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Radial Tractor Tires -- Performance That Counts!

Radial tractor tires offer advantages over bias-ply tires that usually result in increased productivity and reduced fuel consumption.

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The axle power developed by a tractor is distributed four ways: overcoming rolling resistance, wheel slip losses, tire-soil action and useful drawbar work. The most efficient use of tractor power occurs when the drawbar power is maximized and the first three items are minimized.

Radial tractor tires can improve tractive efficiency and extend tire wear. There are benefits and disadvantages of radial tractor tires compared to bias-ply tires. Radial tractor tires should be considered as original equipment on new tractors and as replacements whenever tractor tires are being replaced.

Tire Construction

Tractor tires are classified as bias-ply and radial. Bias-ply tires contain a laminated cord structure beneath the tread. The cords in an individual layer extend from bead to bead in a diagonal direction. Alternating the cord angle for each layer produces a criss-cross pattern (*Figure 1*) that gives the tire carcass structural strength.

Radial tires also contain a multiple layer of cord structure but differ in the orientation and distribution of the cord (*Figure 1*). Radial construction has two belting elements.

First, there are layers of cords running at right angles to the tread or radially from bead to bead. Then, a

second set of cords runs circumferentially around the tire. These two cord structures cause radial tires to perform differently than bias-ply tires. Radial sidewalls flex more than bias-ply tires and produce a larger, more stable ground contact area and softer ride.

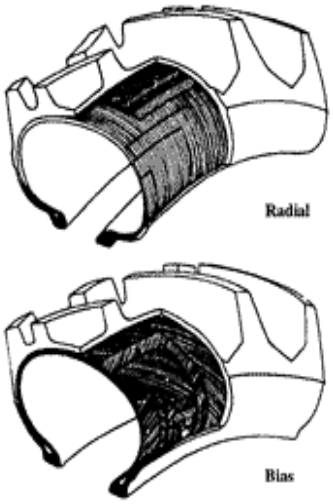

Figure 1. Cords orientation in bias-ply and radial tractor tires.

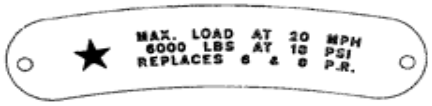

Figure 2. Example of the new radial tire star marking.

Ply-Rating and Symbol Marking on Radial Tires

The Tire and Rim Association and the Rubber Manufacturers Association define ply rating as: "The term used to identify a given type of tire with its maximum recommended load. It is an index of tire strength and does not necessarily represent the number of actual plies in the tire." The ply rating for agricultural tractor tires ranges from 2 to 16.

Both associations changed the ply-rating of radials to a symbol marking. The number of stars gives an index of radial tire strength. The maximum loading for one-star (*) tires in all sizes is at 18 psi inflation pressure. Maximum load for two-star (**) tires is at 24 psi and for all three-star (***) tires the maximum load is at 30 psi.

It is *vital* to understand this change in tire pressures which is different from the bias-ply-rating and radial tires of the past. Some tractor manufacturers strongly recommend not mounting the three-star (***) radial tires on older tractors. *Table I* shows the symbol marking for some typical tires and their closest ply-rating counterpart.

Table I. Symbol/ply rating replacement chart

Tire Size	Bias-Ply-Rating		
	Symbols		
	* @18 psi	** @ 24 psi	*** @ 30 psi
13.6R28	4	6	8
14.9R26	6	_	10
14.9R28	6	8	10

14.9R30	6	8	10
15.5R38	6	_	_
16.9R24	6	8	10
16.9R26	6	8	10
16.9R28	6	8	10
16.9R38	6	8	_
18.4R26	6	8 & 10	_
18.4R34	6 & 8	_	_
18.4R38	6 & 8	10	_
18.4R42	6 & 8	10	_
20.8R34	8	_	_
20.8R38	8	10	_
20.8R42	8	10	_
23.1R34	8 & 10	_	_
24.5R32	10	12	_
30.5LR32	10 & 12	16	_
*Based on comparison of bias-ply and radial tires from Tire and Rim Association Standards.			

Tractive Efficiency

Tractive efficiency is the ratio of the output power (usually drawbar horsepower) to the input power at the axle. Tractive efficiency varies with the weight carried by the tire, soil conditions, tire contact area, inflation pressure and tire size. Tractors that are properly matched with implements, correctly ballasted, and have correct tire pressure are able to produce maximum tractive efficiency, drawbar power, and productivity, as well as avoid excessive soil compaction and saving fuel. *Figure 3* shows that tractive efficiency of radials usually improves by 5 to 15 percent over bias at various slips.

Performance

Numerous tests by tire manufacturers, tractor manufacturers and universities have established the traction advantages and disadvantages of radial tires over bias-ply tires. A summary of these are:

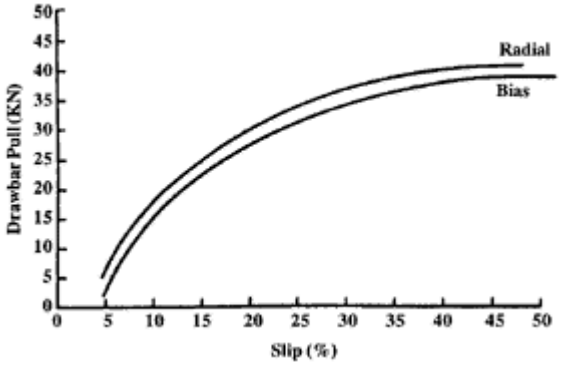

Figure 3. Drawbar curves for radial and bias-ply tire (18.4-38 R-1 Size) operating in untilled soil.

Advantages of Radial Tires:

- *Reduced fuel consumption.* More than 6 percent of the fuel (gallons per acre) on loose soil and more than 8 percent on firm soil was saved as a result of radial tires. Reports of up to 13 percent fuel savings were common.
- *Increased productivity.* Acres covered per hour were increased by more than 2 percent on firm soil and more than 10 percent on loose soil.

- *Reduced tire slip.* Slippage was significantly reduced on all surfaces.
- *Less vibration.* Due to radial tire construction, tires have less tendency to have tire lug-induced vibrations.
- *Increased drawbar pull.* Depending on the surface conditions, the pull may be increased 6 to 10 percent without the addition of ballast.
- *Extended tire life.* Radial tires are heavier than bias-ply tires of equal size, partly because of higher lugs. Tire life is extended by as much as 30 percent over bias-ply tires doing comparable work.

Disadvantages of Radial Tires:

- *Poor transport handling characteristics.* Tire sway increases as speed increases. This is probably due to low lateral carcass stiffness that produces poor handling during transport speeds. Lower transport speeds may be necessary for safe road travel.
- *Poor cultivator control.* Tire sway has a tendency to cause poor cultivator alignment, especially on terraced or hilly terrain.
- *Higher purchase price.* Radial tires generally are more expensive than original bias-ply tires. This cost can be offset by more productivity (see the cost comparison worksheet).
- *Less forgiving of abuse.* Overload or under-inflation will cause sidewall bulge that is more susceptible to sidewall damage and puncture.

Mixing Radials and Bias-ply Tires

When considering a mix of radial and bias-ply tires, remember these general situations:

Singles: Radial and bias-ply tires should not be mixed on the same axle (ie. radial on right and bias-ply on left side). The difference in slip characteristics and rolling radii may cause drive-train problems.

Front Wheel Assist-MFWD: Generally, tractor manufacturers are mixing radial rear tires with bias-ply front tires, although one manufacturer does not encourage the mixing. This is due to the limited number of radial tires produced in the sizes needed for MFWD. However, as more MFWD radial tires are available, they should be used for additional performance. Whenever making a tire size or a change to radial tires on an MFWD tractor, remember to maintain the front to rear speed ratio or the advantage of the MFWD may be lost.

Duals: It has been an acceptable practice to mount bias-ply tires as the outer set of duals with the radials mounted on the inside. The diameter of the outer dual should not be larger than the inner tire nor should the outer dual diameter be more than 1-1/2 inches smaller than the inner tire.

Always use the higher rated tires on the inside. Outer duals should have a lower rating when they are used just for flotation.

If possible, the outer duals should have 4 psi less inflation pressure than the inner tire to absorb shock loads when encountering field obstructions. Tests have shown that radial tires as singles performed significantly better than bias-ply duals especially at higher field speeds. Avoid using duals unless necessary.

The main justification for duals should be if flotation is needed (under good soil conditions) or if the load capacity of single tires is not sufficient. Performance of radial/bias-ply mixed duals likely will fall between the performance of all bias-ply and all radial dual tires.

Four Wheel Drive-4WD: It is not advisable to mix radial and bias-ply tires between axles on a full-size 4WD tractor. The difference in traction characteristics between radial and bias-ply tires could cause performance and wear problems for the tractor. It is more acceptable to use bias-ply tires as outer duals on a 4WD although best performance could be expected with all radials.

Ballast

Generally, the same amount of operating weight (ballast) should be used for either radial or bias-ply tires. Radial tires will slip less than bias-ply tires under similar weight and pull conditions. After a tire switch, follow the outline of properly ballasting a tractor either from your operator's manual or extension materials.

Although it might appear preferable to aim for minimal wheel slip, some slip is necessary to use the soil characteristics to transmit power most efficiently. Proper wheel slip through the control of tractor weight and drawbar pull will give higher tractive efficiency that reduces fuel consumption.

Allowable Tire Loads

Once the tractor-implement has been properly ballasted for a particular operation, check the maximum allowable loads of the Roll Over Protection Structure (ROPS) and tires to assure these have not been exceeded. ROPS load rating can be determined from a plate or decal on the cab.

Operate at the proper inflation pressure. The maximum load that a tire can carry depends on inflation pressure. Low inflation pressures are for less tire load or tire sidewall buckling may occur.

Most efficient operation occurs at the lowest pressure that produces satisfactory tire life. With reduced load and lower inflation pressure, soil compaction is reduced and tractive performance improves.

On hard surfaces use high inflation pressures to reduce tire wear; in soft soils use low inflation pressure to reduce rolling resistance and soil compaction.

Minimum inflation recommendations were lowered from 12 to 6 psi by tire manufacturers in 1992. The key is to use the correct inflation pressure.

First, determine the tractor weight and the weight distribution between the two axles. If a heavy mounted implement or equipment is used, weigh the tractor with it attached and in the transport position.

Using the axle weight, consult the load and inflation pressure tables. *Table II* is for axles with single tire and *Table III* is for duals. From these tables determine the minimum inflation pressure needed in the tire to support the load. Set the tire to the recommended pressure when the tires are cold. Use an accurate tire gauge to check tire pressure often (weekly during peak use).

Table II. Axle load capacities and inflation pressure for radial singles.+

	Axle load capacities (LBS) at various cold inflation pressures (PSI)[1]												
Tire Size	*6*	*8*	*10*	*12*	*14*	*16*	*18**	*20*	*22*	*24***	*26*	*28*	*30****
13.6 R 28	2960	3520	3960	4400	4800	5200	5660*	6000	6400	6840**	7040	7280	7480***
14.9 R 26	3420	4080	4540	5080	5520	6000	6400*	6840	7280	7720**	7920	8360	8800***
14.9 R 28	3520	4180	4680	5200	5820	6160	6600*	7040	7480	7920**	8360	8600	9080***
14.9 R 30	3640	4300	4940	5360	6000	6400	6840*	7280	7720	8160**	8600	8800	9360***
14.9 R 46	4540	5360	6166	6840	7480	7920	8600*	9080	9600	10160**	10720	11040	11680***
15.5 R 38	3860	4540	5200	5820	6400	6840	7280*	7720	8160	8600**	9080	9360	9880***
16.9 R 24	3960	4680	5360	6000	6600	7040	7480*	8160	8600	9360**	9440	9880	10160***
16.9 R 26	4080	4940	5520	6160	6840	7280	7920*	8360	8800	9600**	9720	10160	10720***
16.9 R 28	4300	5080	5820	6400	7040	7480	8160*	8600	9080	9880**	10160	10400	11040***
16.9 R 30	4400	5200	6000	6600	7280	7720	8360*	8800	9360	10160**	10400	10720	11360***
16.9 R 38	4940	5820	6600	7480	8160	8800	9360*	9880	10720	11360**	11680	12300	12800***
18.4 R 26	4940	5820	6600	7480	8160	8800	9360*	9880	10720	11360**	11680	12300	12800***
18.4 R 34	5660	6600	7480	8360	9080	9880	10720*	11360	12000	12300**	13200	13900	14300***
18.4 R 38	6000	7040	7920	8800	9600	10400	11360*	12000	12800	13200**	13900	14800	15200***
18.4 R 42	6160	7480	8360	9360	10160	11040	12000*	12800	13200	13900**	14800	15200	16100***
18.4 R 46	6600	7720	8800	9880	10720	11680	12300*	13200	13900	14800**	15700	16100	17100***
20.8 R 34	6840	7920	9080	10160	11040	12000	12800*	13600	14300	15200**	16100	16500	17600***
20.8 R 38	7280	8600	9600	10720	11680	12800	13600*	14300	15200	16100**	17100	17600	18200***
20.8 R 42	7480	9080	10160	11360	12300	13600	14300*	15200	16100	17100**	17600	18700	19300***
23.1 R 34	7920	9360	10720	12000	13200	14300	15200*	16100	17100	18200**	18700	19800	20400***
24.5 R 32	8600	10160	11680	12800	14300	15200	16500*	17600	18200	19300**	20400	21000	22000***
30.5LR 32	10160	12300	13900	15200	17100	18200	19300*	21000	22000	23400**	24000	25600	26400***

[1]Reference Maximum Transport Speed = 25 mph. For field service the above table maybe increased if the tractor transport speed is not able to exceed these maximum speeds: 20 mph increase table load amounts by 7 percent, 15 mph increase of 11 percent, and 10 mph increase by 34 percent.
+All loads are given for two tires per axle based on Tire and Rim Association Standard.

Table III. Axle load capacities and inflation pressure for radial duals.+

	Axle load capacities (LBS) at various cold inflation pressures (PSI)[1]												
Tire Size	*6*	*8*	*10*	*12*	*14*	*16*	*18**	*20*	*22*	*24***	*26*	*28*	*30****
13.6 R 28	5210	6200	6970	7740	8450	9150	9960*	10560	11260	12040**	12390	12810	13170***
14.9 R 26	6020	7180	7990	8940	9720	10560	11260*	12040	12810	13590**	13940	14710	15490***
14.9 R 28	6200	7360	8240	9150	10240	10840	11620*	12390	13170	13940**	14710	15140	15980***
14.9 R 30	6410	7570	8690	9430	10560	11260	12040*	12810	13590	14360**	15140	15490	16470***
14.9 R 46	7990	9430	10850	12040	13170	13940	15140*	15980	16900	17880**	18870	19430	20560***
15.5 R 38	6790	7990	9150	10240	11260	12040	12810*	13590	14360	15140**	15980	16470	17390***
16.9 R 24	6970	8240	9430	10560	11620	12390	13170*	14360	15140	16470**	16610	17390	17890***
16.9 R 26	7180	8690	9720	10840	12040	12810	13940*	14710	15490	16900**	17110	17880	18880***
16.9 R 28	7570	8940	10240	11260	12390	13170	14360*	15140	15980	17390**	17880	18300	19430***
16.9 R 30	7740	9150	10560	11620	12810	13590	14710*	15490	16470	17880**	18300	18870	19990***
16.9 R 38	8690	10240	11620	13170	14360	15490	16470*	17390	18870	19990**	20560	21650	22530***
18.4 R 26	8690	10240	11620	13170	14360	15490	16470*	17390	18870	19990**	20560	21650	22530***
18.4 R 34	9960	11620	13170	14710	15980	17390	18870*	19990	21120	21650**	23230	24460	25170***
18.4 R 38	10560	12390	13940	15490	16900	18300	19990*	21120	22530	23230**	24460	26050	26750***
18.4 R 42	10840	13170	14710	16470	17880	19430	21120*	22530	23230	24460**	26050	26750	28340***
18.4 R 46	11620	13590	15490	17390	18870	20560	21650*	23230	24460	26050**	27630	28340	30100***
20.8 R 34	12040	13940	15980	17880	19430	21120	22530*	23940	25170	26750**	28340	29040	30980***
20.8 R 38	12810	15140	16900	18870	20560	22530	23940*	25170	26750	28340**	30100	30980	32030***
20.8 R 42	13170	15980	17880	19990	21650	23940	25170*	26750	28340	30100**	30980	32910	33970***
23.1 R 34	13940	16470	18870	21120	23230	25170	26750*	28340	30100	32030**	32910	34850	35900***
24.5 R 32	15140	17880	20560	22530	25170	26750	29040*	30980	32030	33970**	35900	36960	38720***
30.5LR 32	17880	21650	24460	26750	30100	32030	33970*	36960	38720	41180**	42240	45060	46460***

[1]Reference Maximum Transport Speed = 25 mph. For field service the above table maybe increased if the tractor transport speed is not able to exceed these maximum speeds: 20 mph increase table load amounts by 7 percent, 15 mph increase of 11 percent, and 10 mph increase by 34 percent.
+All loads are given for 4 tires per axle (duals) based on Tire and Rim Association Standard.

Tractors operating on steep side slopes should use inflation pressure 4 psi above the recommended

pressures in the rear tires to compensate for lateral weight transfer.

At correct pressures, radial tires appear under inflated. Correctly inflated radial tires exhibit a noticeable bulge or "cheek" just above the footprint. Most tire load and inflation pressure recommendations are based on the "rated deflection" of the radial tire. For example, when comparing the measurement of the tire bulge at the top to the bulge at the contact area, the bottom bulge from the rim out would be about 1 to 1-1/2 inches greater than the bulge at the top.

Compare Cost: Radial vs Bias-Ply

The biggest question on whether to use radials is a matter of economics. The purchase price for radials at the present time is typically higher than bias-ply tires. Whether the advantages of radials will offset the addition in cost will depend on a particular farm management system. Use extension NebFact NF95-245, *Cost Comparison Worksheet for Radial Tractor Tires*, to address your farming practices. In most cases, radial tractor tires give performance that counts.

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