Association of American Railroads

Coupling System & Truck Castings Committee

Presented by
Dan Moseng – BNSF Railway
Jon Hannafious – AAR/TTCI
Today’s Discussion

» Coupling System and Truck Castings Committee
» New Specification M-220: Casting NDT
  • Qualification Method For NDT Spec
» New Specification M-216: Knuckle Fatigue Test
» Summary of Other New Specifications or Those Undergoing Change
» Suspension Component Failure
» Questions and answers
Coupling System and Truck Castings Committee

Committee members

- **Dan Moseng** – BNSF – Chairman
- **Tim Ward** – NS – Vice Chairman
- **Randy Gaston** – UP
- **Kim Bowling** – CSX

- **Rick Brueckert** – TTX – AAB Representative
- **Mickey Clark** – ASF – AAB Representative

- **Jon Hannafious** – Committee Manager, AAR/TTCI
Coupling System and Truck Castings Committee

- Promotes policies, practices and procedures that will maintain/improve supplier casting practices and promote new and improved products for the railroad industry
**Coupling System and Truck Castings Committee**

- Responsible for about 70 AAR Standards, Specifications, and Recommended Practices pertaining to castings in MSRP Sections:
  - S – Casting Details
  - S-II – Truck Details and Casting Codes
  - S-III – Coupler and Yoke Details
  - Indirect Responsibility for some Specifications in Sections D and B

- **Supports 9 AAR Field Manual Interchange Rules covering couplers and castings**
  - Rule 16 – Couplers, Type E and Parts
  - Rule 17 – Couplers, Type E/F and Parts
  - Rule 18 – Couplers, Type F and Parts
  - Rule 19 – Yokes, Type E
  - Rule 20 – Yokes, Type E/F and F
  - Rule 22 – Uncoupling Levers
  - Rule 47 – Truck Bolsters
  - Rule 48 – Truck Side Frames, Transoms, and Spring Planks
  - Rule 82 – Welding and Associated Heat Treatment
Coupling System and Truck Castings Committee

- Approves:
  - Side Frames & Bolsters
  - Couplers, Yokes, Knuckles, Follower Blocks
  - Uncoupling Levers
  - Foundries for Casting of Products listed above
  - Reconditioning Shops (M-212 & M-214)

- Monitors Industry Failures & Addresses Casting Failure Issues
New or Modified Specifications

- **New Specifications Planned for Release in 2008**
  - M-220 – Casting Component NDT Requirements
    - Magnetic Particle Inspection of Railroad Knuckles
  - M-216 – Knuckle Fatigue Test

- **Specification Modification – In Progress**
  - M-205 – Addition of Yoke Fatigue Test to Existing Static Test
  - M-211 – Couplers and Yokes, AAR Approved – Purchase and Acceptance
  - M-214 – Side Frames and Bolsters, Used and Reconditioned – Classification and Reconditioning
  - M-212 Couplers and Yokes, Secondhand – Classification and Reconditioning
  - M-217/218/219 Articulated Connectors
  - M – ??? – Specification for “One-Piece Truck”
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New Specification M-220 *(Released September 19, 2008)*: *Casting Component Nondestructive Testing*

- M-220 was developed to address a need for NDT of castings
- The Main body describes AAR administrative requirements, and the appendices will have specific guidelines for various components
- Appendix A has been completed: **Magnetic Particle Inspection of Railroad Knuckles - Guidelines & Procedures**
- Other appendices will be added in the future with guidelines and procedures for NDT of other Components
- AAR Strategic Research Initiatives at TTCI are investigating NDT techniques for side frames and bolsters. This will provide input for future specifications
Appendix A Includes:

- Requirements and Procedures for Manufacturers & reclamation shops
- Car repair shops, RIP tracks, and mobile operations
- Inspector Qualification
- Equipment & Supplies
- Causes for Rejection

The AAR Field Manual will be revised to allow cause for knuckle removal using Magnetic Particle Testing.
M-220 Appendix A: Guidelines & Procedures
Magnetic Particle Inspection of Railroad Knuckles

❖ Who Will Be Required To Perform Knuckle MPI?
  ● Mandatory: Manufacturers and Reclamation Shops
  ● Optional: Car repair shops, RIP tracks, and mobile operations

❖ Inspector Qualification
  ● ASNT Level I or higher or equivalent AAR member corporate program
  ● An ASNT Level III professional or equivalent AAR member professional must approve the training

Fig. A.1 Pulling-face area of knuckle
M-220 Appendix A: MPI Equipment & Supplies

- Electromagnetic AC yoke
- Dry powder magnetic particles
- White powder liquid penetrant spray developer
  - Mandatory for field inspections & reclamation facilities
  - Not required for manufacturers
- Magnetic particle field indicator (pie gauge)
- Light source providing minimum of 50 foot candles
- Lint-free rags
- Cleaner
- Ruler/tape measure accurate to 1/16 in.
M-220 Appendix A: Causes for Rejection

- **Car repair shops, RIP tracks, and mobile operations**
  - Cracks greater than 1/4 in. long
  - For knuckles containing defects, we will refer to Rule 16, 17, or 18

- **Manufacturer and Reclamation Inspections**
  - Knuckles must be free of surface cracks, and surface discontinuities (hot tears, inclusions, porosity) with width, length, or depth dimensions greater than 1/8 in.
  - A grouping of five or more pin holes within a 1 in.² area and 3/16 in. or greater deep individual pin holes greater than 1/16 in. in diameter and greater than 3/16 in. deep
Visually inspect knuckle, including the flag hole
Clean the pulling face area of the knuckle, and visually inspect after cleaning
Spray developer onto the pulling face area of the knuckle
Position the yoke at knuckle placement #1 and energize
Apply the dry magnetic particles
Examine the knuckle for any accumulations of magnetic powder at flux leakage areas
Repeat for knuckle placements #2 and #3
Clean the the knuckle to remove magnetic particle dust and developer
Three yoke placements to look for vertical cracks in the pulling face

Fig. A.1 Pulling-face area of knuckle

Fig. A.2 Horizontal yoke placement on knuckle

M-220: Knuckle Inspection Procedures for Car Repair Shops, RIP tracks, and Mobile Operations
M-220: Knuckle Inspection Procedures for Car Repair Shops, RIP tracks, and Mobile Operations
Two additional placements to look for horizontally oriented defects

A recently sand- or shot-blasted surface is acceptable for inspection

The use of developer is not mandatory
Today’s Discussion

- Coupling System and Truck Castings Committee
- New Specification M-220: Casting NDT
  - M-220 Magnetic Particle Technique Qualification (Hannafious)
- New Specification M-216: Knuckle Fatigue Test
- Summary of Other New Specifications or Those Undergoing Change
- Suspension Component Failure
- Questions and answers
Objective

To determine the capability of the dry magnetic particle method to detect linear indications greater than 0.250-inches in length in accordance with Association of American Railroads Specification M-220

- For car repair shops, RIP tracks, and mobile operations

Compare results to the capability of conducting visual inspections currently utilized
M-220 Magnetic Particle Technique Qualification

- **Approach**
  - The M-220 MT technique was evaluated using “probability of detection” (POD), a proven method for procedure qualification.
  - Performed a POD with 36 flawed and 24 unflawed knuckles.
  - Four industry participants participated in the POD evaluations (BNSF, UPRR, NS, and TTX).
M-220 Magnetic Particle Technique Qualification

- TTCI Approach
  - Provided one day of industry training and one day of inspection (POD subset)
  - Calculated individual and combined PODs
**M-220 Magnetic Particle Technique Qualification**

60 Knuckles Prepared for Inspection in Shop
M-220 Magnetic Particle Technique Qualification

- Magnetic Test to Visual Test Results Comparison
  - Lowest MT “Hit” result is greater than highest VT
  - MT false calls less than 10% in all cases
M-220 Qualification: MT to VT Results Comparison

- MT hit near 90% vs. VT at 75%, MT false call rate less than 10%
- MT demonstrated a higher capability than VT in detecting linear indications greater than 0.10-inches and achieved a near 100% POD
Today’s Discussion

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  - Qualification Method For NDT Spec
- **New Specification M-216: Knuckle Fatigue Test (Moseng)**
- Summary of Other New Specifications or Those Undergoing Change
- Suspension Component Failure
- Questions and answers
New Specification M-216
Release Planned for 2008

- Fatigue Test for Type E and Type F Knuckles
- Includes
  - Test machine requirements
  - Load spectrum
  - Reporting requirements
New Specification M-216 – Fatigue Test for Type E and Type F Knuckles

- A test for evaluating the fatigue life of knuckles
- Utilizes a known load spectra as measured in revenue service
- Consideration was given to knuckle test results accumulated over the past 10 years
- Was put out for industry comment via Circular Letter on 12/19/06, and after much consideration and slight modification was recently agreed to by manufacturers and CSTCC
- Requires fatigue testing of four knuckles in addition to the static testing defined in AAR Specification M-211.
### New Specification M-216 – Knuckle Fatigue Test

Load Cycles: Repeat to Failure of the Knuckle. 1,058 cycles are equivalent to approx. 1,000 miles

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Norfolk Southern load frame used to test knuckles and coupler bodies.

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New Specification M-216 – Knuckle Fatigue Test

Historical test result, plotted below, were used as a guideline for the new specification

- The average life of the four knuckles tested must exceed 600,000 cycles
- No individual knuckle to exhibit a life below 400,000 cycles
- Goal of the CSTCC is to eliminate the poorest performing knuckles, and to bring up the average performance
Today’s Discussion

◆ Coupling System and Truck Castings Committee
◆ New Specification M-220: Casting NDT
  ○ Qualification Method For NDT Spec
◆ New Specification M-216: Knuckle Fatigue Test
◆ Summary of Other New Specifications or Those Undergoing Change
◆ Suspension Component Failure
◆ Questions and answers
A draft for this specification has been completed. M-211 finishing standards will be significantly strengthened in a manner similar to M-210.

- **Welding & Weld Repair**
- **Tracking and Traceability**

M-211 should be released by January 2009 for comment.
A TAG was formed with CSTCC and the Truck Component Reconditioner Association to update and strengthen M-214. Work is complete, draft is in final edit.

An updated M-214 will go out for Comment in early 2009.
Objective: Improve yoke casting quality and reliability.

Add a fatigue test requirement to test for casting conditions not identified in the static tests.

Review and update the current specification as needed (admin, static test procedures and loads, etc.)
Objective: Improve coupler reconditioning quality and reliability. Focus will be on areas with known failures and other problems.

Work is just beginning.
New Specifications – M-217/218/219 (Articulated Connectors)

◆ Objective:
  ○ Improve articulated connector casting quality and reliability

◆ A TAG has been formed with CSTCC and suppliers to create:
  ○ M-217 will be the manufacturing and acceptance specification
  ○ M-218 will be a test specification using the draft M-205 (Yoke Test) basic layout
  ○ M-219 will be for reconditioning
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- Questions and answers
Casting Suspension Component Failure Locations

Trailing 1 Year Window, Failures Per Year

1/1/05 1/1/06 1/1/07 1/1/08 12/31/08
Component Failure Example 1

- Break initiated at internal rib
- Initiation site was weld with inclusions
Component Failure Example 2

- Break initiated at internal rib
- Initiation site was likely a torch wash (martensite)
Component Failure Fact Summary

- All were brittle failures (no signs of fatigue) manufactured in 2003 and 2004 - inspection could not identify cracks, there were none
- No full derailments occurred
- Castings met static AAR load requirements
- Casting material met mechanical property requirements
- Some signs of thin walls on casting, but nothing major
- As compared to the previous failure issues, decision on what to do was more difficult, as previous issue components did not meet AAR specifications
- Though martensite was found on some failures, it was allowed at the time – Specifications have been changed since that time, that would have caused these castings to be Re-heat-treated.
Component Failure Risk Assessment

- Data and investigations did not provide CSTCC with a primary cause and therefore no solution
- Undertook a risk assessment this year to provide direction
- Risk Assessment would allow CSTCC to select the lower projected cost of two options:
  - Cost of being passive (15 year NPV of allowing components to remain in service, assuming a number of them would fail each year, and costs are associated with the cleanup)
  - Cost of removing components from service now
Assumptions:

- All castings made in 2003 and 2004 were suspect (11,000 and 22,000 respectively).
- Castings were installed in cars, and those cars were categorized by four levels of hazard based on the commodity being transported.
- Those hazard levels could be associated with the cost of derailment.
- Half of all failures would result in derailment, and product would be released in 9% of all derailments.
Component Failure Risk Assessment

Number of Cars with Suspect Castings (Assumed)
Manufactured in 2003-2004

Number of Cars

Hazard Level of Commodity

- High: 516
- Medium: 992
- Low: 413
- Minimal / None: 14579
Component Failure Risk Assessment

Break Even: Compare the Costs of Being Passive with the Costs of Removing Castings Now.

- Cost of Being Passive - High Hazard Cars
- Cost of Being Passive - Medium Hazard Cars
- Cost of Being Passive - Low Hazard Cars
- Cost of Being Passive - Non Hazard Cars
- Replacement Cost, High Hazard Cars
- Replacement Cost, Medium Hazard Cars
- Replacement Cost, Low Hazard Cars
- Replacement Cost, Non Hazard Cars

Costs ($)

Expected Number of Casting Failures per Year

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CSTCC concluded that we take action if the number of casting failures climbs to four per year

- Then will remove castings from approximately 500 high hazard cars

- CSTCC awaiting decision higher level AAR Committee
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