A3401

Tractor Ballasting

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The farm tractor is the most used machine on a Wisconsin farm. The better it performs, the better your farm's total machinery system will perform.

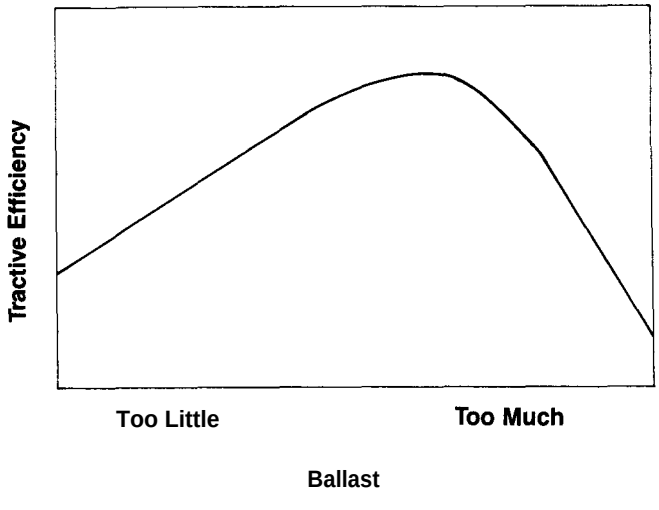
Tractor ballast influences performance and operating costs, including fuel consumption, tire life, tractor life, and drive-train load. Improper ballasting can increase soil compaction and field operation time. When you determine proper ballasting, consider fuel economy, the tires' maximum load capacity, and tractor safety and stability.

Effects of Incorrect Ballasting

The load carried by the drive wheels determines the tires' ability to deliver axle power to the drawbar or hitch. An optimum weight (Figure 1) maximizes the tires' efficiency in converting axle power to pulling power, and minimizes the power lost in moving the drive tires over the soil.

The magnitude of wheel slip is a good indicator of proper ballasting. Inadequate ballasting allows tires to slip excessively and reduces the power available to pull an implement. Excessive ballasting reduces wheel slip but increases soil compaction and decreases available power and the machine's field capacity.

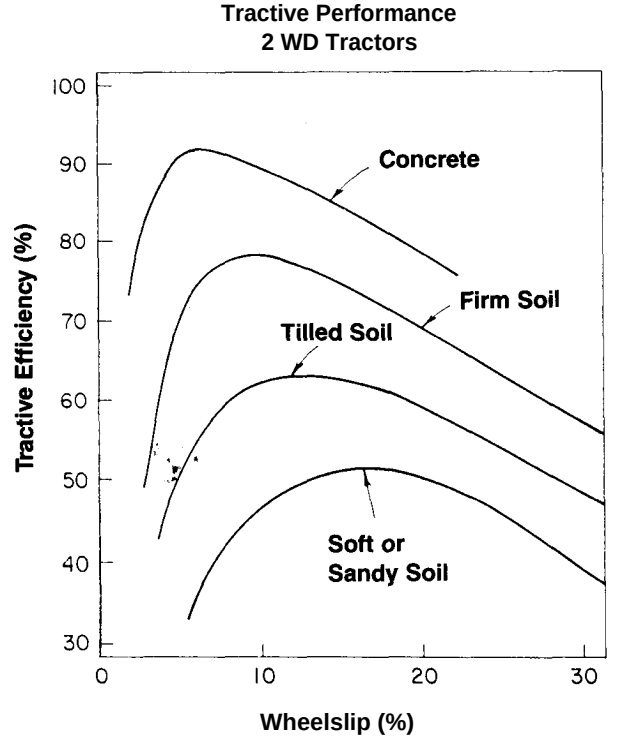
Ballast and wheel slip affect tire life. Insufficient ballast and excessive wheel slip increase tire tread wear. Too much ballast can overload tires and ruin tire sidewalls.



Weight distribution between the front and rear wheels affects tractor stability. The front wheels of a two-wheel-drive tractor should carry enough weight to provide adequate steering control and prevent the tractor from tipping over backward while pulling an implement. In some situations, you may have to add ballast to the front end of a two-wheel-drive tractor. The tractor must weigh enough to maintain control on hills when pulling massive loads such as large grain tanks and manure tanks. Remember that excessive weight may crush the roll-over protective structure (ROPS) if the tractor upsets.

Measuring Wheel Slip and Ballasting for Efficiency

To determine efficiency, check wheel slippage while the tractor is under load. Optimum wheel slippage depends on soil conditions. "Tractive efficiency" which is the percent of the axle power available for pulling an implement, is plotted against percent wheel slip in Figure 2. For the most fuel-efficient operation, wheel slip should near the point of maximum tractive efficiency. Optimum slip is 8 to 10 percent on a firm soil; 14 to 16 percent on soft or recently tilled soil (Figure 2).



Measuring wheel slip is the best way to determine proper ballasting, and it only takes a few minutes.
To determine slip of the drive wheels:

1. Mark the side of a drive wheel with chalk or tape.
2. As the tractor pulls the implement at normal forward speed and depth, place a stake in the soil where a mark comes down to the soil surface.
3. Place a second stake in the soil where the tire completes ten revolutions.
4. Raise the implement and count the number of revolutions (to the nearest one-tenth revolution) required to drive the tractor between the two stakes.
5. Calculate the slip using the following formula:

$$\% \text{ slip} = \frac{(10 - \text{no-load revolutions})}{10} \times 100$$

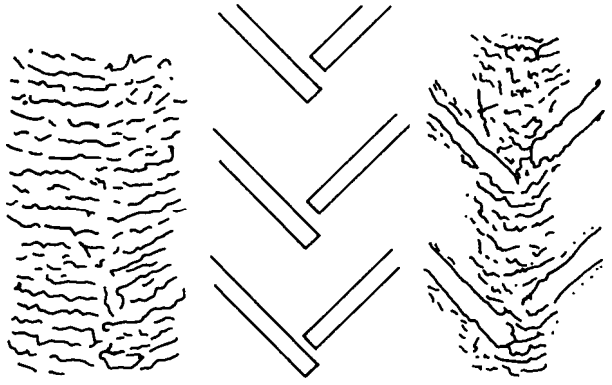
Example: If the tractor took 9 revolutions between the stakes under no load, then:

$$\% \text{ slip} = \frac{10 - 9}{10} \times 100 = 10\%$$

Measure just one drive wheel unless plowing with one drive wheel in the plow furrow. In that case, measure both drive wheels and average them.

You can also estimate wheel slip, which is quicker but less precise. Inspect the tire print after the tractor has passed pulling a load under normal operating conditions. The tire print should be somewhat distorted. Excessive ballasting produces very defined tire prints with little or no distortion. Inadequate ballasting leaves little or no sign of tire prints. (See Figure 3.) Soil type and moisture can affect these thumb rules.

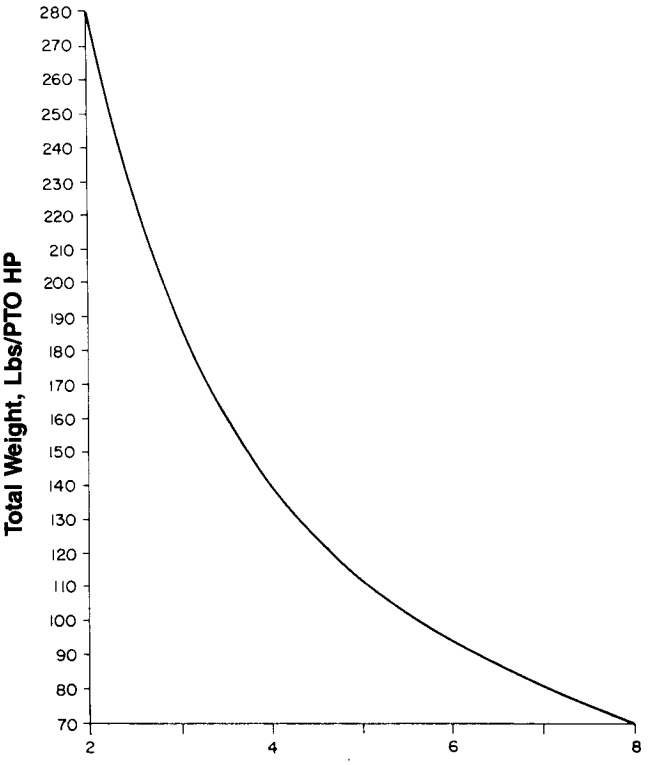
If the wheels slip less than 8 percent, remove ballast to improve efficiency. If wheel slip is over 16 percent, add ballast. In some cases, the improved efficiency may not justify the difficulty of adding or removing ballast.



Too Little **Too Much** **Proper Weight**

Ballasting Based on Tractor Size

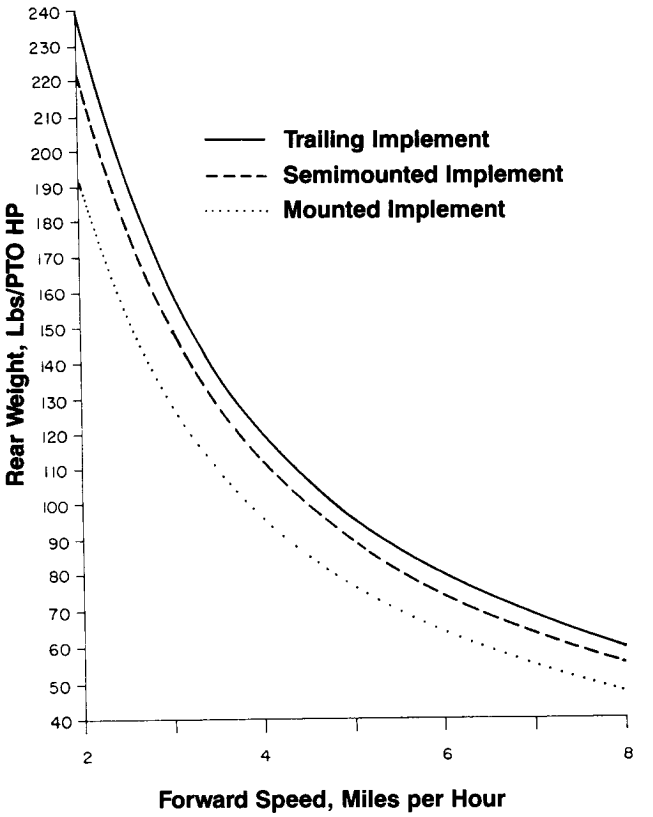
You can use power take-off (PTO) horsepower and forward speed to estimate ballasting needs. Figure 4 estimates the total tractor weight per PTO horsepower for a four-wheel-drive tractor with a trailing implement. Figure 5 estimates the rear-wheel weight per PTO horsepower for a two-wheel-drive tractor in various situations. Both figures assume tilled soil. For firm soil, reduce the value by 10 pounds per PTO horsepower; for soft or sandy soil, add 10 pounds per PTO horsepower. These guidelines are for tractors operating at 75 to 85 percent of maximum power. Remove some ballast from tractors operating under smaller loads.



Ballasting and Tire Capacity

Don't exceed the tire's recommended load-carrying capacity when ballasting for efficiency. The capacity depends on the tire size, ply rating and tire pressure. Table I lists maximum loads for some common tractor tires.

An 18.4-34 tire at 20 psi can carry 5,660 pounds. A two-wheel-drive tractor equipped with these tires could carry 11,320 pounds (2 x 5,660) on the rear axle. This includes all ballast.



Ballasting for Stability and Safety

The front wheels must carry adequate weight to ensure steering control and safe operation under load. Table II lists the recommended static weight distributions for various tractor designs and hitching systems. The front wheels of tractors with front-wheel assist require a certain amount of weight to ensure traction. For true four-wheel-drives, the front and rear axles should carry equal amounts of weight operating under load. Because of weight transfer, four-wheel-drive tractors should have 60 percent of their weight on the front wheels and 40 percent on the rear wheels under static conditions.

Table II. Weight distributions for various tractor designs.

Tractor design	Front	Rear
2-wheel-drive, trailing impl	25	75
2-wheel-drive, semi-mounted impl	30	70
2-wheel-drive, mounted impl	35	65
Front-wheel assist	40	60
Four-wheel-drive	60	40

Consult the operator's manual to make sure the ROPS can handle the added weight. The ROPS is designed for some maximum tractor weight, and may fail if tractor plus ballast exceed this weight. If the

Table 1. Tractor tire load capacities in pounds at various tire pressures *for a single tire.* (Tire ply ratings in parentheses)

	Tire Pressure in PSI					
Tire size	**14**	**16**	**18**	**20**	**22**	**24**
9.5-24	1330(4)	1430(4)	1540(4)	1630(4)		
11.2-24	1600(4)	1740(4)	1860(4)			
12.4-24	1920(4)	2080(4)	2230(6)	2370(6)	2510(6)	2640(6)
13.6-28	2420(4)	2620(6)	2810(6)	2980(6)	3160(6)	
14.9-28	2880(6)	3120(6)	3340(6)			
15.5-38	3160(6)	3410(6)	3660(6)	3890(6)	4110(8)	4330(8)
16.9-24	3540(6)	3800(6)	4040(8)	4270(8)	4490(8)	
16.9-28		3780(6)	4050(6)	4310(8)	4560(8)	4790(8)
16.9-30		3900(6)	4180(6)			
16.9-34		4140(6)	4440(6)			
16.9-38		4380(6)	4700(6)	5000(6)	5280(6)	5560(6)
18.4-26		4390(6)	4700(8)	5000(8)	5290(8)	5560(8)
18.4-30		4680(6)	5010(8)	5330(8)	5630(10)	5930(10)
18.4-34		4970(6)	5320(8)	5660(8)	5980(10)	6290(10)
18.4-38		5250(6)	5630(8)	5990(8)	6330(10)	6660(10)
20.8-34		6010(8)	6440(8)			
20.8-38		6360(8)	6820(8)	7250(10)	7670(10)	
23.1-26		6280(8)	6730(8)	7160(10)		
23.1-30		6700(8)				
23.1-34		7110(8)				
24.5-32		8180(10)	8700(10)			

total tractor weight is less than the tires' maximum load-carrying capacity, then ROPS strength is not a problem.

Much of the preceding has dealt with ballasting for high drawbar or hitch loads, such as plowing and disking. When towing a massive load, such as a large manure tank or a forage harvester and a full forage wagon, the tractor must be able to safely stop or control the towed machine, especially at high speeds. In this case, the tractor should weigh as much or more than the towed implements. Or, you can install brakes on the towed equipment.

Methods of Ballasting

If your tractor needs added ballast, you have several choices.

Cast weights attach to the drive wheels or front end of the tractor. Cast weights allow you to quickly change ballast as ballasting requirements dictate.

Adding liquid, usually a calcium chloride solution, to the drive tires is more economical but harder to change. The amount of liquid ballasting you can add depends on tire size and the concentration of the solution. Table Ill lists the added ballast for several tire sizes when the tire is filled to the valve stem at its highest position. Never completely fill a tire with solution—it can destroy the tire. Leave some air space for volume changes.

The calcium chloride must be sufficiently concentrated so it doesn't freeze or form slush in cold weather.

Slush-free points of:

2 pounds calcium chloride per gallon of water = 13° F.

3.5 pounds calcium chloride per gallon of water= -12° F.

5 pounds calcium chloride per gallon of water= -53° F.

Table Ill. Liquid ballast for tractor tires.

	Water		2#/gal[a]		3.5#/gal		5.0#/gal	
Tire size	Gal.	Lbs	Gal. water	Lbs	Gal. water	Lbs	Gal. water	Lbs
9.5-24	17	142	16	165	15	178	14	187
11.2-24	24	200	22	227	20	237	19	253
12.4-24	30	250	28	290	26	308	25	333
13.6-28	43	359	39	403	37	439	35	467
14.9-28	53	442	49	507	46	545	43	574
15.5-38	66	550	60	620	56	663	53	707
16.9-24	61	509	55	569	52	616	49	654
16.9-28	69	575	63	651	59	699	56	747
16.9-30	73	609	67	693	63	746	59	787
16.9-34	82	684	75	775	70	829	66	880
16.9-38	90	751	82	848	77	912	73	974
18.4-26	79	659	73	755	68	805	64	854
18.4-30	89	742	82	848	77	912	72	960
18.4-34	100	834	91	941	85	007	81	1081
18.4-38	110	917	100	034	94	113	89	1187
20.8-34	128	1068	117	210	109	291	103	1374
20.8-38	140	1168	128	324	120	421	114	1521
23.1-26	128	1068	117	210	109	291	103	1374
23.1-30	143	1193	131	1355	123	1457	116	1547
23.1-34	159	1326	145	1499	136	1610	128	1708
24.5-32	170	1418	156	1613	146	1729	138	1841

[a]pounds of calcium chloride per gallon

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Produced by the Department of Agricultural Journalism, University of Wisconsin-Madison.

A3401 Tractor Ballasting (1987)

RP-10-87-1M-20-E

This publication is available from your Wisconsin county Extension office or from:
Agricultural Bulletin, Rm. 245
30 N. Murray St.
Madison, Wisconsin 53715
Phone 606-262-3346

Editors, before publicizing, contact Agricultural Bulletin to determine availability.

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