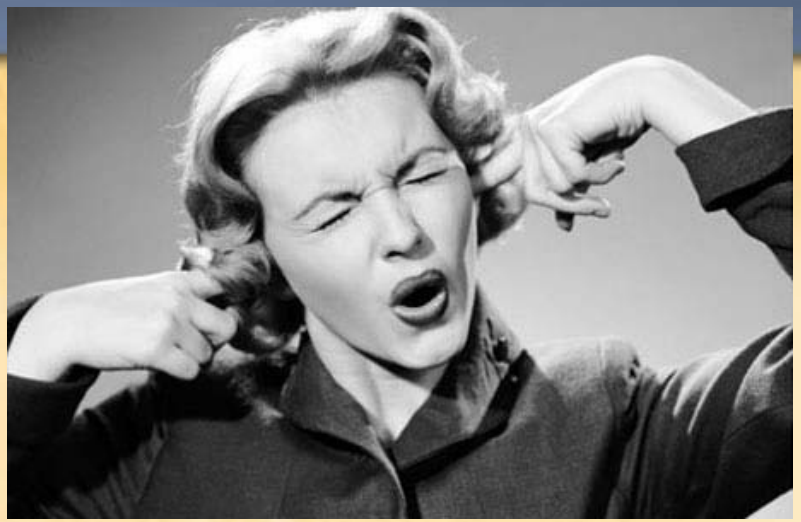
Tuned-mass-dampers to reduce wheel-squeal

- Complaint
- Identification of the problem
- Measurements
- Possible measure
- Prototyping
- Testing
- Implementing



The complaint

PCC Trolley car Greenline MBTA

Identification of the problem

Noise study

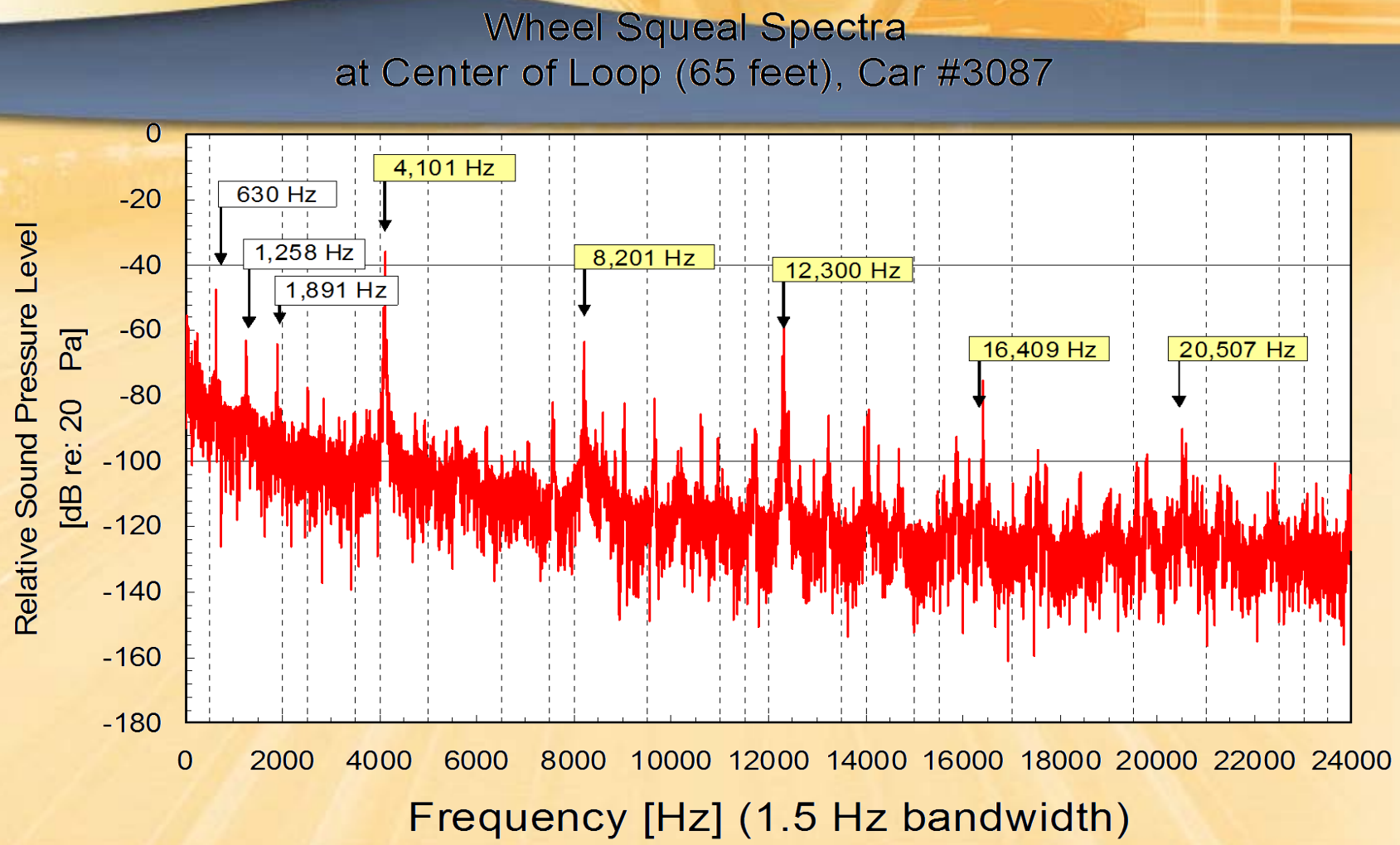
- Where, Loop at Ashmont station
- Who, HMMH
- When, July 20, 2010
- What, wheel squeal spectra and “rubbing”

Identification of the problem

Where, Loop at Ashmont station

Identification of the problem

Noise study



Identification of the problem

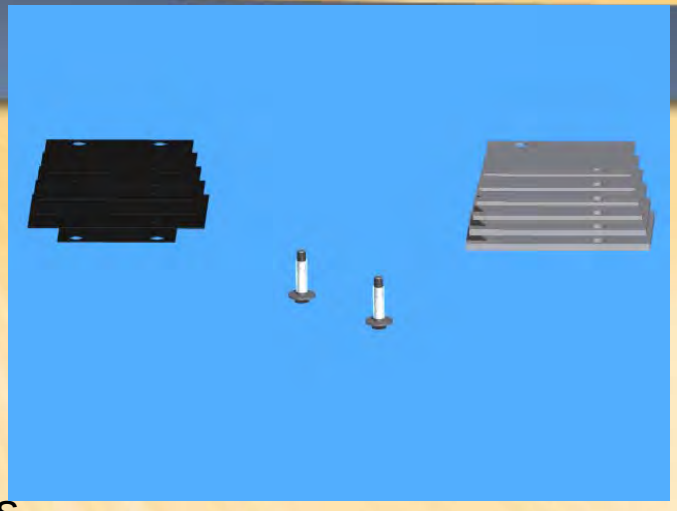
Noise study

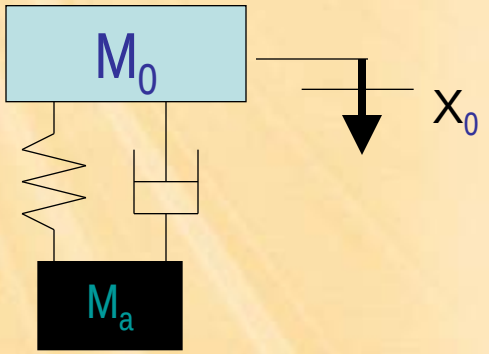
From the same report we derived the following:

- the average sound measurements in the immediate neighborhood were between 85 and 95 dBA, and 99 to 106 dBA in the center of the loop.
- The frequencies highlighted in yellow shows the “squealing” spectrum which is the predominant condition that occurs during the pass bys. The primary frequency for “squealing” is 4100 Hz with harmonics at 8200, 12300, 16400 and 20500 Hz.
- The figure also shows the “rubbing” spectrum which occurs for relatively brief periods (a few seconds) during the pass bys. The primary frequency for “rubbing” is 630 Hz with harmonics at upper frequencies.

A possible solution
Wheeldampers

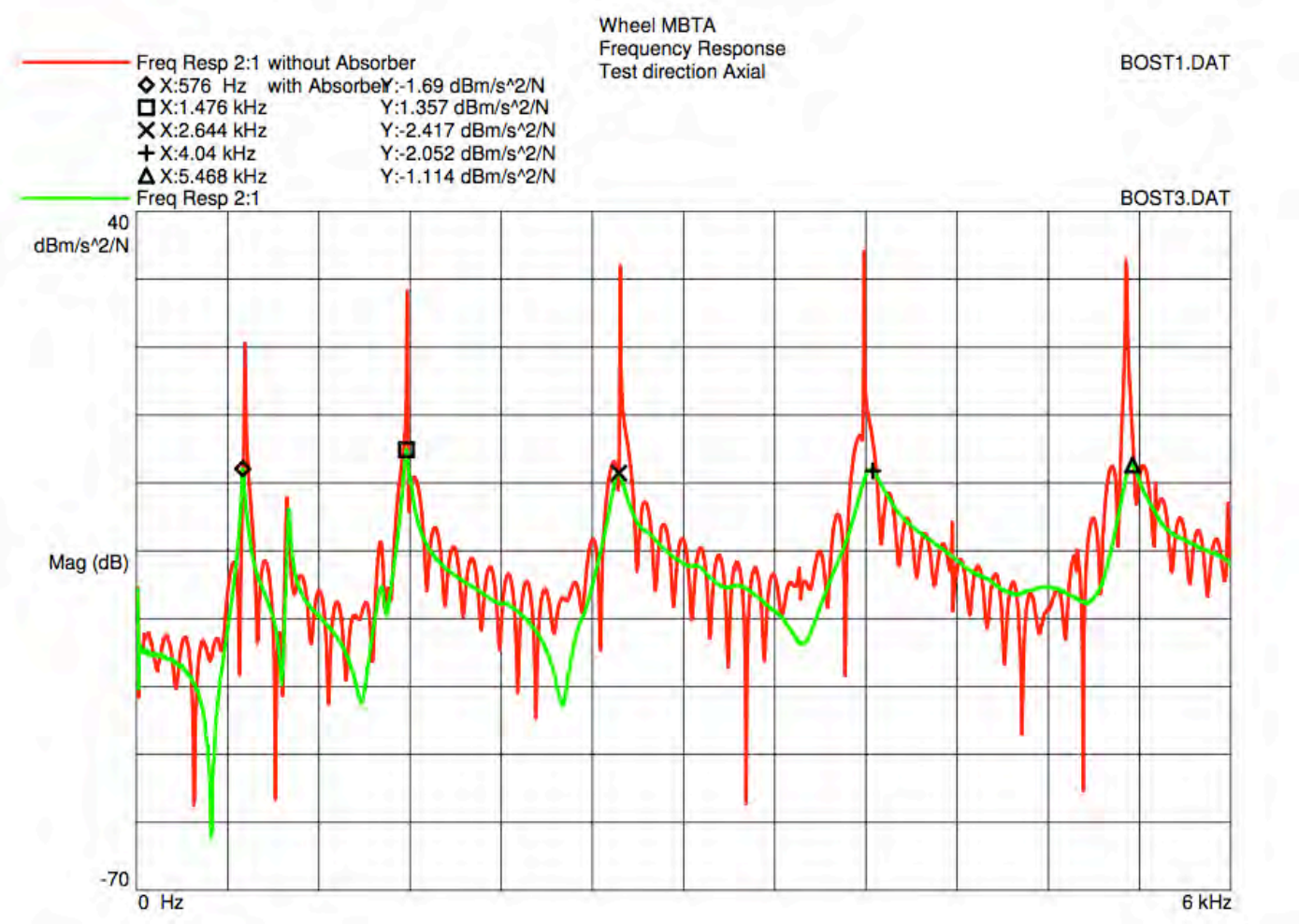
- Sandwich assembly
  - -heavy, stiff plates
  - -light, elastic material.
    - (When deformed, the elastic material heats up)
  - -Enables broadband reduction
- Conceptually simple
  - -minimize displacement x_0 of M_0 by:
  - -Selecting the mass m_a, damping and stiffness
  - -broad band
- Challenges
  - -Selecting the right values
  - -Selecting dampers





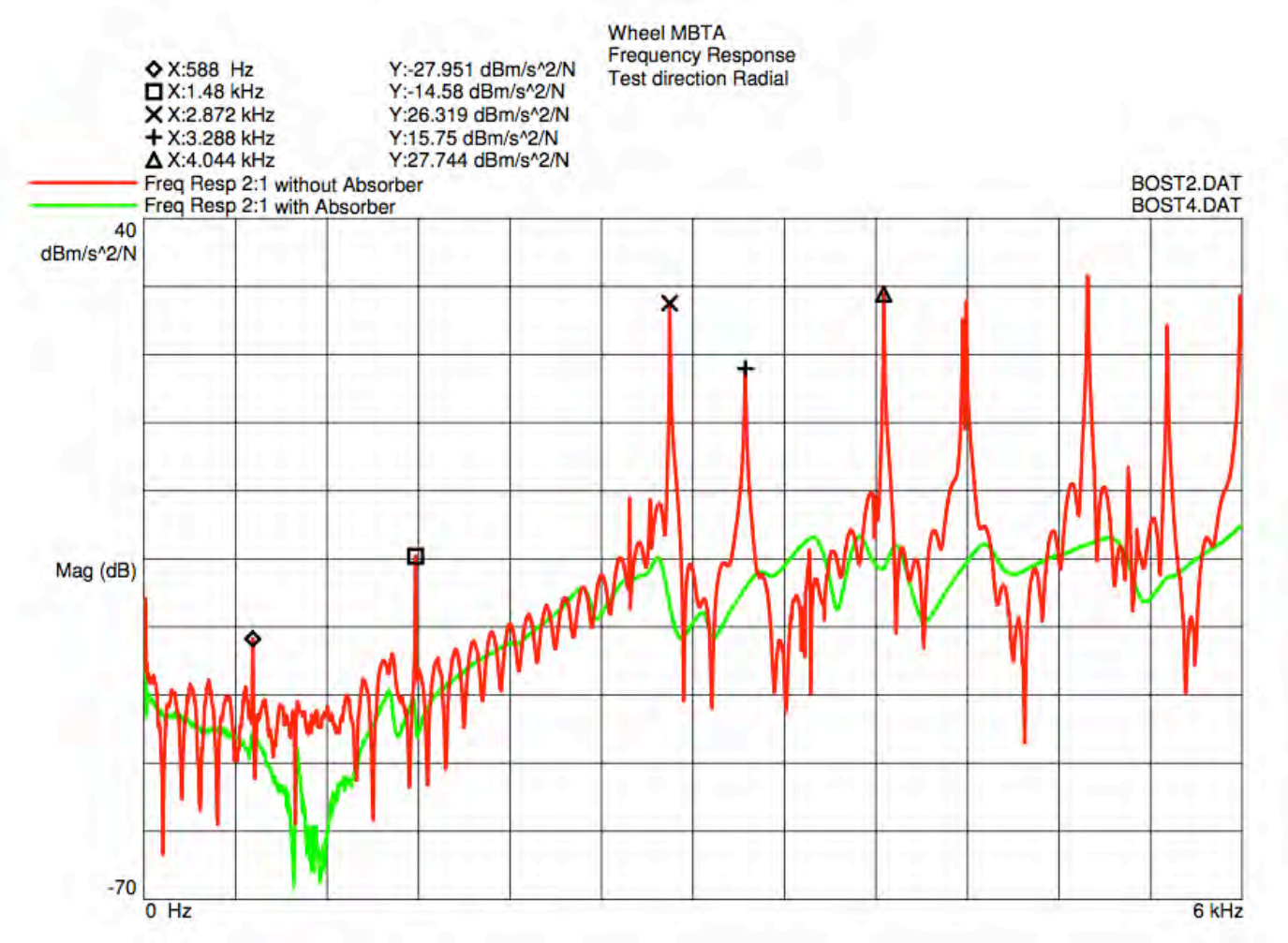
A possible solution

Measuring the wheel(axial) in our lab



A possible solution

Measuring the wheel(radial) in our lab



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Wheeldamper
advantages

Advantages:

- Source solution
- No maintenance
- Low LCC
- Easy to install
- The tuned mass dampers are designed uniquely for a particular wheel

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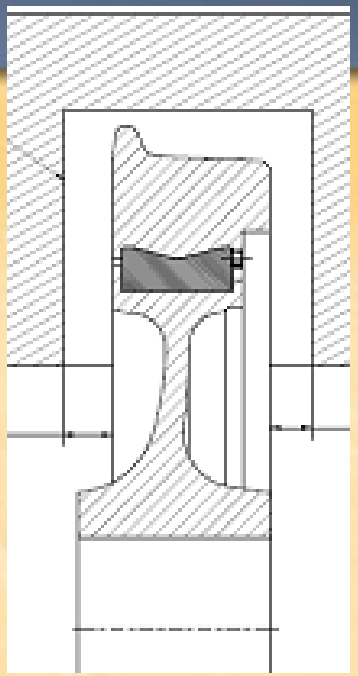
Prototyping
possibilties

- “Dynamic” envelope
  - vehicle
  - track
- Fixation
  - Speed
  - Bolt-on or clamped

Dynamic envelope
the vehicle

How much space is available to install the damper



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Fixation
Preliminairy design

- Speed

  >60mph RSA(ring segment)

  <60mph RSA and/or GT(bolted-on)

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Fixation
Bolt-on(GT)

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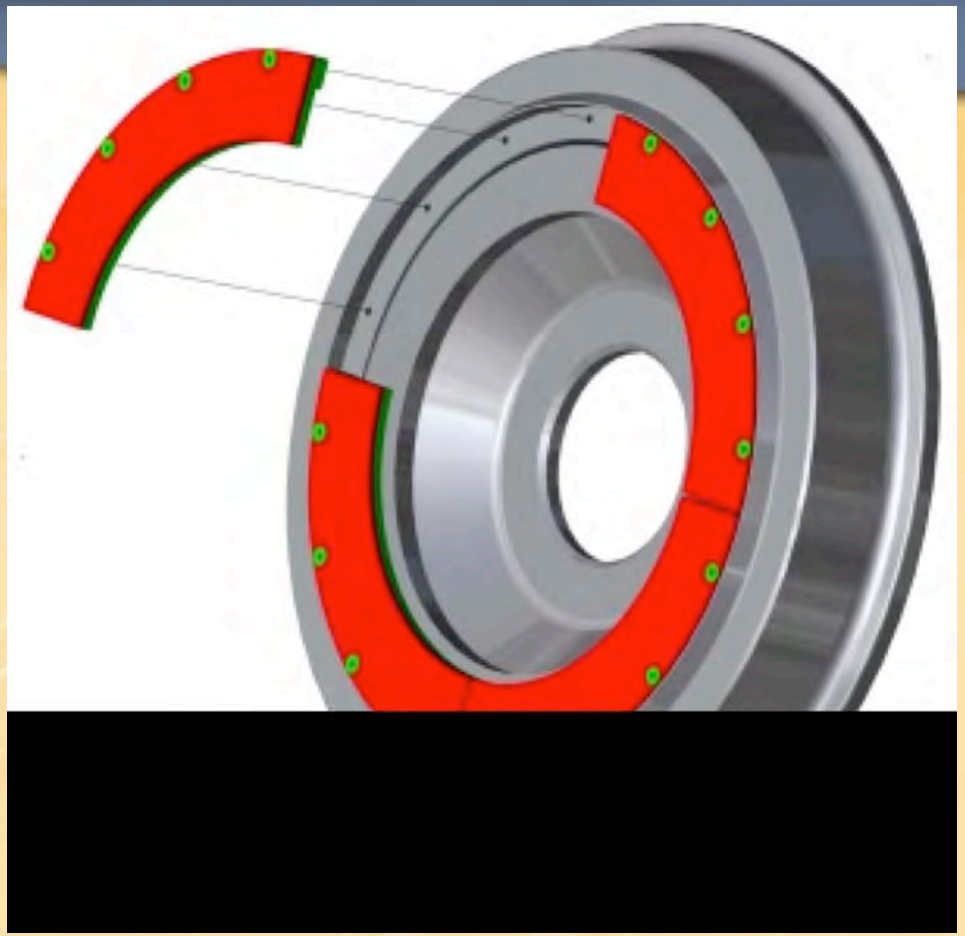
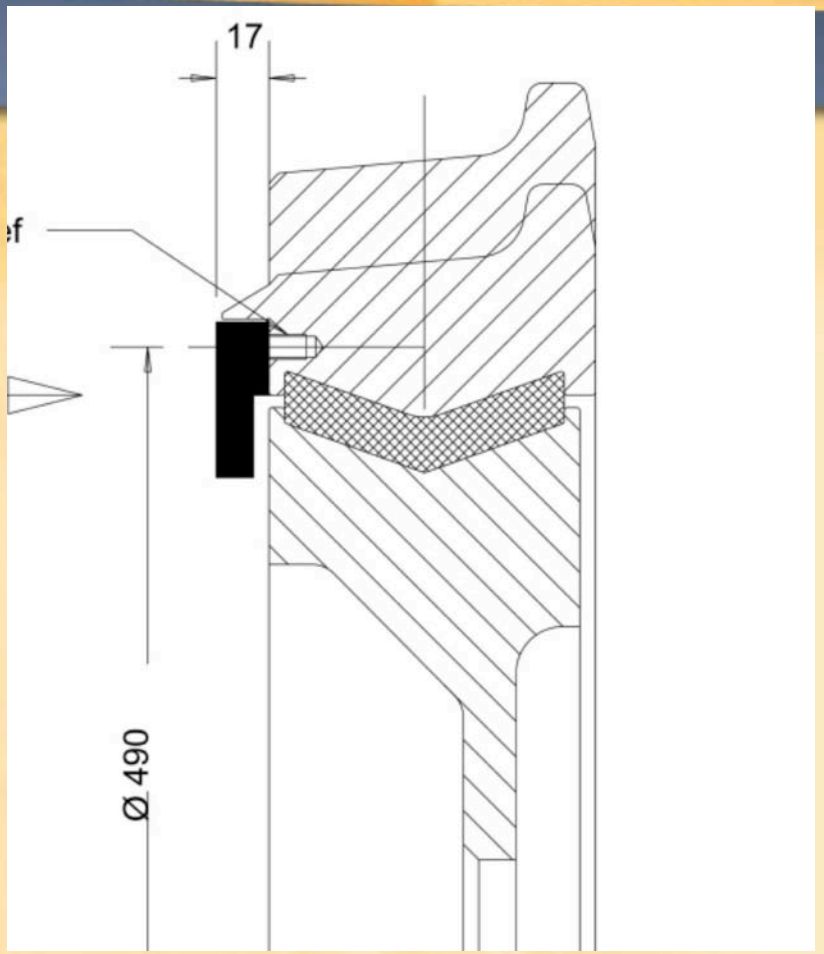
Fixation
Bolt-on





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Fixation
Clamped(RSA)

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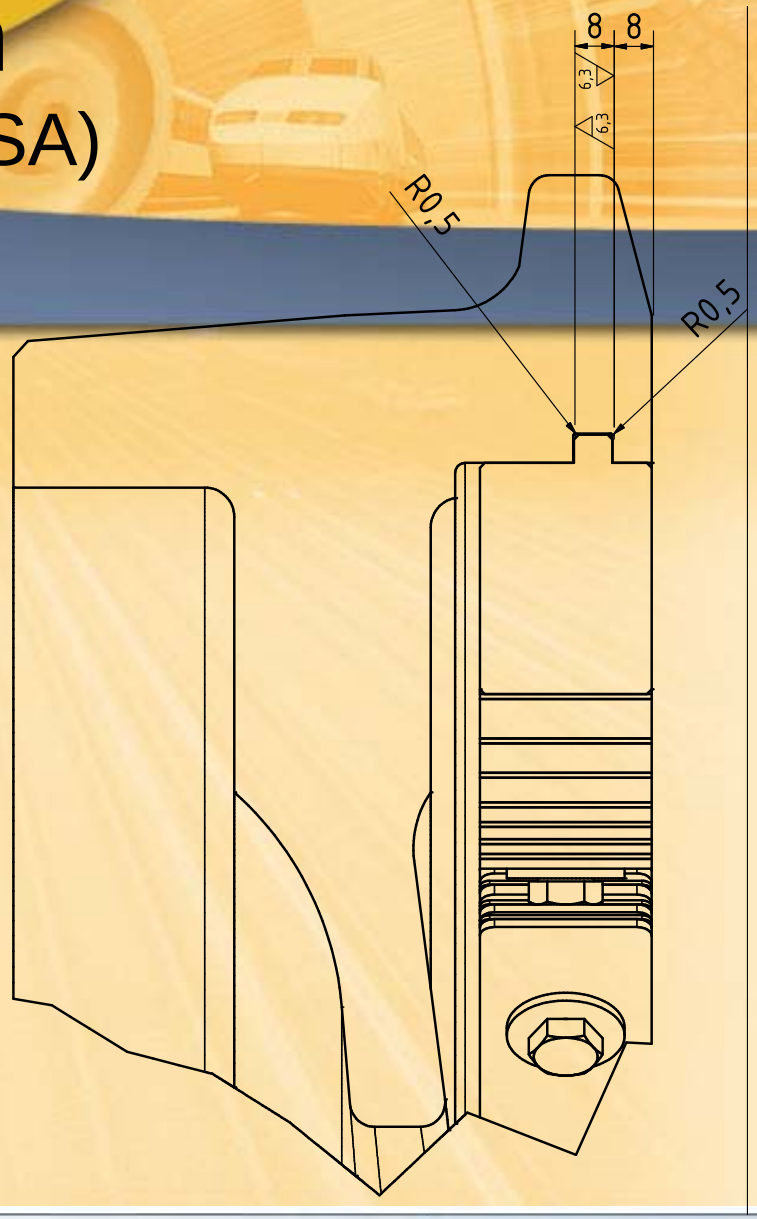
• FORGED COMPONENTS
• NOISE CONTROL

Fixation
Clamped (RSA)



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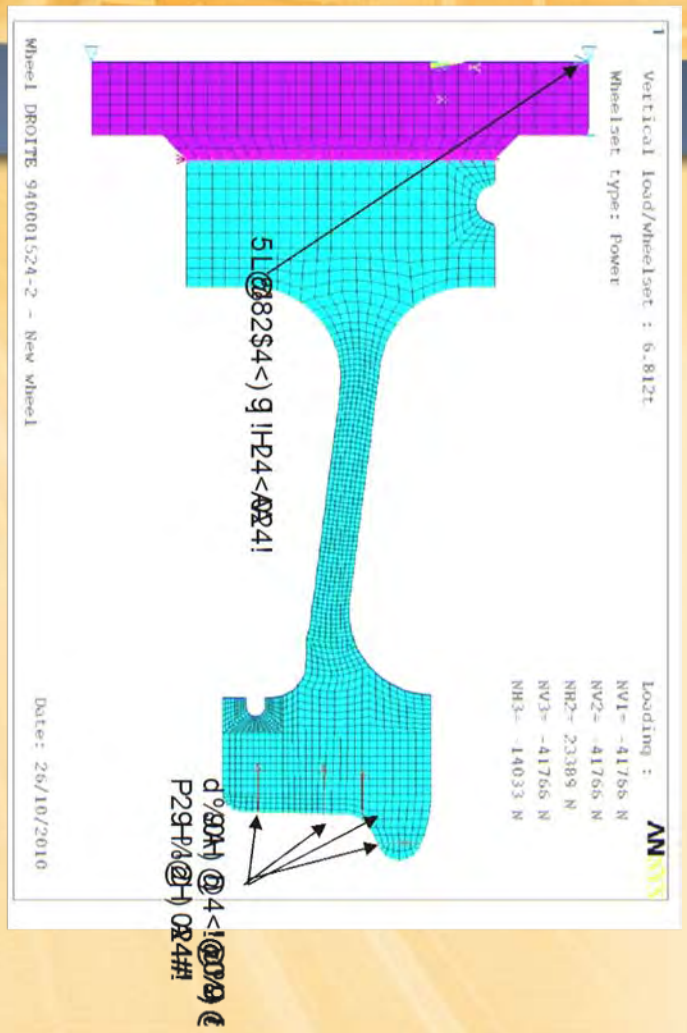
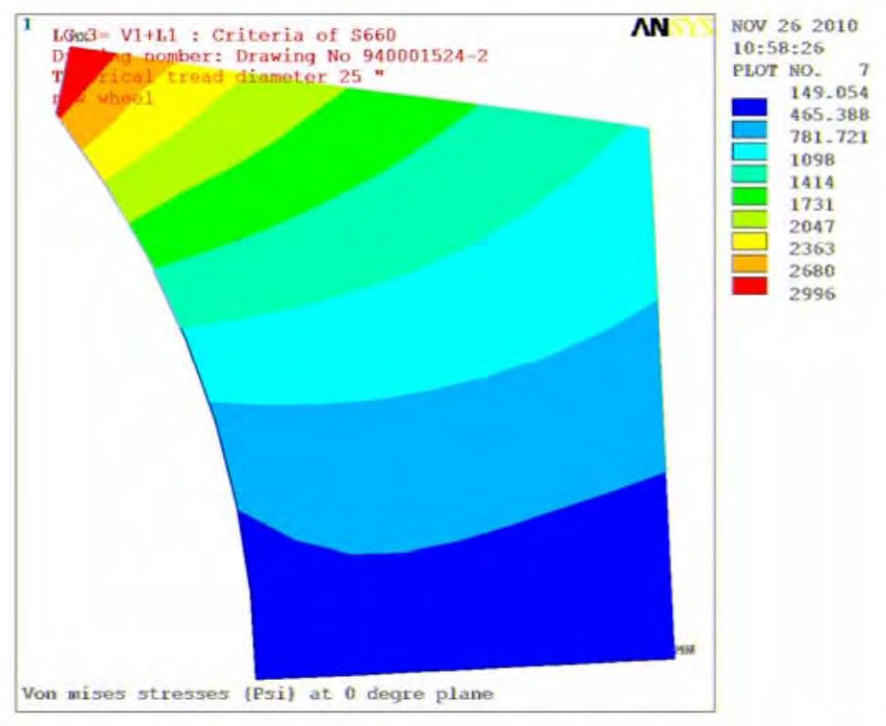
Validation of design
Using FEA

Conducted by GHH-Valdunes

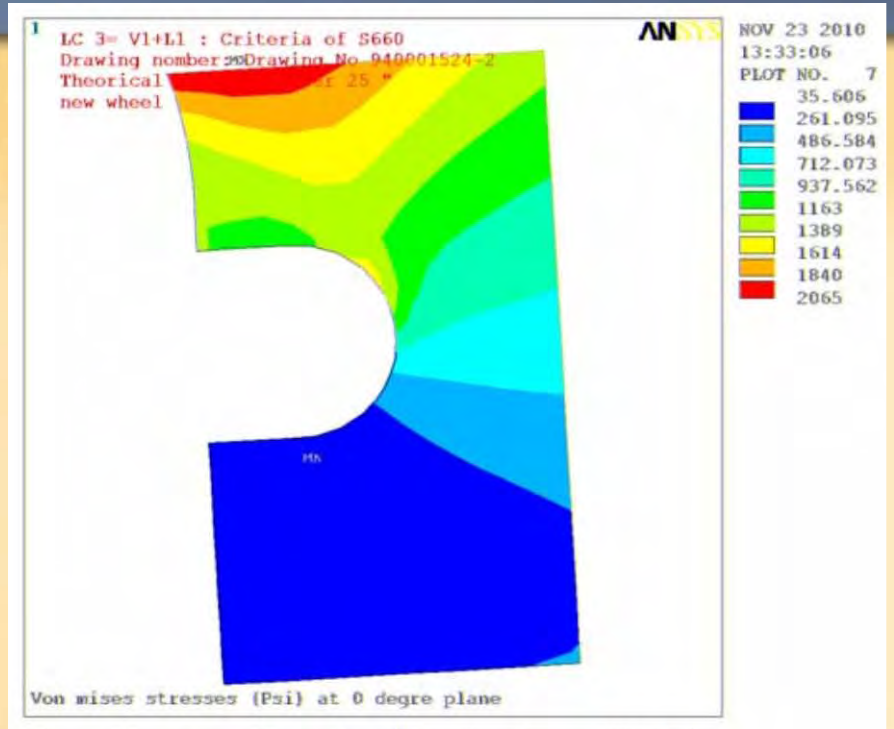
- Norm(s):
  - -AAR S660
  - -EN 13979-1 / UIC 510-5
- Parameters used(modelling):
  - -Thermal loading
  - -Mechanical loading
  - -Boundery conditions



Validation of design
(new wheel, stresses on the groove)

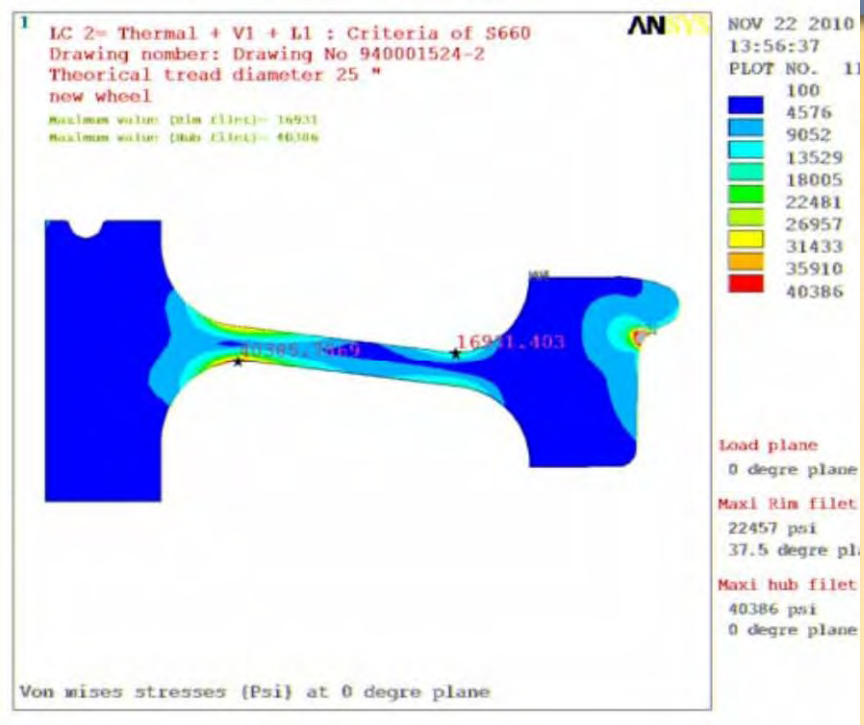


New wheel - configuration #1 - load case V1+L1

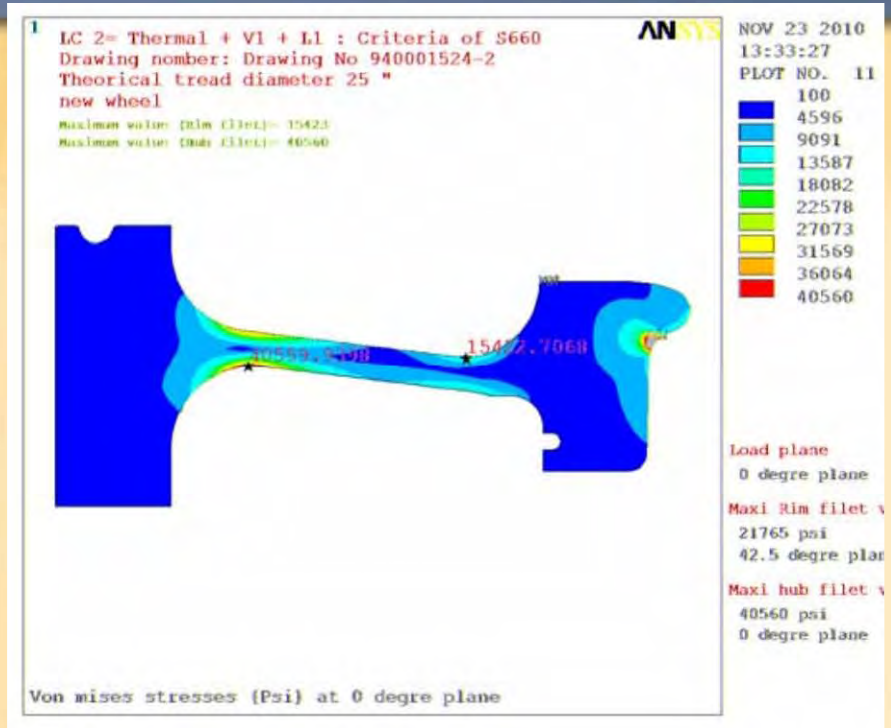


New wheel - configuration #2+ - load case V1+L1

Validation of design
(new wheel, stresses on the web)

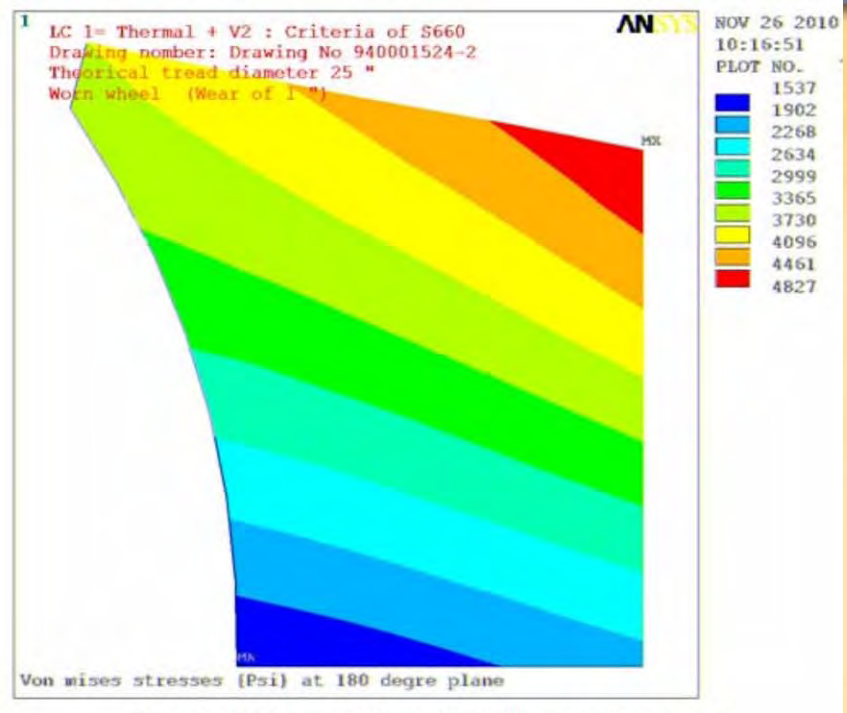


New wheel - configuration #1 - load case thermal + L1 + V1

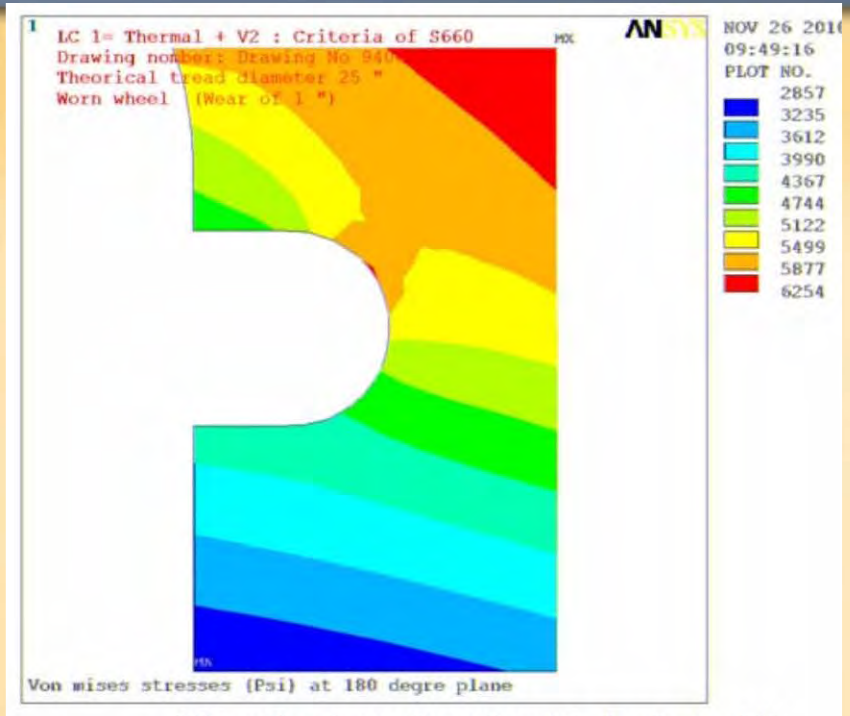


New wheel - configuration #2 - load case thermal + L1 + V1

Validation of design
(worn wheel, stresses on the groove)

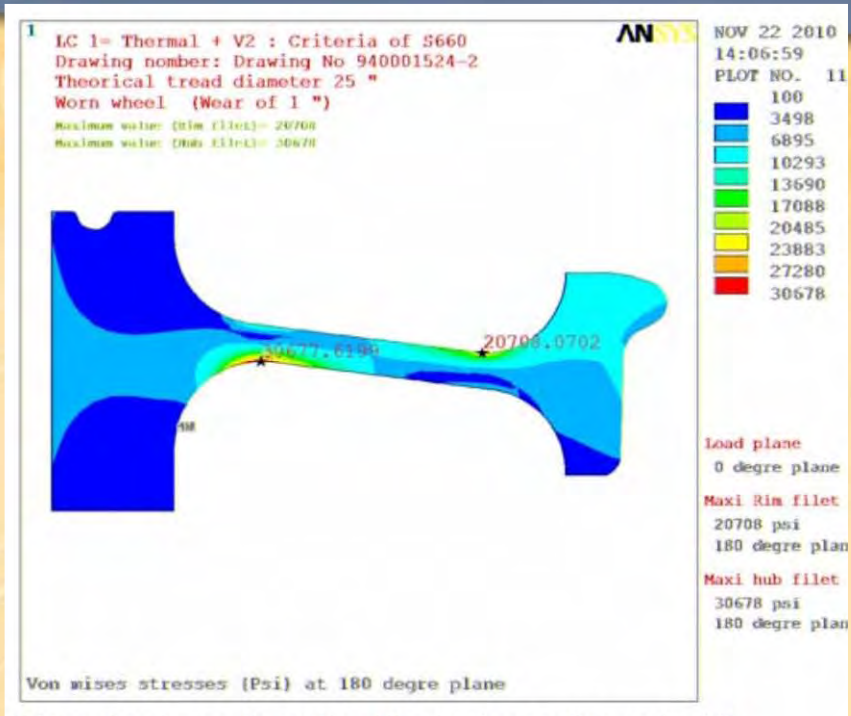


Worn wheel - configuration #1 - load case V2

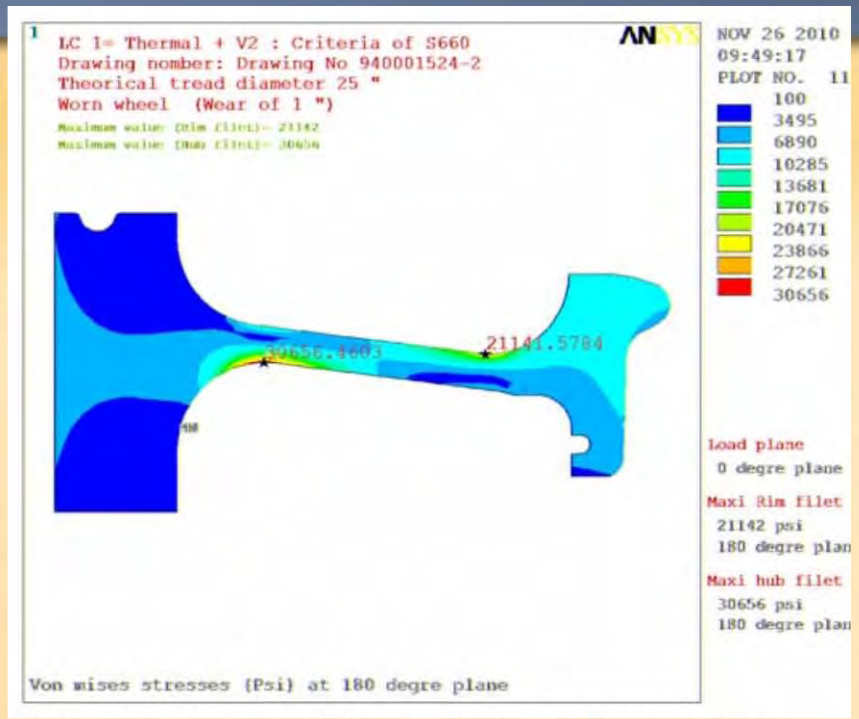


Worn wheel - configuration #2 - load case V2

Validation of design
(worn wheel, stresses on the web)



Worn wheel - configuration #1 - load case thermal + V2



Worn wheel - configuration #2 - load case thermal + V2

Validation of the design

The result of the FEA

Conclusion

- The analysis, through the AAR standard, but also the fatigue analysis following the EN standard, shows that the machining of the groove in the wheel has almost no influence on the behaviour of the wheel.
- The stresses in the groove are under the yield limit and the fatigue behaviour show a very low dynamic stress range. Some values in the web are higher than 145 MPa (21,030 psi). This limit is an indicative value for a black wheel.

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Wheeldamper

The test

- Preparing the wheel
- Damper installation
- Measurements with and without

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Preparing the wheel

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Damper installation

- Installation on a assembled truck
- Unbalance
- Shifting

Installation
Check unbalance

Distance between segments

Compressing the spring

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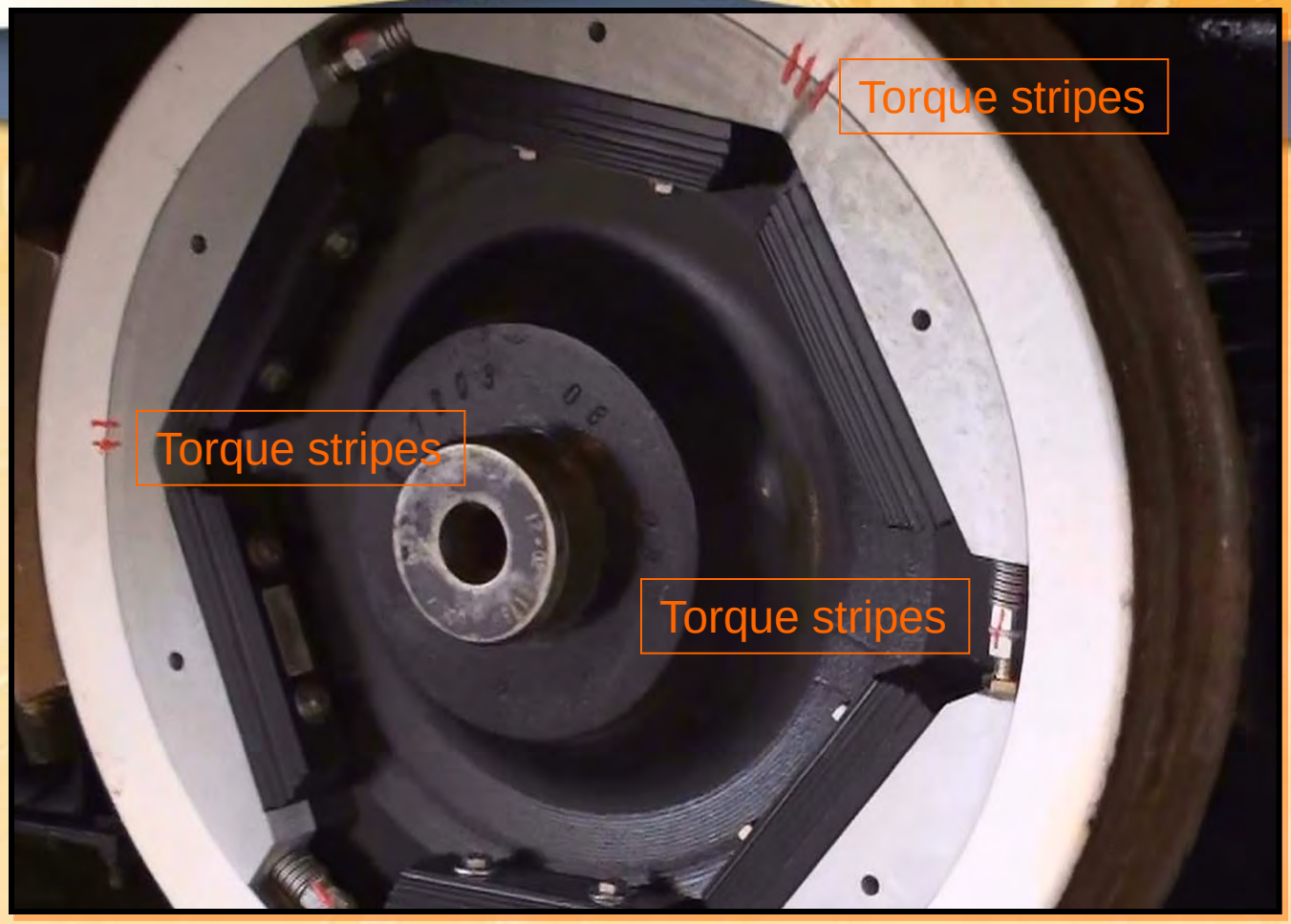
Installation
Check fixation

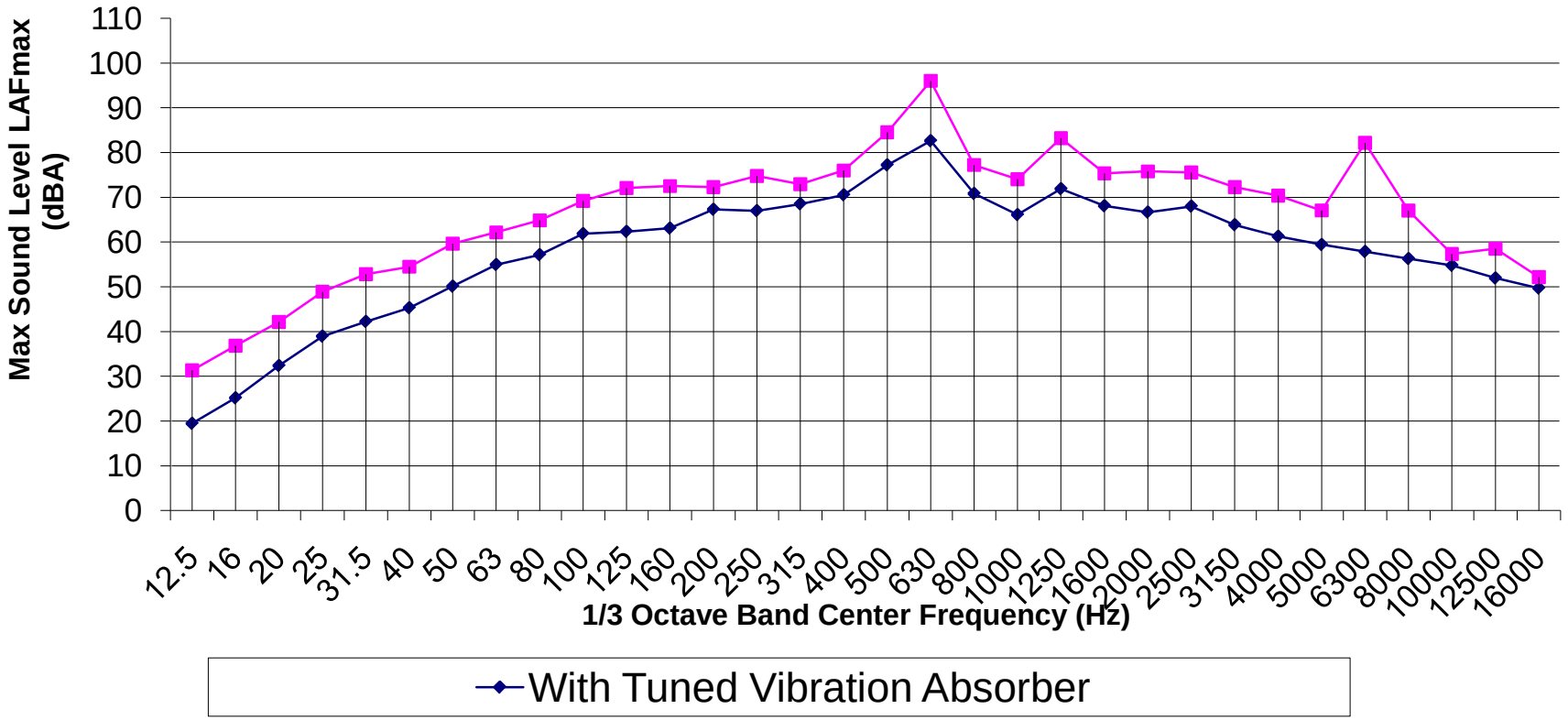


Torque-stripes on hardware and segments

Measurements

Sound Level Frequency Spectrum Ashmont Loop

Train 3268, Average Sound Level for With & Without Tuned Vibration Absorber



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Conclusion

- Results are positive, 15dB(A) reduction
- Run new tests
- What can be done to reduce the sound at 630Hz?

Thank you for you attention

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