U.S. Department of Transportation

Federal Railroad Administration

RESEARCH RESULTS

FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

RR 23-14 | **August** 2023

Tensile Test Results of Samples Taken from Critical Areas of Railcar Bolsters

SUMMARY

The Federal Railroad Administration (FRA) collaborated with the Association of American Railroads' (AAR) Coupling System and Truck Castings Committee and Transportation Technology Center, Inc. (TTCI) to investigate possible solutions to railcar side frame and bolster failures.

Recent side frame and bolster failures on North American railroads can be mostly attributed to either fatigue or brittle failure. Most of the brittle failures can be attributed to marginal strength and poor impact resistance of the cast steel material. A brittle failure can occur instantaneously and under stresses that may be below the yield strength of the material.

TTCI tests indicated that the probability of brittle failures may have been higher than previously expected. This probably was the case for cars that operate primarily in cold weather because of the increased brittleness of the material in lower temperatures.

Of the 313 samples studied, over 50 percent failed one or more tensile test criteria specified for Grade B+ material performance. Figure 1 shows the generalized results for the samples, which were taken from the cast body and the keel block. For the samples taken from the body of the casting, the criteria most often not met were elongation and area reduction. For the keel block samples, yield point was the most failed criterion.

The tensile test showed that even at a moderate temperate, the material may have been more rigid than desired. The samples cut from the bolster had low occurrences of tensile and yield point failures when other criteria were met. However, because elongation and area reductions are indicative of the ductility of the material, lower temperatures are more critical, because the material becomes more brittle.

Not all samples taken from the keel block passed the minimum tensile test criteria. The relatively high number of yield point failures was intriguing, but not necessarily alarming, because the matching bolster samples did not display the same phenomenon.

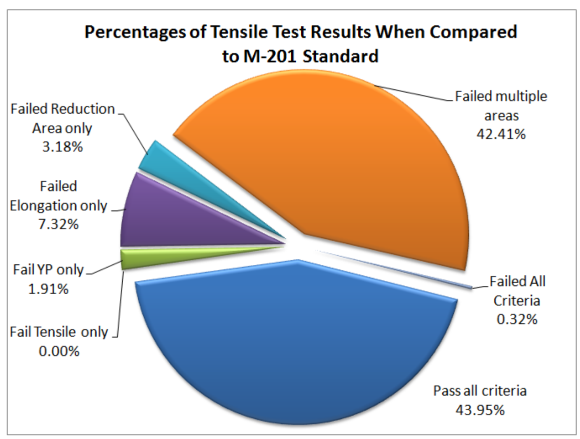

Figure 1: Pass/Fail Chart for All Samples with Failure Criteria

BACKGROUND

Side frame and bolster failures incurred by North American Railroads in recent years can be mostly attributed to either fatigue or brittle failure. Fatigue failures have most often resulted from less-than-desirable welding/casting workmanship and casting solidity. Most brittle failures can be attributed to marginal strength and poor impact resistance of the cast steel material. A brittle failure can occur instantaneously and under stresses that can be below the yield strength of the material.

The Coupling System and Truck Castings Committee and Transportation Technology Center, Inc. believe that modifications are necessary to improve the performance and to reduce the occurrence of brittle failures of cast components. FRA has collaborated with these groups to study possible solutions.

OBJECTIVES

This project focused on improving the chemistry, material quality, and life of grade B+ castings. To fully examine the mechanical properties of the casting, Charpy, dynamic tear, and tensile tests were conducted. This report focuses on the results and findings from the tensile testing.

Tensile testing was used to measure the strength and ductility of materials under uniaxial tensile stresses. Using the tensile testing values, the ultimate tensile strength and yield point could be extrapolated.

Close examination of the numerical and physical results from the testing was used to make recommendations to improve the life, chemistry, and casting quality of grade B+ materials.

METHODS

Testing methods were taken from ASTM International manuals. ASTM A370 was used to determine the methods, and testing was conducted at room temperature.

RESULTS

An early indication from the tensile testing was that the probability of brittle failures may have been higher than previously expected. Note that the evidence to support this was based only on the tensile testing reported here.

The standard for Grade B+ materials is outlined in the AAR M201 standard. AAR M201 requires that Grade B+ materials prepared from a keel block have the following properties: a tensile strength of 80 ksi, a yield point of 50 ksi, an elongation of 24 percent, and a reduction area of 36 percent. If the test samples are taken from the cast body, the material must have 80 percent of the previously mentioned tensile and yield point values (1). These requirements are based on the ASTM Standard A370 testing procedures for a 2-inch gage length sample.

For the 313 samples tested, including 20 keel block samples, Figure 2 shows 44 percent fulfilled all criteria specified in AAR M201 standard.

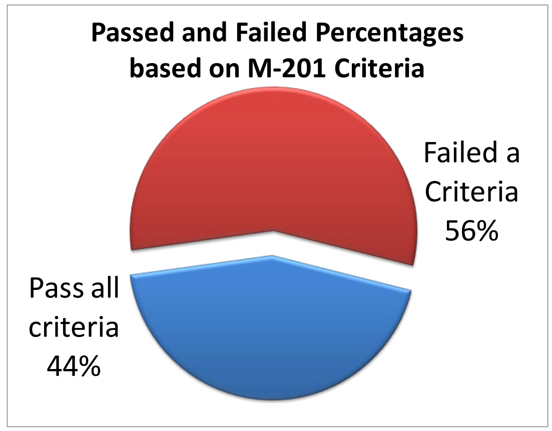

Figure 2: Pass Fail Chart for All Samples

For samples cut from the bolsters, only one failed the yield point criteria. Samples that failed the tensile criteria also failed the elongation or area reduction criteria. Two samples failed all criteria, one of which was discarded from the sample population because of a surface defect. Figure 3 shows the bolster samples' tensile test results.

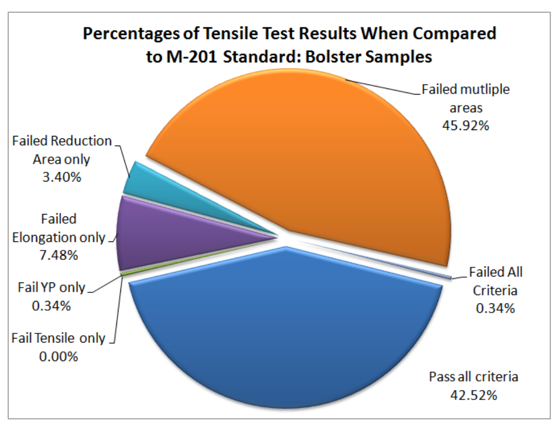

Figure 3: Pass/Fail Chart for Bolster Samples with Failure Criteria

For the samples cut from the keel blocks, five failed the yield strength criteria, one failed the elongation criteria, and one failed multiple areas. Figure 4 shows a breakdown of the keel block samples' tensile test results.

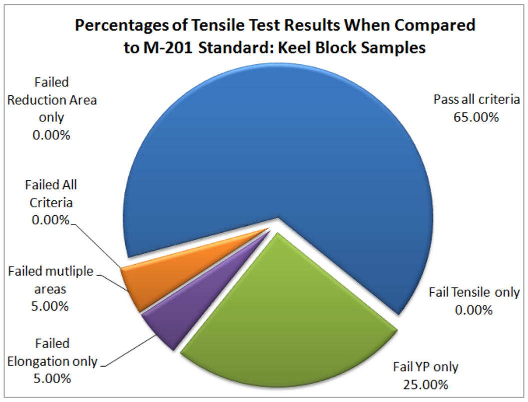

Figure 4: Pass/Fail Chart for Keel Block Samples with Failure Criteria

CONCLUSIONS

The tensile test results showed that even at a moderate temperature, the material may have been more rigid than desirable. The samples cut from the bolster did have a low occurrence of tensile and yield point failures when the elongation and area reduction criteria were met.

However, because elongation and area reductions are indicative of the ductility, lower temperatures are more critical because the material becomes more brittle.

Also note that not all the samples taken from the keel block passed all the criteria. The relatively high number of yield point failures was noteworthy, but not necessarily alarming, because it was not displayed in the matching bolster samples.

The difference in material properties could have been due to the solidification of the casting where the samples were taken. Because the keel block is smaller, it tends to have more uniform properties during the cooling cycle, and therefore, it may have had higher ductile properties.

FUTURE ACTION

Post test results should be compiled and studied thoroughly to determine the best way to improve the castings. An iterative process with the manufacturers is expected to be a cost-effective way to improve castings.

REFERENCES

1. Association of American Railroads. (2005). *Manual of Standards and Recommended Practices*, Section S, Casting Details Specification M-201. Washington, DC.

ACKNOWLEDGEMENTS

TTCI conducted this research – primarily Kari Gonzales and Devin Sammon.

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KEYWORDS

Bolsters, tensile test, brittle failure, castings, grade B+

CONTRACT NUMBER

F33315-86-C-5169