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

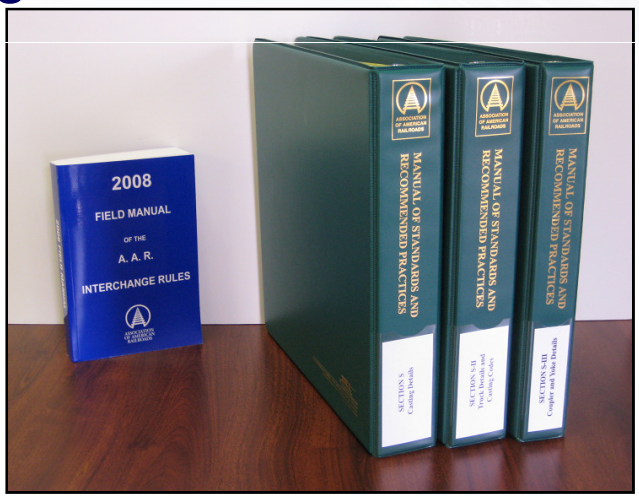
  - **Jon Hannafious** – Committee Manager, AAR/TTCI

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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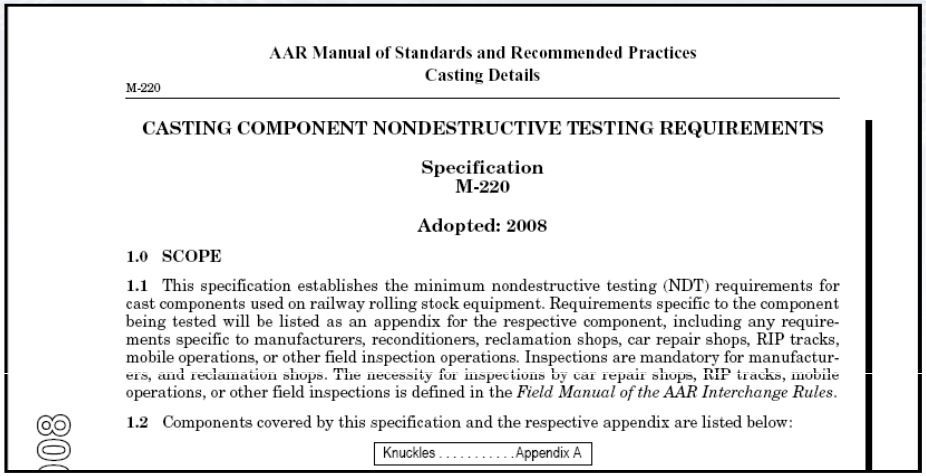
New Specification M-220 (Released September 19, 2008): Casting Component Nondestructive Testing

- 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

M-220 Appendix A: Guidelines & Procedures Magnetic Particle Inspection (MPI) of Railroad Knuckles



AAR Manual of Standards and Recommended Practices
Casting Details
M-220

CASTING COMPONENT NONDESTRUCTIVE TESTING REQUIREMENTS

Specification
M-220

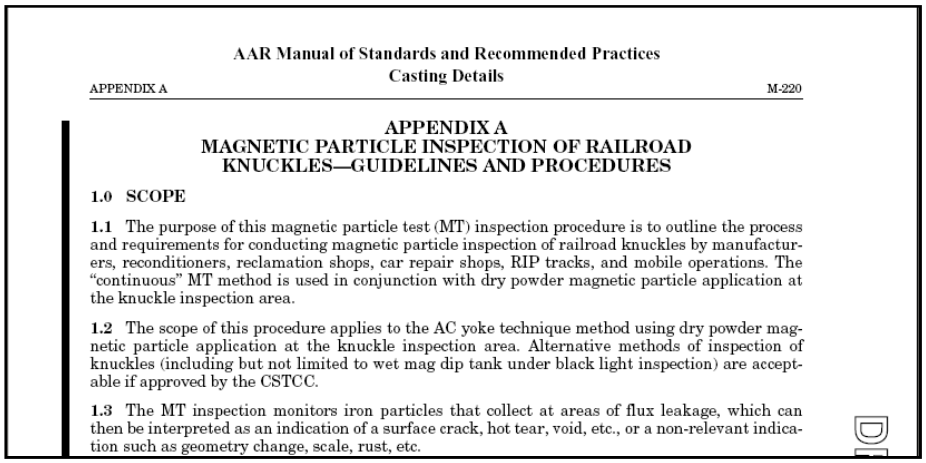
Adopted: 2008

1.0 SCOPE

1.1 This specification establishes the minimum nondestructive testing (NDT) requirements for cast components used on railway rolling stock equipment. Requirements specific to the component being tested will be listed as an appendix for the respective component, including any requirements specific to manufacturers, reconditioners, reclamation shops, car repair shops, RIP tracks, mobile operations, or other field inspection operations. Inspections are mandatory for manufacturers, and reclamation shops. The necessity for inspections by car repair shops, RIP tracks, mobile operations, or other field inspections is defined in the *Field Manual of the AAR Interchange Rules*.

1.2 Components covered by this specification and the respective appendix are listed below:

Knuckles	Appendix A



AAR Manual of Standards and Recommended Practices
Casting Details
APPENDIX A M-220

APPENDIX A
MAGNETIC PARTICLE INSPECTION OF RAILROAD KNUCKLES—GUIDELINES AND PROCEDURES

1.0 SCOPE

1.1 The purpose of this magnetic particle test (MT) inspection procedure is to outline the process and requirements for conducting magnetic particle inspection of railroad knuckles by manufacturers, reconditioners, reclamation shops, car repair shops, RIP tracks, and mobile operations. The "continuous" MT method is used in conjunction with dry powder magnetic particle application at the knuckle inspection area.

1.2 The scope of this procedure applies to the AC yoke technique method using dry powder magnetic particle application at the knuckle inspection area. Alternative methods of inspection of knuckles (including but not limited to wet mag dip tank under black light inspection) are acceptable if approved by the CSTCC.

1.3 The MT inspection monitors iron particles that collect at areas of flux leakage, which can then be interpreted as an indication of a surface crack, hot tear, void, etc., or a non-relevant indication such as geometry change, scale, rust, etc.

- **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

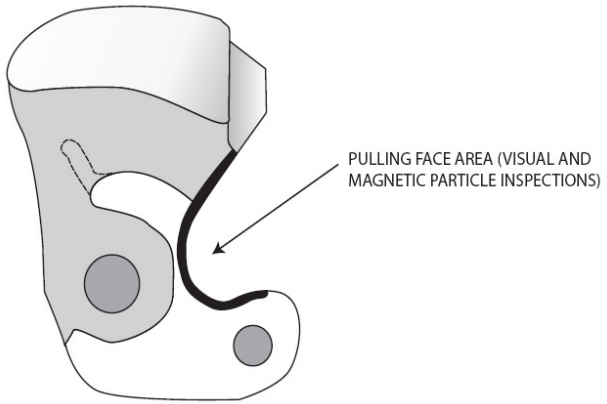


Fig. A.1 Pulling-face area of knuckle

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

M-220: Knuckle Inspection Procedures for Car Repair Shops, RIP tracks, and Mobile Operations

- 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

M-220: Knuckle Inspection Procedures for Car Repair Shops, RIP tracks, and Mobile Operations

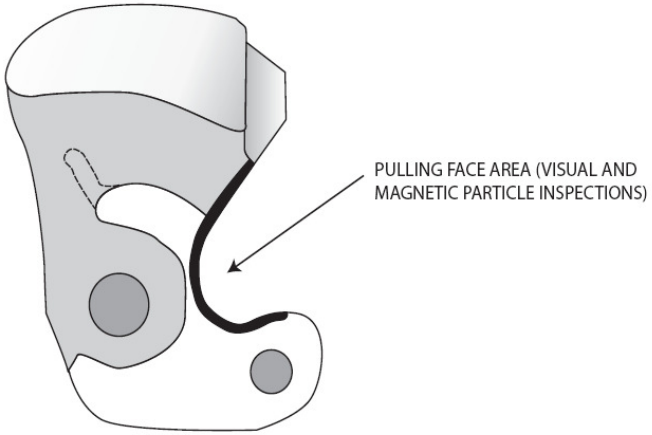


Fig. A.1 Pulling-face area of knuckle

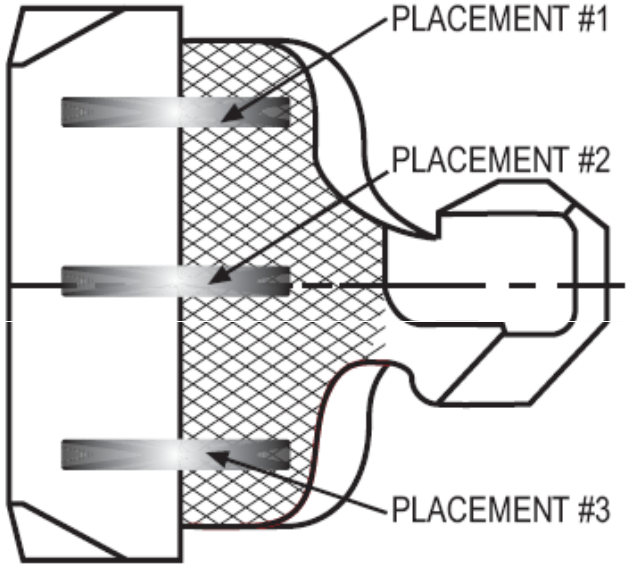


Fig. A.2 Horizontal yoke placement on knuckle

- **Three yoke placements to look for vertical cracks in the pulling face**

M-220: Knuckle Inspection Procedures for Car Repair Shops, RIP tracks, and Mobile Operations

M-220: Knuckle Inspection: Additional Information and Procedures for Manufacturers & Reclamation Shops

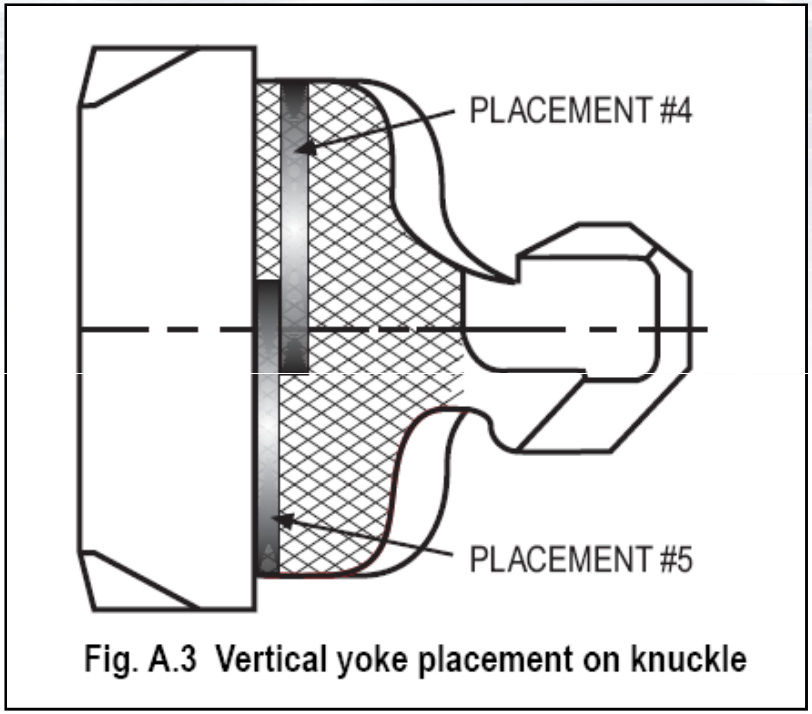


Fig. A.3 Vertical yoke placement on knuckle

- 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

M-220 Magnetic Particle Technique Qualification

- **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

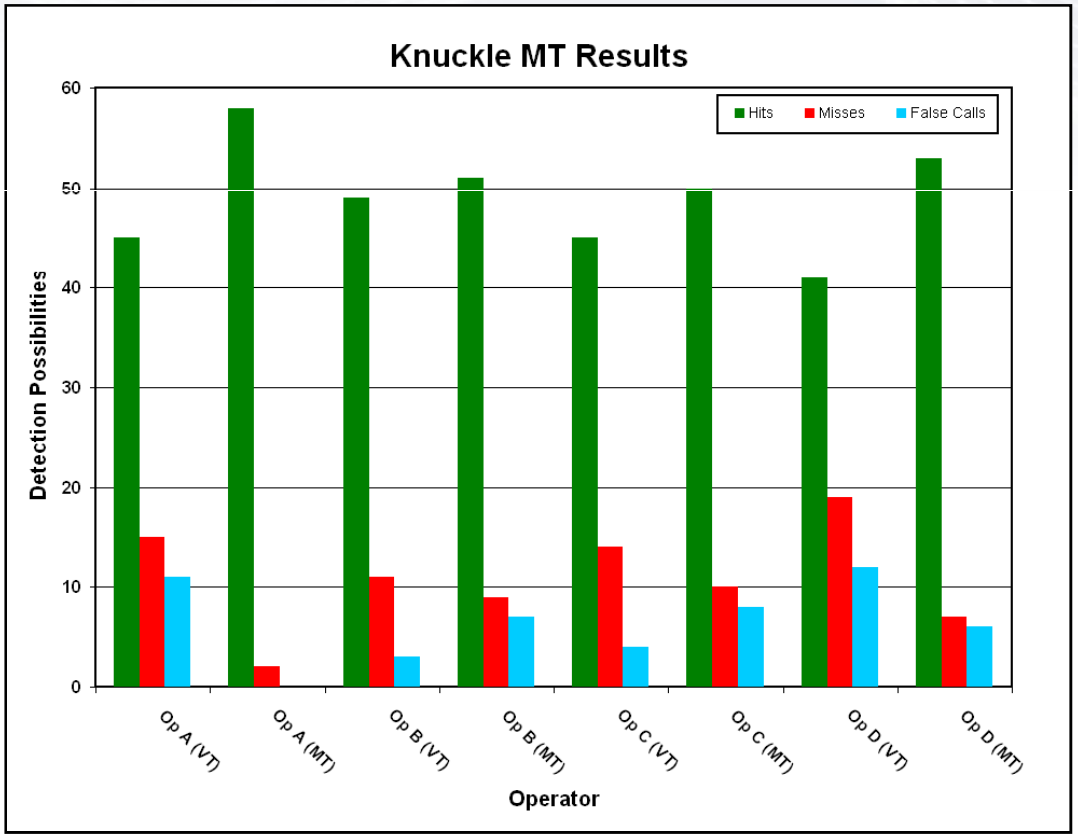
- **TTCI Approach**
  - Provided one day of industry training and one day of inspection (POD subset)
  - Calculated individual and combined PODs

M-220 Magnetic Particle Technique Qualification

60 Knuckles Prepared for Inspection in Shop

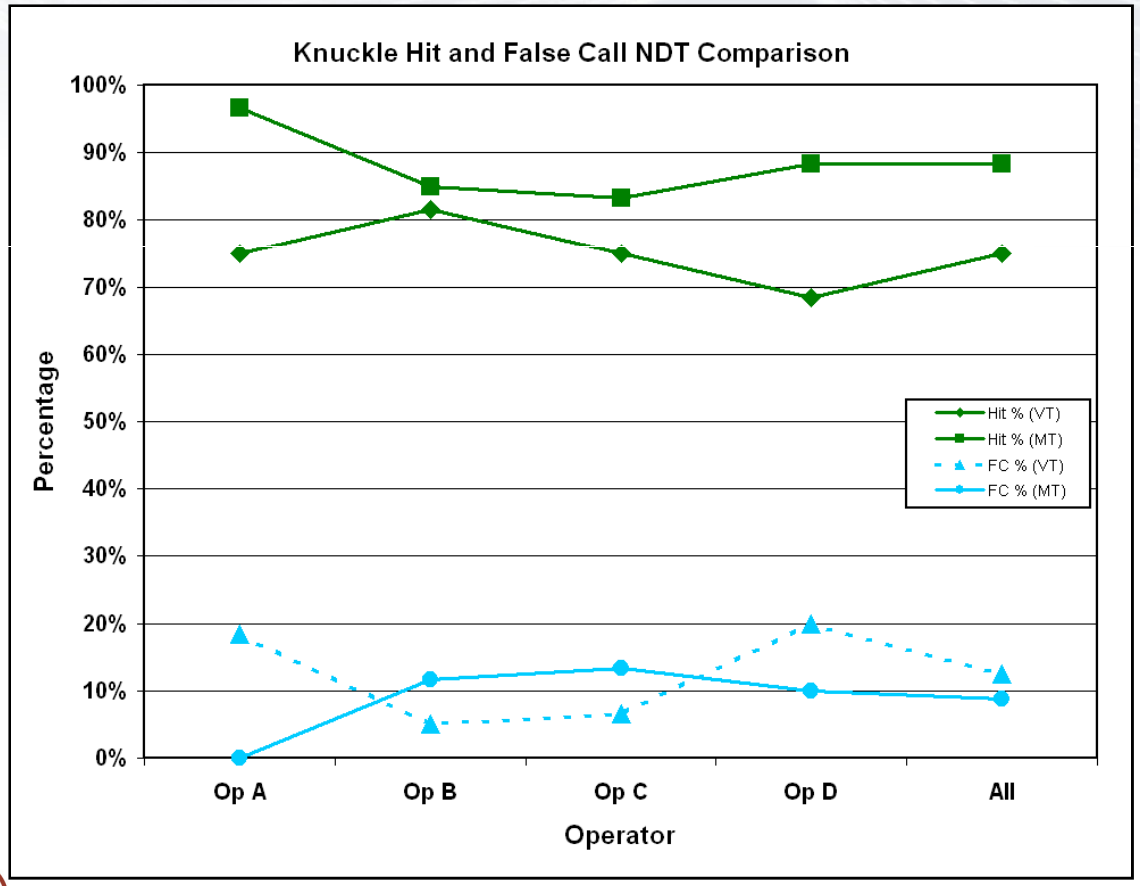
M-220 Magnetic Particle Technique Qualification

- **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**



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- **New Specification M-216: Knuckle Fatigue Test (Moseng)**
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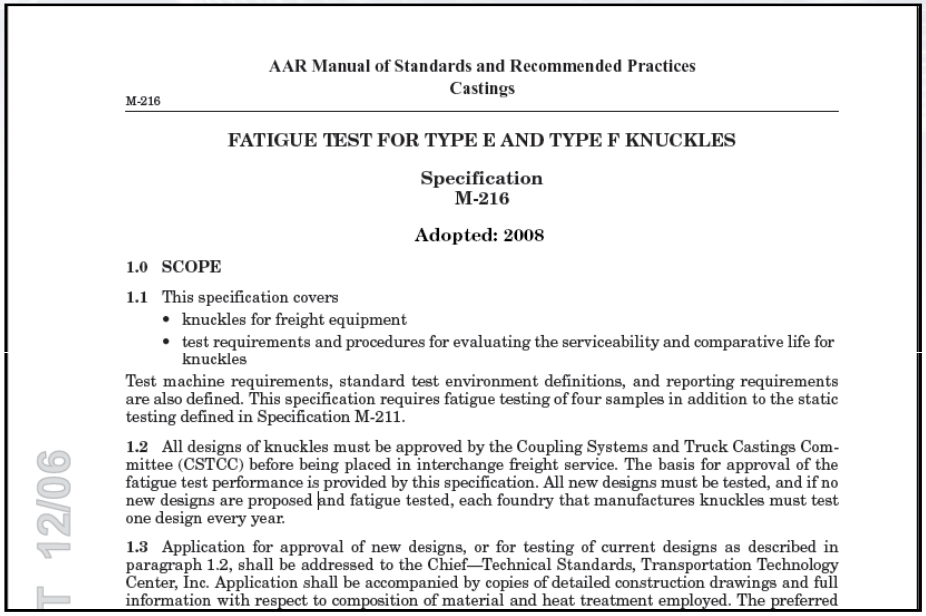
New Specification M-216 Release Planned for 2008

- **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



AAR Manual of Standards and Recommended Practices
Castings

M-216

FATIGUE TEST FOR TYPE E AND TYPE F KNUCKLES

Specification
M-216

Adopted: 2008

1.0 SCOPE

1.1 This specification covers

- knuckles for freight equipment
- test requirements and procedures for evaluating the serviceability and comparative life for knuckles

Test machine requirements, standard test environment definitions, and reporting requirements are also defined. This specification requires fatigue testing of four samples in addition to the static testing defined in Specification M-211.

1.2 All designs of knuckles must be approved by the Coupling Systems and Truck Castings Committee (CSTCC) before being placed in interchange freight service. The basis for approval of the fatigue test performance is provided by this specification. All new designs must be tested, and if no new designs are proposed and fatigue tested, each foundry that manufactures knuckles must test one design every year.

1.3 Application for approval of new designs, or for testing of current designs as described in paragraph 1.2, shall be addressed to the Chief—Technical Standards, Transportation Technology Center, Inc. Application shall be accompanied by copies of detailed construction drawings and full information with respect to composition of material and heat treatment employed. The preferred

T 12/06

- 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

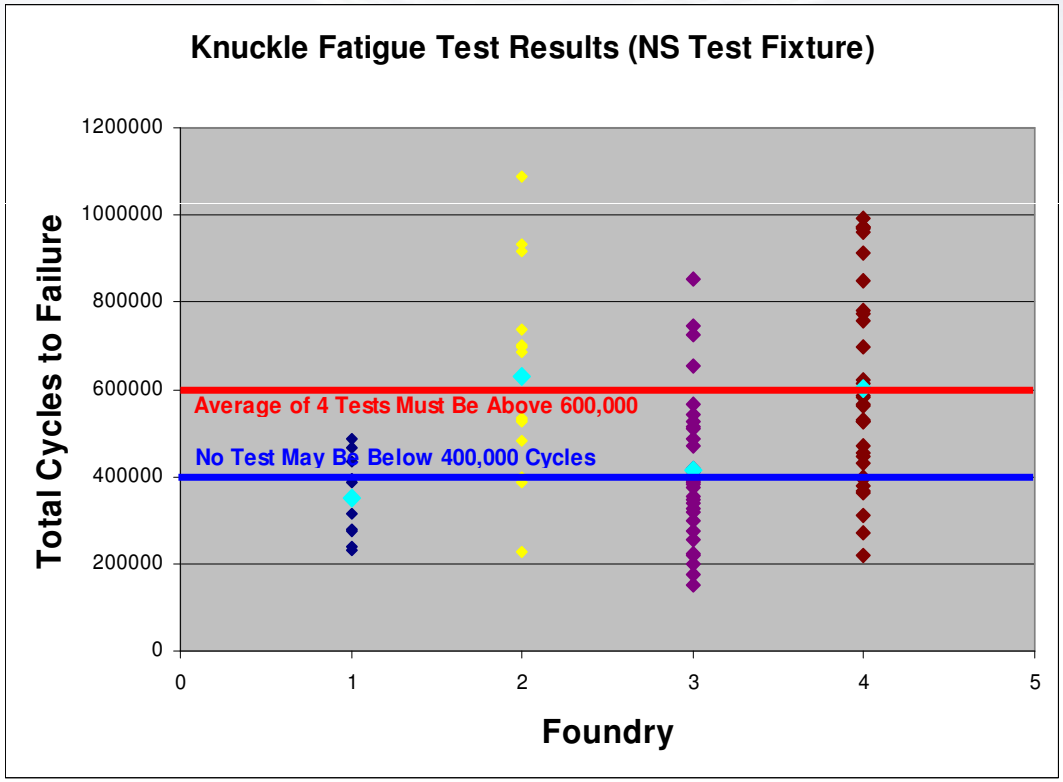
Load Cycles: Repeat to Failure of the Knuckle. 1,058 cycles are equivalent to approx. 1,000 miles

Segment	Number of Cycles (Sinusoidal form)	Total Elapsed Cycles	Cycle Load Range
1	4	4	10 – 300 kips
2	2	6	10 – 280 kips
3	7	13	10 – 260 kips
4	10	23	10 – 240 kips
5	31	54	10 – 220 kips
6	77	131	10 – 200 kips
7	65	196	10 – 180 kips
8	73	269	10 – 160 kips
9	89	358	10 – 140 kips
10	105	463	10 – 120 kips
11	129	592	10 – 100 kips
12	187	779	10 – 80 kips
13	279	1058	10 – 60 kips

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

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

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Modified Specification M-211 – Couplers and Yokes, AAR Approved – Purchase and Acceptance

- 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.

Modified Specification M-214 Side Frames and Bolsters, Used and Reconditioned – Classification and Repair Procedure

- 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

Modified Specification M-205 – Yoke, Coupler – Test Requirements: Objectives

- 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.)

Modified Specification M-212 – Couplers and Yokes, Secondhand – Classification and Reconditioning

- 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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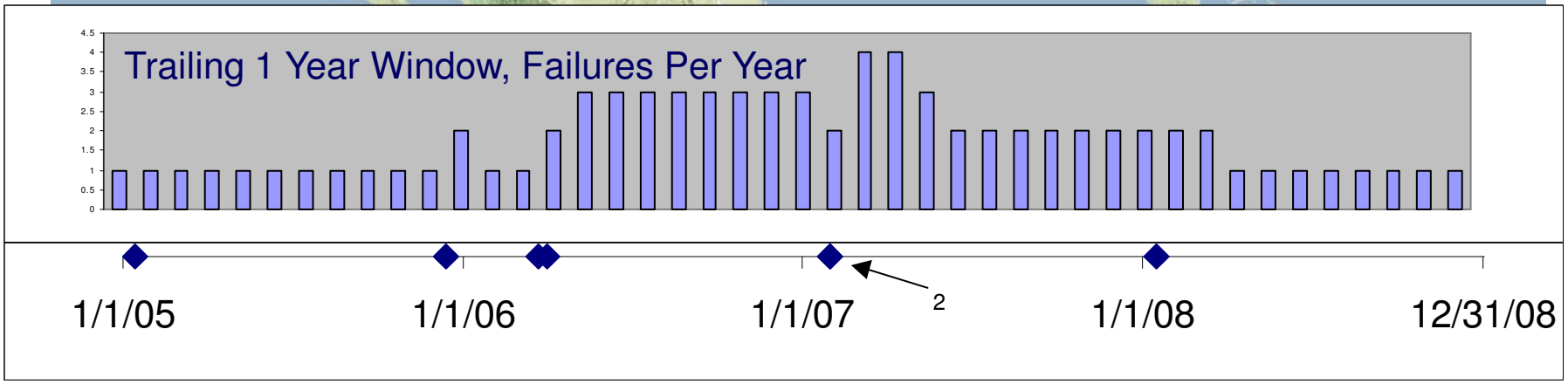
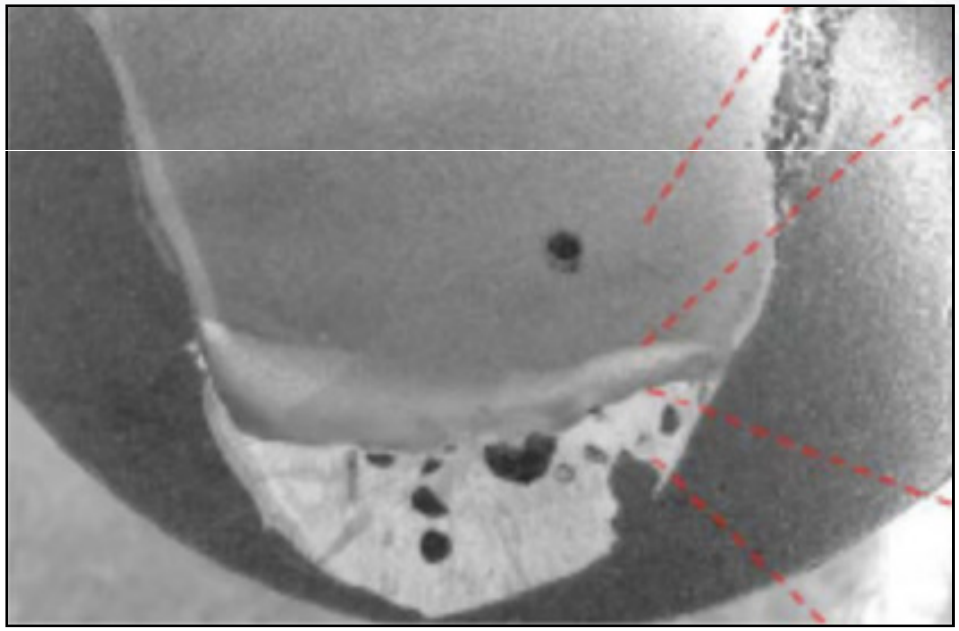
- **Suspension Component Failure (Hannafious)**
- Questions and answers

Casting Suspension Component Failure Locations



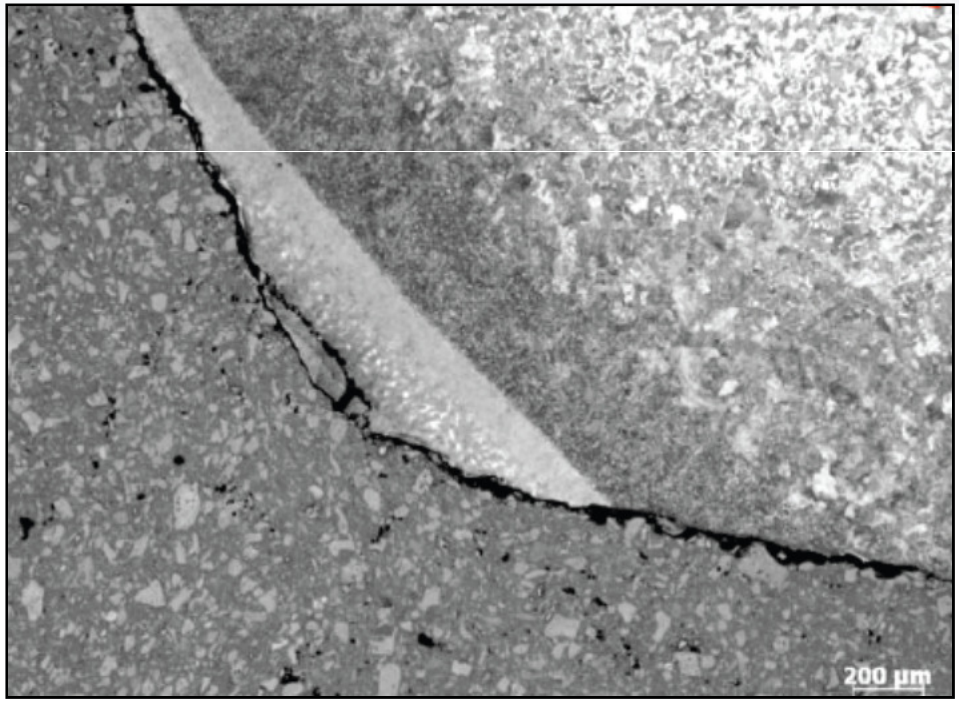
Component Failure Example 1

- 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.

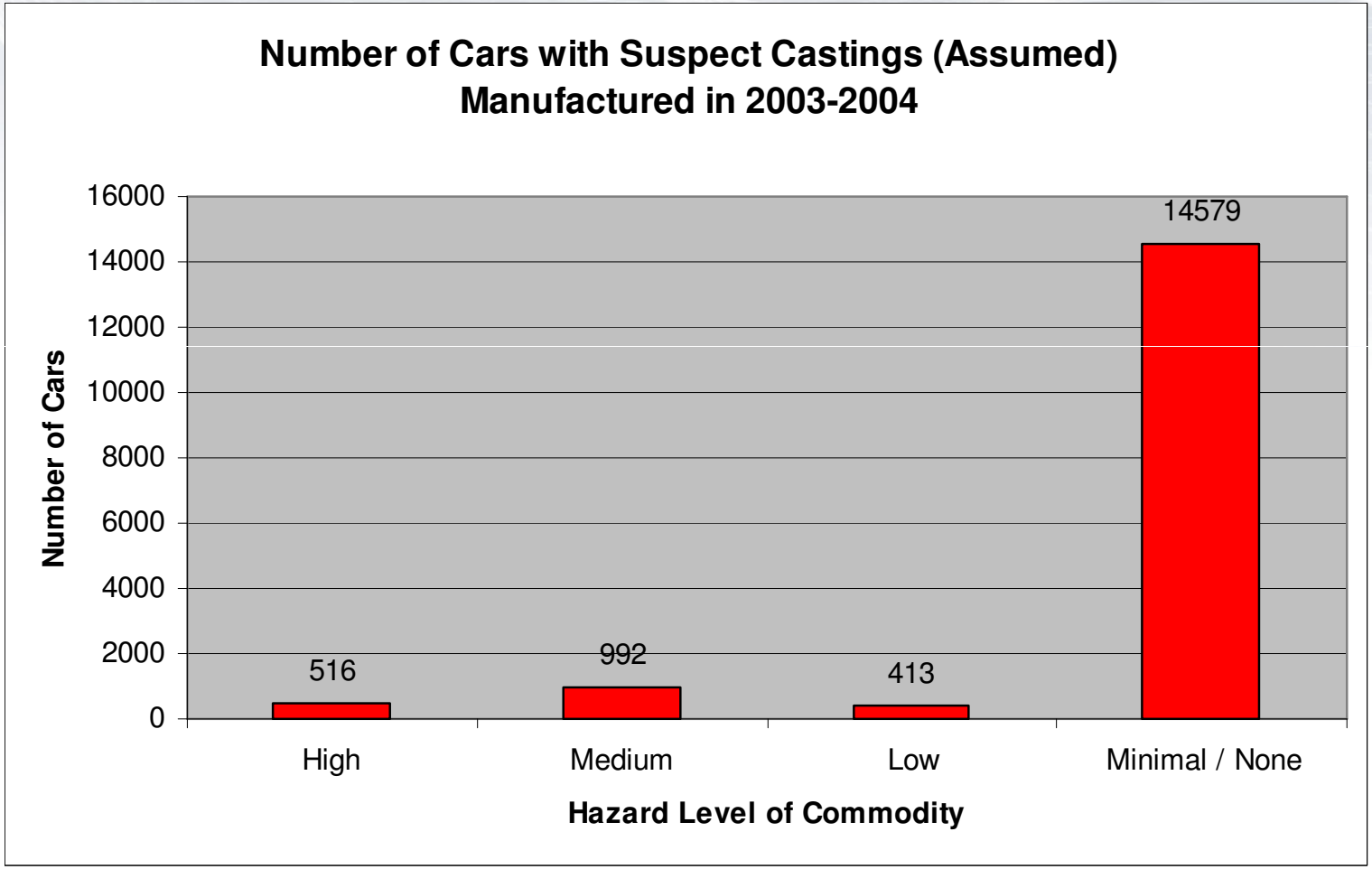
Component Failure Risk Assessment

- 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

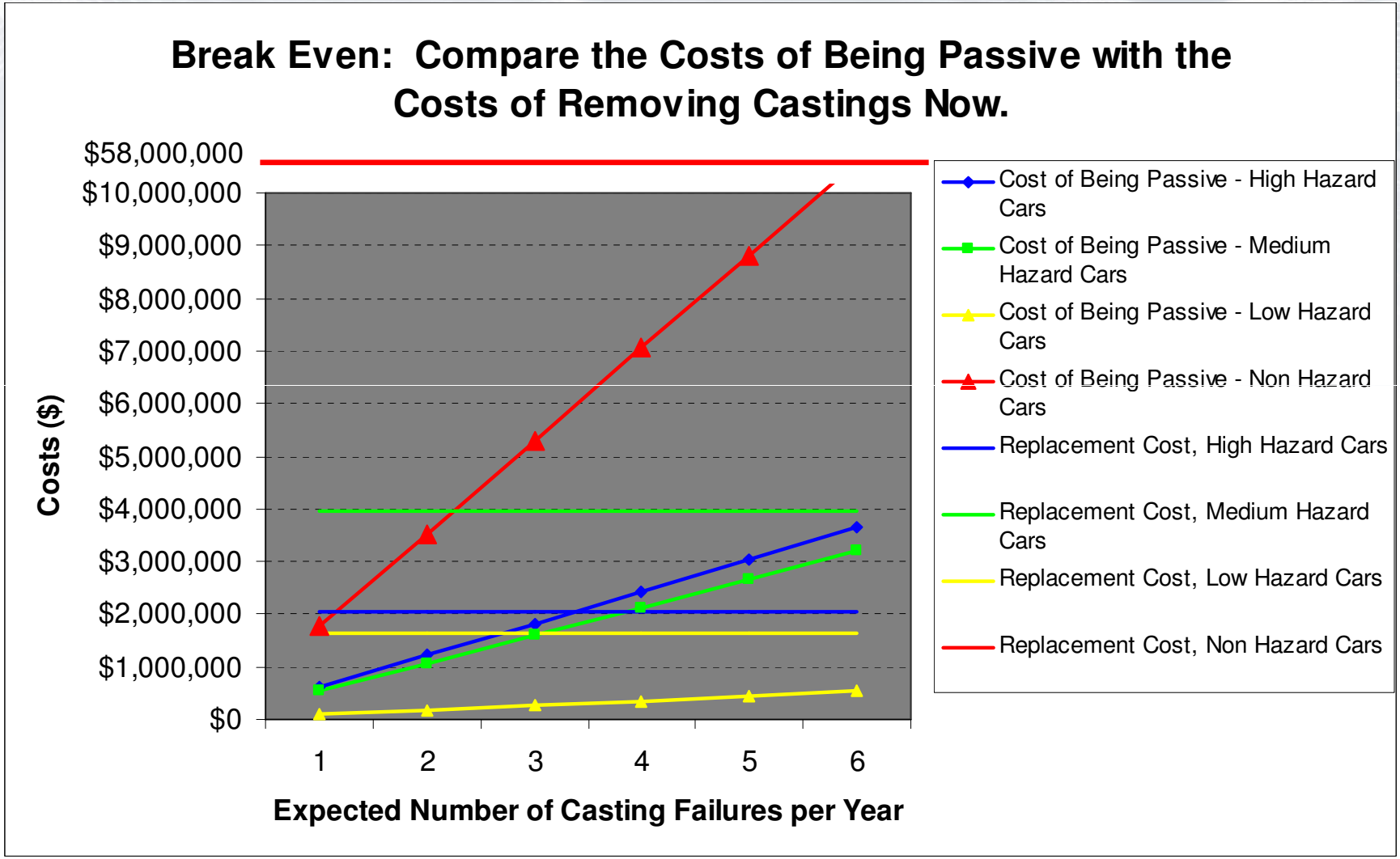
Component Failure Risk Assessment

- 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



Component Failure Risk Assessment



Component Failure - Risk Assessment

- 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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