Failure Progression Modes (FPM)

A Newly Proposed Bearing Failure Mode Identification and Classification System

RBMEC Presentation to
Mechanical Association Railcar Technical Services
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RBMEC Membership

- Roller Bearing Manufacturers Engineering Committee (RBMEC)
  - Brenco, Inc.
  - The Timken Corp.
  - SKF
  - General Bearing Corp.
  - FAG Bearings Corp.
  - NTN Bearing Corp. of America

FPM Presentation Outline

- What are the Failure Progression Modes?
- Why are the Failure Progression Modes Better than the Current System?
  - Accurate
  - Reproducible
  - Ease of Analysis
- Summary of Recommended AAR Document Updates
- Bearing Failure Mode Results

What are the FPMs?

- Bearing Failure Mode Identification and Classification System Developed by Bearing Manufacturers at the Request of Railroads to improve the system
- 13 Modes Represent the Typical Bearing Failure Categories
- Primary Symptoms
- Other Symptoms
- Typical Progression
- Additional Criteria

What are the FPMs?

- **(AD) Adapter**
  - Displaced, Worn, Broken, or Wrong Size Adapter
- **(AP) Application Defects**
  - Installation or Assembly Process
- **(BD) Bearing Destroyed**
  - Unknown Cause, Insufficient Evidence
- **(DS) Displaced Seal**
  - Displaced, Cocked, or Loose Seal
- **(LO) Loose Bearing**
  - Loose Bearing Components
- **(LU) Lubrication**
  - Lubrication Breakdown
- **(MD) Manuf./ Reman./ Recond.**
  - Improper Manufacturing, Remanufacturing or Reconditioning
- **(ME) Mechanical**
  - External Abuse on Bearing
- **(NV) Non Verified**
  - No Evidence of Distress Found
- **(SP) Fatigue Spalling**
  - Material Fatigue or Overloading
- **(TR) Truck Related**
  - Negative Truck Influences
- **(WD) Wheel Defect**
  - Cyclic Impacts Cause Cage Failure
- **(WE) Water Etch**
  - Water Ingress and Raceway Etching

Why the FPMs?

- **Accurate** – Less categories and better defined symptoms yield the correct mode being assigned to each
- **Reproducible** – FPM is more consistent among multiple inspectors and more repeatable when reviewed by individual inspectors
- **Ease of Analysis** – Inspected bearings are presorted by the modes to identify performance trends. Additional detailed information easily accessible from MD11A reports.

Why FPMs? - Accurate

FPM

- 13 Possible Classifications
- Primary and Other Symptoms Limit Crossovers between Modes
- Classifies Modes Instead of Symptoms

Fault Tree (Current)

- 522 Possible Classifications
- Cause of Heat and Initial Defect Qualifiers fit many Failures
- Classifies Symptoms, Not Failure Modes

Why FPMs? - Accurate

Permutations of Initial Defect and Cause of Heat make data analysis confusing. See example below.

Exert from **GII 2.7 MD-11 Reporting**, Helpful Hints …

"2. Heavily spalled or worn cone raceway or worn rollers will cause heavy damage to seal lips. Grease will leak from bearing and foreign matter will enter."

Initial Defect	**Cause of Heat**	**FPM**
CU2	LU1	SP
CN2	LU3	SP
RO2	SE4	SP
CM2	SE4	SP
others …		**SP**

Why FPMs? - Reproducible

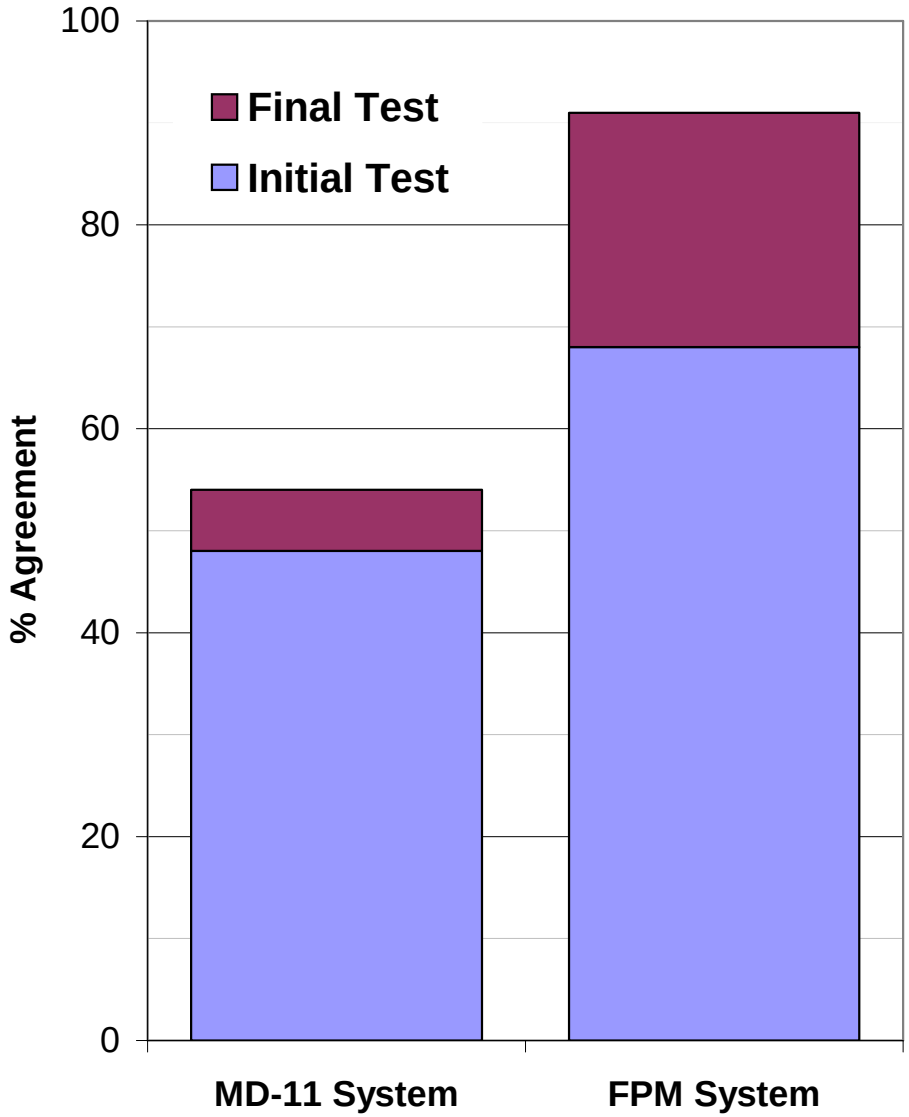
FPM

- 13 Possible Classifications
- Multiple Inspector Agreement >90%
- Dramatic Improvement w/ Review
- Primary and Other Symptoms Limit Crossovers between Modes

Fault Tree (Current)

- 522 Possible Classifications
- Inspector Agreement <50%
- Little Improvement w/ Review
- Cause of Heat and Initial Defect Qualifiers fit many Failures

Why FPMs? - Reproducible



- Multiple Inspectors
- Agreement Improves with Training
- Transferable Data Throughout Industry

Why FPMs? - Ease of Analysis

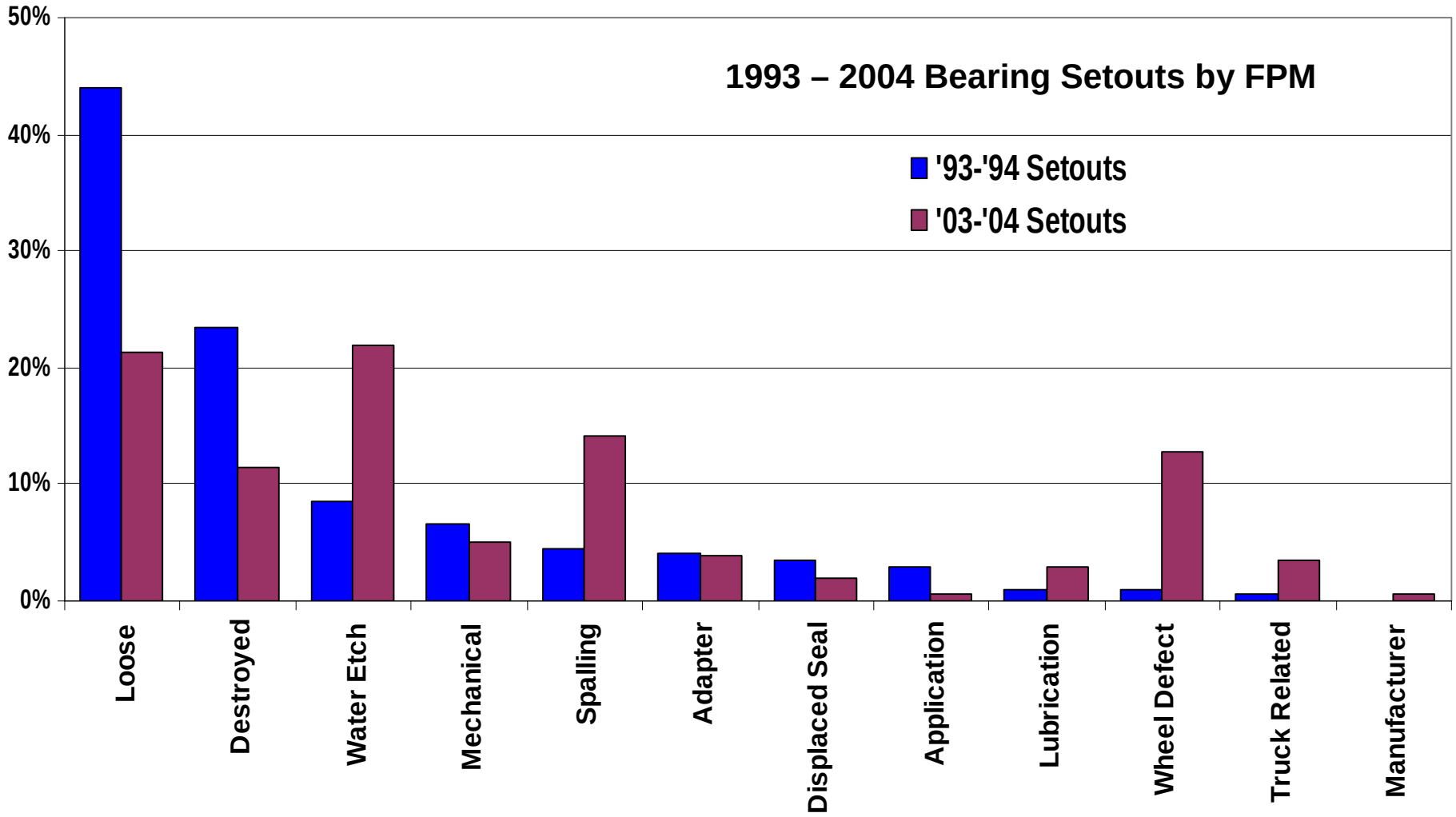
FPM

- Categories Include Probable Contributors
- Non Verified FPM for Detector Accuracy
- Characterizes setouts from ALL detector types
- Identifies New Problematic Trends
- Lends itself to Continuous Improvement

Fault Tree (Current)

- Does Not Include Probable Contributors
- Not Hot, Not Reported
- Designed to review Hot Box setouts only
- Only identifies trends known to exist
- Only identifies resultant internal bearing defects.

Why FPMs? - Ease of Analysis



Summary of Recommended AAR Document Updates

- Revised GII P 2.5.4 through 2.7
- Exchange FPM for Helpful Hints and Flow Chart (Figures 2.1-2.6)
- Exchange revised MD-11 form for current MD-11 form (Figure 4.76)
- FPM and Probable Initial Defects / Contributor Key
- Electronic Submission of MD-11 Form

AAR Detected Roller Bearing Inspection Report

Car Initial / Car Number / Position	Car Type	Journal Size	Date of Failure (Month / Day / Year)	Wheel Tread Defect on Setout Bearing Side
Car Initial ☐☐☐ Car Number ☐☐☐☐☐☐ Position ☐☐	A – Articulated B – Box F – Flat G – Gondola H – Hopper L – Covered Hopper P – Passenger R – Refrigerated S – Double Stack T – Tank X – Locomotive M - Miscellaneous	D – 5 ½ x 10 E – 6 x 11 F – 6 ½ x 12 G – 7 x 12 K – 6 ½ x 9 L – 6 x 8 M – 7 x 9	Month ☐☐ Day ☐☐ Year ☐☐	☐☐ Why Made Code 67, 75, 76, 78, or 11

How Detected	Journal Burn Off	Elastomeric Pad
H – Hot Box A – Acoustic W – Wheel Impact Load Detector T – Truck Performance B – Warm Bearing Trend O – Other ☐	Y - Yes N - No ☐	Y – Yes N – No X - Unknown ☐

Bearing Distressed Verified	Sufficient Field Information Supplied
Y – Yes N – No ☐	Y – Yes N - No ☐

Bearing Inspection Report – Completer for any Roller Bearings Verified to be Distressed

	Defective Bearing	Mate Bearing (If Appropriate)
Certificate Number	☐☐☐	
Date Cup Manufactured	Month ☐☐ Year ☐☐	Month ☐☐ Year ☐☐
Mounting Information	Company Mark ☐☐☐ Shop Code ☐☐ Month ☐☐ Year ☐☐	Company Mark ☐☐☐ Shop Code ☐☐ Month ☐☐ Year ☐☐
Last Reconditioning	Company Mark ☐☐☐ Shop Code ☐☐ Month ☐☐ Year ☐☐	Company Mark ☐☐☐ Shop Code ☐☐ Month ☐☐ Year ☐☐
Times Cup Reconditioned	☐ 0-1-2-3-4	☐
Lubrication	☐☐☐ NFL or FL	
Screw Seal Ring Present	☐ Y – Yes N – No	☐
Seal Manufacturer & Date	Company Code ☐☐ Month ☐☐ Year ☐☐	01 – Timken 06 - Koyo 10 – Brenco DDL 02 – SKF 07 – FAG 11 – Brenco ST212 03 – Brenco 08 – Other 12 – Hyatt 04 – NTN 09 – Tim HDL 13 – 05RBI
Date Cones Manufactured	I Month ☐☐ Year ☐☐ O Month ☐☐ Year ☐☐	I Month ☐☐ Year ☐☐ O Month ☐☐ Year ☐☐
Cage Type	☐ M – Metallic O – Other	☐

Root Cause of Bearing Distress, Failure Mode Reporting

Failure Progression Mode (FPM) ☐☐

AD – Adapter Displaced/ Worn/ Broken	MD – Manufacturer/ Remanufacturer / Reconditioner Defects
AP – Application Defect	NV – Non Verified Setout
BD – Bearing Destroyed, Undetermined	SP – Fatigue Spalling
DS - Displaced Seal	TR – Truck Related
LO – Loose Bearing Failure	WD – Wheel Tread Defect
LU – Lubrication	WE – Water Etch
ME – Mechanical	

Reporting Railroad Mark	Report Must be Sent to:
☐☐☐☐ Investigating Officer _____	AAR WABL Committee Coordinator Email wabl@aar.com Facsimile 719 585 1895 Mail Transportation Technology Center Inc. P.O. Box 11130 Pueblo, Colorado 81001

Bearing Failure Mode Results
from Confirmed Hot Bearings

	2001	2002	2003	2004	Ave.	Yrs.
Loose Components	26%	27%	23%	20%	23%	*14.8*
Water Etch	13%	20%	18%	25%	20%	12.9
Wheel Defect	16%	13%	13%	13%	13%	9.5
Spalled Components	10%	9%	14%	15%	13%	8.6
Bearing Destroyed	17%	9%	12%	11%	12%	11.3
Mechanical Damage	7%	9%	7%	4%	6%	9.2
Lubrication Breakdown	4%	5%	3%	3%	4%	8.3
Displaced Adapter	4%	5%	3%	5%	4%	7.8
Displaced Seal	4%	3%	2%	2%	3%	6.5
Truck Related	0%	0%	5%	2%	2%	3.2
Application Defect	0%	0%	0%	1%	0%	5.1
Manufacturer's Defect	0%	0%	0%	1%	0%	2.7

Specific AAR Why Made Codes

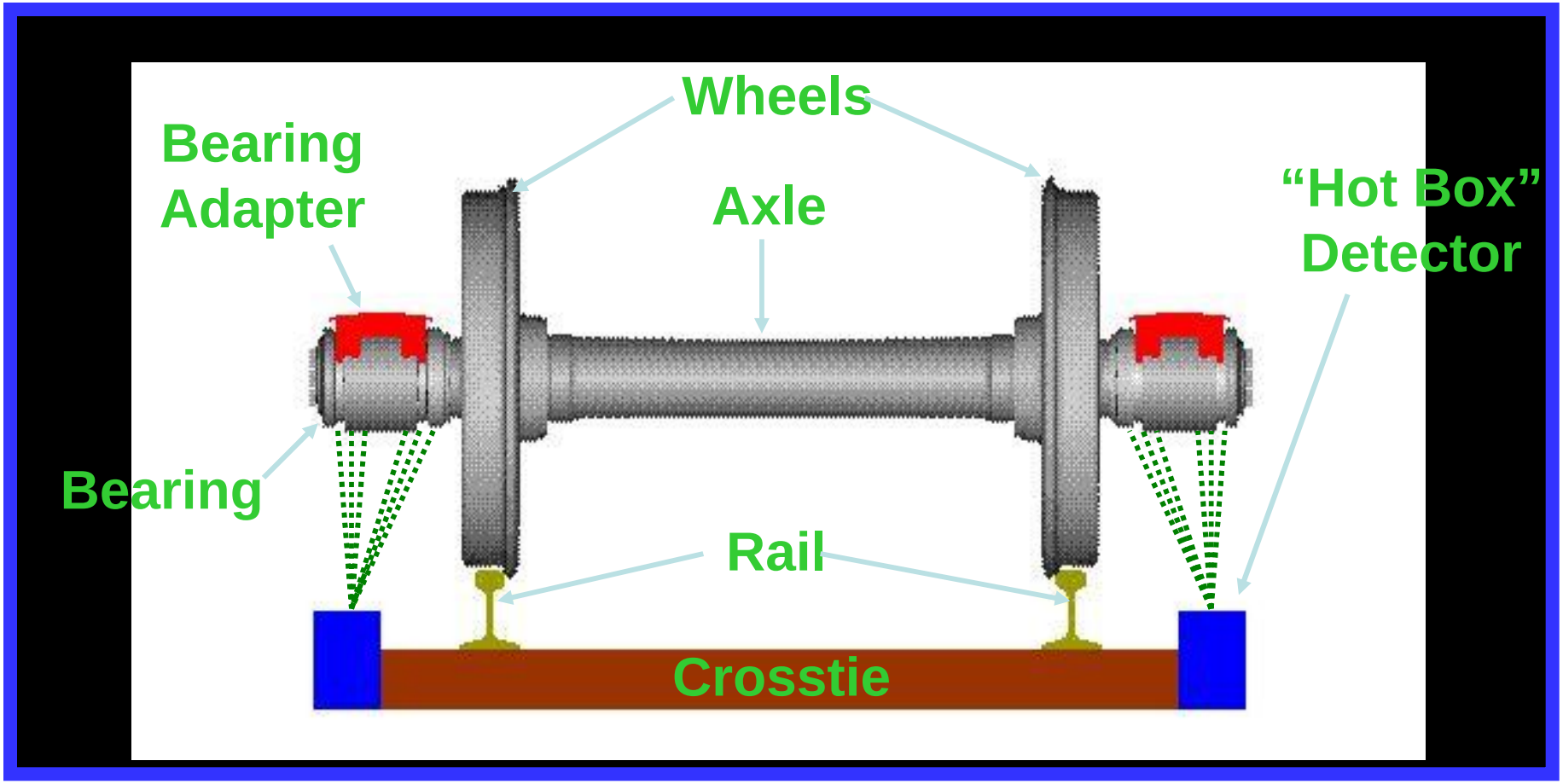
Bearing Related Why Made Codes

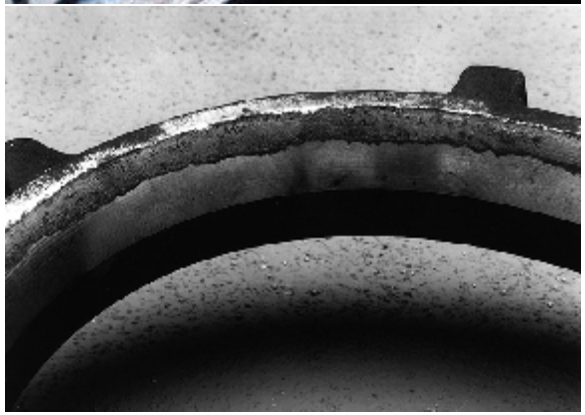
02 = Broken (including cracked)
03 = Missing
04 = Defective
05 = Bent
08 = Wrong (not standard to car)
31 = Fire or heat damage
32 = Submerged
33 = Derailment damage
50 = Roller bearing overheated
92 = Loose or missing cap screws, or other part
93 = Seal loose or cocked out of position
94 = Welding arcing damage
95 = Roller bearing fused due to overheating
97 = Loose backing ring
99 = Damaged seals

Wheel Related Why Made Codes

61 = 80-90 kips wheel as detected by wheel impact detector
65 = High impact wheel as detected by wheel impact detector
67 = Wheel out-of-round detected by gage
75 = Tread shelled
78 = Tread slide flat

Railroad Wheel Set
Typical Bearing Detection





(LO) Loose Bearing Failure: 23%

Hot Bearing Caused by Loose Bearing Components

Primary Symptom

- Journal groove ≥ 0.060” deep from a spun cone

Other Symptoms

- Loose (or missing) Cap screws (<50% of initial torque on average)
- Loose backing ring
- Journal wear ring groove ≥ .010”
- High Lateral ≥ .030”
- Spun cone (highly polished cone bore)
- Small end roller or raceway spalling
- Cone back face wear ≥ .005”
- Opposite cone from spun cone destroyed (spalling, smearing, etc.)
- O’Rings present
- Inboard wear ring has nose chips on inner diameter

Typical Progression

- Low initial clampload, low interference fit, or heavy loading for a long time
- Loss of lateral clampload due to axle flexure, initial oversized cone bore, or undersized journal
- Loss of cone fit; leading to loose cone; leading to point loading of opposite race at small end of the rollers and cup race small end
- Opposite cone and race continue to fatigue – rollers finally skew resulting in obstruction
- Spun cone now takes full load and is destroyed in similar fashion

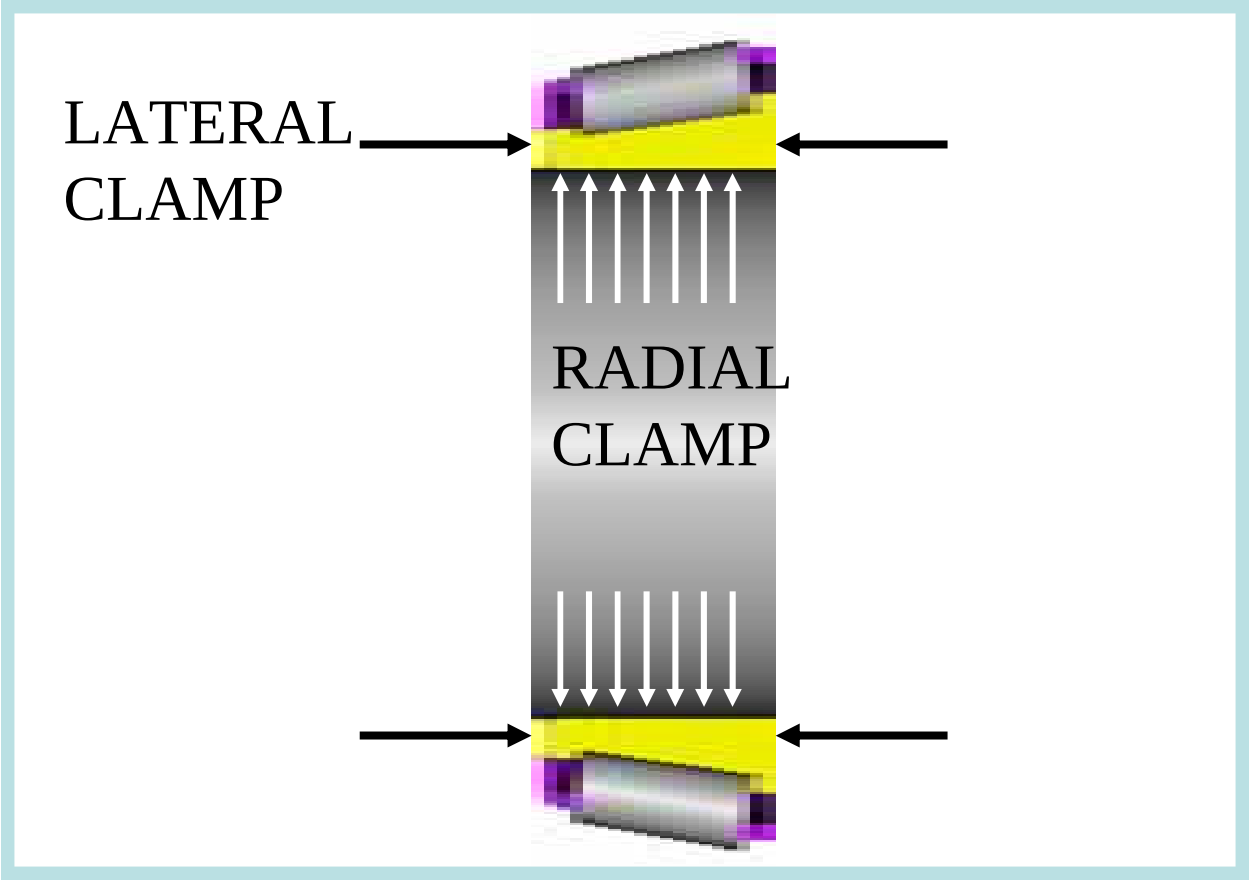
Additional Criteria

Contrary symptoms that may exist:

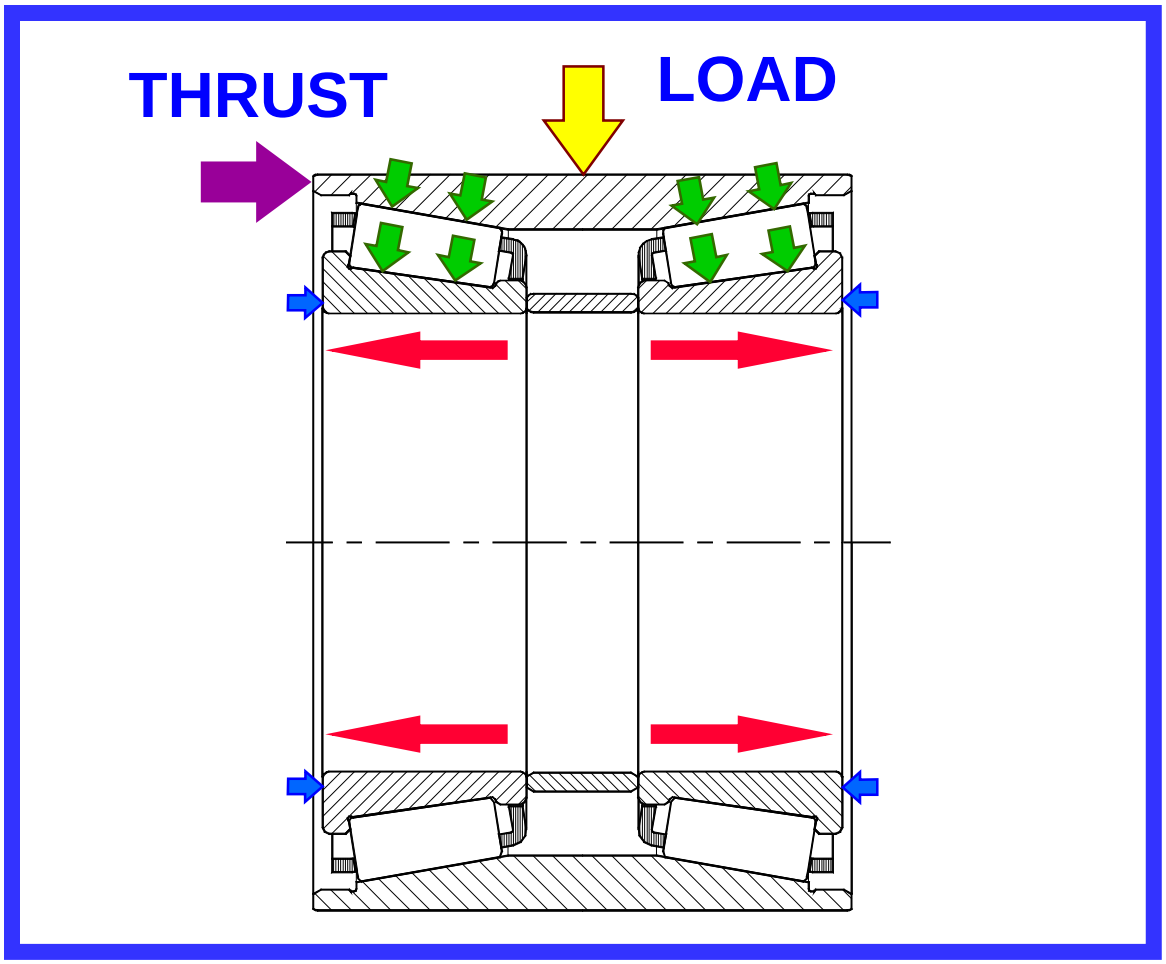
- water etch due to displaced seal
- fragment indentation
- wheel defects with no broken cage

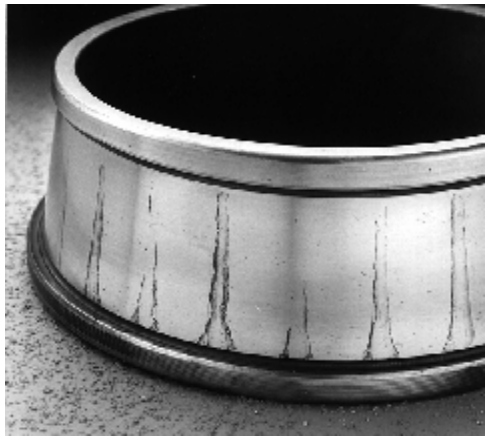
Despite these contrary symptoms, the preponderance of evidence makes this a loose bearing failure.

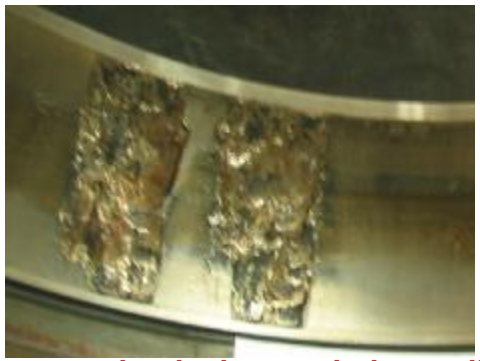
Bearing Clamp



Axle and Thrust Loading







(WE) Water Etch; 20%

Bearing Distress due to Water Ingress and Raceway Etching

Primary Symptom

- Both setout and mate bearing have *Condemnable* etching on races or rollers (as defined in this mode.)

Other Symptoms

- Should be evidence of *Condemnable* etching on the rollers or races to be classified a water etch failure.
- Etching to races or rollers is *Condemnable* if (all should be satisfied):
  - Etch depth can be caught with a 0.010” feeler gage
  - Etch occurs at irregular intervals (less than a roller width apart)
- Rusty bearing parts (cage, spacer, rolling components)
- Bar line water etch spalling (Water etch spalling is often deeper at the edges)
- Water or moisture in grease (grease described as thin or tar like)
- High lateral (≥ 0.030”)
- Severe pitting on cup race edges
- Evidence that cars have been flooded

Typical Progression

- Ingress of moisture and/or contamination
- Roller end scoring
- To race and or roller etching
- To race and or roller spalling
- To cage wear and/or failure
- To skewed rollers
- To race smearing
- To Heat

Additional Criteria

Staining and light etching (no depth) that could have occurred after service should **NOT** be considered.

Contrary symptoms that may exist:

- Loose stack
- Brinelling of raceways
- Broken cage (not associated with wheel condition)

Despite the presence of these contrary symptoms, the preponderance of evidence makes this a water etch failure.

(WD) Wheel Tread Defect; 13%

Bearing Distress Caused by a Wheel Tread Defect

Primary Symptom

- Out of round (OR) ≥0.070" or multiples ≥ 0.050" or wheel impact detection ≥ 90 kips with broken cage

Other Symptoms

- Condemnable Shelling (wm75), tread build up (wm76), out-of-round (wm67), or slid flat (wm78)
- Broken cage
- Skewed rollers
- Smearing races and rollers
- Transfer of roller, race, or cage material

Typical Progression

- Starts with wheel tre ad defect
- Impacts cause cage to break
- Rollers become skewed
- Smearing of races and rollers begins
- Transfer of material
- To seized bearing or excessive heat

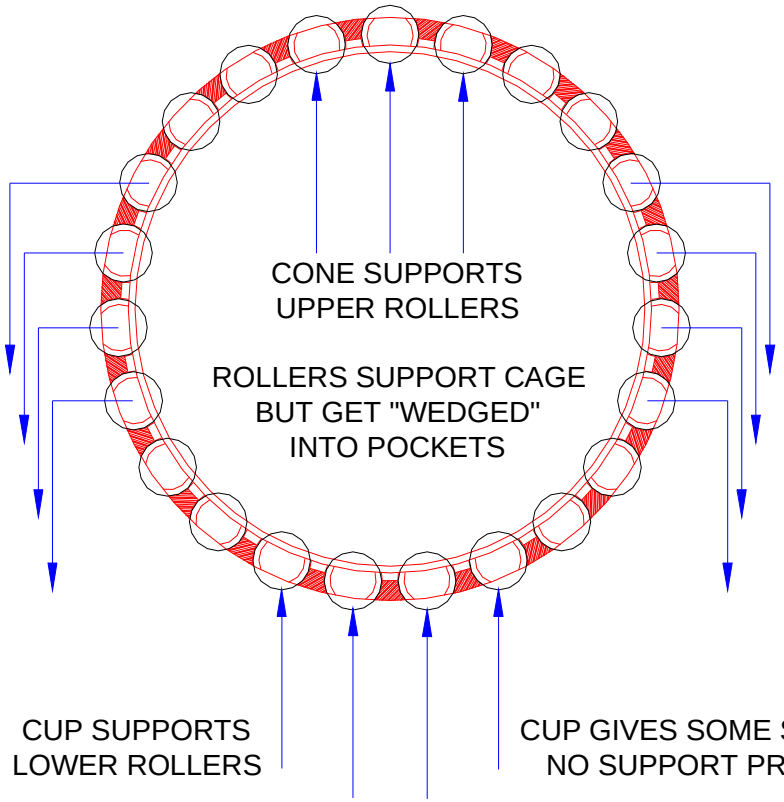
Additional Criteria

Contrary symptoms that may exist:

- Average cap screw torque ≤ 50%
- Cone back face wear ≥0.005
- Water etch
- Light brinelling

Despite these contrary symptoms, the majority of evidence points to a wheel tread defect failure.

Cage Impact Loads



CONE SUPPORTS
UPPER ROLLERS

ROLLERS SUPPORT CAGE
BUT GET "WEDGED"
INTO POCKETS

SIDE ROLLERS
VERTICALLY SUPPORTED
BY CAGE BARS ONLY

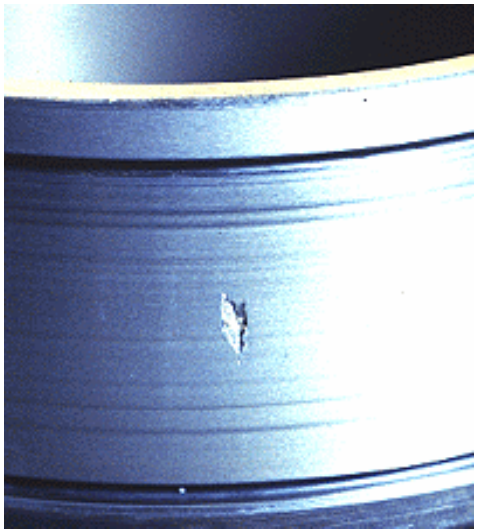
WHEEL IMPACTS CREATE
HIGH ROLLER LOADS THAT
CAGE MUST SUPPORT

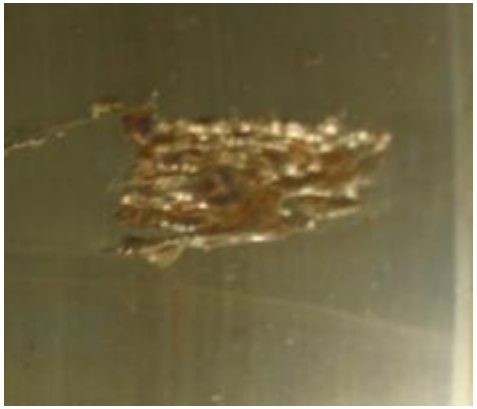
CUP SUPPORTS
LOWER ROLLERS

CUP GIVES SOME SUPPORT TO CAGE LARGE END
NO SUPPORT PROVIDED TO CAGE SMALL END

Steel Cage Failures Resulting From Wheel Impact Loads

Polyamide Cage Failures Resulting From Wheel Impact Loads





(SP) Fatigue Spalling; 13%

Bearing Distress Caused by Material Fatigue Spalling

Primary Symptom

- None

Other Symptoms

- Bearing geometry appears to be good
- Cyclical fatigue spalling of rollers or races
- Component with significant service life
- No water etch, impact or other bar line spalls present
- No point loading from worn, displaced, or wrong adapter
- Raceway that shows fatigue has repaired spalls
- Raceway that shows fatigue has been reground
- HAL (heavy axle loading) Car, 286,000+ lbs on Class F bearing
- Repaired spall that has propagated

Typical Progression

- Intermittent spalls of various sizes around roll track or race
- Spalls appear to originate near center of either race or roller
- Spalls propagate
- Race and/or rollers smear
- Heat

Additional Criteria

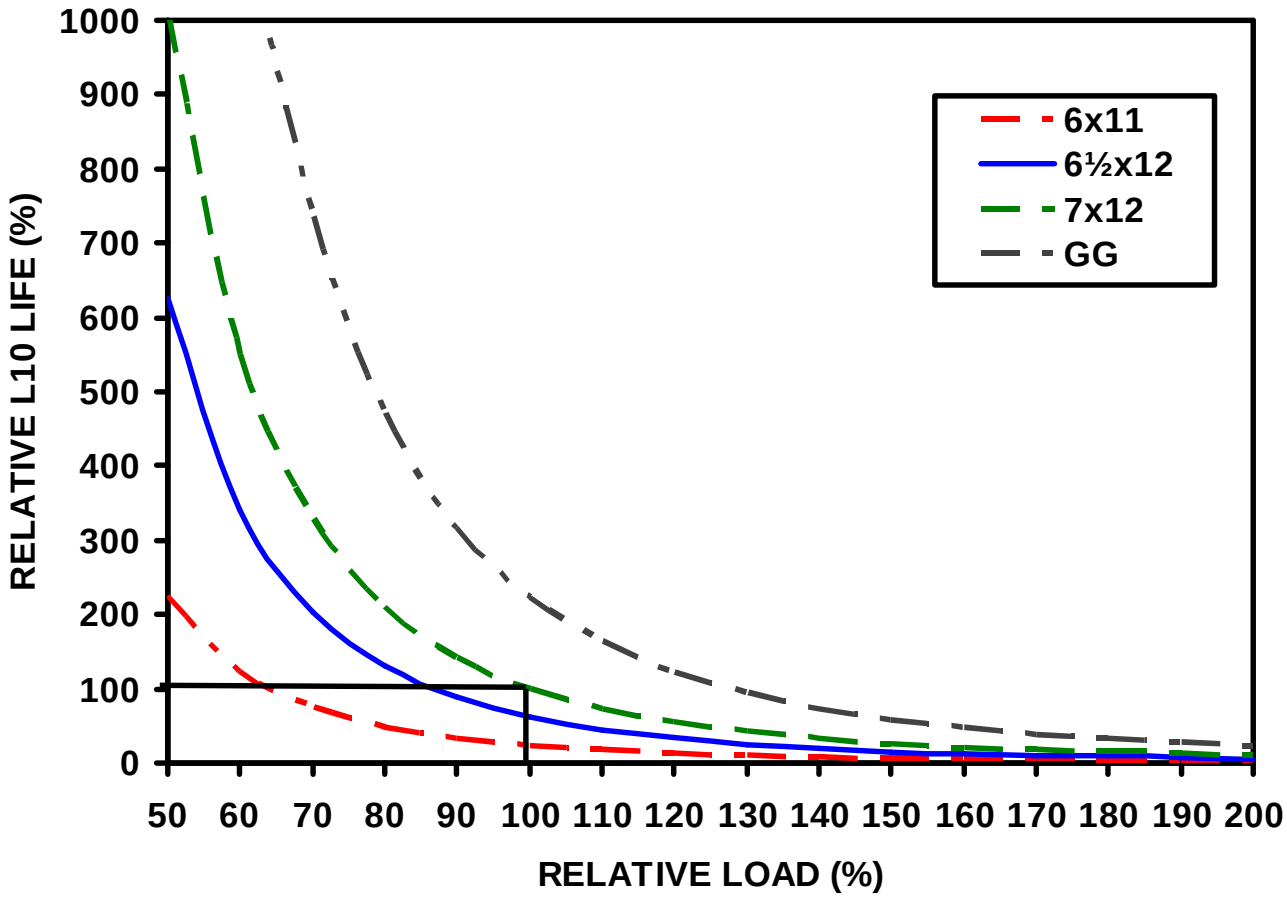
As defined by this Mode, fatigue spalling does **NOT** originate from:

- Water etch
- Impact brinells
- Uneven loading (from loose components, adapter, or truck
- Lubrication loss or breakdown

Fatigue spalling **CAN** originate from:

- Defects in the steel
- Severe or heavy loading (stresses exceeding the strength of the material)
- Reground or repaired raceways

L_{10} Life / Fatigue Spalling



Fragment Indentation Resulting from Spalled Components

(BD) Bearing Destroyed, Undetermined; 12%

Obviously Distressed Bearing with Unknown Cause

Primary Symptom

- Bearing should be considered a Destroyed/Undetermined if there is **NO** definitive indication in the mate or hot bearing as to the cause of failure.

Other Symptoms

- Bearing destroyed, no evidence in mate or hot
- Fused to journal (no pull) no evidence in mate

Typical Progression

- Unknown source of heat
- Heat destroys bearing components
- Bearing components fuse to one another or journal

Indicators for common Failure Modes of destroyed bearings

(For pulled, no-pull, or burn off destroyed bearings, satisfaction of any one criteria lead to the failure mode listed. Note that the failure is not limited to the modes listed, any Failure Mode can be assigned to a burn off or destroyed bearing given proper evidence.)

(LO) Loose

- Cone seat groove on the setout side is > 0.060" (even if wheel defects are present)
- Spun inboard wear ring on setout bearing
- Setout or mate display 3 or more indications of loose bearing
  - average cap screw torque < 50%
  - cone back face wear > 0.005"
  - loose backing ring
  - turned cone (journal grooved < 0.060")
  - seal cap o-rings present
- Mate or setout journal is undersized, no wheel defect is found and the bearing has been in service longer than 4 years(from mount date)
- Bearing can only be partially pulled from journal (1-3"), suggesting that a cone has dropped into a turned journal seat.

(WD) Wheel Defect

- Wheel defects are present, (flat spot out of round wheel) > .070" ,multiples greater than 0.050", or wheel impact detection ≥ 90 kips on the setout side

(WE) Water Etch

- Mate bearing has water damage (e.g. heavy rust in EC, BR or WR, water etch on races or rollers, etc.)

(ME) Mechanical

- Mate bearing has heavy brinelling (condemnable)
- Mate bearing or wheel has other evidence of derailment or impact damage

(TR) Truck Related

- Mate bearing shows symptoms of overloading from truck
- Opposite truck wheelset is available and shows signs of overloading from truck

(ME) Mechanical; 6%

Bearing Distress Caused by External Abuse

Primary Symptom

- None

Other Symptoms

- AAR condemnable Brinelling of raceways (use AAR brinell gage)
- External heat (thaw shed, torch, etc.)
- Cup fractures that occurred in service (not caused in wheel garden after service)
- Evidence of minor/ major derailment damage
- Fluting or electrical arcing
- Foreign substances wrapped around or pulled into bearing
- Damaged or dented seals (not from adapter)
- Impact Spalling

Typical Progression

- Physical abuse to bearing
- Seal damage
- Loss of lube
- Heat generation

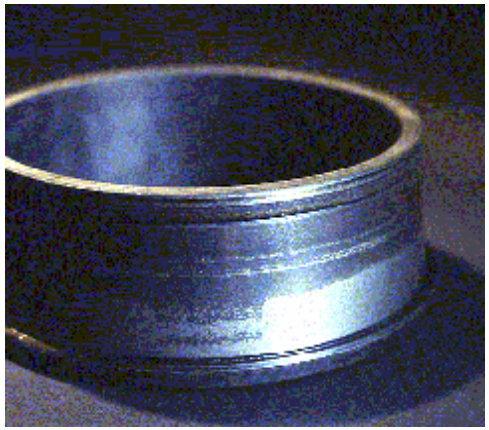
- Rough car handling
- Brinelling of roll tracks (cup and/or cones)
- Spalling originating from brinells (impact spalling)
- Spalls propagate
- Heat generation

Additional Criteria

Any external source of abuse that leads to bearing distress.

(LU) Lubrication; 4%

Bearing Distress Due to Lubrication Break Down



Primary Symptom

- None

Other Symptoms

- Loss of grease noted, without other defects
- Grease is thin and runny or tar like (dramatic change in consistency)
- Roller end scoring
- Races and rollers blue in color (evidence of heat)
- Race and roller smearing, peeling
- Build up of moist road grime on the end cap/ backing ring
- Polished races
- “Burnt” smell to grease
- Pocket bars heavily worn (possibly broken)
- Spalling of cone back rib (no other evidence of spalling)

Typical Progression

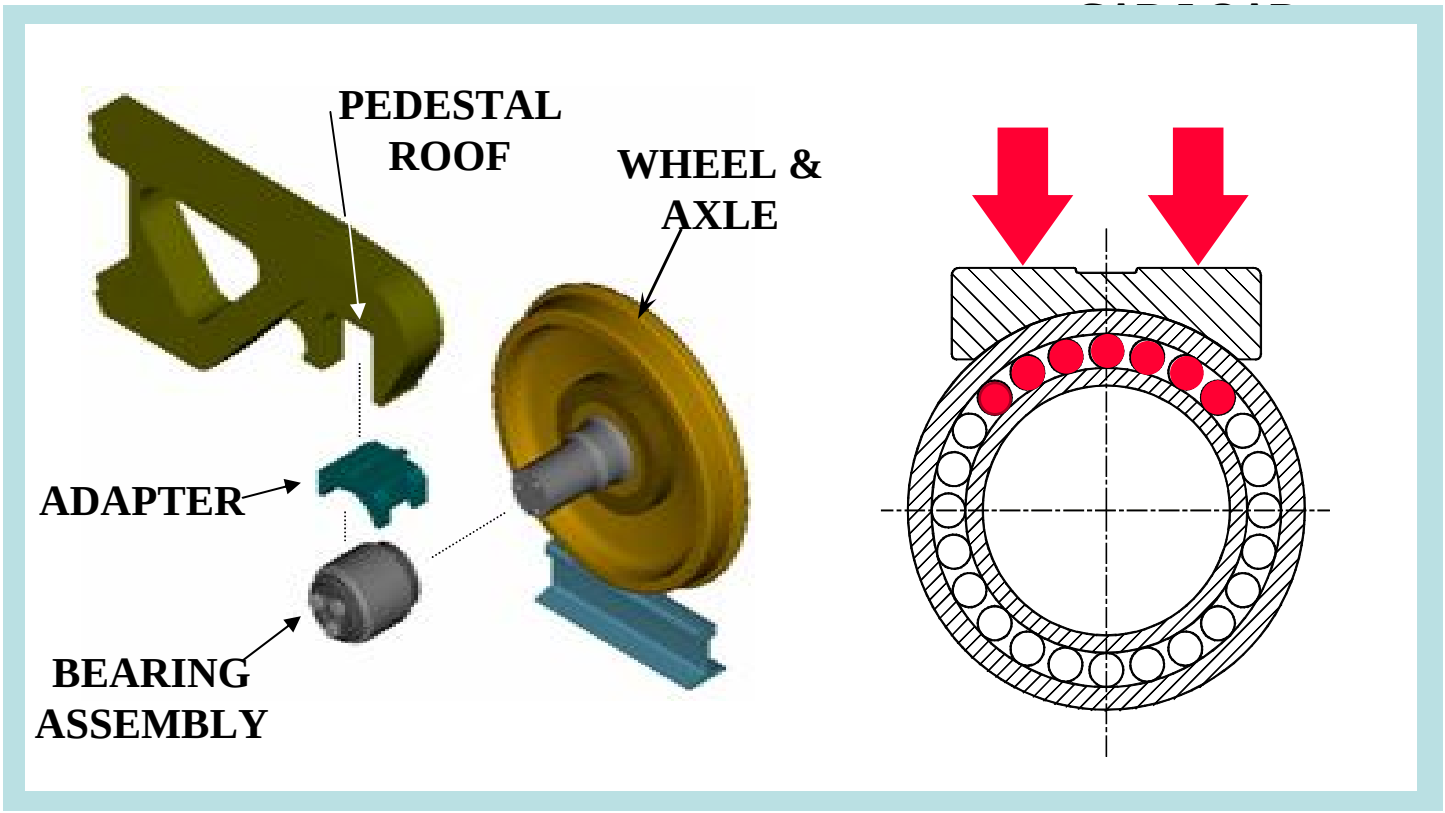
- Lubrication breaks down (Thinning)
- Leads to lubrication loss of base oil (Thickening)
- Leads to roller end scoring
- Polishing of races
- To race and or roller heat (blue race and rollers)
- To race and or roller smearing/ peeling
- To cage wear or breakage
- To skewed rollers
- To more heat

Additional Criteria

Lubrication failure mode is normally not associated with spalling. At any point in the progression process this bearing could produce enough heat to be flagged and setout.

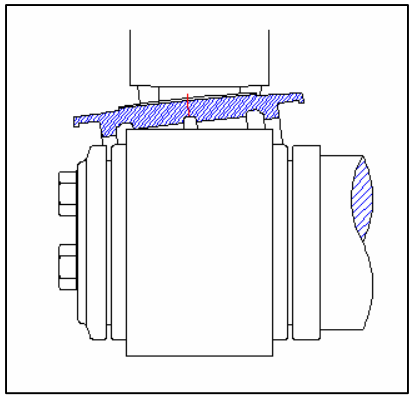
Adapter (AD: 4%)

Worn, Displaced, Broken, or Wrong Size



(AD) Adapter (Displaced, Worn, Wrong Size, or Broken); 4%

Bearing Distress Caused by Displaced or, Worn, Wrong Size, or Broken Adapter



Primary Symptom

- None

Other Symptoms

- Adapter should be determined to be displaced, worn, wrong size, or broken during external inspection in order to be AD failure
- Adapter rubbing on end cap, backing ring, or seal case
- Point loading (evidence on cup outer diameter and corresponding cup race)
- Damaged or dented seal case
- Cracked and/or broken cup counterbore
- Uneven loading, one race favored
- Worn or out of tolerance adapter
- Indication of contact of adapter relief with cup ends (shiny edge)
- Wear bands extend to the edges of the cup OD
- Wrong size adapter
- Adapter broken

Typical Progression

- Displaced adapter or wrong adapter size (noted at external inspection)
- Point loading
- To localized point loaded spalling on races
- To race and roller smearing
- To accelerated spalling
- To heat
- Displaced adapter (noted at external inspection)
- Rubs end cap or backing ring generating heat
- Displaced adapter
- Damages/ displaces seal
- Loss of lubrication or lubrication contamination
- Progresses to heat
- Adapter wears (measured on adapter)
- Relief rubs ends of cup
- Generates heat

Additional Criteria

Contrary Symptoms that may be present:

- Displaced seal (and associated damage)
- Race spalling
- Grease contamination

Despite the presence of these contrary symptoms, the preponderance of evidence points to a defective adapter condition.

Very strong visual evidence should be present during external inspection to make this notation if adapter is not with bearing.

(DS) Displaced Seal; 3%

Bearing Distress due to Displaced, Cocked, or Loose Seal

Primary Symptom

- *None*

Other Symptoms

- Loose seal (rotating in counterbore)
- Displaced or cocked seal (seal bead sheared off)
- Presence of free water in the bearing
- Seal components rubbing together (HDL, LL or Thin Gap)
- Seal rubbing end cap or backing ring
- Uneven seal lip wear
- Loss of lubrication

Typical Progression

- Seal becomes dislodged without obvious influences
- Seal components rubbing against each other (Thin Gap, LL or HDL) or rubbing on backing ring / end cap
- To loss of lube and ingress of water
- To race and or roller smearing
- To race and or roller spalling
- To heat

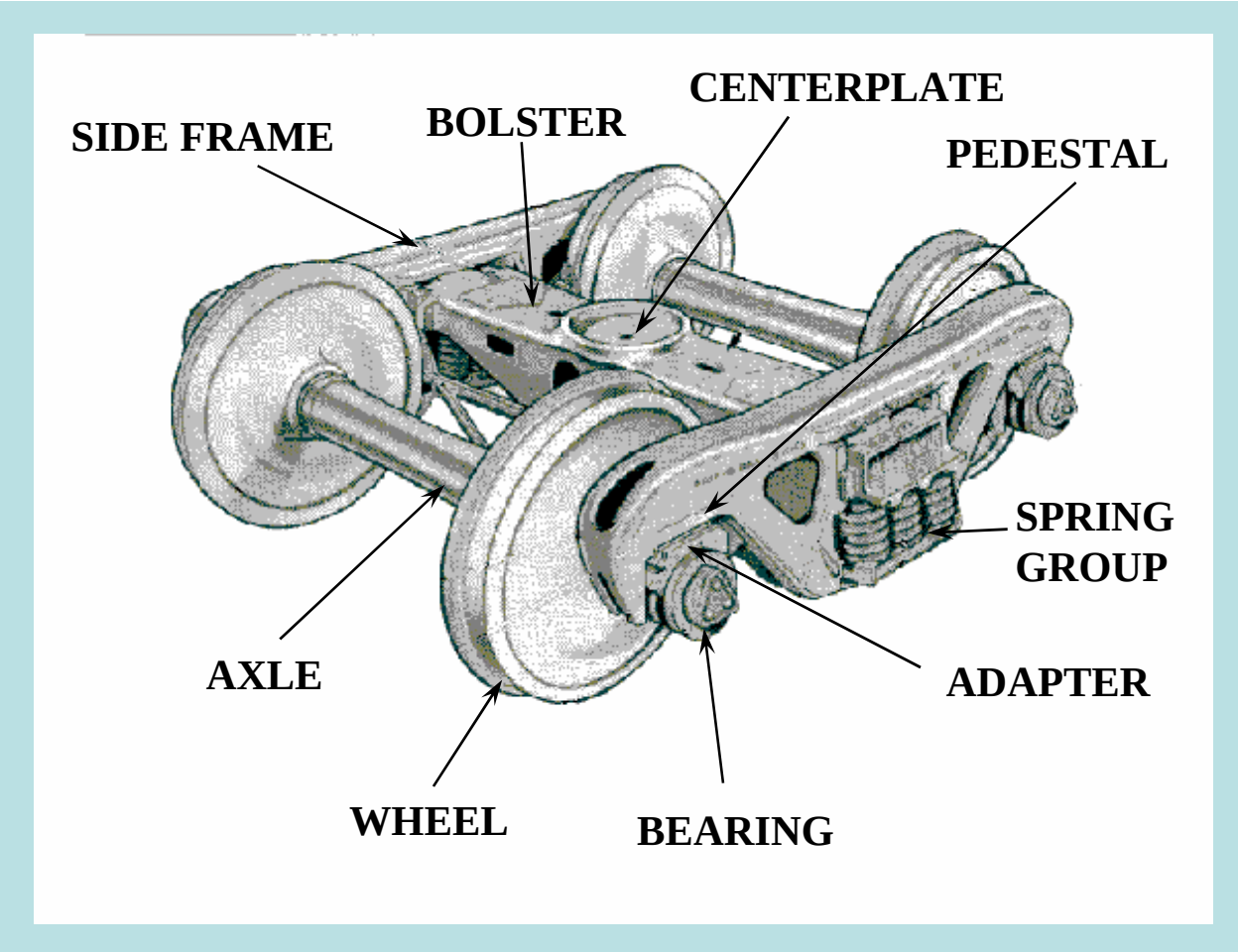
Additional Criteria

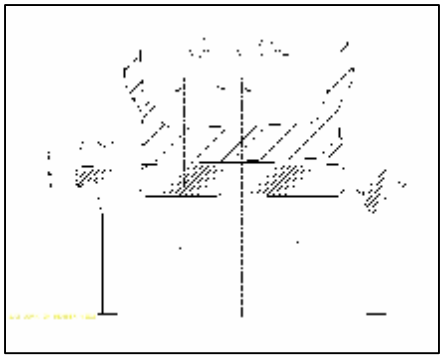
Most cases involve the seal becoming dislodged due to another mode:

- Adapter pinching cup (AD)
- Improper mounting (AP)
- Loose bearing components or debris from inside the bearing (LO, SP, WE, etc.)
- Seal being contacted by adapter or external force (signs of brinelling) (ME)`
- Cup counterbore out of specification (MD)

This failure mode only pertains when there is **NO** clear reason why the seal became loose or displaced

Truck Related Damage (TR: 2%)





(TR) Truck Related Failure; 2%

Bearing Distress Caused by Uneven Loading from the Truck Components

Primary Symptom

Primary – none

Other Symptoms

- Heavily worn cone raceways (typically inboard)
- Spalling in cup, matched to heavily worn cone race
- Heavily worn rollers, matched to heavily worn cone race
- Cage rubbing race (smearing)
- Fine metal particle content in grease (large quantities)
- Cup outer diameter worn over opposite races of the setout and mate bearing

Typical Progression

- Bolster splays due to HAL and high mileage
- Side frames toe inward
- Inboard races/ rollers take more of the bearing load (adapter pinched axially)
- Cone race begins to spall and wear
- Associated cup race and rollers wear and spall
- Cage begins to rub race and smear
- Load is transferred to outboard race and spalling occurs there as well (elliptical at first)

- Failure date ≤ 4 years from mount date
- HAL (Heavy Axle Loading) Car, 286,000+ lbs for a Class F bearing
- Spalling or wear in opposite races of the setout and mate bearing (ex. Setout spalled inboard, Mate spalled outboard)
- Presence of elastomeric or shear pads in system
- Lack of bearing indexing (single adapter pattern on cup outer diameter)
- Broken roof liner

- Truck skews during turning (fails to follow track curve radius)
- Wheelset is pinched to front and back of sideframe on opposite sides
- Inboard race of inside curve position and outboard race of outside curve position are overloaded
- Cup spalling and wear occur on the overloaded races
- Associated cone and roller spalls
- Elastomeric pads prevent cup indexing
- Cup load zone fatigue spalls and wears
- Associated cone race and rollers wear

Additional Criteria

Uneven loading caused by abnormal performance of the Truck assembly (sideframe, bolster, spring group, snubber, side bearing, elastomeric pad, etc.) is classified a truck related failure. Additional conditions in the bearing could be noted from these types of failures.
Typically this type of failure will be repeated among a car set or even a car type running in a common service.

(AP) Application Defects; 0%

Bearing Distress Caused by Installation or Assembly Process

Primary Symptom

- None

Other Symptoms

- Bearing should be ≤ 4 years old (from mount date) to be considered an application defect failure.
- Undersized or oversized journal (≥0.0003” out of range) by second hand axle tolerances
- Out of spec. lateral (≥0.030” or Zero - not free turning)
- Displaced seal
- Handling/ Mounting damage to bearing
- Journal gauling during mounting
- Stress markings on the contact area of the I/B seal wear ring
- Journal length longer than tolerance
- Missing components
- Spacer sheared
- Damaged threads or contaminates in bolt holes
- Loose (or missing) Cap screws (<50% of initial torque on average)

Typical Progressions

- Misalignment of mounting press
- Gouging of journal by IB wear ring
- To displaced IB seal
- To seal damage
- To heat from seal damage
- Undersized journal, reduced radial clamp
- Cone(s) spin during service
- Progresses as loose bearing failure
- Spacer drops during mounting and is sheared
- Internal bearing damage from debris
- Heat generated
- Undertorqued cap screws or journal longer than specified
- Insufficient stack clamp to maintain bearing stack
- Progresses as loose bearing failure

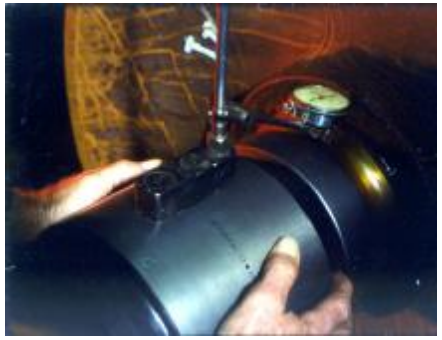
Additional Criteria

Contrary symptoms that may exist:

- Water ingress due to a displaced seal
- Journal grooving due to turned cone

Despite these contrary symptoms, the short life of bearing and supporting evidence points to a mounting problem.

(MD) Manufacturer/ Remanufacturer/ Reconditioner Defect; 0%



Bearing Distress Caused by Improper Manufacturing, Remanufacturing, or Reconditioning of the Bearing

Primary Symptom

Primary – none

Other Symptoms

- Mixed raceway components
- Components that do not meet with AAR acceptable dimensions
- Test products or e xperimental components
- Product included in AAR recalls
- Bearing assembly defects
  - Missing components
  - Improper bench lateral
  - Excessive or inadequate grease charge
- Remanufactured/ reconditioned components that do not meet with AAR accepted practices
- Manufactu ring or processing defects (ex. seamed roller)

Typical Progression

- Assembly defect
- Bearing fails prematurely
- Oversized Cone
- Progresses as Loose Failure

Additional Criteria

Some symptoms are similar to those found in with Application Defect (AP) failures.

This mode includes all failures that are attributed to the improper manufacturing, remanufacturing, or reconditioning of a bearing as well as test/ experimental product that offers a unique failure that cannot be characterized by another mode.

Typically this type of failure will be repeated among product supplied from a manufacturer/ remanufacturer/ reconditioner during a certain time frame.

Bearing Failure Mode Results
from Confirmed Hot Bearings

	Ave.	Yrs.
Loose Components	23%	14.8
Water Etch	20%	12.9
Wheel Defect	13%	9.5
Spalled Components	13%	8.6
Bearing Destroyed	12%	11.3
Mechanical Damage	6%	9.2
Lubrication Breakdown	4%	8.3
Displaced Adapter	4%	7.8
Displaced Seal	3%	6.5
Truck Related	2%	3.2
Application Defect	0%	5.1
Manufacturer's Defect	0%	2.7

Bearing Failure Mode Results
from Confirmed Hot Bearings

	Ave.	Yrs.	OEM	RECON
Loose Components	23%	14.8	21.6	11.4
Water Etch	20%	12.9	16.0	10.7
Wheel Defect	13%	9.5	11.6	8.4
Spalled Components	13%	8.6	13.3	7.5
Bearing Destroyed	12%	11.3	15.2	9.7
Mechanical Damage	6%	9.2	13.5	7.3
Lubrication Breakdown	4%	8.3	11.2	7.2
Displaced Adapter	4%	7.8	11.0	6.9
Displaced Seal	3%	6.5	9.8	5.5
Truck Related	2%	3.2	3.3	3.0
Application Defect	0%	5.1	10.0	3.7
Manufacturer's Defect	0%	2.7	3.9	1.8
Total	100%	9.4	12.2	7.8

FPM Timeline

- Developed by Brenco & Timken in 2002 with BNSF
- Implemented by RBMEC in 2003
  - Dual Reporting
- Proposed to AAR (WABL) in March 2003
- TTCI Analytical Use in 2004
- Now Spearheaded by CN for Adoption

Questions