# ASME SECTION I, BOILER TUBE INSTALLATIONS AND REPAIRS USING THE VIKING TUFF TUBE TRANSITION (PATENT PENDING)

Traditionally, cracked boiler tubes are cut out and replaced with tube material. Based on the provisions of ASME Section I, PW-41.5 sleeve type or socket weld type joints can be used to connect tubes to headers and/or other tubes

Viking Vessel Services has developed a sleeve type header connection (Tuff Tube Transition or 'TTT') for the repair of tubes. The TTT is currently undergoing lab testing to confirm strength. Detailed Finite Element Analysis has been performed under a controlled set of assumptions to attempt to predict the performance of the TTT. As part of the validation, a traditional stub-in tube to header was also analyzed under the same assumptions and conditions with both Carbon Steel and P91 Cr.

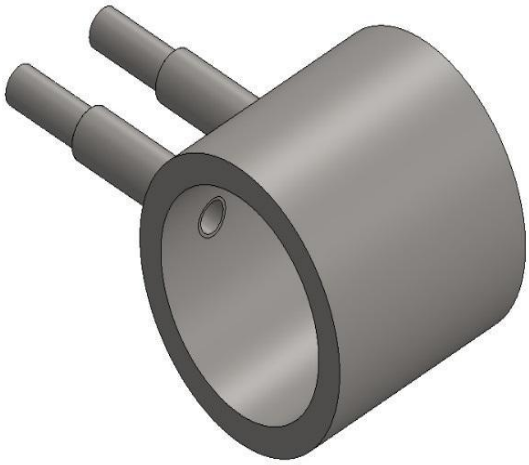

*Figure 1: Tube Coupling Layout (For details refer to Viking drawings)*


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## Carbon Steel Tuff Tube Transition

Analysis of the Tuff Tube Transition shows that the peak stresses are at the interior wall of the header and the tube juncture.

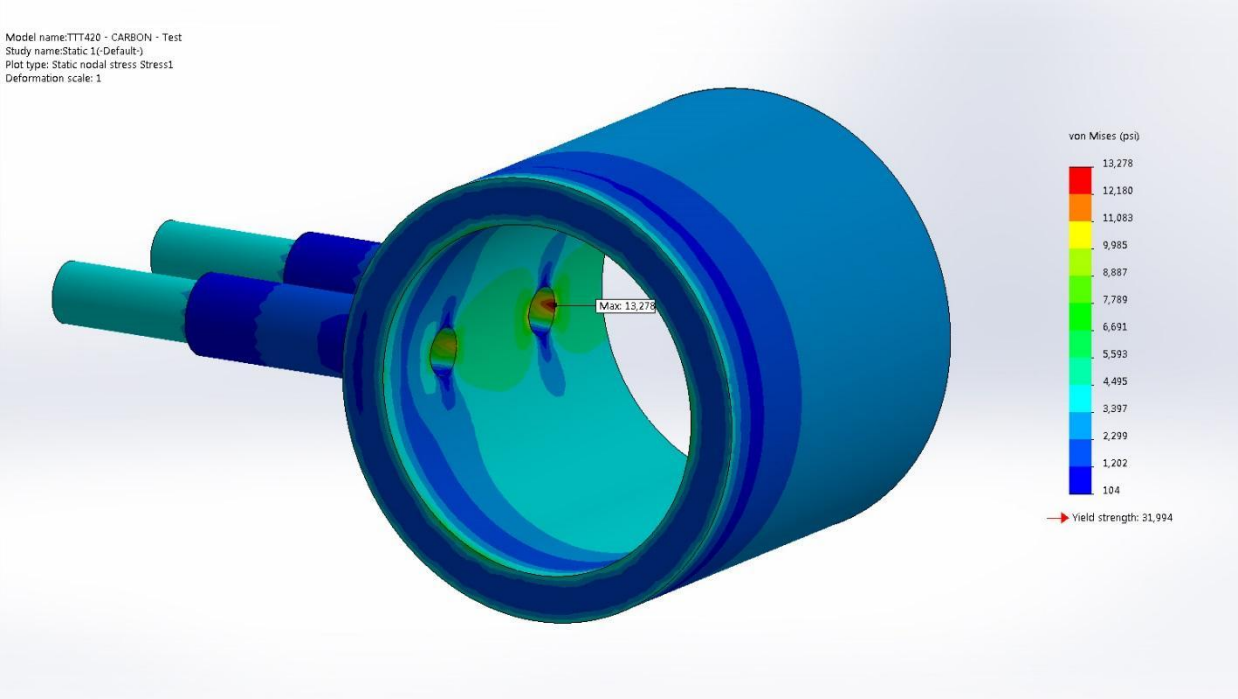


*Figure 2: Tube Coupling Prototype Von Mises Stresses (Carbon Steel)*

As you move away from the interior of the header, the stresses in the Tuff Tube Transition reduce significantly where the stress levels are less than 3,000 psi. As you can see to the left, the actual tube stresses are less than 5,000psi.


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Conversely, the same analysis of the traditional tube repair was performed.

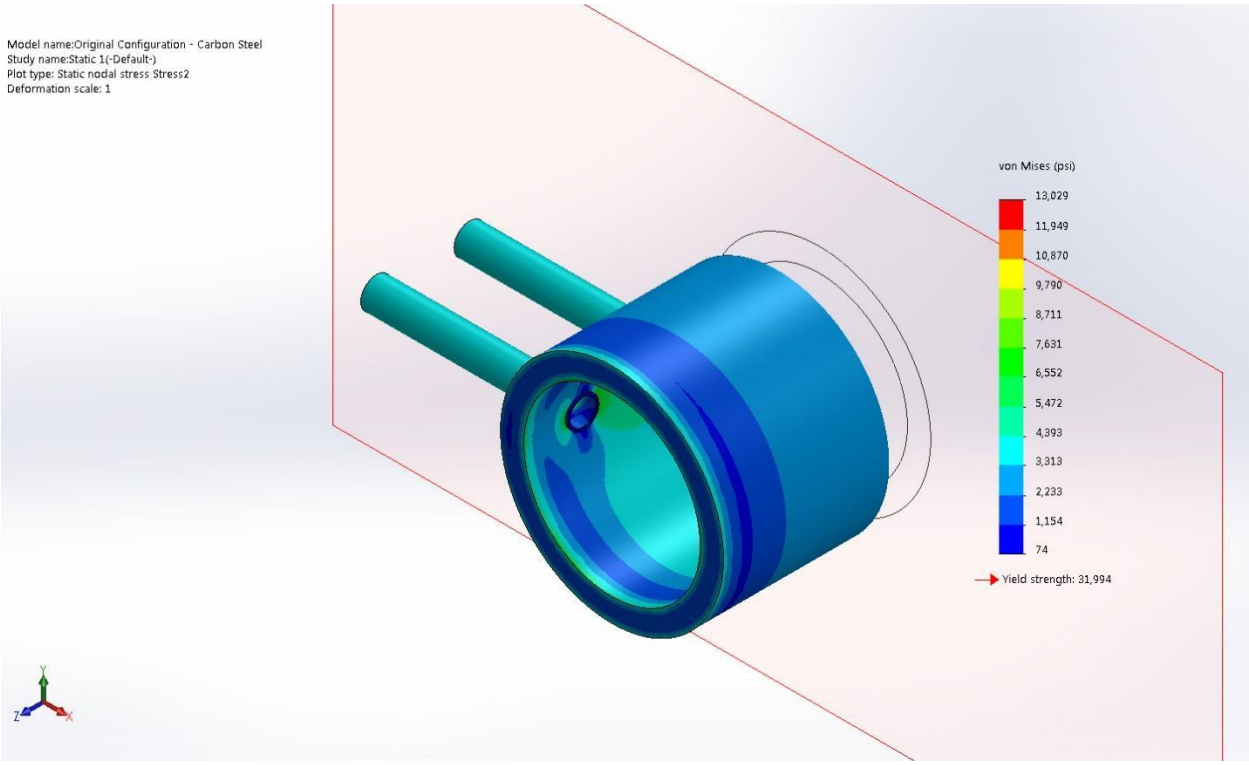


*Figure 3: Traditional Stub-In Tube to Header Von Mises Stresses (Carbon Steel)*

Analysis indicates the peak stresses occur at the same location at the interior of the header to tube wall connection. The magnitude of the peak stress is the same as with the TTT prototype. Tube stresses are similar in both configurations. With further examination, as you move further away from the interior surface of the header, the stresses increase to the tube stresses (<5,000psi)

With the TTT header to tube connection, the stresses are quite localized in the TTT and reduce in the area of the weld connection, whereas in the traditional arrangement stress peak is in the header that translates to the tube weld connection.

Based on experience, most tube failures initiate at the weld. The tube coupling prototype appears to reduce the stresses in the area of the welds by approximately 25-30% in the carbon steel Tuff Tube Transition.


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## P91 Cr Material Tuff Tube Transition

The same analysis has been performed with P91 Cr material with similar results. The pressure and temperature conditions have also changed in this case.

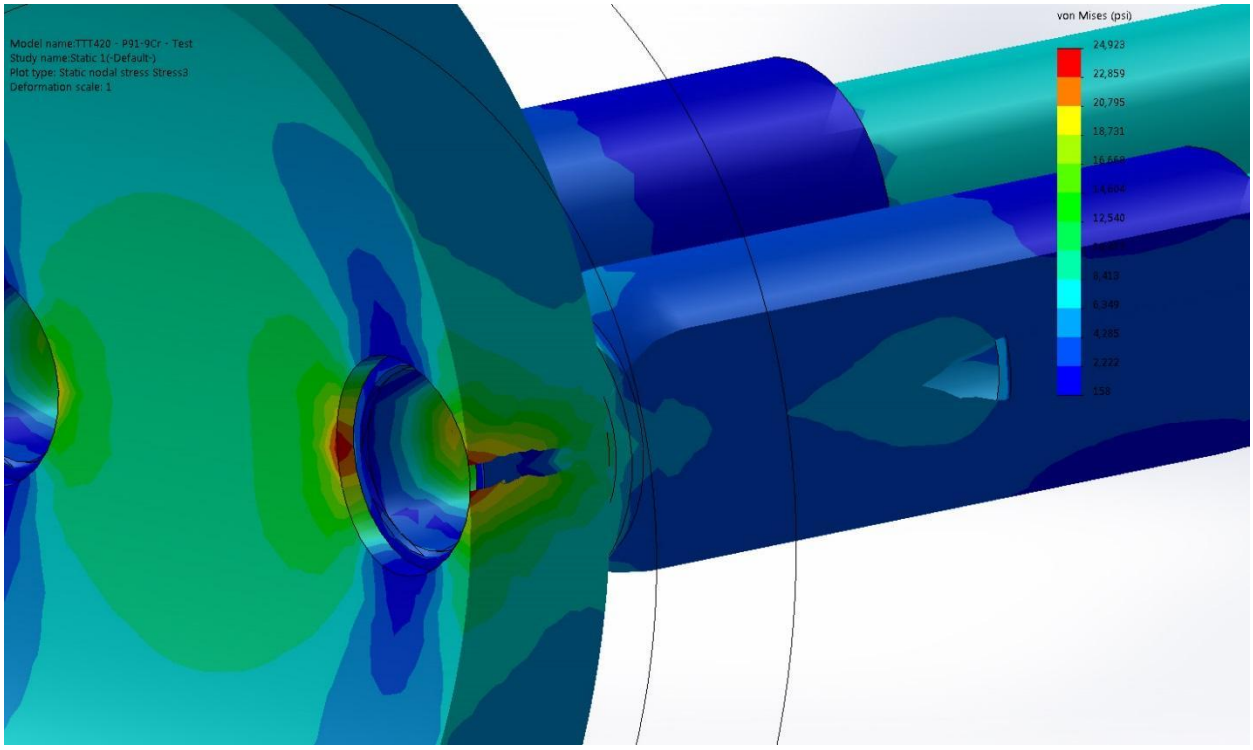


*Figure 4: Tube Coupling Prototype (P91 Cr material)*

Again, analysis of the Tuff Tube Transition prototype shows that the peak stresses are at the interior wall of the header and the tube juncture. The stress in the TTT prototype is low, especially in the area of the welds (<7,000psi).


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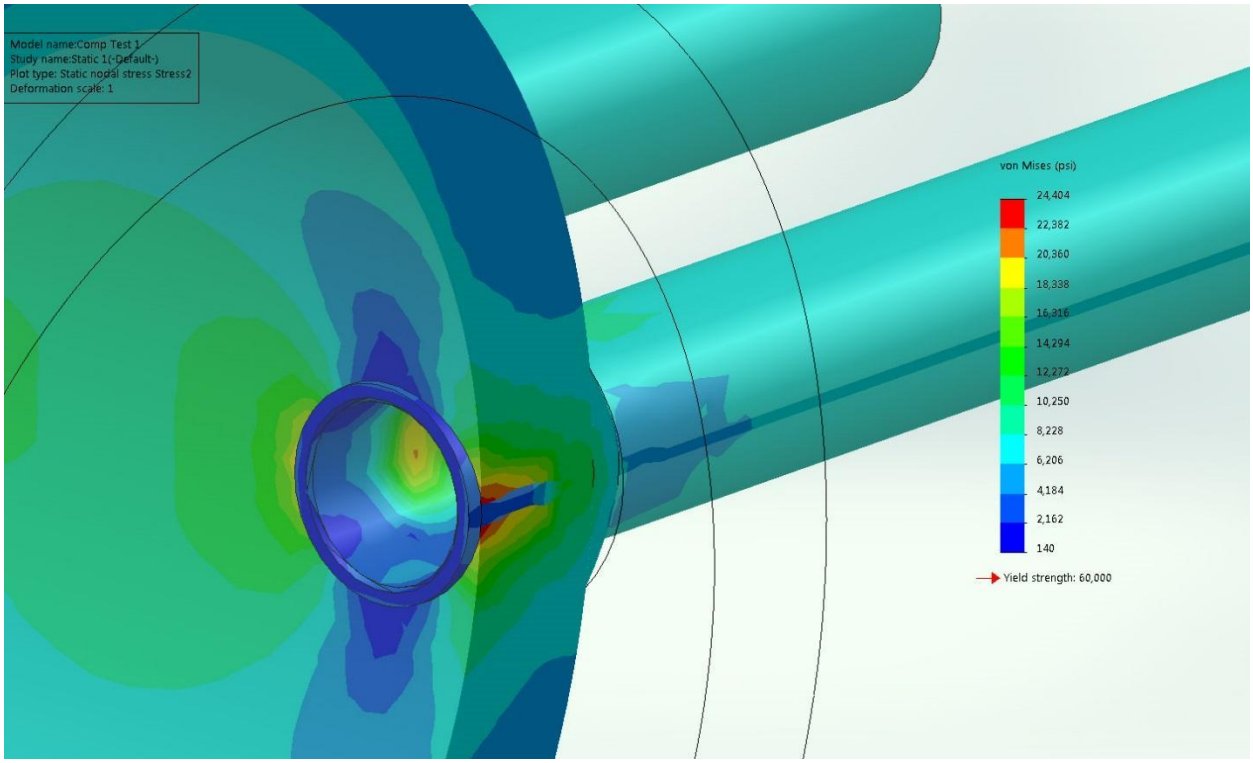


*Figure 5: Traditional Stub-In Tube to Header Von Mises Stresses (P91 Cr material)*

Analysis indicates the peak stresses occur at the same location at the interior of the header to tube wall connection. The magnitude of the peak stress is the same as with the TTT prototype. Tube stresses are similar in both configurations. With further examination, as you move further away from the interior surface of the header, the stresses increase to the tube stresses (<8,000psi).

In the P91 Cr configuration, the TTT prototype header to tube connection and the traditional tube connection, stress peak is in the header that translates to the tube weld connection; however, the average weld area stresses are lower in the TTT.

The TTT appears to reduce the stresses in the area of the welds by approximately 12-15% in the P91 Cr prototype.

The TTT prototype indicates to be a better connection, easier to install during a repair situation, and increases the life expectancy before another repair is required. Please review the detailed analysis reports for more details on the analysis performed, and the results on fatigue life.