DISC WHEELS OR SPOKE WHEELS?

FOR AND AGAINST!

Where would Mankind be today had the wheel not been invented? We'd all probably be sitting in the same cave beating a piece of raw meat with a rock. The invention of the wheel has certainly played a role as one of the major factors in the emergence and growth of civilisation. Transportation of commodities and product was made possible by the introduction of wheeled vehicles.

It is generally thought that the wheel originated in either Mesopotamia or Western India, probably over 5,000 years ago. Gradually, knowledge of the wheel spread to Europe, but design and construction made little progress on the original "3 piece" wooden and spoked forms during the early period of history. It was not until the nineteenth century, with the introduction of mechanical power and improved roads, that the wheel design made significant advances:-

About 15,000 patents for wheels were taken out in the period 1855 to 1940 with the greatest stimulus to the development of road transport being provided by the production of the first pneumatic tyre by John Boyd Dunlop in 1888. The great wheel invention of all time was that of C.K. Welch, who in three days of inspired contrivance, in 1890, converted Dunlop's unmarketable embryo device to a new detachable tyre, simply and readily saleable for assembly by any customer. The Welch invention is still used worldwide.

Further impetus to road transport development was given with the lifting of the 4mph speed limit for motorised vehicles in Britain in 1896 and the licensing of the first pneumatic bus tyres in London in that same year.

The design of the multi-piece wheel rim for commercial vehicles was patented in 1912 and has been little changed over the years.

Lighter vehicles were developed in the mid-nineteen-twenties and this resulted in the introduction of the wire spoked wheel for passenger cars. Shortly before world war two the spoked wheel was superseded by the ventilated disc type to assist brake cooling and improve manufacturing techniques.

In the 1960's commercial wheel development made significant progress with the wide base rim and tests on tubeless design to reduce weight and improve tyre performance, and as we moved into the eighties considerable research was initiated to find new raw materials for wheel construction.

One of the safest items on a vehicle is the wheel. This is necessarily so since a wheel failure can result in a serious accident.

The excellent performance of today's steel wheel is not the result of over-designing. It is the result of many years of laboratory and proving ground testing coupled with historical field experience. The general design of the wheel for heavy commercial trucks and buses is not expected to change to any significant degree but the question of preference or otherwise for disc wheels versus spoke wheels continues.

Heavy, low speed, off-the-road vehicles are almost universally transported with tyres on demountable rims and cast spoke wheels. Passenger cars and light trucks are as universal in their use of disc wheels bolted on to a hub. It is in the field of medium and heavy trucks, buses and trailers combinations for over-the-highway use that these two concepts of wheel design overlap.

Looking at the Australia market for commercial vehicles, the ratio is 55 - 45% in favor of spider hubs, for trailers spider hubs dominate at about 95% and for the passenger bus market disc wheels command 100% of the fitment. As the input of Japanese manufactured vehicles increases, the emphasis will swing further towards disc wheels on commercial trucks. However, the heavy end of the commercial vehicle market and heavy trailers will basically remain committed to spider hubs.

In the U.S.A. the heavy truck market mix in 1985 was 41% spider - 59% disc wheels and by 1990 this ratio is expected to be 31 - 69%. Trailers fitment in 1985 - U.S.A. - was 45% spider hub wheel assembly and will drop to 30% by 1990.

One of the important claims made by disc wheel proponents is that disc wheels are truer running in service than spoke wheels, that is, they have lower lateral and radial run-out. Radial run-out is a measure of the out-of-roundness of a wheel from its true centre while lateral run-out is a measure of the out-of-squareness or wobble of the wheel.

Despite the many claims of disc wheel proponents it is difficult to document their views in precise terms. Disc wheels retain a specific runout when mounted onto a vehicle, since the disc centre is firmly attached to the rim and is centred onto the hub by a positive means. However, the run-out of a demountable spider rim depends entirely on the skill of the tyre serviceman and the time and effort allotted to mounting the rim onto the spoke wheel by adjusting the wheel clamps.

In 1970 an extensive survey was conducted in the U.S.A. of wheel radial and lateral runout as it actually existed on truck-trailers fleets. Seven fleets using disc wheels and seven using demountable spoke wheels were checked. After ten years the survey was repeated to determine whether there was any improvement. The fleets were all random picked.

In the second survey, eight fleets were picked, four that used disc wheels and four on spider hubs with equal numbers of tubeless also covered. The following is the analysis:-

TABLE 1

NUMBER OF WHEELS MEASURED

	1970			1980		
	SPOKE	DISC	TOTAL	SPOKE	DISC	TOTAL
Total Wheels	320	224	544	288	288	576
Trailer Wheels	72	68	140	128	128	256
Tractor Drive Wheels	191	124	315	128	128	256
Tractor Steering Wheels	57	32	89	32	32	64
Tubeless Wheels	85	126	211	142	144	286
Flat Base Wheels	235	98	333	146	144	290
Inner Dual Wheels	132	96	228	128	128	256
Outer Dual Wheels	131	96	227	128	128	256

TABLE 2

RUNOUT READINGS OF MEDIAN WHEELS BY CATEGORY

	LATERAL		RADIAL	
	Median		Median	
	69-70	79-80	69-70	79-80
All Wheels				
Disc	.051	.041	.059	.046
Spoke	.105	.095	.080	.078
Flat Base				
Disc	.033	.036	.053	.045
Spoke	.109	.112	.077	.086
Tubeless				
Disc	.065	.046	.065	.047
Spoke	.100	.087	.089	.071
Tractor Steering				
Disc	.044	.045	.050	.045
Spoke	.089	.064	.061	.051
Tractor Drive Axle				
Disc	.054	.043	.065	.045
Spoke	.105	.094	.085	.076
Trailer Axle				
Disc	.045	.038	.057	.046
Spoke	.108	.109	.090	.087
Inner Duals				
Disc	-	.040	-	.045
Spoke	-	.095	-	.072
Outer Duals				
Disc	-	.042	-	.046
Spoke	-	.108	-	.092

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The Spoke wheel proponents make the point that tyre changing is relatively easy to handle, the tyre/rim assembly is lighter but agree that truing-up on on the spider hub takes time. Only minimal problems exist with stud length and nut freeze on. As tyre sizes get bigger spider hub assembly is more attractive. However, manufacturers of spider hubs must qualify the balance and/or runout of their product if the final assembly is to run true.

Which wheel type should be used for which application is a very hazy area. Some operators buy one type simply because they like it. No logic involved, they simply like that type. After a fleet operator establishes his fleet on one type of wheel, its often very difficult for his successor to change on to the other type. However, modern day Managers are very conscious of the trends to higher horsepower, greater braking torques, increased axle loading and speed levels and are prepared to introduce new technology to maintain efficiency.

The cost factor must also be a consideration. Disc wheels in general cost less than spoke wheels on smaller trucks and Cast Spokes cost less than disc wheels on many of the bigger rigs.

One of the early drawbacks for Disc wheels has been their weight. Every kg. that the truck's engine must haul that isn't payload decreases the operating efficiency of that truck. However, today some of the models on offer are approximately the same in tare weight with either spoke or disc wheel assembly so the inroduction of forged alumimium disc wheels to the market with their weight saving benefits adds flexibility in the options for wheels for the operator favoring disc wheels.

For example, the weight of ten (10) 9.00 x 22.5 steel wheels on a standard prime mover is 470 kgs. and the wheel weight with 9.00 x 22.5 forged aluminium wheels is 263 kg. for a tare weight saving of 270 kg. This means fuel savings when weight saved is not replaced with payload.

Those who use disc wheels claim one big advantage that assists tyre wear. The tyre, rim/wheel go on the truck as one unit and the unit is mounted against a machined hub so that wheels running true to line is automatic. However, in today's higher horsepower and increased braking torque levels, wheel security is the biggest concern with disc wheels.

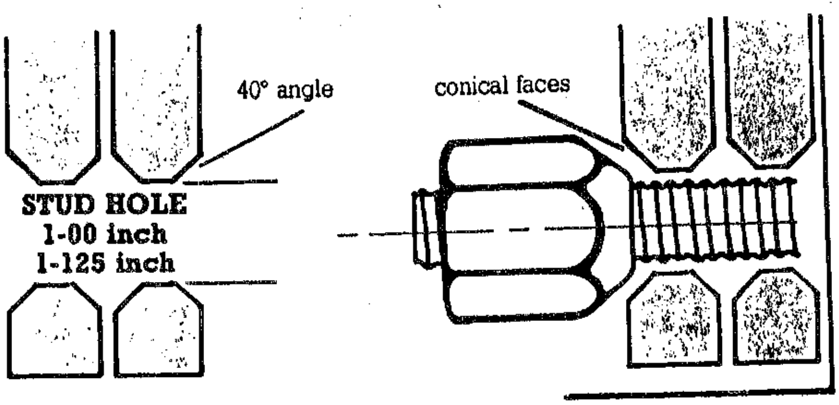
On the surface, truck wheels look pretty much the same as passenger car wheels, only bigger. They are seemingly plain and round, they come on the truck when you buy it, and they will most likely last the life of the truck. In reality, truck wheels are complex technical units, they are not plain round things, and because there are so many variations it's easy to use the wrong wheel in the wrong application. This is not so with spider hubs and their rim fitment. Wheel security is a real concern with disc wheels, so the disciplines highlighted for spoke wheel fitment now require attention in disc wheel fitment.

There is now an increasing awareness by fleet engineers that wheel fixings for disc centred wheels are so varied that vehicle safety demands closer attention to their tightening torque and sequence. There really should be no question of wheel nuts working loose.

The modern range of trucks on ten-stud wheel mounts is fitted with wheels that have plain stud holes in the wheel whereas the wheels supplied until recent times had tapered or conical stud holes. The bolt circle diameters are the same and thus the wheels can be mounted to the hubs of new and old vehicles. The variation in wheel nut taper and the flat-collar nuts supplied with the newer wheels when fixed to the incorrect stud hole means that wheel security is suspect and potentially dangerous. Let's explain:-

The variety of wheel fixings likely to be encountered in mixed vehicle fleets is illustrated as follows.

British Standard Drilling



ENGLISH STANDARD
10 STUD 335 P.C.D.

For wheels manufactured to the British Standard Drilling the correct fitting is based on the correct location of the angled face of the nut matching the countersinking of the stud hole. This is referred to as stud hole mounting. The wheel has to be lifted from resting on the uppermost wheel studs to obtain correct seating of the countersinking with the conical face of the nut.

Care must be taken to ensure that wheel nuts are properly located before final tightening takes place.

The following is the standard British practice for wheels of various stud hole drillings with wheel nut tightening sequence.

Number of Stud Holes	Dia. of Studs	Pitch Circle Dia. of Stud Holes mm.	Wheel Bore mm.	Hub Spigot Dia. mm.	Dia. for Hub Flange or Brake Drum Facing ins.	Minimum Dia. for Flat or Wheel Nave ins.
6	18mm.	205	161	160	9.85	10.00
8	18mm.	275	221	220	12.50	12.75
8	5/8 in. B.S.F	275	221	220	12.50	12.75
8	7/8 in. B.S.F	275	221	220	12.50	12.75
10	7/8 in. B.S.F	335	281	280	14.75	15.00

Caution

Low torque can cause broken studs, cracked discs, loss of wheel, enlarged bolt holes, excessive wear on the wheel disc face and hub face. Excessive torque can cause broken studs and nuts, burr on the edge of the countersink.

Damaged or rusty threads can affect the tightening of a nut to the extent that whilst the torque wrench would "break" at the correct setting, the nut would not necessarily be exerting that force on the nave of the wheel. It is thus most important to ensure that the studs are free from rust and lightly oiled. The oil must be kept off the cone face of the nut and the countersinking of the hole as this will also give an incorrect torque reading.

If wheel nuts are heard to "crack" on tightening, they are almost certainly overtightened.

Finally, before lifting the wheel on to the hub make sure that the mating surfaces - the face of the brake drum, the nave of the wheel - are free of foreign matter that could affect the seating of the wheel(s).

Standard torque recommended for tightening British wheels with ten stud mounting is 375/425 Ft.Lbs. - (510/580 Nm) - with a recheck of tightness when the vehicle has covered approximately 50 km of travel.

When axle loading on two wheels reaches 5 T and modern day speeds are employed this torque level may be insufficient. To get enough preload with a coned nut the tightening torque needs to be 450 Ft.Lbs (610 Nm) but at this torque there is risk of stud hole-spread because the wheels may not be strong enough. So McKay are now upgrading material specifications and centre nave thickness to allow for increased torque in the 450/500 Ft.Lb. range.

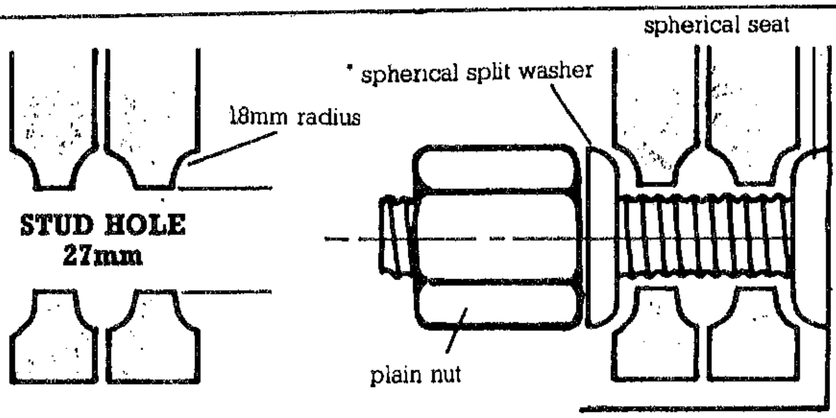
The problem with coned nut fixing at higher torque loadings is the effort lost in friction - and the increasing effect of this with time. With successive changes of the wheels on a unit the nut friction increases - needing more and more torque to provide enough preload on the studs so that wheel nuts really need to be changed after twelve wheel removals.

With commercial vehicle wheels the stress fluctuations are high. The bigger the offset the worse the fluctuation because of the superimposed cantilever load. As the imposed load fluctuates so does the preload; that is the root of the trouble.

At any given moment the preload varies, from stud to stud, between plus 4 and minus 3 tonnes. Every stud goes through this cycle in every revolution. If one or two nuts slacken or a stud breaks the lives of the remaining studs are then in jeopardy because the load fluctuation ranges from 3.2T to 5.6T when the acceptable level is plus or minus 3.5T. This shows why it is so important to keep all wheel nuts tight to avoid wheel nave distortion. Wheel offset puts the lower studs in compression and the upper ones in tension. As the wheel rotates they exchange positions and the direction of stress is continually changing.

DIN STANDARD

10 STUD 335 P.C.D.



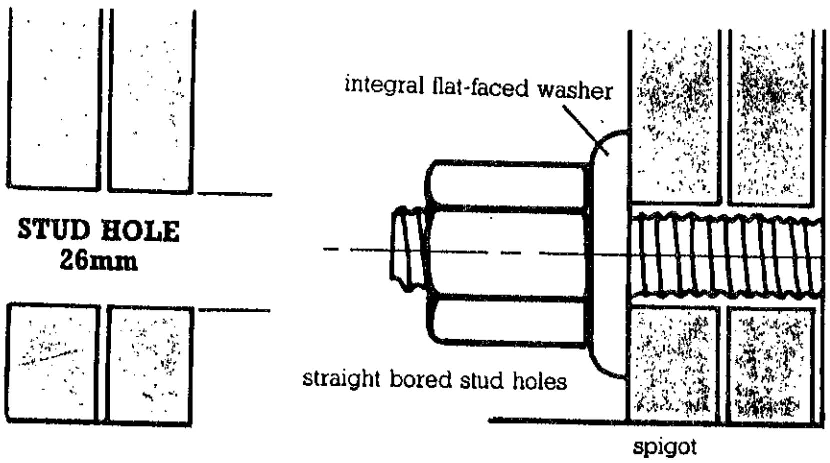
*or single nut with spherical radius.

Tightening torque normally recommended for spherical centring wheel fastening by flat collar nut with spherical spring washer is 260 Ft. Lbs (350 Nm) but research in Europe where this standard was first introduced now suggest up to 450 Ft. Lbs - 610 Nm.

Stud breaking can be a common occurrence when loose washers are used. An inspection of the wheel holes will generally find the conical faces of the hole are bright only half way round - just towards the rim. The bright marks reflect the off centre locationof the washer on tightening.

I.S.O. SPIGOT MOUNT

10 STUD 335 P.C.D.



As more clamping force was needed to resist higher engine and braking torque the spigot mount or hub piloted disc wheel was introduced. All of the later model European and Japanese heavy commercial vehicles reaching our market are fitted with this wheel which complies with International Standard 150-4107.

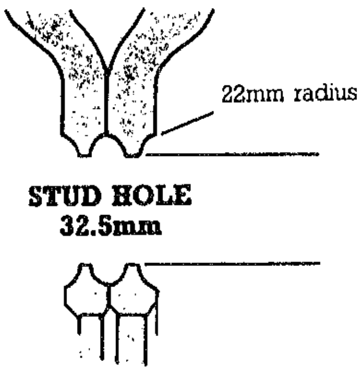
The objective of the spigot wheel is different from that of the conical (British Standard) and the spherical (D.I.N. Standard) wheel. Here, preload is not the main functioning of the tightening, the nut has to be tight on the horizontal axis to provide clamping pressure on the vertical axis to carry the load and resist all the dynamic forces without shifting.

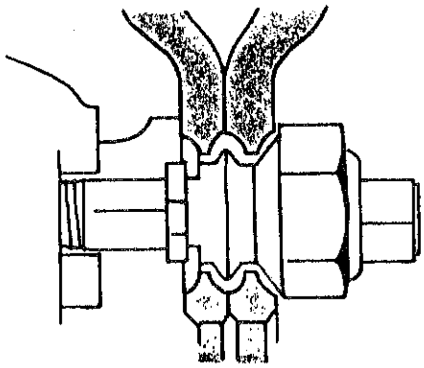
With all fixing systems there is the matter of the nuts remaining tight when subjected to vibration. That depends on frictional force at the threads, expecially with spigot wheels where the nuts have less face friction. So dry threads have a better chance of holding tight than lubricated ones.

Some early production had an uninterrupted spigot and as a result spigots tend to seize. An interrupted spigot, with three or five fingers, is preferred. Wheel sticking can readily be avoided by applying a thin coating of lubricant to the hub spigot prior to mounting. Freylube is a particularly good lubricant for this purpose. It is a high viscosity, high melting point material, resists washing away and does not contain heavy metals.

Early torque recommendations for mounting spigot wheels was set at 400-450 Ft. Lbs (540/610 Nm) but experience and research in Europe now recommends that torque of 510/600 Ft. Lbs (690/810 Nm) should be applied, particularly for high horsepower, high axle load vehicles.

JAPANESE-AMERICAN BUDD
8-10 STUD 285 P.C.D.



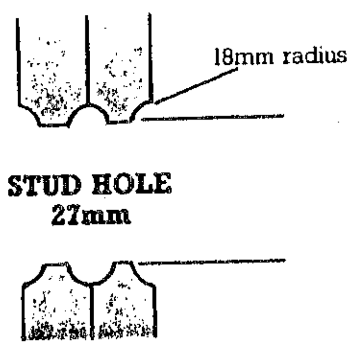


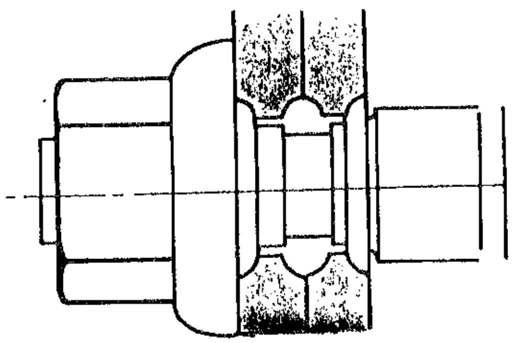
four double nut system

The "Budd" wheel system was introduced back in 1917 and until well after World War II was the standard disc wheel fixing. It has now been superceded by the ISO-spigot mount which is rapidly becoming the standard for all heavy vehicles.

American "Budd" standard drillings are identified by the stud located ball seat mounting. For dual wheels the method of fixing is by an inner and outer cap nut with right hand and left hand studs and nuts so that each wheel is tightened individually. For front wheel mounting a single cap nut is used.

JAPANESE DIN
10 STUD 335 P.C.D.





Disc wheel summary - when replacement wheels of any type are supplied by a dealer to a fleet, a check should be made to compare the stud hole drilling of the wheel with that of the old one, to ensure they are of the same type.

The fixing of tapered stud hole wheels on spigot mounted hubs should <u>only</u> be undertaken as an emergency measure in order to get the vehicle back to base. It should never be a permanent fix.

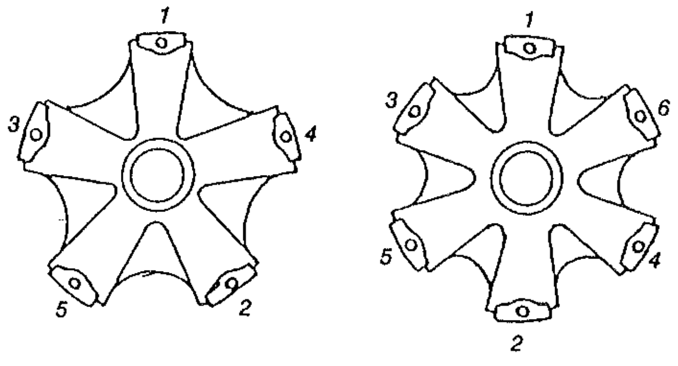
The integral nut for spigot mounted I.S.O wheel fixings are right hand threads for all positions.

Coned nuts dissipate a good deal of tightening torque in their interface friction. It takes approximately 40 percent more torque to induce enough preload with coned nuts as it does with flat collar nuts. It the tapered surface distorts it takes even more torque to produce enough preload - so over tightening can be self defeating for tapered stud hole wheels.

Finally, never let oil or grease near any part including nuts and studs and keep all mating surfaces clean.

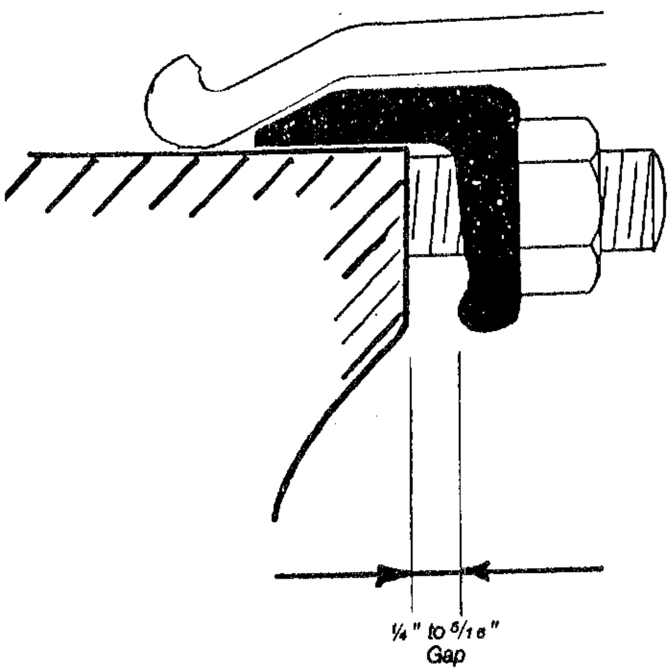
<u>DEMOUNTABLE RIMS - SPIDER HUBS</u>

The correct method of tightening demountable rims to spider hubs is most important if loose wheels are to be avoided and wobbly wheels are not allowed to ruin tyre life. The sequence for tightening five and six spoke assemblies and the torque recommended for the most commonly used 3/4" nut is as follows:



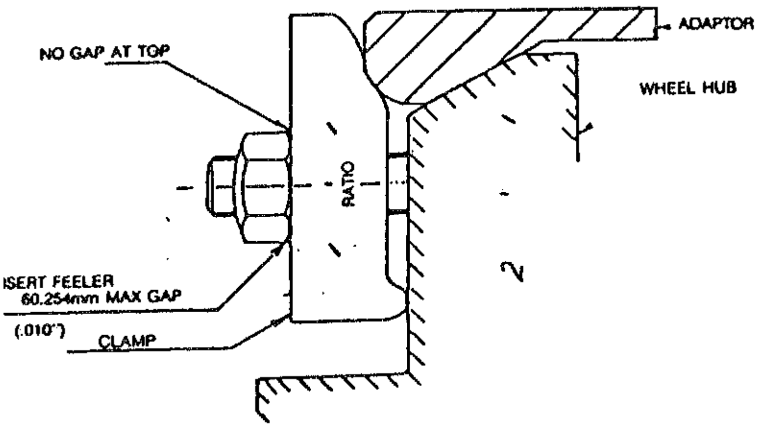
After making sure all mating surfaces, that is the spoke head, rim clamp, spacer and rim, are clean then a good rule of thumb, as to whether the correct spacer and/or clamp is being used is to check the clearance between the end of the spoke and the heel of the clamp at 80% of the recommended torque.

This should not measure more than 1/4" to 5/16" gap. A larger gap will tend to bend the stud and so long as there is clearance at the heel of the clamp of even one millimetre the final torque load will not cause any problems.

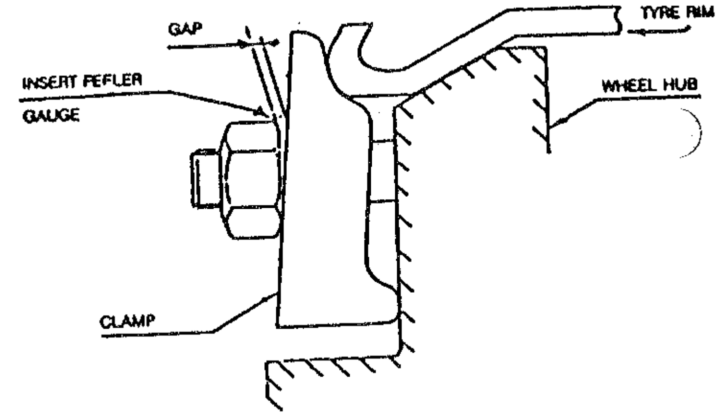


On-front wheels and wide singles, because of the different clamping action, the heel of the clamp must touch the end of the spoke head. The correct fitting of the front clamp assembly is vital to safety. For a better understanding of this we show right and wrong illustrations.

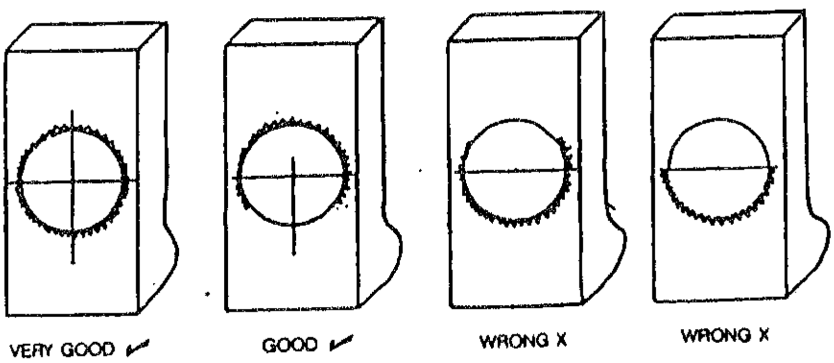
RIGHT



WRONG



CHECK BEARING OF NUT TO CLAMP TO ENSURE CORRECT FITMENT



IN GENERAL THE TOP HALF SHOULD SHOW BEARING
I E CLAMP WHEEL NOT TOE OF CLAMP

On demountable rims, lugs should be tightened uniformly in a triangulated or criss-cross sequence, rotate wheel so the stud being tightened is in the top position, to achieve trueness of the rim on the wheel, and lug nuts should be torqued properly so they do not loosen in use. It is important that both dual and single wheel assemblies are spun and checked for lateral run-out which must be within 2mm. On disc wheels, stud nuts should be drawn up and tightened in a criss-cross sequence also. See rim and wheel manuals for more installation details. Lug or stud nuts should be checked for tightness after the first 100 kms of travel and once each week thereafter.

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