Tyre Performance Design Limits

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Purpose of Document

To provide critical safety information to assist in the selection of off-road tyres. This work was conducted after the author had been given misleading and incorrect advice by tyre dealer 'experts' or else they could not provide the information needed to allow an informed choice of tyre size.

Background

I recently had to decide to either replace, or upgrade the worn 265/75R16D ('D' = 8 ply rating) 4WD tyres on my Landcruiser 100 series (I changed the original 17 inch alloy rims for 16 inch steel rims). I had not been all that happy with these tyres on the rear of my vehicle as they got very hot when deflated to the pressures needed for sand or gravel road driving. To be fair, I must confess that I have dual wheel carriers on the rear tow bar, a long range fuel tank and Black Widow drawers all of which put a very heavy load on the rear end even before I pack for the trip and attach the Ultimate Camping Trailer. I weighed the vehicle on a public weigh bridge and was surprised at it tipping the scales at 3570 kg without the long range tank filled and carrying very little load (Ultimate Camping Trailer not connected).

Whilst attending a sand driving course, a well respected 4WD driving instructor (Peter Reynolds) thought that my existing tyres were bulging too much at the pressures needed for sand driving and suggested that I should change the 265/75R16D tyres to the larger 285/75R16D tyres. I bounced this idea off three different 4WD tyre supplier 'experts' who disagreed and told me that the 265/75R16E ('E' = 10 ply rating) had a higher maximum load rating than the 285/75R16D and that I should use those; I pointed out that the 265'E maximum load rating was at 80psi and the 285'D maximum load rating was at 65 psi, and further that I never intended to drive off-road with either 80 or 65 psi in my tyres. When I asked about load ratings at realistic off-road tyre pressures, none could provide me with the required information, so I decided to research the problem myself.

Here is the problem:

For the loads I am carrying, the tyre pressures I must use to achieve traction or ride comfort what are the maximum speeds I can safely drive at with either the 265/75R16 or 285/75R16 and which tyre size is the most suitable for my use.

When driving off-road we change our tyre pressures to suit the conditions.

Bitumen:	40 to 55 psi
Gravel:	25 to 35 psi depending on the conditions.
Sand:	15 to 25 psi (no option if you do not want to get bogged)

These pressures are not determined by the maximum tyre load carrying capacity at the maximum pressure but by practical terrain considerations. The real question is what are the load ratings of these tyres at these practical pressures and how much can I increase my load by driving slower and hence generating less heat in the tyres?

In practical terms, once you have packed for a trip, the load on the vehicle is fixed, and the tyre pressure is governed by the type of terrain, within sensible limits, it appears that the only thing that can change is the safe speed at which the tyre will not overheat and cause permanent damage. A manufacturer providing information on maximum load at 80psi is of little use if I run at 40-50psi on the bitumen, 25-35psi on the gravel and 15-25psi in sand.

Here is a comparison of the load rating of the two tyres I was considering at different tyre pressures. Note that I have extrapolated the values below 35 psi. I found this information by spending many days of internet searching:

Load vs Inflation Pressure

Figure 1: Comparison of Load vs Pressure for 265/75R16 and 285/75R16

Tyre load rating will increase with reduced speed as less heat will be generated. I have shown a comparison of the two tyre sizes under consideration at different speeds and different pressures. The front and rear load line is my estimate the load of my vehicle when fully loaded for a trip.

What Speeds Can I Safely Drive at With the 265/75R16 Tyres?

The predicted load per tyre for each of the front and rear tyres is shown as the horizontal line on the diagram below.

Sand: With 20psi in the front tyres and 27.5 psi in the rear tyres, both tyres will have the same footprint and the maximum sustained speed that I can safely drive at is 20kph (dotted blue line).

Bitumen: With 34 psi in the front tyres and 46 psi in the rear tyres, both tyres will have the same footprint and the maximum sustained speed that I can safely drive at is 104 kph. These are the minimum safe pressures for sustained driving at this speed.

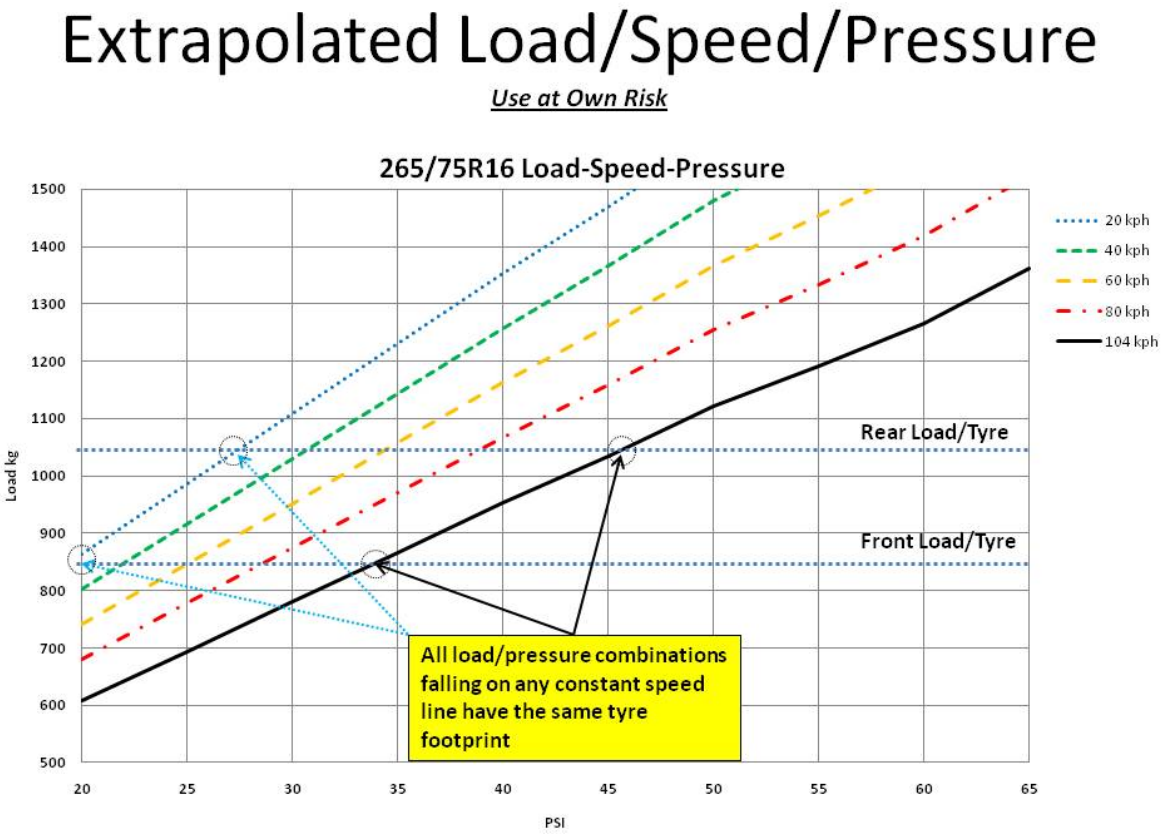

Figure 2: Loaded Vehicle Load vs Pressure at Different Speeds for 265/75R16

What Speed Can I Safely Drive at With the 285/75R16 Tyres?

The predicted load per tyre for each of the front and rear tyres is shown as the horizontal line on the diagram below.

Sand: With 18 psi in the front tyres and 26 psi in the rear tyres, both tyres will have the same footprint and the maximum sustained speed that I can safely drive at is 40kph (dashed green line). This means that for these conditions, I can safely drive at twice the speed (40 kph vs 20 kph) using the 285/75R16 tyres compared with the 265/75R16 tyres. (Or I could drive at 60 kph with 20 psi in the front tyres and 29 psi in the rear tyres)

Bitumen: With 29 psi in the front tyres and 39 psi in the rear tyres, both tyres will have the same footprint and the maximum sustained speed that I can safely drive at is 104 kph. These are the minimum safe pressures for driving at this speed.

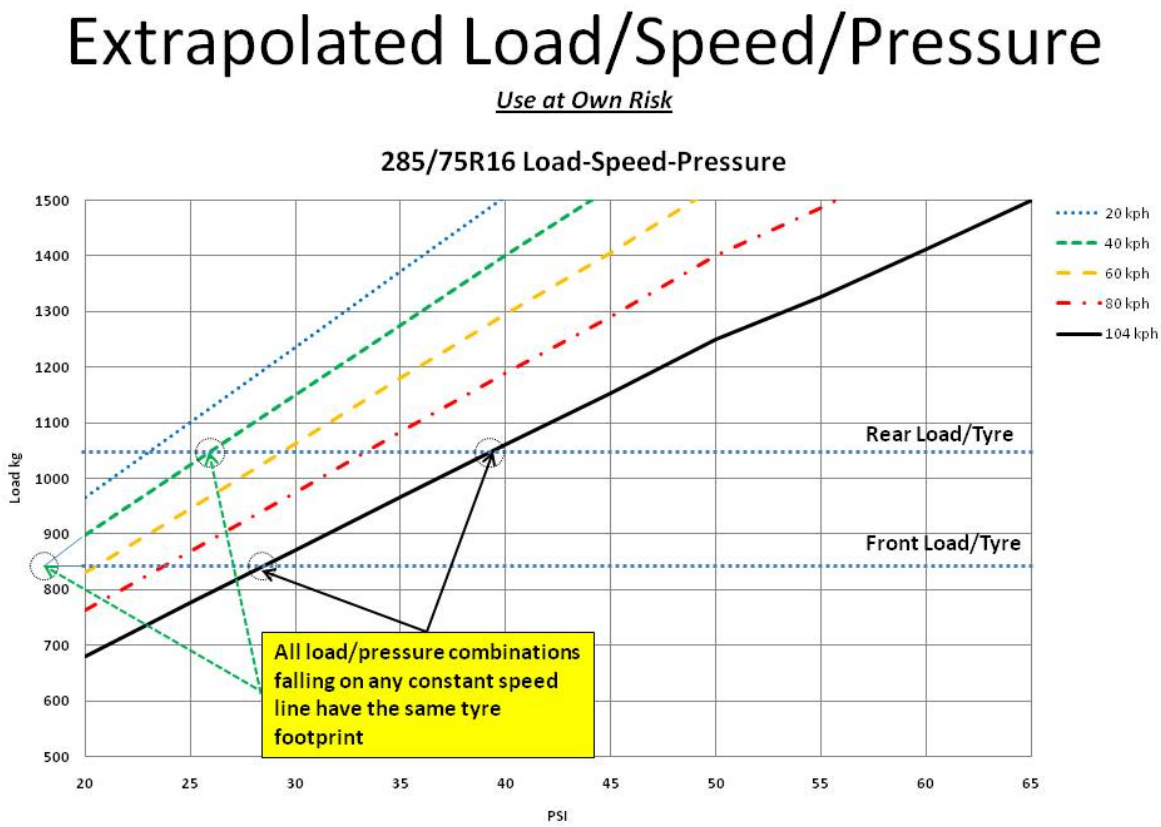

Figure 3: Loaded Vehicle Load vs Pressure at Different Speeds for 285/75R16

Note that the 285/75R16 has better load rating at all speeds and loads than the 265/75R16, meaning that you can safely drive at increased speed without the danger of overheating the tyres.

After doing this research, I fully understand the reason for my tyres getting so hot on the Canning Stock Route where I had 18 psi in the front tyres and 20 psi in the rear tyres.

Selecting the 285/75R16 is the obvious choice for my vehicle.

Practical Check of Chart Information

The US Tire and Rim Association use the measurement of the distance from the bottom of the rim to the floor to achieve a constant footprint. I conducted the following test to verify that the chart provided the correct information to achieve the constant footprint.
An unloaded Landcruiser 100 series with 285/75R16E tyres was weighed on a public weighbridge and shown to have a front load of 780kg per tyre and a rear load of 985kg per tyre. These values are drawn on the chart Figure 4 below and using the 80kph speed line, the corresponding pressures for the above loads for the front and rear tyres were determined to be 21psi and 30psi respectively.

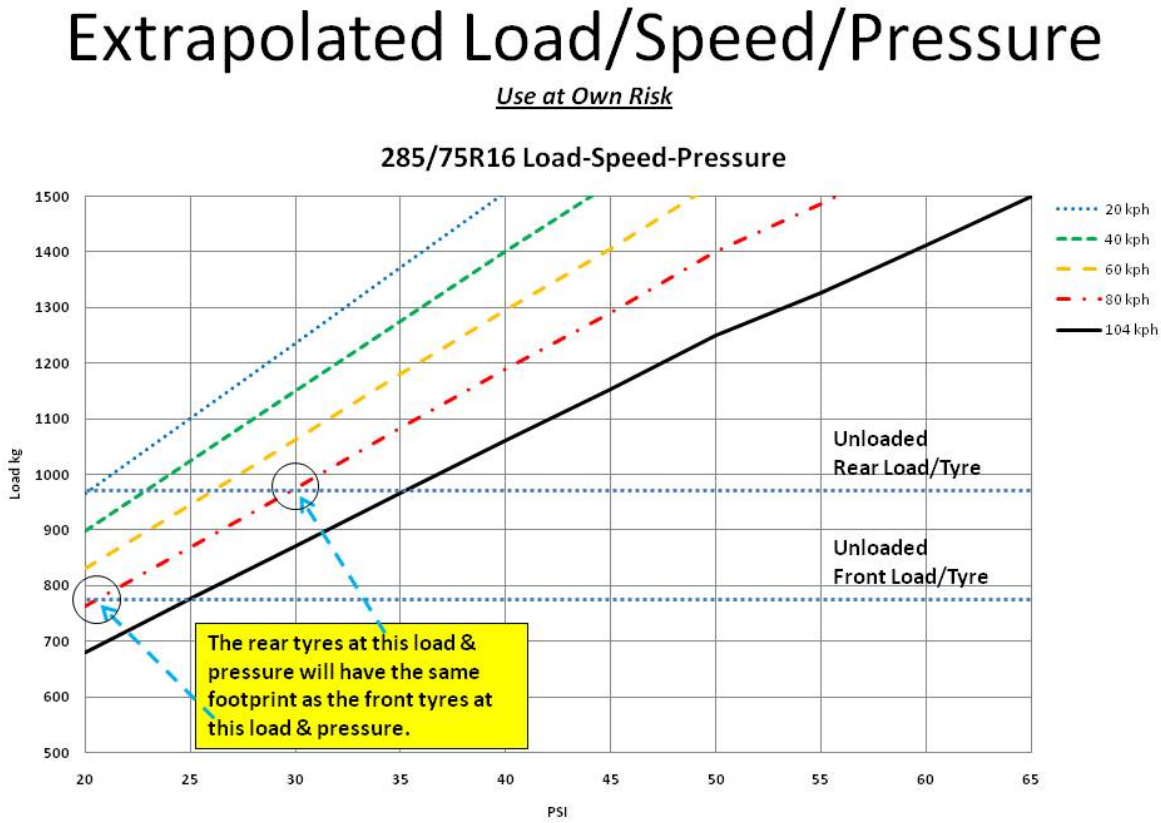

Figure 4: Unloaded Vehicle Load vs Pressure at Different Speeds for 285/75R16

The distance from the bottom of the rim to the flat concrete driveway was measured before the tyres were deflated to the above values and shown to be 167mm. After deflating the front tyre to 21psi the distance from the bottom of the front rim to the driveway was shown to be 152mm. After deflating the rear tyre to 30psi the distance from the bottom of the rear rim to the driveway was measured at 154 mm.

Given the accuracy of the measuring instruments and assumptions of even distribution of loads between the left and right sides, the 2mm difference in rim height means that they are essentially at equal heights within measurement accuracy. I also measured the length of the tyre footprint and both the front and rear tyres had the same length foot print within measurement accuracy.

I think that carrying the chart around with you is much easier than trying to measure tyre footprint lengths in the outback.

Using the Charts

To use the charts all you need to do is to follow these steps.

1. Weigh you vehicle front and rear to determine the load per tyre front and rear.
2. On the chart for your tyre size draw two lines across, one for the front load per tyre and another for the rear load per tyre.
3. Use the chart to determine the safe load, pressure and speed combinations you can drive at.

For example: The chart at the top for the 285/75R16 indicates that with the given loads for the front and rear tyres, then;

a. I can drive safely at 80kph with 24 psi in the front tyres and 34 psi in the rear tyres.
b. I can drive safely at 60kph with 20 psi in the front tyres and 29 psi in the rear tyres.
c. I can drive safely at 40kph with 18 psi in the front tyres and 26 psi in the rear tyres.

The first two (a. and b.) could correspond to corrugated road driving whereas case c. could be for sand driving.

Conclusion:

Having a reasonably accurate knowledge of the load on each of the front and rear tyres is critical to the selection of tyres for a vehicle. In the case of the 100 Series Landcruiser considered, with the dual spare wheels, the long-range fuel tank and the Black Widow drawers, the safe choice for off-road driving, is the 285/75R16 rather than the 265/75R16.

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