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Submission by Standard Steel, LLC

Accident No.	DCA14MR014
Location	Casselton, North Dakota
Date	December 30, 2013
Railroad	BNSF Railway

Executive Summary

On Monday, December 30, 2013 at 2:11 PM CST, a westbound BNSF Railway grain train (G-RYLRGT9-26A) consisting of 112 cars derailed 13 loaded cars (the 43rd through 55th cars from the lead end locomotive) outside the Twin Cities Division in Casselton, North Dakota. The 45th car (#486653) obstructed the adjacent track. An eastbound BNSF Railway petroleum crude oil train (U-FYNHAY4-05T), consisting of two buffer cars and 104 fully loaded DOT-111 tank cars, collided with grain car 486653, resulting in the further derailment of two locomotives, and 20 cars (the 1st through 20th cars from the lead end locomotive) spilling more than 400,000 gallons of crude oil which subsequently caught on fire. Approximately 1500 civilians from the Casselton area were evacuated. No injuries were reported for either train crew, nor for any civilians. An axle was found, broken, probably from the 45th, 46th, or 47th car in the grain train.

Included in the NTSB report was an analysis using Finite Element Modeling (FEA) of a void in the body of the axle. Employing sophisticated techniques, the approximate shape of the void was determined and was used in the models. Typical loading parameters were used, including loaded car weights and an estimated side load to compensate for centrifugal forces during curving and wind loads. The analysis included these loads on a void-free model, and a model in which the void was extant. The analysis showed the Mises and bending stresses in the void–free model to be lower than those of the model including the void. Projections were made that indicated the axle including the void was more likely to fail.

Standard Steel is of the opinion that:

Finite Element Modeling is essential in design work, but invariably lacks sufficient science for failure analysis. Historical loading patterns, residual stresses from heat treat and machining, actual dimensions and actual mechanical properties and fatigue data from the region of the void are just some of the information that may affect the modeling results and may not have been available to the analyst. We certainly understand the limits of FEA; other limitations of the model were included in the report summary. The 17,500 psi endurance limit which was used in the report to assess the probability of failure comes from full scale axle fatigue testing done by the AAR over 80 years ago. Manufacturing processes for axles and axle designs have changed much in the intervening years. If the tests were repeated today, I would be surprised if the endurance limit would be that low. Also, the endurance limit from that investigation represented a surface initiated crack, and not an internally generated crack.

As with any fatigue crack, two phases determine the life of a part: the initiation phase and the propagation phase. This axle was remounted in April, 2010, having been in coal service for about 7 years. After being remounted, the axle failed in 3 to 3-1/2 years. Elastic FEA does not fully address the initiating phase, as plastic deformations are required for crack initiation. An axle could remain in service for many years and never initiate a fatigue crack. Some initiating event such as a derailment, increased loads, high impacts from a spalled rail or a shelled wheel, or even from machining the axle body to a smaller diameter would result in increased stresses enough to start the crack. The presence of the void does not mean crack propagation immediately resulted upon entering service.

In my opinion, the FEA was competently done and addresses the importance of the position and shape of a void on susceptibility to fatigue in an axle. Therefore Standard Steel concluded the analysis lacks sufficient information to reliably predict this failure.

Sincerely,

Steven Dedmon
Director Technology and Research & Development
Standard Steel, LLC