



# Passenger Wheel Set Assembly

**Abstract:** This standard provides the minimum requirements for the assembly of rail vehicle wheel sets. It also addresses training requirements, safety implications and the technical rationale for certain practices.

**Keywords:** axle, interference, press fit, wheel, wheel assembly, wheel set geometry

**Summary:** This document establishes a standard for minimum requirements for passenger wheel set assembly. It combines industry best practices and establishes limits and ranges on certain parameters associated with wheel set assembly.

**Scope and purpose:** This standard shall be used by passenger railroads when performing wheel set assembly functions. It is to be used in conjunction with the railroads' internal requirements and original equipment manufacturer (OEM) recommendations. This standard covers the assembly of wheel set components for use in passenger rail vehicles operating on mainline railroads, as well as light rail and heavy rail transit vehicles.

This document represents a common viewpoint of those parties concerned with its provisions, namely operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, recommended practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a transit system's operations. In those cases, the government regulations take precedence over this standard. The North American Transportation Services Association and its parent organization APTA recognize that for certain applications, the standards or practices, as implemented by individual agencies, may be either more or less restrictive than those given in this document.

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## **Introduction**

*This introduction is not part of APTA PR-M-S-019-17, "Passenger Wheel Set Assembly."*

The purpose of this standard is to provide a standardized method for the assembly of wheel sets used in modern North American passenger train cars applicable to all rail modes for which specified wheel or bearing dimensions are provided herein.

This standard is based on specifications for wheel-to-axle assembly developed by the Association of American Railroads (AAR). Many features from AAR specifications have been included herein by reference. In addition, new procedures have been introduced specific to passenger rail systems beyond requirements of AAR. This standard is designed to be universal in its application to passenger systems.

Components of passenger railroad wheel sets are assembled onto axles and are held together by friction of interference fits that must be sufficiently strong to withstand the forces encountered during service. The strength of an interference fit is critical to the performance and safety of the wheel set assembly.

Passenger railroads have relied on the *AAR Manual of Standards and Recommended Practices*, Section G-II, "Wheels and Axle Shop Manual," for the assembly of their wheel sets. This manual is published and maintained by the AAR Wheels, Axles, Bearings and Lubrication Committee.

The manual specifies minimum manufacturing standards related to the press-fit assembly of wheels and bearings onto axles. Because the AAR is concerned almost exclusively with the operation of freight railroads, the manual may not sufficiently address press-fit assembly features unique to passenger railroad operations, including components other than wheels and bearings, such as inboard bearing axles and shrink-fitted components. AAR may also not sufficiently address variations in passenger car manufacturers' specifications or the influence of wheel slip control systems, as examples.

As a result, passenger railroad wheel assembly shops often rely heavily on the judgment of experienced personnel, which may not be universally applied for best performance, nor developed with contemporary assembly procedures. Many passenger railroads are also concerned about the retirement of experienced personnel and the resulting loss of valuable engineering and practical expertise. Newer staff may not be fully aware of the safety implications of the jobs they are performing, nor of the technical rationale for certain

practices. This could lead to wheel assembly practices evolving over time without the benefit of scientific bases.

Passenger rail operating agencies must develop and maintain written documentation of their policies, rules, regulations and procedures to ensure safe and efficient operation of their rail systems. The independent evolution of wheel set assembly procedures among independent transit authorities could have a detrimental effect on the safety of passenger rail service and on the cost of providing that service.

This standard uses in part the experiences and best practices of numerous passenger railroad operators, plus new scientific information, in order to establish a common set of rules for the assembly of passenger car wheel sets.

# Passenger Wheel Set Assembly

## 1. General

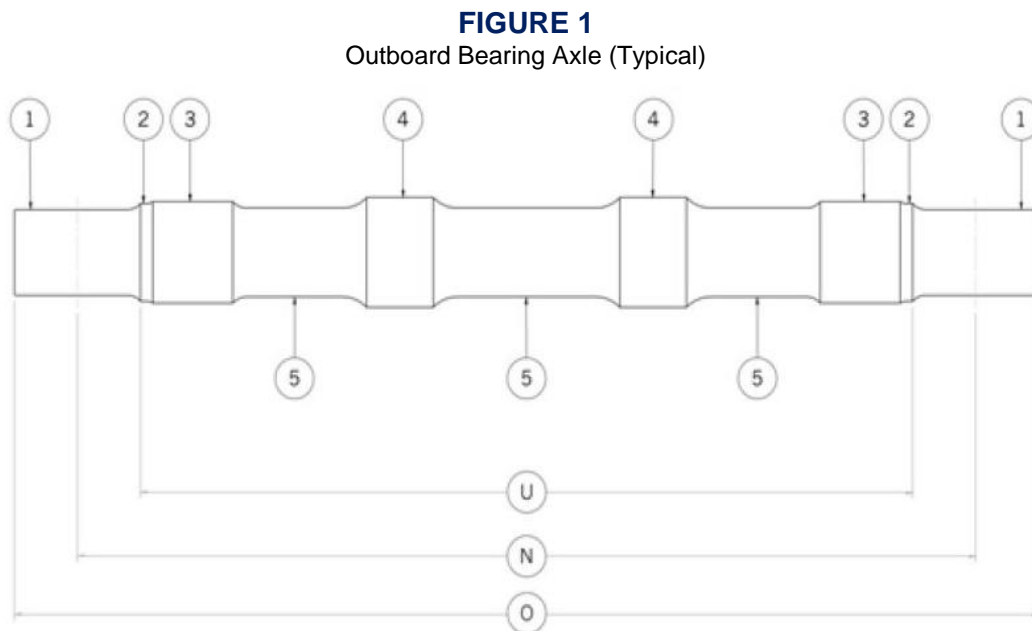
All work must comply with the requirements of this safety standard.

All work must comply with the applicable requirements of the latest issue of the *AAR Manual of Standards and Recommended Practices*, Section G-II, “Wheel and Axle Shop Manual,” latest issue where referenced in this standard. If in conflict, this standard takes precedence.

## 2. Nomenclature for axles

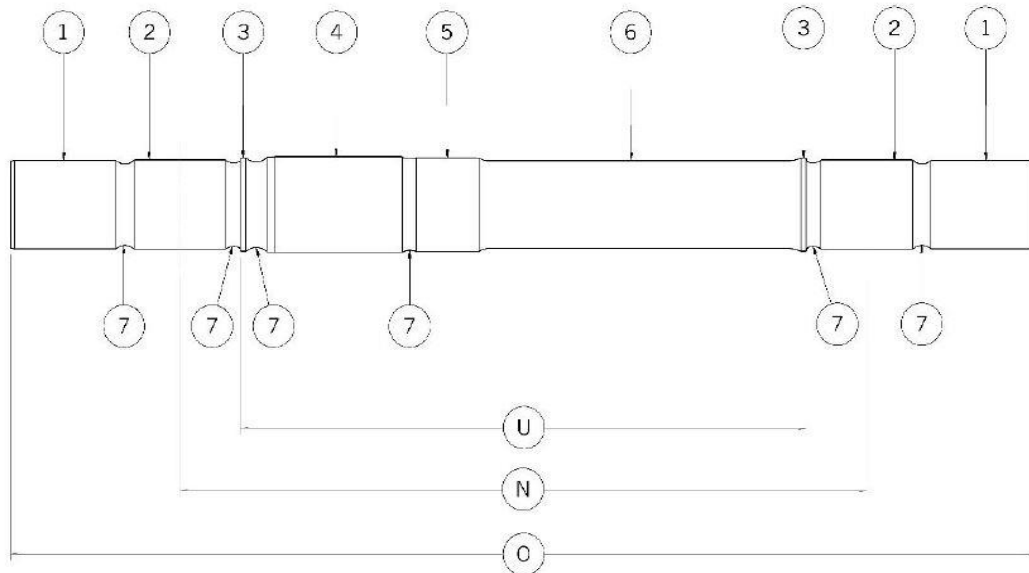
See [Figure 1](#) and [Figure 2](#).

- **Body:** For an outboard bearing axle, the body is the portion of the axle between the wheel seats. The body of an inboard bearing axle is the portion of the axle between the two bearing shoulders.
- **Body segment:** Any part of the body of an axle onto which no component is fitted.
- **N-dimension:** The distance between the centerlines of the two axle bearings.
- **O-dimension:** The overall length of an axle.
- **U-dimension:** For outboard bearing axles, the distance between the inboard edges of the two axle bearing fillets. The U-dimension for inboard bearing axles is the distance between the two axle bearing shoulder faces.



**Key:** 1=Bearing seat, 2=Dust guard seat, 3=Wheel seat, 4=Brake disc seat, 5=Body segment, U=Bearing location, N=Bearing centerline, O=Overall length

**FIGURE 2**  
Inboard Bearing Axle (Typical)



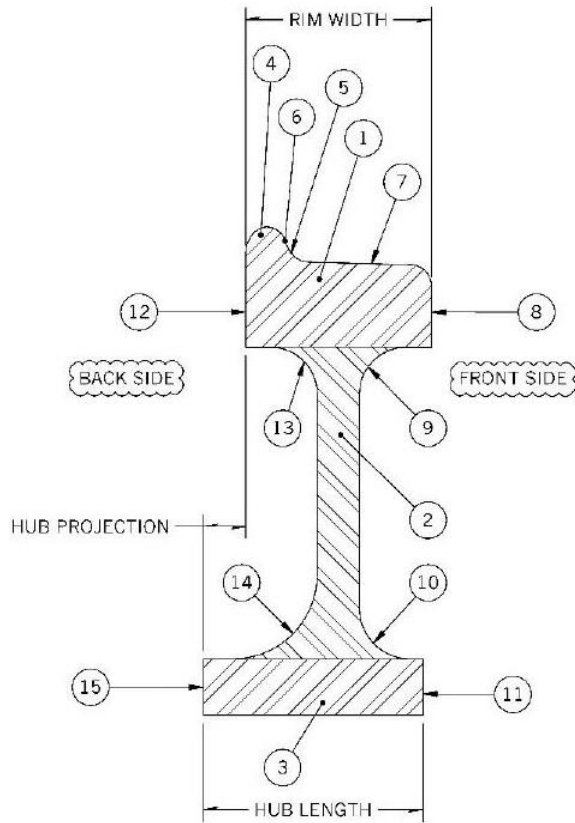
**Key:** 1=Wheel seat, 2=Bearing seat, 3=Bearing shoulder, 4=Gear unit seat, 5=Ground brush seat, 6=Body, 7=Relief groove, U=Bearing location, N=Bearing centerline, O=Overall length

### 3. Nomenclature for wheels

- **Back:** The side of the wheel that faces inboard when assembled to an axle.
- **Front:** The side of the wheel that faces outboard when assembled to an axle.
- **Rim:** The diametrically outer section of the wheel.
- **Hub:** The diametrically inner section of the wheel.
- **Wheel plate:** The thin portion of the wheel that connects the wheel hub to the wheel rim.
- **Tread:** The two-dimensional outermost curved surface of the wheel rim. The tread is the area of the wheel that makes contact with the rail.
- **Bore:** The two-dimensional innermost circular surface of the wheel hub. The bore is the area of the wheel that makes contact with the axle seat onto which it is mounted.
- **Hub projection:** The distance by which the back hub-face projects beyond the back rim face. The hub projection is referred to as positive when it projects beyond the back rim face and negative when it projects inward from the back rim face. A negative hub projection may also be referred to as a hub depression. The hub projection shown in **Figure 3** is a positive hub projection.
- **Gage point:** The defined location of the theoretical point of contact between the surface of the wheel flange and the surface of the rail profile.



**FIGURE 3**  
Wheel Nomenclature



**Key:** 1=Rim, 2=Plate, 3=Hub, 4=Flange, 5=Flange throat, 6=Tread, 7=Front rim face, 8=Front rim fillet, 9=Front hub fillet, 10=Front hub face, 11=Back rim face, 12=Back rim fillet, 13=Back hub fillet, 14=Back hub face

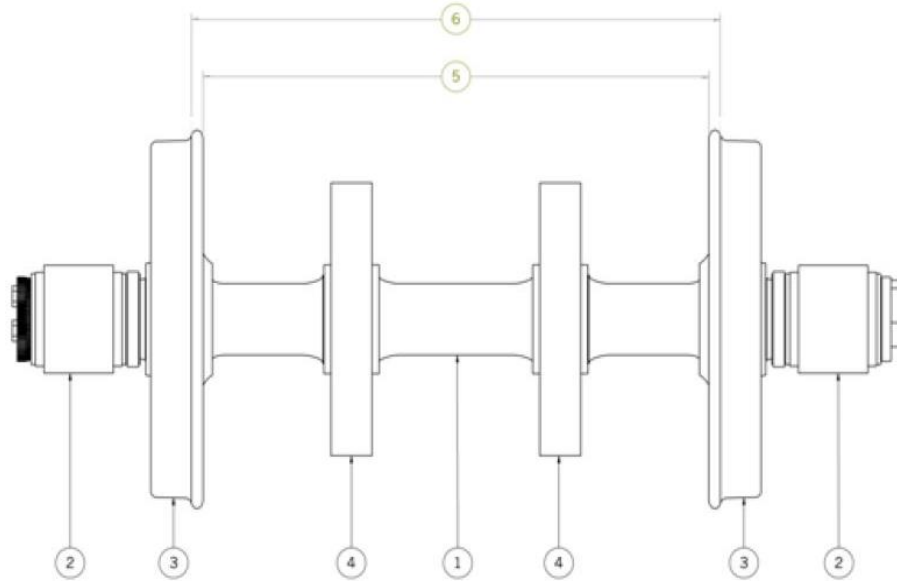
#### 4. Nomenclature for wheel set assemblies

See [Figure 4](#) and [Figure 5](#).

- **Wheel gage:** The distance, measured parallel to the axle centerline, between the gage points of wheel flanges on the two wheels assembled to an axle.
- **Back-to-back:** The distance, measured parallel to the axle centerline, between the back rim faces of two wheels assembled to an axle.

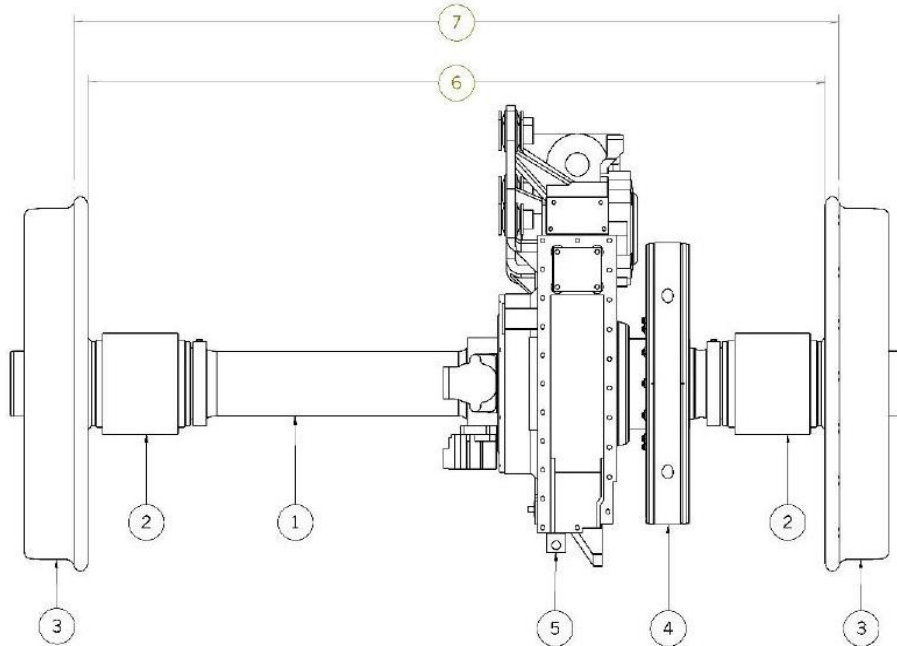
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**FIGURE 4**  
Outboard Bearing Wheel Set Assembly (Typical)



**Key:** 1=Axle, 2=Bearing, 3=Wheel, 4=Brake Disc, 5=Back-to-back, 6=Wheel gage

**FIGURE 5**  
Inboard Bearing Wheel Set Assembly (Typical)



**Key:** 1=Axle, 2=Bearing, 3=Wheel, 4=Brake Disc, 5=Gear unit, 6=Back-to-back, 7=Wheel gage

## **5. New axle manufacture and condition**

1. All new axles must meet the requirements of APTA *Recommended Practice* PR-M-RP- 008-98, “Passenger Car Axle Design.”
2. All new axles must be manufactured by a facility having AAR approval for the manufacture of axles.
3. Imperfections in new axles that are the result of handling damage or inadvertent strikes with other objects may be repaired as described in Section 6, provided that the total area of all repairs made on a seat is less than 2 percent of the area of the seat on which the repairs are made.
4. The area of any single repair must not exceed 0.600 sq in. This area is roughly equivalent to that of a U.S. quarter-dollar coin.
5. Axle seats may be electro-chemically plated in accordance with *AAR Manual of Standards and Recommended Practices*, Section G-II, and AAR Specification M-967.

## **6. Secondhand (used) axle condition**

1. All secondhand axles must be qualified for reuse in accordance with this standard.
2. Prior to qualification of secondhand axles, all coatings, including paint and rust inhibitors, must be removed.
3. Secondhand axles must be cleaned thoroughly so that they are free of dirt, dust, rust, oil, grease and other contaminants.
4. Secondhand axles should be polished using an abrasive medium or wire brush as the final cleaning operation prior to dimensional and nondestructive testing (NDT) operations.
5. Relief grooves and fillet radii should be polished in an axial direction, not circumferentially. Seats may be polished circumferentially.
6. The marks resulting from the polishing of relief grooves may be at an angle no greater than 30 deg relative to the longitudinal centerline of the axle.
7. The surface finish  $R_a$  after polishing of relief grooves must meet the requirement specified for the axle when it was new. Relief grooves may be cold-rolled or burnished to achieve the specified surface finish.
8. Imperfections on the surface of axles, other than superficial scores, must be repaired to eliminate sharp edges and corners. These imperfections include nicks, scrapes, dents and other imperfections that may be present.
9. Imperfections may be removed locally with files, by polishing with an abrasive medium or by grinding with a handheld grinder.
10. Whenever files are used on any seat, the filed area must be subsequently polished with an abrasive medium to remove any sharp striations created by the file.
11. Abrasive media used for polishing or repair of imperfections should not be coarser than 80 grit.
12. Superficial scores are not considered imperfections and need not be repaired. However, the seat on which the scores are present must be polished with an abrasive medium to smooth the edges where the scores intersect the surface of the seat.
13. All repaired imperfections must meet the following requirements:
  - a) Sharp edges of any imperfection must be completely removed. The repaired surface must be continuous and smooth and contain no abrupt changes or steps.
  - b) The repaired area must meet the surface roughness requirement specified for the area immediately surrounding it. The depth of any repaired area must not exceed 0.125 in. as measured from the original surface.
  - c) The area of any single repair must not exceed 0.600 sq in. This area is roughly equivalent to that of a U.S. quarter-dollar coin.
  - d) The combined area of all repairs to any seat must not exceed 10 percent of the total surface area of that seat.

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- e) For axle bearing seats, the combined area of repairs to the fitted area of each bearing cone must not exceed 5 percent of that fitted area.
  - f) Imperfections may be removed by turning or by machine grinding.
  - g) Axle areas other than wheel seats that are turned or machine ground must meet the surface finish requirements for new axles.
  - h) Axle wheel seats that are turned or machine ground must have a surface finish  $R_a$  no greater than 150  $\mu$ -in.
14. Longitudinal scores, including superficial scores and other sharp imperfections at the intersection of any seat and an adjacent relief groove may not be repaired locally, i.e., using handheld tools. Axles with this condition must be repaired by machine grinding or by turning.
  15. When imperfections are repaired by machine grinding or by turning, the entire seat must be machined, and any imperfections at the intersection of any seat and an adjacent relief groove must be completely removed.
  16. When imperfections, other than those imperfections at the intersection of any seat and an adjacent relief groove, are present after machine grinding or turning, those imperfections may be removed locally as described in this section.
  17. A deep-blue hue present on the surface of an axle after it has been cleaned and polished is evidence that the axle has been overheated. Overheated axles must be scrapped.
  18. Axles with evidence of a weld strike or a burn mark from a torch must be scrapped.
  19. Axles that are more than 40 years old or that are known to have accumulated more than 10 million miles of service must be scrapped. Axle age is based on the date the axle was finish machined as evidenced by the “Y” code and the “Y” date. If there is no “Y” code or date on the axle, then the age will be based on the date the axle was forged. Axles that show neither of these dates must be scrapped.
  20. The full length of all secondhand axles must be magnetic particle tested (MT) in accordance with ASTM E1444/E1444M-11, *Standard Practice for Magnetic Particle Testing*, or with *AAR Manual of Standards and Recommended Practices*, Section G-II.
  21. Axles with MT flaw indications may be repaired in accordance with this standard. Repaired axles must be MT retested after any repairs are made.
  22. Secondhand axles with MT flaw indications must be scrapped when those flaws cannot be removed.
  23. All secondhand axles must be ultrasonic tested in accordance with *AAR Manual of Standards and Recommended Practices*, Section G-II. Solid axles must be ultrasonically tested from the outside diameter of the axle. Hollow axles that have a bore designed for radial testing must be ultrasonically tested from within the inside of the axle.
  24. Inspect all secondhand axle seat diameters prior to mounting components onto those seats.
  25. For AAR-class axle designs, the minimum wheel seat and bearing seat diameters must meet the requirements shown in **Table 1** and **Table 2**. For all other seats onto which components—e.g., brake discs, gear units, gears or couplings—will be fitted, the limits of acceptability for the diameters of those seats must be specified by the operator of the vehicle on which the axle is used. When no acceptability criteria is given, the seat diameters must meet the tolerances specified for new axles.
  26. The U-dimension for inboard bearing axles must not be greater than the new axle maximum specification and not more than 0.030 in. under the new axle minimum specification.
  27. The U-dimension for outboard bearing axles must not be greater than the new axle maximum specification and not more than 0.060 in. under the new axle minimum specification.
  28. Axle seats may be electrochemically plated in accordance with *AAR Manual of Standards and Recommended Practices*, Section G-II, and *AAR Specification M-967*.

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**TABLE 1**

Inboard Bearing AAR-Class Axles, Bearing Seat and Wheel Seat Diameter Limits (inches)

AAR Bearing Class	Bearing Seat (min.)	Bearing Seat (max.)	Wheel Seat (min.)	Wheel Seat Nominal New	Wheel Seat Oversized (max.)
D513	5.1905	5.1615	4.880	5.130	5.180
E563	5.6905	5.6915	5.380	5.630	6.680
F613	6.1905	6.1915	5.880	6.130	6.180

**TABLE 2**

Outboard Bearing AAR-Class Axles, Bearing Seat and Wheel Seat Diameter Limits (inches)

AAR Bearing Class	Bearing Seat (min.)	Bearing Seat (max.)	Wheel Seat (min.)	Wheel Seat Nominal New	Wheel Seat Oversized (max.)
CC750	5.0030	5.0040	7.250	7.500	7.625
D775	5.1905	5.1915	7.500	7.750	7.875
E825	5.6905	5.6915	8.000	8.250	8.625
F875	6.1905	6.1915	9.750	8.750	8.875
G925	7.003	7.004	9.250	9.500	9.625

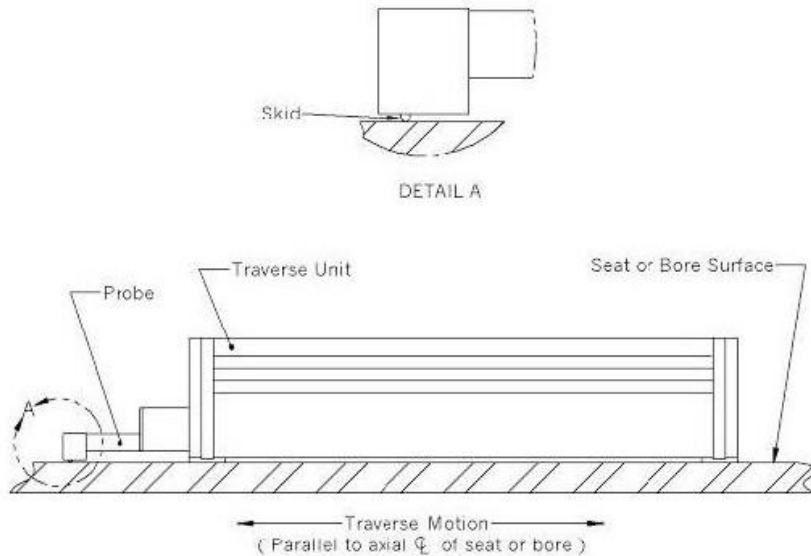
## 7. New wheels

1. At the time of their manufacturing, monobloc steel wheels must be manufactured in accordance with the latest revision of APTA PR-M-S-012-99, “Manufacture of Wrought Steel Wheels for Passenger Cars and Locomotives,” or to the latest revision of AAR Specification M-107/M-208, “Wheels, Carbon Steel.”
2. Wheels must be assembled to axles by press-fitting.
3. Wheels must be bored by turning or machine grinding.
4. Wheels fitted to an axle must be of the same tape size and bear the corresponding tape size marking.
5. Wheel bore finishes must meet the following requirements:
  - a) Wheel bores must be measured using a suitable instrument with a spatial resolution (cut-off setting) of 0.030 in.
  - b) The mean surface roughness  $R_a$  must not be greater than 374  $\mu$ -in.
  - c) The peak to valley surface finish,  $R_z$ , must not be greater than 1859  $\mu$ -in.
  - d) The mean peak spacing,  $R_{sm}$  must be less than 0.033 in.
  - e) **Figure 6** shows a sketch of a profilometer used to measure surface parameters.

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FIGURE 6

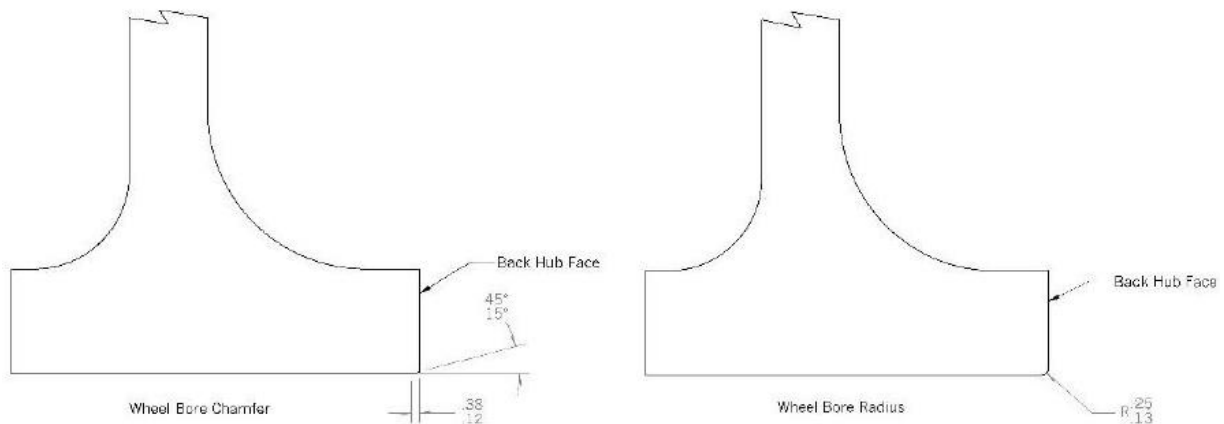
Sketch of Profilometer Used to Measure Surface Parameters



6. Wheel bores must be cylindrical within a limit of 0.002 in.
7. Whenever a taper exists in the bore within the 0.002 in. limit, the taper must be positive; i.e., the larger diameter must be at the back of the bore and the smaller diameter at the front of the bore.
8. Monobloc wheels must be manufactured from wrought steel.
9. Resilient wheels and tired wheels must be manufactured in accordance with OEM requirements.
10. For wheel bores, the combination of variations in out-of-round and taper must be less than or equal to 0.002 in.
11. Wheels must have a chamfer or radius at the back of the bore to facilitate press-fitting of the wheel. The requirements for these lead chamfers and radii are shown in **Figure 7**.
12. Any sharp edge at the front of the wheel bore must be broken after the bore has been machined.
13. Wheels must achieve the mounting forces specified in Section 9.

FIGURE 7

Wheel Bore Chamfers



## **8. Secondhand (used) wheels**

1. Secondhand wheels need not be bored prior to assembly, provided that they meet the other requirements of Section 7. Secondhand wheels that are not bored prior to assembly must meet all the additional requirements in this section.
2. All secondhand wheel bores must be qualified for reuse in accordance with this standard.
3. Secondhand wheels mounted to the same axle must be within one tape size of one another.
4. Secondhand wheel bores must be cleaned thoroughly so that they are free of dirt, dust, rust, oil, grease and other contaminants.
5. Secondhand wheel bores must meet the requirements for surface finish specified in Section 7.
6. The bores of secondhand wheels must be polished with an abrasive medium or wire brush prior to dimensional inspection.
7. Imperfections on the surface of bores, other than superficial scores, must be repaired to eliminate sharp edges and corners. These imperfections include nicks, scrapes, dents and other imperfections that may be present.
8. Imperfections may be removed locally with files, by polishing with an abrasive medium or by grinding with a handheld grinder.
9. Whenever files are used on any bore, the filed area must be subsequently polished with an abrasive medium to remove any sharp striations created by the file.
10. Abrasive cloths used for polishing or repair of imperfections should not be coarser than 80 grit.
11. Superficial scores are not considered imperfections and need not be repaired. However, the bore on which the scores are present must be polished with an abrasive medium to smooth the edges where the scores intersect the surface of the bore.
12. All repaired imperfections must meet the following requirements:
  - a) Sharp edges of any imperfection must be completely removed. The repaired surface must be continuous and smooth and contain no abrupt changes or steps.
  - b) Repaired areas must meet the surface roughness requirements of Section 7, Item 5.
  - c) The depth of any repaired area must not exceed 0.120 in. as measured from the original surface.
  - d) The area of any single repair must not exceed 0.600 sq in. This area is roughly equivalent to that of a U.S. quarter-dollar coin.
  - e) The combined area of all repairs to any seat must not exceed 10 percent of the total surface area of that seat.
  - f) Imperfections may be removed by turning or by machine grinding.
  - g) Bores that are turned or machine ground must meet the surface finish requirements for new wheels.
13. Longitudinal scores, including superficial scores and other sharp imperfections in the bore that extend to the front or back hub face, may not be repaired locally, i.e., using handheld tools. Bores with this condition must be repaired by machine grinding or by turning.
14. When imperfections are repaired by machine grinding or by turning, the entire bore must be machined, and any imperfections in the bore that extend to the front or back hub face must be completely removed.
15. When imperfections, other than those imperfections described in Item 12, are present after machine grinding or turning, those imperfections may be removed locally as described in this section.
16. Evidence of a deep-blue hue present on the surface of a wheel indicates that the wheel has been overheated. Overheated wheels must be scrapped.
17. Wheels with evidence of a weld strike or a burn mark from a gas or arc torch must be scrapped.
18. Wheel bores must have the interference fit specified in Section 9 relative to the seat onto which they will be mounted.
19. Wheels must achieve the mounting forces specified in Section 9.

## 9. Wheel mounting forces and interference fits

**Table 3** specifies the mounting forces and interference fits for wheels mounted on AAR-class inboard axles when those axles have nominal new wheel seat diameters as shown in the table.

**TABLE 3**  
 Inboard AAR Class Bearing Axles

AAR Bearing Class Axle	Bearing Seat Diameter (in.)	Wheel Seat Diameter (in.)	Int. Min. (0.0001 in.)	Int. Max. (0.0001 in.)	Force Min. (U.S. short ton)	Force Max. (U.S. short ton)
<b>D513</b>	5.1915	5.130	45	82	54	91
<b>E563</b>	5.6915	5.630	50	89	60	102
<b>F613</b>	6.1915	6.130	55	97	65	110
<b>K613</b>	6.1915	6.130	55	97	65	110

**Table 4** specifies the mounting forces and interference fits for wheels mounted on AAR-class outboard axles when those axles have the nominal new wheel seat diameters shown in the table.

**TABLE 4**  
 Outboard AAR Class Bearing Axles

AAR Bearing Class Axle	Bearing Seat Diameter (in.)	Wheel Seat Diameter (in.)	Int. Min. (0.0001 in.)	Int. Max. (0.0001 in.)	Force Min. (U.S. short ton)	Force Max. (U.S. short ton)
<b>CC750</b>	5.0040	7.500	118	67	80	136
<b>D775</b>	5.1915	7.750	121	70	83	141
<b>E825</b>	5.6915	8.250	129	74	88	149
<b>F875</b>	6.1915	8.750	136	79	94	159
<b>K875</b>	6.1915	8.750	136	79	94	159
<b>G925</b>	7.0040	9.250	144	84	99	168

For axles not included in **Table 3** or **Table 4**, use the mounting forces and interference fits shown in **Table 5** for axles designed in U.S. customary units and dimensions.

**TABLE 5**  
 Axles — U.S. Customary Unit Designs

Inch Class Axle	Wheel Seat Min. (in.)	Wheel Seat Max. (in.)	Int. Min. (0.0001 in.)	Int. Max. (0.0001 in.)	Force Min. (U.S. short ton)	Force Max. (U.S. short ton)
500	4.750	5.000	44	80	53	90
525	5.000	5.250	47	84	55	93
550	5.250	5.500	49	88	58	98
575	5.500	5.750	51	91	61	103
600	5.750	6.000	53	95	64	108
625	6.000	6.250	56	99	66	112
650	6.000	6.500	58	103	69	117



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**TABLE 5**  
 Axles — U.S. Customary Unit Designs

Inch Class Axle	Wheel Seat Min. (in.)	Wheel Seat Max. (in.)	Int. Min. (0.0001 in.)	Int. Max. (0.0001 in.)	Force Min. (U.S. short ton)	Force Max. (U.S. short ton)
675	6.500	6.750	60	106	72	122
700	6.750	7.000	63	110	75	127
725	7.000	7.250	65	114	77	130
750	7.250	7.500	67	118	80	136
775	7.500	7.750	70	121	83	141
800	7.750	8.000	72	125	86	146
825	8.000	8.250	74	129	88	149
850	8.250	8.500	77	133	91	154
875	8.500	8.750	79	136	94	159
900	8.750	9.000	81	140	97	164
925	9.000	9.250	84	144	99	168
950	9.250	9.500	86	148	102	173
975	9.500	9.750	88	151	105	178
1000	9.750	10.000	91	155	108	183

Use the mounting forces and interference fits shown in **Table 6** for axles designed in metric dimensions.

**TABLE 6**  
 Axles — Metric Designs

Class (mm)	Seat Min. (mm)	Seat Max. (mm.)	Int. Min. (mm)	Int. Max. (mm)	Force Min. (U.S. short ton)	Force Max. (U.S. short ton)
100	94	100	0.087	0.163	41	69
106	100	106	0.093	0.172	44	74
112	106	112	0.099	0.181	46	78
118	112	118	0.104	0.190	49	83
124	118	124	0.110	0.199	52	88
130	124	130	0.115	0.208	54	91
136	130	136	0.121	0.217	57	96
142	136	142	0.126	0.226	59	100
148	142	148	0.132	0.235	62	105
154	148	154	0.138	0.244	65	110
160	154	160	0.143	0.253	67	113
166	160	166	0.149	0.262	70	119
172	166	172	0.154	0.271	72	122
178	172	178	0.160	0.280	75	127

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**TABLE 6**  
 Axles — Metric Designs

<b>Class (mm)</b>	<b>Seat Min. (mm)</b>	<b>Seat Max. (mm.)</b>	<b>Int. Min. (mm)</b>	<b>Int. Max. (mm)</b>	<b>Force Min. (U.S. short ton)</b>	<b>Force Max. (U.S. short ton)</b>
184	178	184	0.166	0.289	78	132
190	184	190	0.171	0.298	80	136
196	190	196	0.177	0.307	83	141
202	196	202	0.182	0.316	85	144
208	202	208	0.188	0.325	88	149
214	208	214	0.193	0.334	91	154
220	214	220	0.199	0.343	93	158
226	220	226	0.205	0.352	96	163
232	226	232	0.210	0.361	98	166
238	232	238	0.216	0.370	101	171
244	238	244	0.221	0.379	104	176
250	244	250	0.227	0.388	106	180

Forces are expressed in units of short tons in all four tables.

Diameters are expressed in inches in **Table 3**, **Table 4** and **Table 5** and in millimeters in **Table 6**.

Interferences are expressed in 0.0001 in. in **Table 1**, **Table 2** and **Table 3** and in millimeters in **Table 4**.

**Table 3**, **Table 4** and **Table 5** apply to wheel seats where the fitted length of the wheel bore on the seat is between 5.50 and 7.00 in.

**Table 6** applies to wheel seats where the fitted length of the wheel bore on the seat is between 135 and 175 mm.

For all tables, in each row of the table, for wheel seat diameters greater than the diameter shown in the “Seat Min.” column and less than or equal to the diameter shown in the “Seat Max.” column, wheels must have an interference fit between the values shown in the “Int. Min.” and “Int. Max.” columns. Wheels must achieve a mounting force between the “Force Min.” and “Force Max.” values.

## 10. Bearings

1. Axle bearings must be manufactured in accordance with APTA *Recommended Practice* APTA PR-M-RP-008-98, “Passenger Car Axle Design,” published in March 1999, or AAR Standard M-934, “Freight Car Journal Roller Bearings,” as applicable.
2. Outboard and inboard wheel bearings that are press-fitted onto axles must meet the mounting forces and seating forces/spike forces specified in Section 11.
3. Bearings that are shrink-fitted to their seats must be assembled in accordance with the applicable OEM requirements.

## 11. Axle bearing mounting forces

AAR-class inboard bearings must achieve the mounting and seating forces shown in **Table 7**.

**TABLE 7**  
Inboard Bearing Mounting Forces

AAR Bearing Class	Mount Min. (U.S. short ton)	Mount Max. (U.S. short ton)	Seat Min. (U.S. short ton)	Seat Max. (U.S. short ton)	Spike Min. (U.S. short ton)	Spike Max. (U.S. short ton)
D	4	10	20	35	20	35
E	5	12	25	40	25	40
L	5	12	25	40	25	40
F	5	15	35	50	35	50
K	5	15	35	50	35	50

AAR-class outboard bearings must achieve the mounting and seating forces shown in **Table 8**.

**TABLE 8**  
Outboard Bearing Mounting Forces

AAR Bearing Class	Bearing Seat Diameter (in.)	Mount Min. (U.S. short ton)	Mount Max. (U.S. short ton)	Seating Min. (U.S. short ton)	Seating Max. (U.S. short ton)
D	4.6915	5	15	45	55
E	5.6915	5	20	45	55
L	5.6915	5	20	45	55
F	6.1915	5	25	45	55
K	6.1915	5	25	45	55
G	7.0040	5	25	60	70
GG	6.5040	5	25	60	70
GG	6.8750	5	25	60	70

1. Bearings other than AAR-class bearings must be mounted in accordance with the applicable OEM requirements.
2. Inboard bearings must be seated against the axle bearing shoulder with the prescribed seating force.
3. Inboard bearings must produce a spike force when pressed against the axle bearing shoulder by the wheel as the wheel makes contact with the bearing.
4. Outboard bearings must be seated against the bearing seat fillet.
5. Outboard bearing end cap screws must be torqued in multiple stages up to the final torque values specified by the bearing manufacturer.
  - a) In the first stage, each end cap screw must be torqued to between 50 and 75 percent of its final torque value using a star-pattern tightening sequence.
  - b) Subsequent stages may add additional torque using a star-pattern tightening sequence.
  - c) In the final tightening stage, each end cap screw must be tightened to the torque value specified by the bearing manufacturer.

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- d) For outboard bearings that use a cap screw locking device, install the locking device as required by the bearing manufacturer. Mark locking plates as specified in *AAR Manual of Standards and Recommendations*, Section G-II.

## **12. Other components**

Components other than wheels and bearings shall be assembled in accordance with the applicable OEM requirements.

## **13. Press-fitting**

1. Immediately prior to assembly, both the components and the axles onto which they are to be assembled must be fully temperature stabilized to within 5 °C of ambient room temperature or to within 10 °C of one another.
2. The bores of all press-fitted components, as well as the seats onto which those components will be fitted, must be clean and free of grease, oil, dirt, dust and other contaminants.
3. Prior to assembly, the bore and seat dimensions of the components being fitted must be measured. These measurements must be recorded and for the interference fit must be within the tolerances prescribed by this standard.
4. An approved lubricant from Section 20 must be used at the interface between the two components.
5. The lubricant must be applied to the full length of the bore of the component and to at least the first half of the seat onto which it will be fitted. The first half of the seat is half the length of the seat starting at the end at which the component initially makes contact during the press-fitting operation.
6. All press-fitted components must be assembled by applying the mounting force concentrically and evenly to the hub of the component. For bearings, the inner race or a subcomponent of the bearing in contact with the bearing's inner race is equivalent to the hub.
7. The pressing operations must be continuous and cannot be interrupted from the start of the operation until the component has reached its final location.
8. All displacement versus mounting force data taken from fitting components must be recorded and preserved using a chart recorder or a data collection system.
  - a) The recorder data must include the displacement of the fitted component as it is being mounted and the corresponding force applied.
  - b) Digital data collection systems must record both the displacement and the corresponding force at a sampling frequency of at least 25 samples per inch of displacement.
9. Each press-fit recording must contain the following component identification data:
  - a) serial number of the component
  - b) type of component, e.g., wheel, brake disc, bearing
  - c) serial number of the axle onto which the component is assembled
  - d) time and date of assembly
  - e) operator identification
10. The maximum mounting force obtained must meet the requirement for the component mounted.
11. The shape of the load pressing plotted data must meet the requirements specified in the *AAR Manual of Standards and Recommended Practices*, Section G-II.
12. Components not meeting the prescribed mounting force or chart shape are misfits and must be labeled immediately as misfits.
13. Misfitted components must be completely removed from the axle onto which they were mounted.
14. Misfitted components may be remounted.
15. Wheels mounted on the same axle must be of the same tape size for new wheels and within one tape size of one another for secondhand wheels.

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16. The radial circular runout and the axial circular runout for wheels must be measured and recorded after assembly. The measurements must be taken relative to the axle bearing seats by rotating the wheel set assembly on mounted bearings or on bearing seats while measuring the runouts.
17. Radial runout must be measured in the direction perpendicular to the longitudinal centerline of the axle and measured on the tread of the wheel within ½ in. of the taping line.
18. Axial runout must be measured in the direction parallel with the longitudinal centerline of the axle.
19. Axial runout must be measured at either the back rim face, the front rim face or the flange of the wheel.
20. Radial and axial runouts must meet the requirements of **Table 9**.

**TABLE 9**  
 Radial and Axial Runouts for Wheels

<b>Max. Service Speed (mph)</b>	<b>Radial (0.001 in.)</b>	<b>Axial (0.001 in.)</b>
85	30	60
125	10	20
160	5	15
200	5	12

21. Axle bearings must be rotated by hand after mounting to ensure that they rotate smoothly and freely.
22. Axle bearings that do not rotate smoothly or freely by hand must be labeled as misfits and must be dismantled from the axle.
23. The axial play for axle bearings must be measured and recorded after mounting.
24. The axial play for bearings may be measured by hand or by the use of a mechanical device designed for the purpose.
25. The axial play for bearings must be no greater than 0.020 in. when measured by hand.
26. To measure the bearing play by hand, use the following procedure:
  - a) Rotate the bearing back and forth through at least one full revolution.
  - b) With the heels of your hands, apply a strong force evenly at two areas 180 deg apart on the face of the bearing cup. Apply the force in an axial direction.
  - c) Using the tips of your fingers, pull the bearing back in the opposite direction.
  - d) Measure the movement of the bearing.
  - e) Repeat steps b) through d) at least two more times. The repeatability of the measurements must be within 0.001 in.
27. Measure and record the back-to-back measurement in at least three equidistant locations or, alternatively, measure and record the minimum and maximum back-to-back measurements. For narrow flange wheel profiles, the back-to-back measurement must be between 53.250 and 53.375 in.

## **14. Shrink-fitting**

1. Components other than wheels and AP-style bearings may be assembled to axles by shrink-fitting.
2. Because shrink-fitted components do not have a mounting force chart, it is extremely important that the dimensions of the bore and the corresponding seat be measured carefully prior to assembly to ensure that the required interference will be present when the components cool.
3. The diameter of the bore of a shrink-fitted component and the diameter of the seat onto which it is fitted must be recorded.
4. To facilitate removal, the seat onto which a component will be shrink-fitted may be coated with an approved lubricant capable of withstanding the heat from the component.
5. Press-fitted components may be used to achieve final positioning of a shrink-fitted component.

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6. For shrink-fitted components that are moved to their final position by contact with press-fitted components, the length of pressed travel for the shrink-fitted component must be less than or equal to 0.500 in.

## **15. Tapered fits**

1. Taper-fitted components must be mounted in accordance with the applicable OEM requirements.

## **16. Quality assurance**

1. Each wheel set assembly facility shall have a documented quality assurance system and a quality assurance manual describing that system.
2. The quality system shall meet the requirements of *AAR Manual of Standards and Recommended Practices*, Section J, Specification M-1003.

## **17. Records**

1. Data records of all press-fitted components defined in Section 13, Items 7 and 8, plus dimensional data defined in Section 9, must be maintained for 20 years.
2. The serial numbers of all components of any wheel set assembly processed for maintenance or overhauling, i.e., any wheel set for which any component is removed, must be recorded.
3. The railroad operating authority shall keep records of all wheel set assemblies applied to any revenue service vehicle. These records must be maintained for 20 years and include the following information:
  - a) the vehicle number to which the wheel set assembly is applied
  - b) the position of the wheel set assembly within the vehicle
  - c) sufficient information from the wheel set assembly to uniquely identify it
  - d) the date on which the wheel set assembly was applied to the vehicle
  - e) records for magnetic particle inspections of axles

## **18. Personnel**

1. Personnel involved in the assembly of wheel sets must demonstrate knowledge and proficiency of the requirements of this standard as ensured through training certifications provided by the transit operator or wheel set assembly shop.

## **19. Equipment**

1. All equipment used for the assembly of wheel sets must be accurate and consistently capable of meeting the requirements of this standard.
2. Press chart and data collection recorders must be accurate within  $\pm 1$  percent of the maximum reading recorded for force.
3. Press chart and data collection recorders must be accurate within  $\pm 3$  percent of the maximum reading recorded for distance traveled.

## **20. Assembly lubricants**

1. The following lubricants or equivalent may be used for press-fitting operations:
  - a) all AAR-approved press-fitting lubricants
  - b) Dow Corning Molycote G-n paste
  - c) Fuchs-Lubritech Gleitmo 100
2. The following lubricants or equivalent may be used for shrink-fitting:
  - a) Dow Corning Molycote G-n paste
  - b) Fuchs-Lubritech Gleitmo

## **Related APTA standards**

**APTA PR-M-RP- 008-98**, “Passenger Car Axle Design”

## **References**

Association of American Railroads, *Manual of Standards and Recommended Practices*, Section G-II, “Wheel and Axle Shop Manual,” March 2012.

American Society for Testing and Materials:

ASTM E1444, “Standard Practice for Magnetic Particle Examination”

E1444/E1444M-11, “Standard Practice for Magnetic Particle Testing”

ASME B46.1, “Surface Texture (Surface Roughness, Waviness, and Lay)”

## **Definitions**

**AAR-class bearing:** Bearings manufactured in accordance with the *AAR Manual of Standards*, Section H, “Journal Bearings and Lubrication,” for use on bearing seat diameters as described therein.

**ambient temperature:** The temperature of the local surroundings. Inside a temperature-controlled building, ambient temperature is the same as room temperature.

**AP-style bearing:** A roller bearing assembly in which all the components are contained in a single unit. AP bearings contain two cone assemblies, a spacer ring between the cones to control axial clearance, a one-piece cup, and lubricant sealing systems at each end of the cup. Also known as an “AP-type” bearing or simply an “AP” bearing.

**component:** A part or a subassembly having a unique function within the assembly in which it is incorporated. Wheels, bearings, gears, gear units, brake discs, transmissions and couplings are components of wheel set assemblies. A component of a component is a subcomponent.

**circular runout:** See ASME-Y14.5.

**grinding:** The removal of metal using a stone wheel or a wheel or disc composed of other materials specifically designed for the removal of metal. Machine grinding is grinding that uses a machine tool, appropriately referred to as a grinder. Hand grinding is grinding using a handheld power tool.

**interference fit:** The difference in diameters between two assembled components where the bore of the fitted component is smaller than the seat onto which it is fitted.

**machining:** The removal of metal from a component using a machine tool, specifically by machine grinding or by turning.

**monobloc wheel:** A one-piece wheel made from a single piece of steel.

**mounting force:** The final force achieved during the press-fitting of two components discounting any spike force. See [Figure 5](#).

**new:** The condition of a component or assembly that has never operated in service.

**press-fitting:** The assembly of two components using an interference fit.

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**relief groove:** A radius undercut between two adjacent seats. The purpose of relief grooves is the reduction of stress concentrations in the area between two closely sized diameters adjacent to each other.

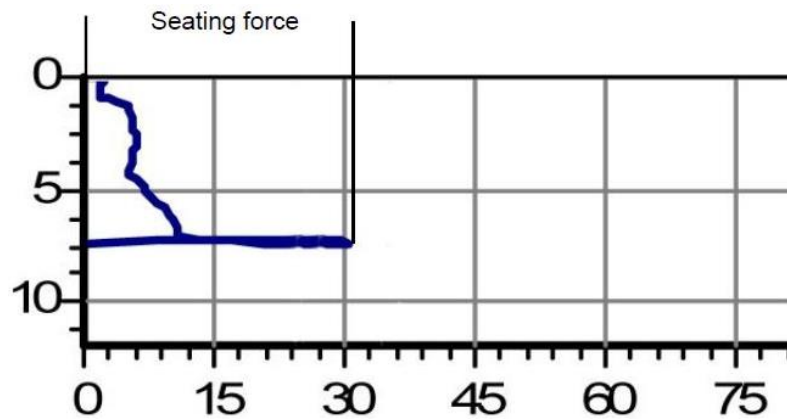
**resilient wheel:** A multi-piece wheel in which the tire is separated from the wheel center with resilient elements.

**score:** A linear scratch in the surface of a seat running axially along the seat. A superficial score is a score that is less than 0.002 in. deep.

**seat:** A cylindrical or conical surface onto which a component is assembled by means of an interference fit, e.g., wheel seat, bearing seat, brake disc seat.

**seating force:** The absolute force applied to a component that is mounted against a constraint. See **Figure 8**.

**FIGURE 8**  
Seating Force



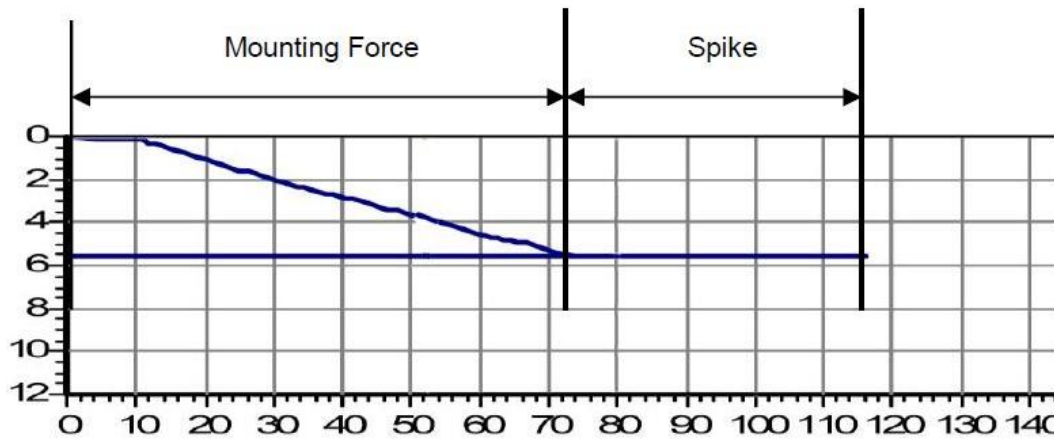
**secondhand:** A used component or assembly that has operated in service.

**short ton (U.S. short ton):** 2000 lbs.

**spike:** The force applied to a press-fitted component after that component has contacted a restraint. The restraint may be a shoulder, fillet or a previously fitted component that is constrained. The magnitude of the spike is the difference between the maximum force applied after contacting the constraint and the force applied immediately before contacting the restraint. See **Figure 9**.



**FIGURE 9**  
Mounting and Spike Forces



**shrink-fitting:** Fitting accomplished by heating or cooling a component to a temperature sufficient to temporarily create a clearance between the bore of the component and the seat onto which it will be assembled.

**surface finish:** The geometric irregularities that define the texture of a surface. All references to surface finish and the metrics and parameters quantifying the surface finish such as  $R_a$ ,  $R_z$ , etc., are as defined in ASME B46.1.

**tape size:** The number of eighths of an inch by which the circumference of the wheel, at the taping line, exceeds 84 in. Tape sizes are applicable only to wheels.

**taping line:** The diameter of the wheel at the wheel tread taken from a measurement of wheel circumference using a tape positioned on the wheel tread at the center of the contact area between wheel tread and top of rail with the wheel set centered between the rails.

**temperature stabilized:** A component is temperature stabilized when its entire mass has reached the ambient temperature of the environment in which it resides.

**tire:** The rim section of a multi-piece wheel.

**tired wheel:** A multi-piece wheel that uses a steel tire connected (with or without resilient elements) to a wheel center. The wheel center may be steel, aluminum or other material.

**turning:** The removal of material from a part using a cutting tool in a lathe. The removal of material takes place with a stationary cutting tool in contact with the rotating part.

**wheel set assembly:** A collection of components fully assembled into a single unit that allows rolling movement of the rail vehicle to which it is attached.

**Abbreviations and acronyms**

<b>AAR</b>	Association of American Railroads
<b>ASNT</b>	American Society for Nondestructive Testing
<b>ASTM</b>	American Society for Testing and Materials
<b>NATSA</b>	North American Transportation Services Association
<b>NDT</b>	nondestructive testing
<b>MT</b>	magnetic particle testing
<b>OEM</b>	original equipment manufacturer
<b>R<sub>a</sub></b>	mean surface roughness as defined in ASME B46.1-2009
<b>R<sub>sm</sub></b>	mean peak spacing as defined in ASME B46.1-2009
<b>R<sub>z</sub></b>	peak to valley height as defined in ASME B46.1-2009
<b>UT</b>	ultrasonic testing

**Summary of document changes**

**Document history**

<b>Document Version</b>	<b>Working Group Vote</b>	<b>Public Comment/ Technical Oversight</b>	<b>CEO Approval</b>	<b>Policy &amp; Planning Approval</b>	<b>Publish Date</b>
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