

## WHEELS, AXLES, AXLE GEARS AND PINIONS

This instruction covers the inspection and maintenance of wheels, axles, axle gears and pinions on Switchers (SW), Branch Line (BL), General Purpose (GP), Special Duty (SD), Freight (F) and Passenger (E) type locomotives.

Wheels and axles are inspected for visible defects each trip, as part of the inspection required by Federal Locomotive Inspection Law. Wheels are also periodically checked for wear, sharp flanges, shelling, cracks, and flat spots to see that they are within the limits prescribed by the Interstate Commerce Commission, Bureau of Locomotive Inspection.

Wheel and axle defects which require the removal of any particular wheel set are fully defined and illustrated in the "Wheel and Axle Manual," published by the Association of American Railroads, 59 E. Van Buren St., Chicago, Illinois.

**NOTE:** See AAR Wheel and Axle Manual for complete information, including use of gauges for checking wear and defects. The AAR gauge and the wheel defect gauge may be purchased from Pratt & Whitney Company.

Defects in axle gears may also require removal of wheel sets. Such defects usually are in the form of a gear failure or damage to the gear due to breakage of the motor pinion.

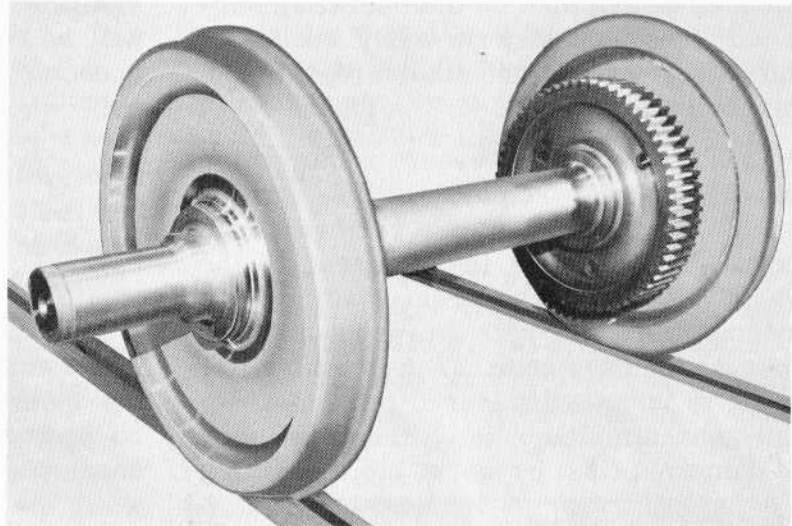


Fig. 1 - Wheel Set With Axle Gear

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### REMOVAL OF WHEEL SETS

Wheel sets may be removed while a truck is under the locomotive, or the truck itself may be removed and taken to a truck overhaul section of the shop where wheel sets are removed for maintenance.

The weight of the locomotive should be supported on the locomotive jacking pads before dropping wheel sets. If this is not done, serious damage may result.

**NOTE:** Axle journal bearing surfaces should be protected when the journal boxes are removed.

### REMOVAL OF WHEELS AND AXLE GEARS

After the wheel set, Fig. 1, has been removed from the locomotive, it may be necessary to press off the wheels and axle gear as well as to remove the roller bearing inner races for inspection and servicing.

\*This bulletin is revised and supersedes previous issues of this number.

When wheels are pressed off, be careful to apply the pressure uniformly over the end of the axle to avoid upsetting it. Always use a pressure block (see Fig. 6) between the end of the axle and the ram of the press. An upset condition of the axle end will cause the journal to swell locally at the outer end, which would be transferred to the outside of the inner race as a high spot on the operating surface. This would cause early failure of the race, and might interfere with the assembly of the box over the journal.

The amount of pressure required for wheel and gear removal is disregarded when wheels and gears are removed from axles. The wheel at the gear end of the wheel set should be pressed off by removing the gear with it, using a press yoke against the gear. If the wheel press capacity is not sufficient to remove wheel and gear simultaneously, the wheel may be removed first by use of blocks against the top and bottom of the wheel rim. The

wheel should be rotated so the stampings on the wheel rim are under the blocks, lessening the possibility of cracking the wheel. Break the wheel loose. Remove blocks and apply pressure to the gear hub. Break the gear loose and remove wheel and gear separately.

When inspection shows that a considerable reduction in one wheel diameter will be required to remedy a defect, it is economical to dismount just one wheel. If both wheels are turned to the required diameter, a considerable loss of service metal will be incurred by the other wheel. See AAR Wheel and Axle Manual, paragraph 288, for analysis of this condition.

If the axles are not Magnafluxed, all wheel work may be done without disturbing the inner races. They should, however, be protected against damage by applying sheet copper or brass sleeves over them while the wheel work is in process.

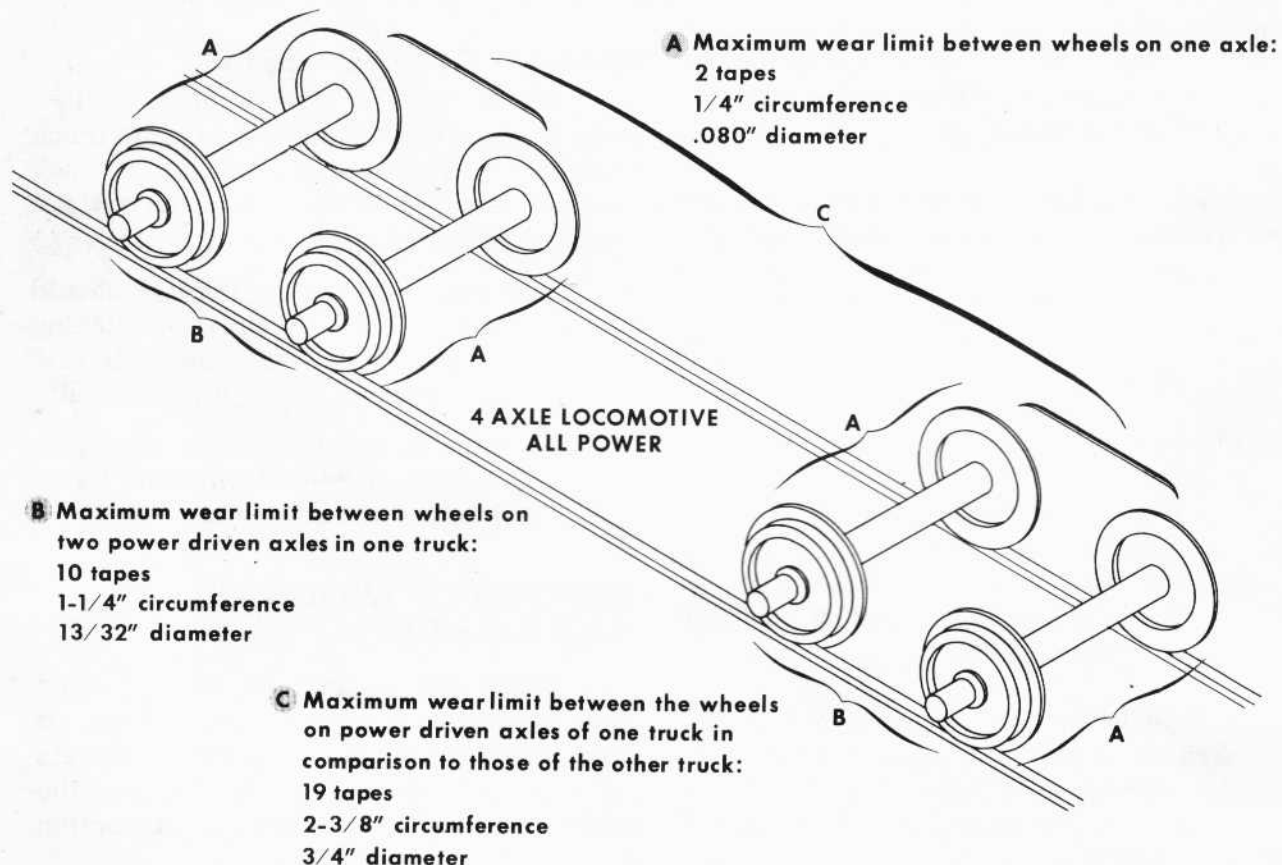


Fig. 2 - Wheel Wear Limits - 4 Axle Locomotives

## WHEELS

Wheels are two nominal diameters, 36" and 40". The 36" diameter wheels are used on six wheel passenger locomotive trucks with an idler axle. The 40" wheels are used on all other trucks.

Two types of wheel treads are used, as follows:

- Taper - "E" locomotives  
Switching locomotives  
F, BL, SD and GP locomotives having maximum permissible speeds of 70 MPH or less (61:16 gear ratio or lower)
- Cylindrical - F, BL, SD and GP locomotives having maximum permissible speeds of 75 MPH or over (60:17 gear ratio or higher)

## WHEEL WEAR LIMITS

In addition to the defects listed in the AAR Wheel and Axle Manual, the maximum wear limit for wheels in service is 2 tapes (1/4" in circumference, or .080" in diameter) between wheels on the same axle, see dimension "A," Fig. 2.

The wheel sizes on power axles that are driven by the same generator may vary up to 10 tapes (1-1/4" in circumference or 13/32" in diameter) between power axles on one truck and up to 19 tapes (2-3/8" in circumference or 3/4" in diameter) between power axles on two trucks. These are shown as dimensions "B" and "C" respectively in Fig. 2.

On six-wheel trucks with idler axles, the variation between the size of either pair of power wheels and the idler wheels must not exceed 25 tapes (3-1/8" in circumference or 1" in diameter).

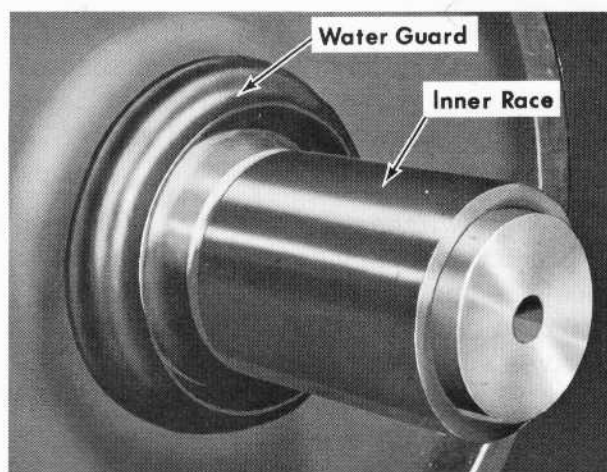
The wheel seat should be checked for taper and machined to AAR specifications if the wheel seat taper exceeds .002" per foot on diameter.

The micro inch finish on the hub of the flange side of the wheels must not be more than 15 micro inches.

## Water Guard

The water guard, Fig. 3, remains in place for the life of the wheel. The water guards can be pried off, after being heated sufficiently with a torch to release the shrink fit and reused on the new wheels. Remove the water guard from the wheel hub after the wheel has been removed from the axle. To apply the water guards, heat them in an open flame or by torch to a black heat at 500° F. to 700° F. and shrink them in place on the wheel hub. They should be pushed tightly against end of wheel hub.

Water guard 8102844 should be applied to 36" wheels on all E class locomotives. Water guard 8259873 should be applied to all 40" wheels, except on switcher locomotives with friction journal bearings or grease lubricated roller journal bearings.



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Fig. 3 - Water Guard

## AXLES

Axles for freight and passenger locomotives are Type E-12. Axles for switcher locomotives are designated as E-12-X. The power axles used for 36" and 40" wheels differ in some dimensions although the diameters of wheel seats and journals are the same on both types as are the axle gear seat diameters.

Because of possible dangers resulting from axle cracks, it is recommended

that axles be given a Magnaglo or Magnaflux test whenever a wheel is removed, regardless of length of service. The roller bearing inner races should also be removed so that the axle under the bearing race can be visually inspected for fretting and then Magnaflux tested. (See "Magnaflux inspection" at end of this instruction.)

Crack indications on an axle in the transverse plane are dangerous and the axle should be scrapped, unless individual railroad specifications authorize crack removal procedures. The axle should be scrapped if suspension bearing journals or the journals of axles for friction type boxes show evidence of bearing seizure accompanied by thermal cracks. Copper penetration makes the axle steel very brittle and subject to breakage. A distressed axle should never be reused until inspected for copper penetration and approved for use by the Railroad Engineer of Tests.

Axles should be checked for runout and should not exceed .030" total indicator reading with journal box bearing at zero. If the axle has over .030" total runout, it should be scrapped.

On switcher locomotives equipped with friction bearings, the journal taper should be checked. If taper exceeds 1/32" it should be reworked. On switcher locomotives equipped with roller bearings the taper should be reworked if it exceeds .001".

New and service dimensions for axles are shown in Fig. 4.

Axles and axle gears may be used until worn to maximum wear limits, if Magnaflux inspection reveals no defects.

If axles are not Magnafluxed at each wheel removal, it is recommended that the axle be scrapped after two pair of wheels have been worn to maximum wear limits.

In order to insure accurate axle measurements, the micrometers used should be checked against a known standard. Axles should always be measured when they are cold, never when they are

warm from machining. All fillets and axle ends must be polished free of tool marks, and each time wheels are turned, all burrs or other irregularities should be polished off axle ends. If it is necessary to machine axle ends, the same amount should be removed from each end to insure that the axle is centered in the truck after assembly.

If the axle has a spline for a speed governor drive, the spline should be visually inspected and replaced if any of the teeth are found broken, chipped, cracked or have rounded edges.

The journals should also be checked for taper and machined if the taper exceeds 1/32" for the length of the journal. The micro inch finish of a maximum of 15 micro inches must be maintained.

If the wheel set has been removed from a truck involved in a wreck, the inner races must be removed and the journals of the axles should be Magnaglo or Magnaflux tested.

#### Axle Journal - Roller Bearing (See Fig. 4)

The minimum axle journal diameter is governed by the interference fit between the axle journal and the bearing inner race.

On axles manufactured prior to July, 1951, the new axle journal diameter was 6.503" to 6.5015". This provided a minimum interchangeable interference fit of .0015" to the inner race, which can have an I.D. of 6.500" to 6.499".

On axles manufactured after July, 1951, the new axle journal diameter is 6.504" to 6.503". This provides a minimum interference fit of .003" to the inner race.

A service limit of 6.5015" minimum axle journal diameter provides an interchangeable interference fit of .0015". If it is desired to use a selective fit, an axle journal diameter of 6.5005" can be used with an inner race having a minimum I.D. of 6.499" to obtain the .0015".

The minimum interference fit of .0015", for any axle, is only permitted providing that:

1. Inner race does not show fretting in excess of 20% of total I.D. surface.
2. Axle journal surface does not show fretting in excess of 1" wide or 10% of the total surface.

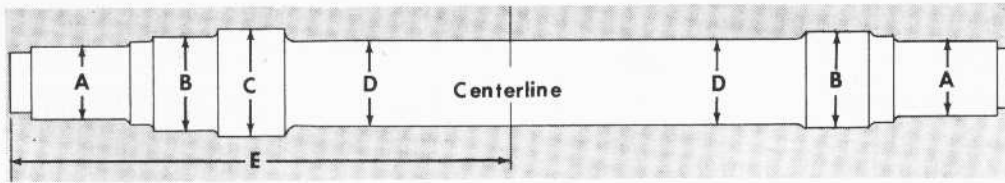
When an axle journal is machined and a .020" undersized race is used, the interference fit should be .003" to .005". Refer to Fig. 5.

If the .0015" interference fit can not be obtained with a standard inner race, the

axle journal can be machined and a .020" undersized inner race can be used. Refer to Fig. 5. However, the interference fit should be .003" to .005".

**Axle Journal - Friction Bearing**

Friction bearing axle journals that have been worn MECHANICALLY may be reduced to not less than 6.250" diameter and a 3/4" minimum fillet radius must be maintained. All tool marks MUST be polished from the fillet. If an axle journal has worn to 6.125" diameter, the axle should be scrapped



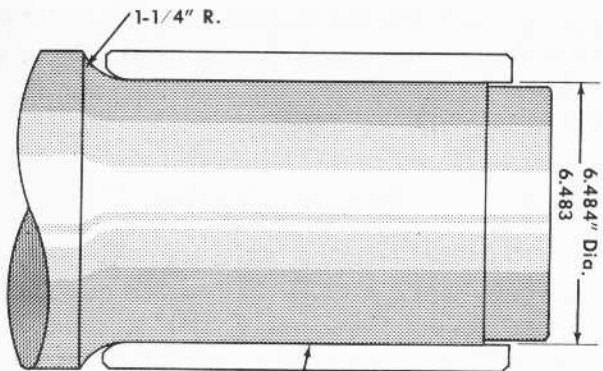
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REF.	DESCRIPTION	ALL F, GP, SD, BL		ALL E POWER AXLE IDLER AXLE				SWITCHER ROLLER BEARING FRICTION BEARING			
		New	Service	New	Service	New	Service	New	Service	New	Service
	Axle Part No.	8054494		8049628		8051302		8189049		8068674 & 8170414	
	Water Guard No.	8259873		8102844		8102844		None		None	
	Nominal Axle Diam.	8"		8"		8"		8-1/4"		8-1/4"	
A	JOURNAL										
	Max. Diam.	6,504	6,504	6,504	6,504	6,504	6,504	6,504	6,504	6,500	6,500
	Min. Diam.	<sup>1</sup> 6,503	6,5015	6,503	6,5015	6,503	6,5015	6,503	6,5015	6,495	6,250
		<sup>1</sup> 6,5015	<sup>2</sup> 6,5005								
			<sup>3</sup> 6,483								
	Max. Taper	.001		.001		.001		.001		.0312	
	Max. Out of Round	.001		.001		.001		.001		.005	
B	WHEEL SEAT										
	Max. Diam.	9,231	9,231	9,231	9,231	9,231	9,280	9,231	9,231	9,231	9,231
	Min. Diam.	9,230	9,125	9,230	9,000	9,230	9,000	9,230	9,000	9,230	9,000
	Max. Taper	.002		.002		.0006/ft.		.002		.002	
	Max. Out of Round	.002		.002		.002		.002		.002	
C	GEAR SEAT										
	Max. Diam.	9,251	9,251	9,251	9,251	--	--	9,251	9,251	9,251	9,251
	Min. Diam.	9,250	9,250	9,250	9,250	--	--	9,250	9,250	9,250	9,250
	Max. Taper	.002		.002		--		.002		.002	
	Max. Out of Round	.002		.002		--		.002		.002	
D	SUPPORT BEARING										
	Max. Diam.	8,002	8,002	8,002	8,002	--	--	8,252	8,252	8,252	8,252
	Min. Diam.	7,998	7,875	8,000	7,875	--	--	8,250	8,125	8,248	8,125
	Max. Taper	.005		.005		--		.005		.005	
	Max. Out of Round	.005		.005		--		.005		.005	
E	END TO $\phi$ OF AXLE										
	Max.	45-1/2	45-1/2	45	45	45	45	46-3/8	46-7/16	46-3/8	46-7/16
	Min.	45-15/32	45-1/4	44-3/4	44-3/4	44-31/32	44-3/4	46-7/16	46-1/8	46-7/16	--

NOTE: All dimensions are in inches.

- <sup>1</sup> Axles manufactured prior to July 1951.
- <sup>2</sup> Only if used with an inner race I. D. of 6,499.
- <sup>3</sup> Axle machined for use with .020" undersized inner race.
- <sup>4</sup> Seal used in journal box.

Fig. 4 - Axle Dimensions



Do not finish this surface with roller or burnisher. This diameter to be measured when axle is cold. Axle to be round within 0.001 of an inch. Taper not to exceed 0.001 per foot on diameter.

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Fig. 5 - Axle Journal For .020"  
Undersized Inner Race

### Support Bearing Area

The maximum axle diameter reduction at the support bearings should not exceed 1/16" due to the axle loading on some locomotives. However, 3/32" and 1/8" undersize support bearings are available for railroads wanting bearings below the recommended minimum undersize of 1/16".

### Wheel Seat Area

Wheel seats may be ground undersize to the limits given in Fig. 4. However, at the gear end, the transition between the wheel seat and the gear seat must be a smooth radius and the wheel seat length should be increased from 1/16" minimum to 5/32" maximum to insure that the undersized wheel bore does not contact the shoulder.

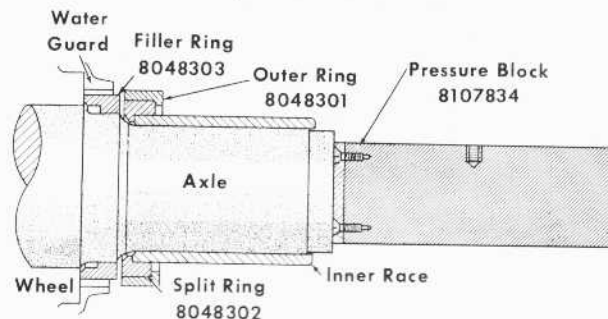
## JOURNAL BEARING INNER RACE

Induction heater 8254202 is recommended for removing and installing the journal bearing inner race.

If an induction heater is not available, the inner race may be pressed off with the wheel by interposing split ring 8048302 between the race and the wheel hub, see Fig. 6.

The race should be thoroughly inspected before reapplication, following the procedure below:

1. Inspect the I. D. surface for fretting. If fretting is evident on more than 20% of the total surface, the race should be discarded. If the journal shows fretting not over an inch wide and O.D. of the axle measures the minimum diameter (refer to Fig. 4), where fretting exists, either a new race, or a race that has been removed from another axle should be applied. When applying a used race to a used axle, it is preferable to use a race with little or no signs of fretting.
2. Inspect for indenting, scoring or pitting on the O.D. surface. If any imperfections are found on the roller paths reject the race for further use.
3. Measure the I. D. of the race with a micrometer. Dimensions are 6.499" minimum and 6.500" maximum. The maximum out of round limit is .001".
4. Inspect for hardness with a scleroscope, or other suitable hardness tester similar to the Ernst tester, in the approximate center of each roller path (3" to 4" from each end of the race). If a hardness tester is used which leaves an indentation larger than a Rockwell 15 N impression, the indentation must be stoned flat with a smooth stone. Hardness should not be below 75 Shore Scleroscope (Rockwell "C" 56).



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Fig. 6 - Inner Race Removal

The inner race is applied by heating it in an induction heater and shrinking it to the axle. If an induction heater is not available, heat inner race in oil to a maximum of 300°F. and shrink to the axle. Wipe the oil from the inside of the race before it is reapplied. When heated, the race can be easily slid into place. Take care to properly position the race before it cools and seats on axle. The use of asbestos gloves is recommended for handling the hot race. A split collar 8164608, shown in Fig. 7, clamped around the journal will space the race the proper distance from the journal fillet. Due to slight variations in axle length, it is preferable to locate the race from the fillet rather than from the end of the axle. Under no conditions should the shrink fit of the race encroach upon the journal fillet. See Fig. 9 for the dimension of inner race to fillet.

NOTE: The split collar 8164608 cannot be used to locate the inner race on axles with the seal ring used with grease lubricated roller bearings. On these axles the inner race is spaced 1/32" from the edge of the seal ring by using 1/32" thick strips or a 1/32" thick collar against the seal ring.

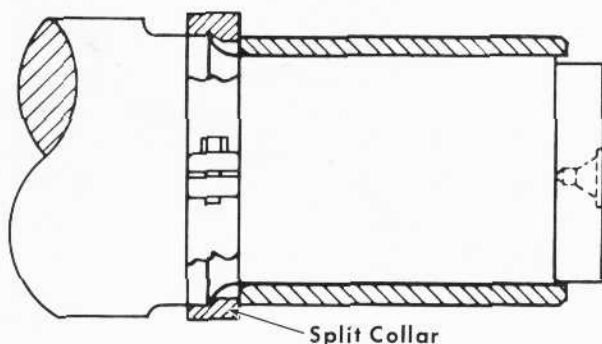


Fig. 7 - Locating Inner Race

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## AXLE GEARS AND TRACTION MOTOR PINIONS

Axle gears for all locomotives are the same design, the gears differing only in pitch diameter and number of teeth.

Each time a wheel set is removed from a truck for any reason, the gear should be thoroughly inspected. Wear

limits for axle gears and traction motor pinions are given in the inspection procedure below:

1. After the gear has been removed, examine the inner face of the gear hub and polish off any marks that may have been made while removing gear.
2. Visually inspect for broken, chipped, spalled or pitted teeth. Pinions and axle gears should be rejected when more than 20% of the total working surface of tooth is spalled or pitted. Axle gears should be scrapped when either one of the working surfaces is worn to the point where a step 1/32" deep exists in the root of the gear tooth where contact with the pinion ends.
3. Check for wear limits, determined by dimension across the tip of the tooth. The minimum allowable dimension at this point is 5/16" for one piece axle gears and 1/4" for two piece axle gears, Fig. 8. Pinions are similarly measured and qualified according to size as indicated below.

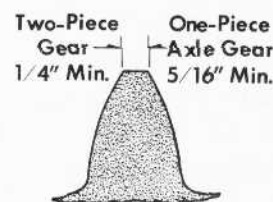


Fig. 8 - Axle Gear Wear Limits

Pinion Teeth	Limit
12	1/16"
15-16-17-18	1/8"
19-20-21-22-25	3/16"

Burrs at the corner, where the tooth wear surface and the tip of the tooth meet, should be removed before the above measurements are made. Matching of pinions and axle gears is not necessary, if these limits are held.

4. Inspect the bore in the axle gear for scoring. To obtain the proper press-on tonnage for the axle gear, the bore surface must be in good condition. Inspect the gear hub wear face for grooving and micro inch finish. The face must be free of grooves and the finish must not be more than 20 micro inches.

5. Inspect for cracks by Magnaglo or Magnaflux.

Fatigue cracks on axle gears and traction motor pinions usually start in the fillet at the root of the teeth on motor side, approximately 1/2" from the end, and progress to the side of the gear. Fatigue cracks in the axle gear or pinion at the root of the teeth are dangerous and the axle gear or pinion should be replaced.

The axle gear, if not subjected to Magnaglo or Magnaflux, should not be used beyond the life of two axles.

## MOUNTING OF WHEELS AND AXLE GEARS ON AXLE

See AAR Wheel and Axle Manual, Section XV, for detailed information on mounting procedure.

Wheels to be mounted on a road locomotive axle should be mated with a maximum variation of 1/2 tape (1/16" in circumference or .020" in diameter); on switchers, wheels on the same axle should

not vary more than 1 tape. If new or used wheels are not available within these limits, they should be matched as closely as possible, and turned and ground after mounting.

The interference between the wheel bore and the wheel seat should be between .008" and .010". The interference between the gear bore and the gear seat should be between .010" and .012".

Referring to Fig. 9 for mounting dimensions, assemble wheel set as follows:

1. To locate the center of the axle, mark the axle with chalk, and measuring from the ends of the axle, scribe the chalk with a blunt instrument. The metal of the axle must not be permanently marked in any way such as prick punching or scribing with a sharp instrument.
2. Press axle gear onto the axle with a pressure of between 55 and 125 tons. When reused axles or gears are assembled, the mating surfaces must not be scored.

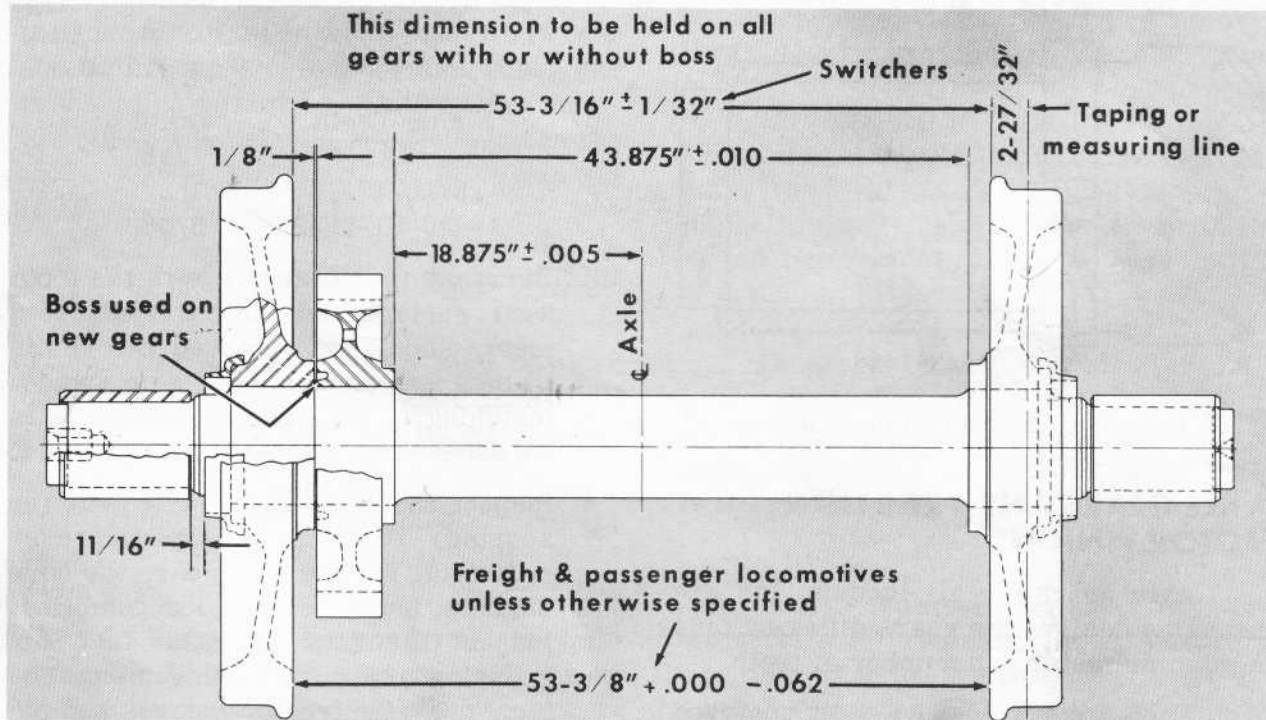


Fig. 9 - Dimensions For Assembling Wheel Sets

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3. Press on the wheel opposite the gear end.
4. Press on wheel next to the gear. For new or used wheels on a new axle with the wheel seat reground, the pressure required should be 80 to 130 tons.

NOTE: White lead may be used as a lubricant when mounting wheels and axle gears.

A permanent Record of Pressure Graph should be made for every mounting operation. The pressure rise indicated on the graph should be gradual as shown in Fig. 10. The four graphs illustrate pressure curves ranging from ideal to acceptable.

All axle gears manufactured since late in 1946 have a boss on the spider, just above the axle bore. This boss protrudes 1/8" beyond the face of the gear hub. With the use of this new gear, it is no longer necessary to check the 1/8" clearance between the axle gear and the wheel. As the wheel is being pressed solid against this boss, this clearance will be attained automatically. On all axle gears of previous manufacture, it is necessary that this 1/8" clearance between wheel hub and gear hub be maintained.

Wheels on idler axles are mounted according to standard wheel practice.

### MATCHING OF WHEEL SETS IN TRUCKS OR LOCOMOTIVE UNITS

On locomotives with 4-wheel trucks, wheel sizes between different axles may

vary up to 3/4" in diameter in any individual locomotive unit. This same rule applies to switchers.

On locomotives having 6-wheel trucks, used wheel sizes between different power axles in any truck may vary up to 3/4" in diameter. The variation between the size of either pair of power wheels and the idler wheels must not exceed 1" in diameter. On new trucks, the variation between power axle wheels should not exceed 3 tapes (3/8" in circumference or .120" in diameter), and a variation between power and idler wheels should not exceed 14 tapes (1-3/4" in circumference, or 9/16" in diameter). New wheels may vary from normal size to 14 tapes oversize.

### MAGNAFLUX INSPECTION

The Magnaflux Corporation should be contacted for suitable equipment and technical aid.

The Magnaflux inspection mediums in order of sensitivity are Magnaglo bath, wet Magnaflux bath, and dry powder method. All are applicable and the choice will depend on facilities and conditions under which the inspection is to be made.

Operator technique is important when using Magnaflux powder in that crack indications can be masked by too much powder, or overlooked if too little or an uneven application of powder is made. A bulb type applicator will give satisfactory results if used properly.

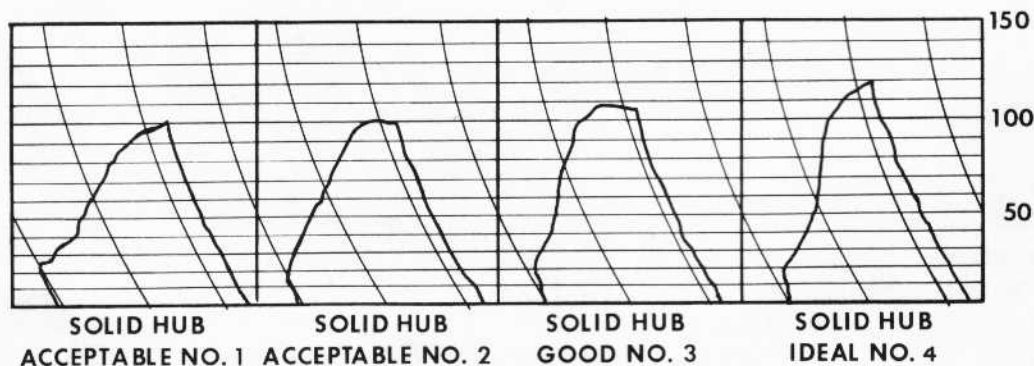


Fig. 10 - Typical Pressure Graph

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The Magnaflux or Magnaglo method of inspection is very searching, and indiscriminate scrapping of parts showing Magnaflux or Magnaglo indications without regard to their effect on part function may

be very costly to the railroad. If doubt exists concerning the significance of a specific Magnaflux or Magnaglo indication, the railroad's Engineer of Tests should be consulted.

<u>Part</u>	<u>Magnetization</u>	<u>Current</u>
Axle	Four turn coil - *Continuous	500-600
Axle Gear	Three turn coil - *Continuous	200-300
	Hairpin coil - **Residual	150-200
Pinions	Three turn coil - *Continuous	200-300
	Hairpin coil - **Residual	150-200
	Mounted on brass bar	2000-3000

\*Inspection medium applied while part is being magnetized.

\*\*Inspection medium applied after part has been magnetized.