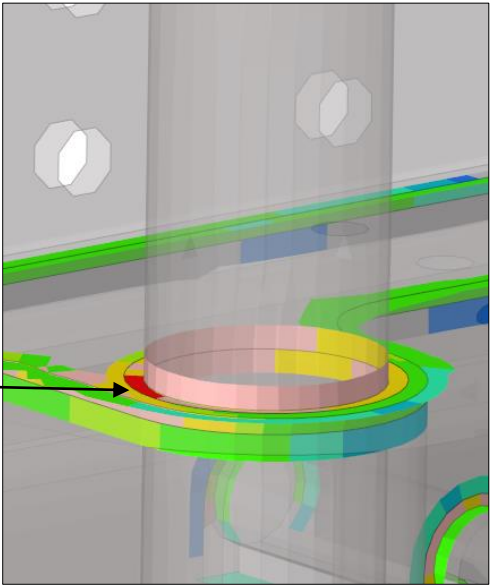
Failure Region



CAE Result for Existing Design

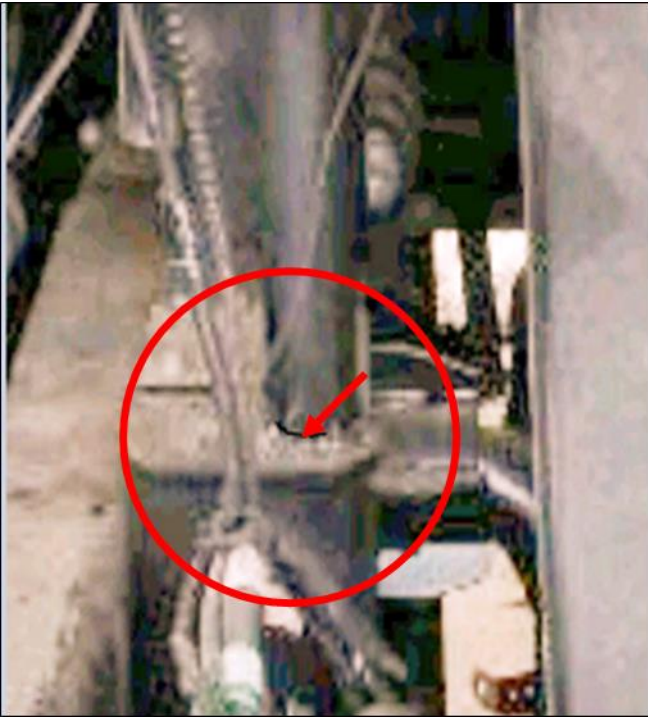


Loc, Damage
> 1.0

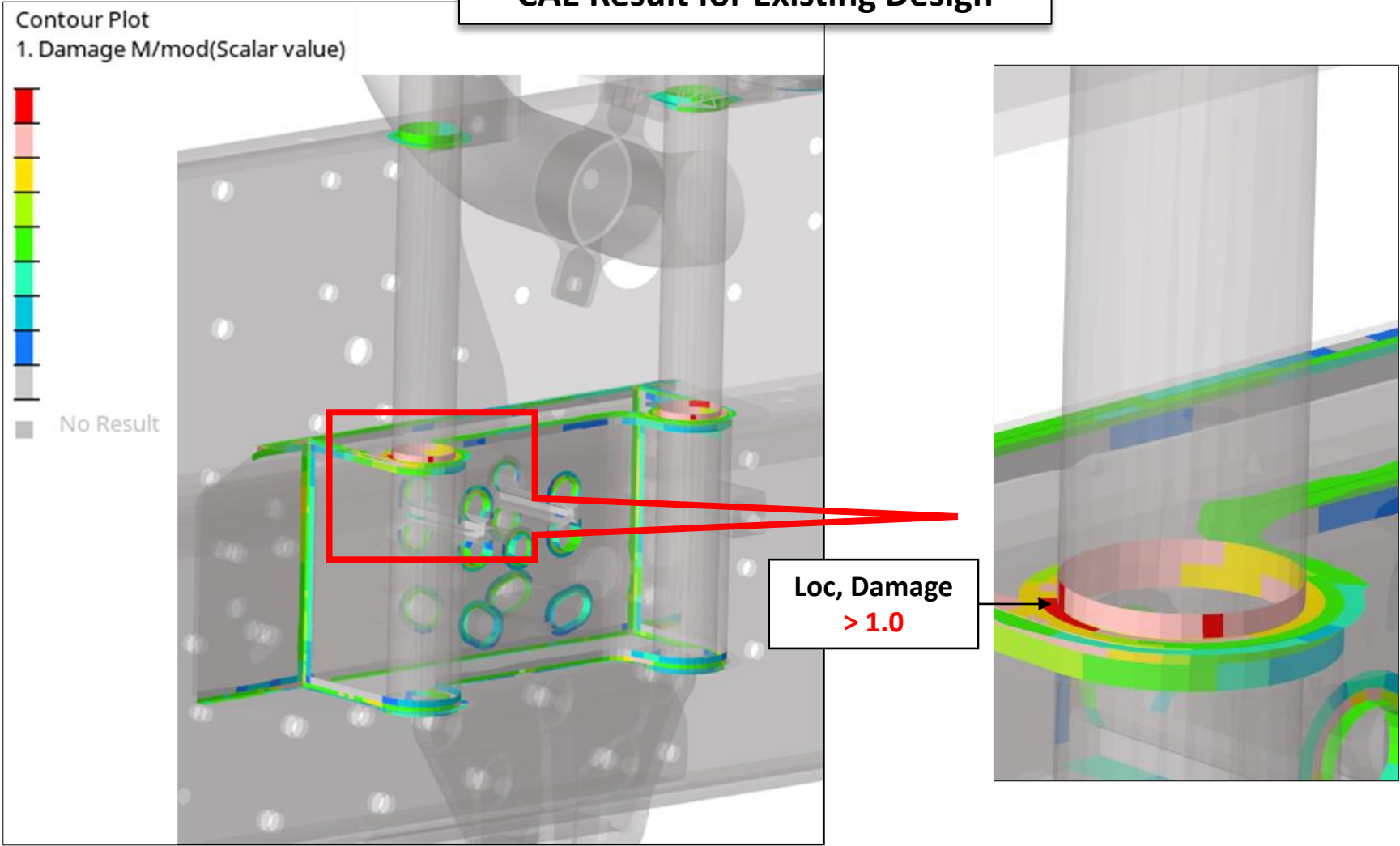


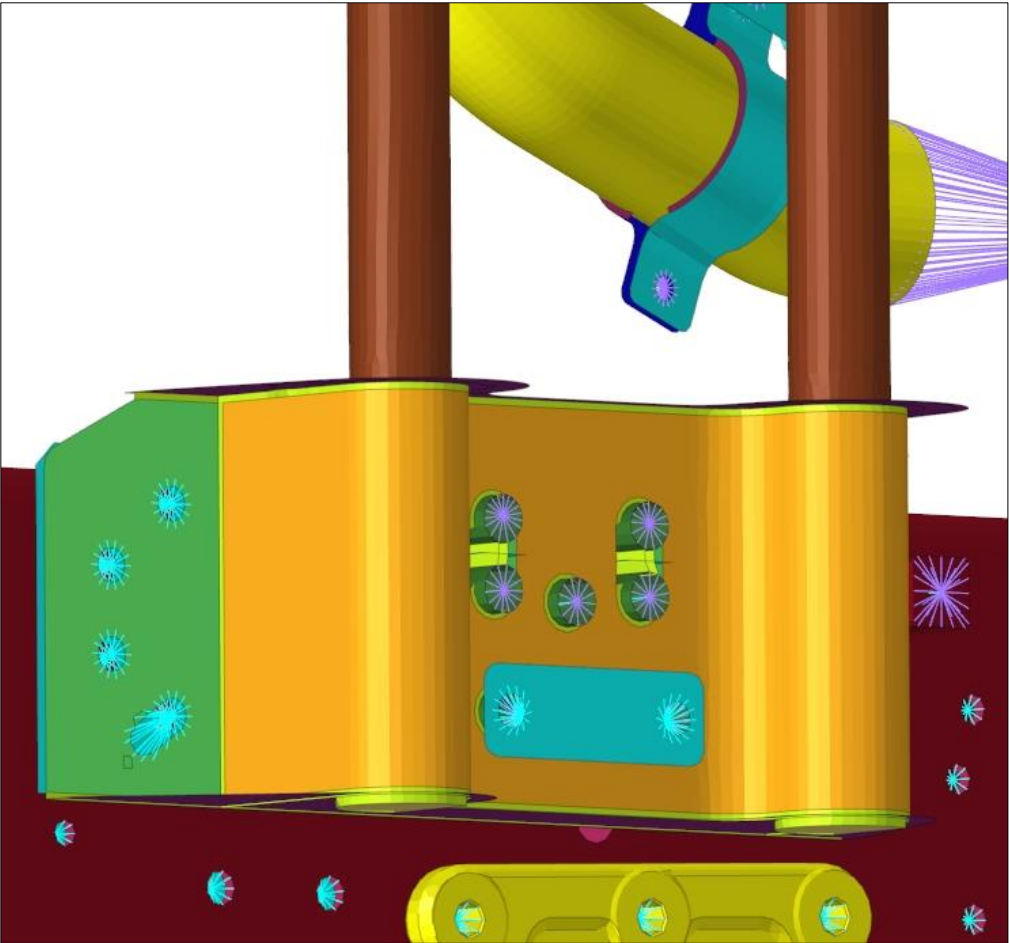
CAE Result & Failure Correlation – Generic PSD Profile

Failure Region



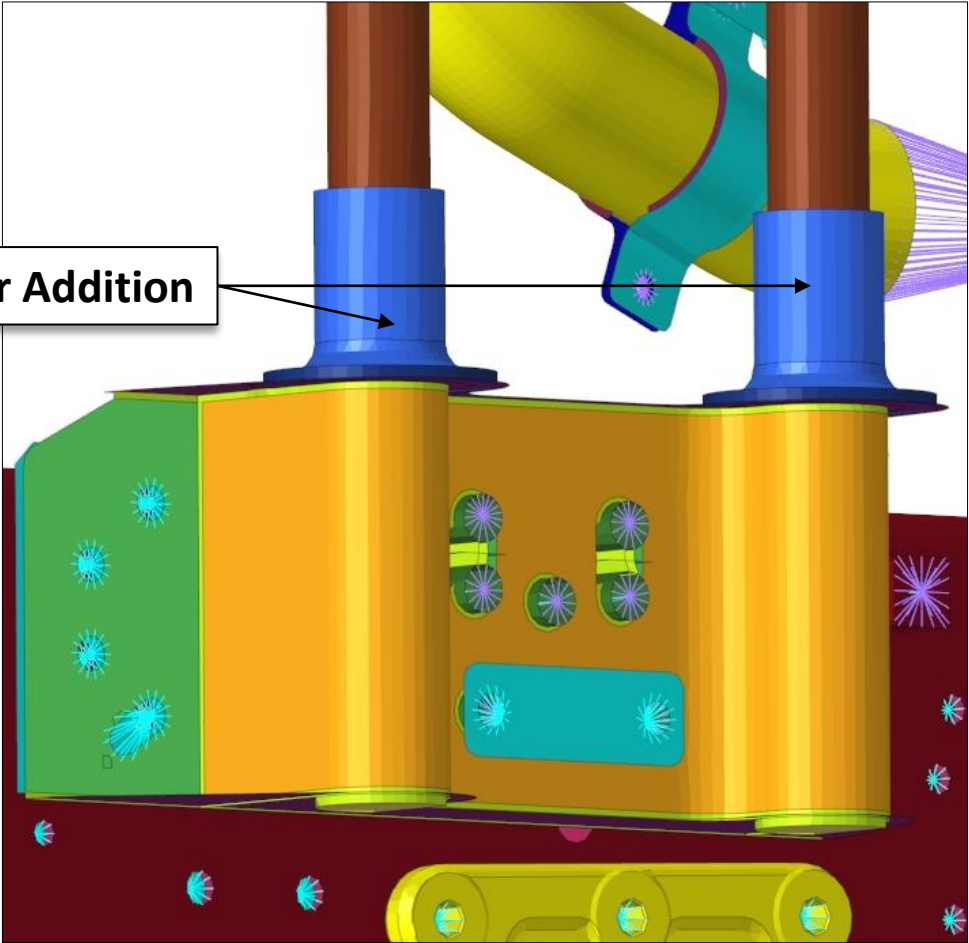
CAE Result for Existing Design





Existing Design

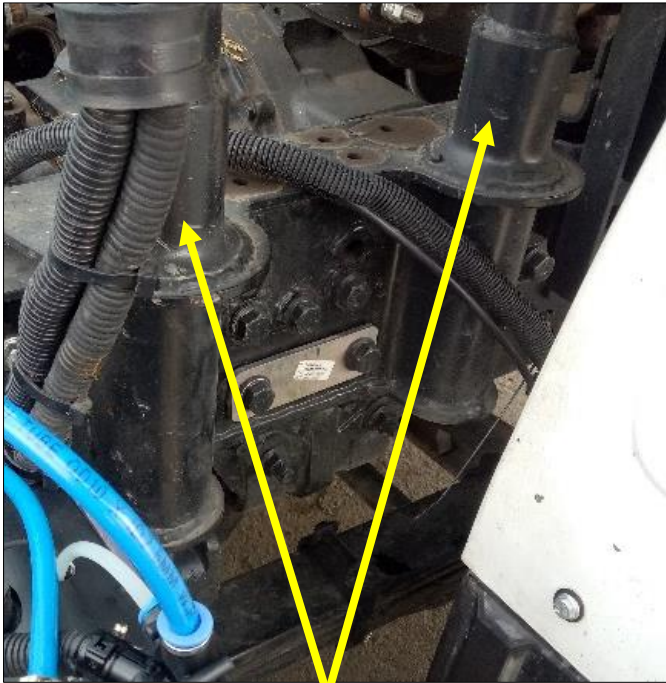
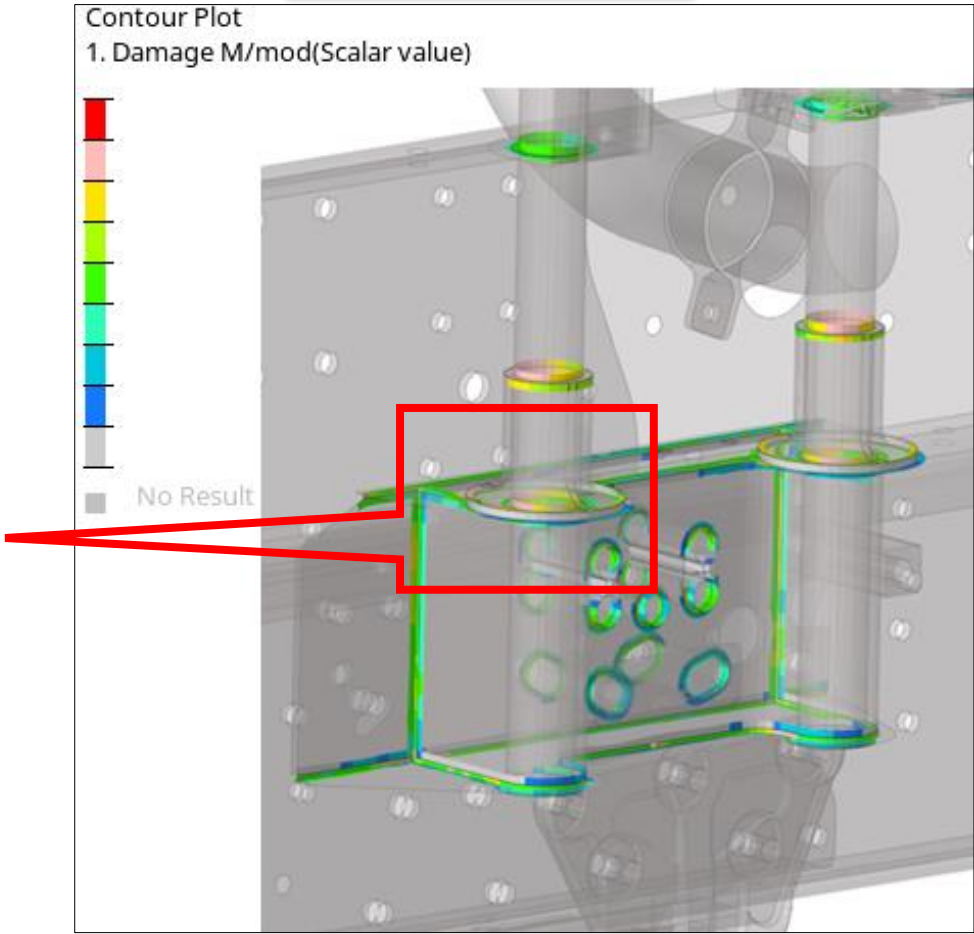
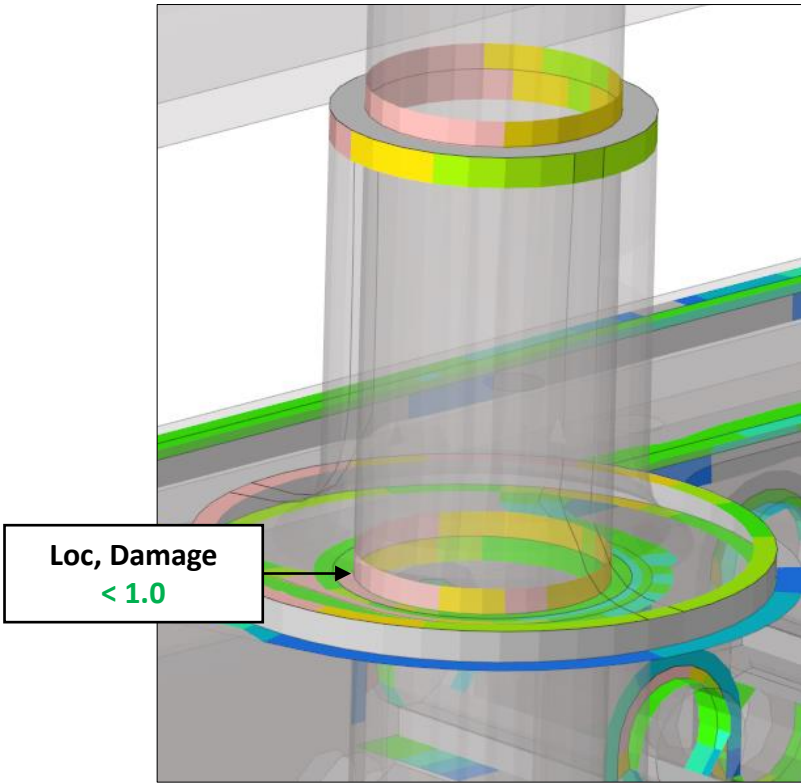
Collar Addition



Proposed Design

Design Modifications : Result & Implementation

Proposed Design



Collar Design Implemented in assembly

- Weld definition using FEMFAT Visualizer.
- PSD data generation using FEMFAT Lab.
- FEMFAT Spectral has been used for
 - Validation of generic PSD
 - PSD data is E-E-E (easy, effective and efficient) for use.
 - Use of Power spectral input data make computational time saving process.
 - Weld failure simulation & RCA validation.
- Multiple design iteration in shorter time duration.

➤ We'd like to thank:

- FEMFAT team for providing technical support and platform to showcase our work
- Mr. Kiran Karale (Program Manager – Digital Solution)
- Mr. Ranjit Babar (Deputy General Manager, Digital Solution, TMCV)
- Mr. Rohit Vaidya (General Manager, Head Digital Solutions, TMCV)
- Mr. Mahesh Shinde (Senior General Manager, VATS Head Office, TMCV)

- <https://femfat.magna.com/modules>
- Manual FEMFAT LAB
- <https://femfat.magna.com/product-info/femfat-lab>
- Manual FEMFAT Spectral



Thank You for attention

Any Questions?