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TRUCK TYRE PRESSURES EFFECTS ON TRUCK AND ROAD

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ABSTRACT

Truck tyre pressures were investigated to find the net effect of operating at 85 psi rather than the more typical 100 psi. Consideration was given to tyre wear, tyre damage, fuel consumption and road wear. A simple cost benefit study was completed to show a method of combining these influences. While each situation must be evaluated the results of this study indicate potential savings for the forest road owner.

INTRODUCTION

Selection of the correct pressure to suit tyre loading can have advantages for the truck and road owners. It is not unusual to hear of pressures in the range of 95 to 110 psi. Our research of existing literature indicates that lower pressures are possible. The current legal limits are; 101.5 psi for bias ply tyres and 119.6 psi for radial ply tyres.

One word of caution, however. The figures and values presented here are from a number of sources and should only be used as a guide. Each truck operator must verify the correct pressure for his situation (load and speed) with the tyre supplier. Be aware that steering axle tyres are normally more highly laden and so require higher pressures than others on the rig.

This Report shows the effects of truck tyre pressure on both direct and indirect log transport costs.

BACKGROUND

This subject has been brought to LIRA's attention by the Central Tyre Inflation (C.T.I.) research projects in U.S.A. Their work is aimed at increased log truck mobility on lower standard roads by reducing tyre pressures (to 50 - 60 psi). Commercial use of C.T.I. is still some time away as axles have to be specially manufactured and tyres have to be approved for this application. Discussions in New Zealand have, however, pointed to a halfway house. Tyres common to the industry have the ability to carry typical loads at pressures below the 90 - 110 psi range.

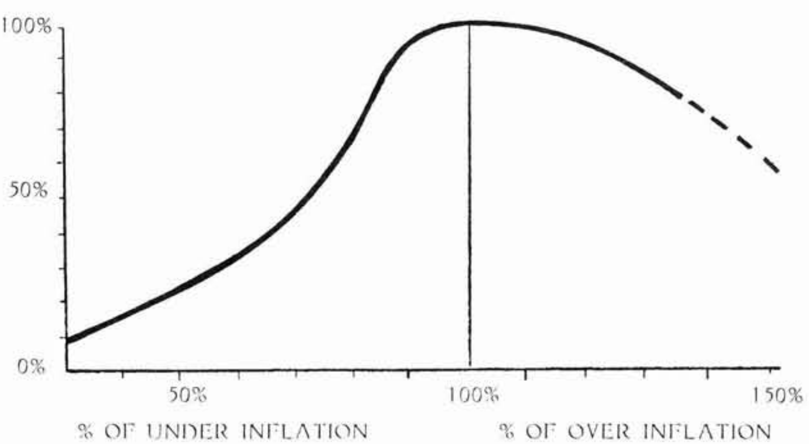

Figure 1

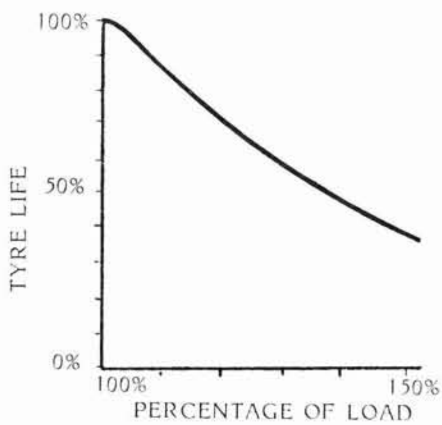

Figure 1a

Effect of Inflation and Load on Bias Ply Tyres

RADIAL LOAD AND INFLATION TABLES/TRUCKS,
BUSES AND TRAILERS USED IN HIGHWAY SERVICE

(Tyre Load limits in kilograms at various cold inflation pressures kPa/psi

SIZE	Used As	380/55	415/60	450/65	485/70	515/75	550/80	585/85	620/90	655/95	690/100	725/105
9.00R20)	Single	-	1610	1710	1810	1910	2000	2090 (10)	2170	2250	2340(12)	2420 (14)
10R22.5)	Twin	1500	1590	1670	1760	1830(10)	1910	1980	2050(12)	2120	2190	2260 (14)
10.00R20)	Single	-	-	1950	2050	2160	2260	2370	2460(12)	2560	2650	2740 (14)
11R22.5)	Twin	1710	1800	1900	1990	2080	2160(12)	2250	2320	2400(14)	2480	2550 (16)
11.00R20	Single	-	-	2110	2240	2350	2460	2570	2680(12)	2780	2880	2980 (14)
	Twin	1860	1960	2060	2160	2260	2350(12)	2440	2530	2620(14)	2700	2780 (16)

Figure 2 - Dunlop Tyre Chart (1988). These figures refer to ideal running conditions on flat, straight, sealed highway

RECOMMENDED TYRE PRESSURE

The correct tyre pressure for any truck tyre depends on the load it carries and its speed. Maximum service life can be expected for a cord tyre if its pressure is kept in the range of 94 - 110% of the recommended inflation pressure (Fitch, 1984). It has not been possible to obtain a graph for steel belt tyres. Tyre manufacturers advise that steel belt radial tyres are less susceptible to increased wear with over inflation. They are, however, vulnerable to failure from :

- Bead cracks. Usually caused by low pressure which allows the side walls to bend sharply over the wheel rim;
- Tread separation. Usually caused by low pressure allowing increased flexing and heat build up.

It should be noted that the recommended tyre pressure is based on a cold tyre. With running, temperature increases and heat from tyre flexing has to be dissipated to the surrounding air. As temperature increases so does pressure and the tyre becomes more rigid, thereby reducing flexing and heat input. Increased tyre temperature also increases heat transfer to the surrounding air. These two trends oppose each other so that at some temperature a heat balance is achieved (provided the tyre does not suffer heat degradation before this temperature is reached).

HOT TYRE PRESSURES MUST NEVER BE BLED DOWN. Bleeding hot tyre pressures to the (cold) recommended values will increase flexing.

The resulting increase in heating will send the tyre temperature even higher, almost certainly to the tyre's detriment.

Choosing the correct pressure does not mean using the maximum recommended for the tyre. All manufacturers should have a chart which shows the correct pressure for the load on the tyre. In New Zealand a trailer axle will carry about 7 tonnes on class one roads. From Figure 2, a 11R22.5 tyre has a recommended pressure of approximately 60 psi for this load (Dunlop, 1988). Adding 20% gives 72 psi which makes for a firmer tyre which runs cooler. This increase in pressure also allows time for slow leaks to be detected before pressure drops to a damaging level.

OVER-INFLATION

If, however, a pressure of 100 psi is used in this tyre for the same load, service life will reduce. Figures 1 & 1a allow us to predict what this might be for bias ply tyres. Expressing the over-inflation as a percentage of the recommended pressure gives 100/67 x 100% = 149%. Now referring to the figure and extrapolating the over-inflation curve (dotted line) we see the service life drops below 80% of optimum.

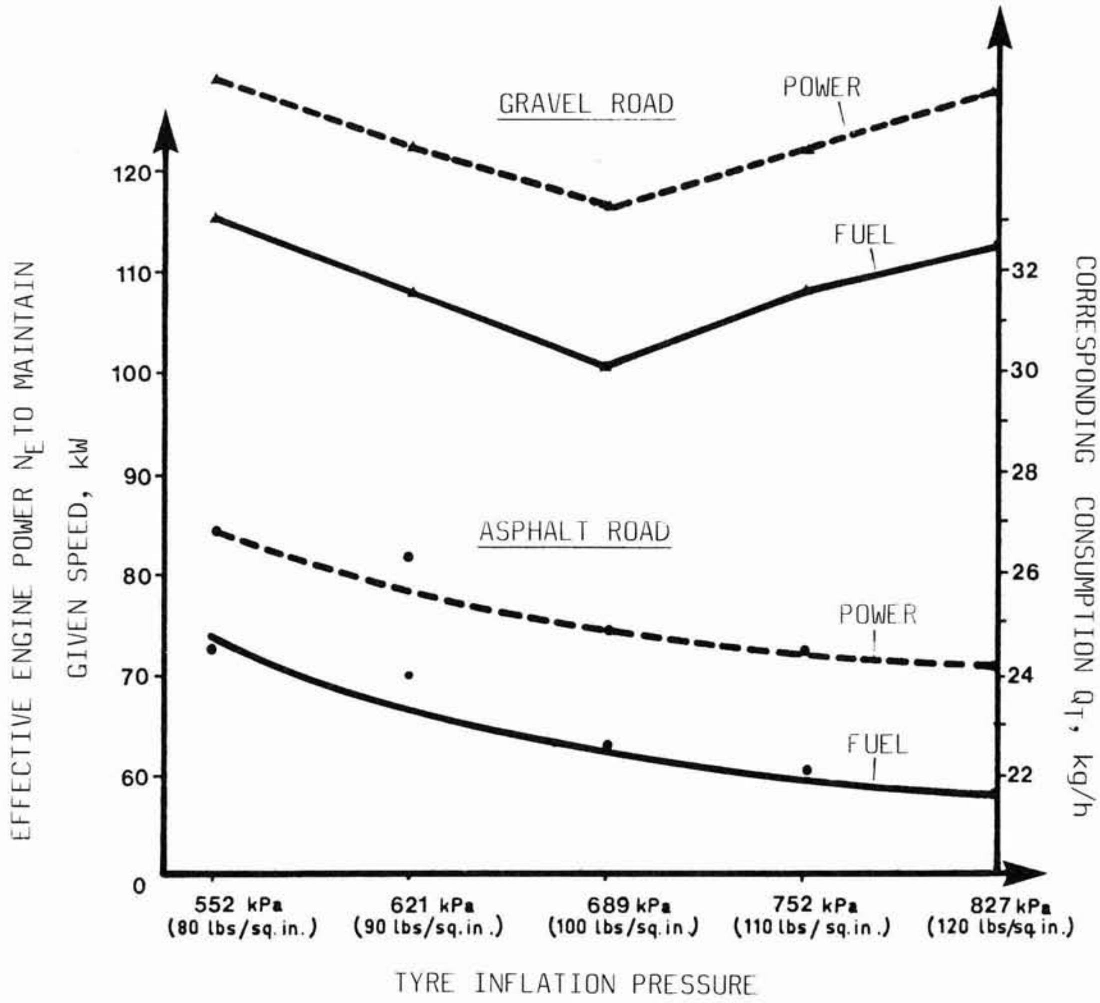

Figure 3 - Fuel Consumption vs Tyre Pressure (for sealed and unsealed roads in Canada)

The tyre nominated above, however, is a steel belted radial which means the drop in service life will be less. In lieu of published data this report assumes an 8% reduction, i.e. for "top of line" tyres a life change from 60,000 km to 55,000 km. Truck operators can consult or keep records to find the appropriate reduction for their operation.

FUEL CONSUMPTION

Tyre pressure affects rolling resistance and so fuel consumption. Two different trends exist, one for sealed and another for unsealed roads, as shown in Fig. 3. On seal, fuel consumption keeps reducing as pressure increases, but unsealed running has an optimum at some intermediate pressure. Figure 3 shows research results presented by FERIC (Lubjic, 1985) and so represents Eastern Canadian conditions and loads. Vehicle Gross Weight = 43.5 tonne; 6 x 4 truck plus 3 axle semi; tyre size 11.00 x 22.

LIRA has not been able to locate information to determine the optimum pressure for typical New Zealand highway/bush operations. Since most operations are predominantly over sealed roads, an error in unsealed performance has a reduced effect on any complete trip estimate.

For this investigation lets assume the results in Figure 3 are typical. It shows an increase of about 10% in fuel consumption for a 20 psi pressure drop.

Typically this could mean 60 litre/100 km at 100 psi and 66 litre/100 km at 80 psi. It should be noted that this change in fuel consumption requires further research to find optimum values for New Zealand operations.

TYRE DAMAGE AND PUNCTURES

Subjectively pressure must have some effect on the number of punctures. At high pressures the tyre tread has little flexibility to accommodate sharp obstacles and they are more likely to be driven through the tread.

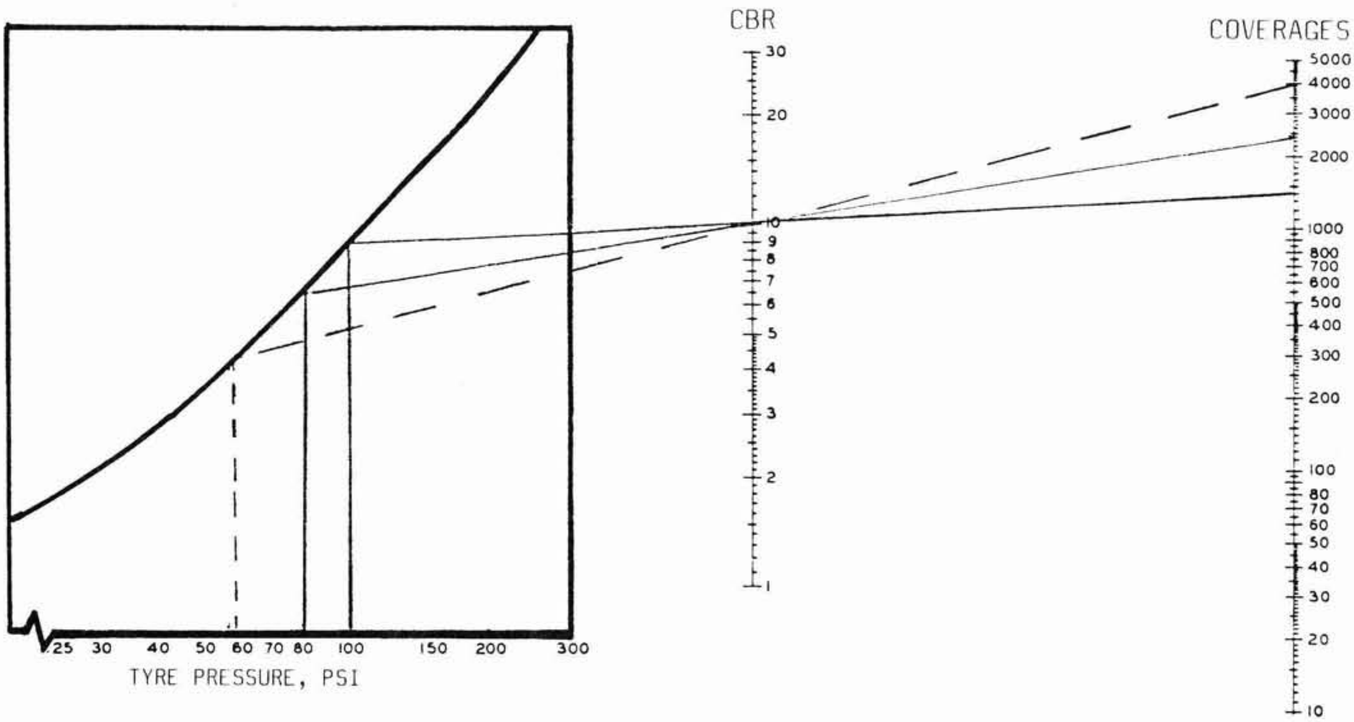

Figure 4 - Number of Axle Passes vs Tyre Pressure (7 tonne axle load on unsurfaced soil) (from Ahlvin, R.G. & Hammitt II)

Low pressures allow considerable flexing which may cause dual tyres to touch or side walls to crush against the rim. It appears reasonable to assume that the best pressure, somewhere in mid range, is that recommended by the manufacturer for the load.

A literature search has revealed no studies of the relationship between pressure, load and puncture or tyre damage.

Discussions with a local log truck contractor have indicated that dropping tyre pressures to 80 psi has reduced the number of tyres destroyed from 12 to 6 per annum per truck. His records on punctures are not accurate enough to show any change in damage repairs.

ROAD LIFE

All roads will only survive a certain number of vehicle passes. This number is dependent on many factors, one of which is tyre pressure. Figure 4 shows a nomogram which predicts the number of vehicle passes (Ahlvin & Hammitt, 1975). For a road strength of 10 CBR the number of coverages for tyre pressures of 100 and 80 psi respectively are approximately 1,400 and 2,400. Note that coverages are the number of 7 tonne axle coverages, not vehicle passes. The nomogram given here is for unsurfaced soil. Aggregate surfaced roads show similar trends. Also of interest is the road performance under 55 psi tyre pressures (dotted line) as would be the case with Central Tyre Inflation (C.T.I.) vehicles.

COST-BENEFIT STUDY

There are then, at least four factors (tyre life, fuel consumption, tyre damage and road life) influenced by changing truck tyre pressure. The following scenario presents a process by which a decision on the best solution could be chosen. You will need to change the input values to assess your own situation.

A trucking contractor operates on a haul distance of 100 km with a six axle rig on class one roads. His average payload is 25 tonnes. He would like to know if changing from 100 psi to 80 psi will offer any advantages.

(i) **Tyre Life**

From above tyre life is :

60,000 km at 80 psi
55,000 km at 100 psi

Lets look at the loaded direction only and assume that all the truck tyres are new and the trailer tyres are retreaded.

Prices :

New $525
Retread $250

Total Cost of Tyres :

$10 \times 525 + 12 \times 250 = \$8{,}250$

Total Work Done :

Payload x Distance

Work (for 60,000 km tyre life) :

25 x 60,000 tonne-km
= 1,500,000 tonne-km

Tyre Cost/Tonne-km (60,000 km, 80 psi) :

$$\frac{8{,}250}{1{,}500{,}000} \times 100 \text{ cents/tonne-km}$$

= .550 ¢/tonne-km

Tyre Cost/Tonne-km (50,000 km, 100 psi) :

$$\frac{60{,}000}{55{,}000} \times \frac{8{,}250}{1{,}500{,}000}$$

= .600 ¢/tonne-km

Savings on a 100 km trip per tonne :

(.600 - .550) x 100
= 5 cents/tonne

(ii) **Fuel Consumption**

Fuel costs 61¢/litre before G.S.T.

Cost per tonne for the 100 km trip :

At 60 litre/100 km :

$$\text{Cost} = \frac{\text{Quantity of Fuel x Fuel Cost}}{\text{Payload}}$$

$$= \frac{60 \times 61}{25} \text{ ¢/tonne}$$

= 146.4 ¢/tonne

At 66 litre/100 km :

$$\text{Cost} = \frac{66 \times 61}{25} = 161 \text{ ¢/litre}$$

Increased Cost = 14.6 ¢/tonne

(iii) **Tyre Failures**

It is assumed that each tyre failure (destruction) costs half the price of a new tyre (i.e. 50% worn). Also labour of $50 is included.

If we assume that lowering the pressure saves 6 total tyre failures per annum, and that the truck makes 700 trips per year (3 per day x 235 days) :

Increased cost per tonne =

$$\frac{6 \times 312.50 \times 100}{700 \times 25} \text{ ¢/tonne}$$

= 10.7 ¢/tonne

$$\left(\text{Cost per tyre} = \frac{\$525}{2} + \$50\right)$$

= $312.50

(iv) **Road**

Lets look just at the spur road and assume that the unsurfaced natural ground is used at first.

Length : 0.5 km
Strength : CBR 10
Weight of Produce : 12,000 tonnes

Assume that the loaded direction only influences road life and that one truck load is equivalent to 5 coverages on Figure 4.

With 80 psi tyre pressure 2,400 coverages can be achieved.

The total tonnage across the road without repair then is :

$$\frac{2{,}400}{5} \times 25 = 12{,}000 \text{ tonnes}$$

At the higher pressure of 100 psi only 1,400 coverages are achieved before major maintenance.

Let's assume $1,000 is spent upgrading the road to complete transport of the crop.

Additional road cost per tonne =

$$\frac{1000 \times 100}{12{,}000}$$

= 8.3 cents/tonne

(v) **Net Result**

	TOTAL	TRUCK OPERATOR
SAVINGS :		
Tyre Wear Costs	+ 5.0	5.0
Tyre Destruction Costs	+ 10.7	10.7
Road (Spur Only)	+ 8.3	-
Subtotal	24.0	15.7
Additional Cost : Fuel	- 14.6	- 14.6
TOTAL SAVING	9.4¢/tonne	1.1¢/tonne
Saving per annum (17,500 tonnes)	$1640	$190

Note : This is for one case study.

CONCLUSION

Tyre pressure makes significant changes to :

- Tyre Costs
- Fuel Consumption
- Road Costs

The combination of these to determine the lowest total transport cost requires a simple cost benefit study similar to that presented in this report. In the scenario given in this report the truck owner would have achieved a minor benefit by reducing tyre pressure. Actual tyre performance for each operation can be recorded by the operator, thus allowing an accurate cost benefit study. Operational factors such as reduced time spent on tyre service may also support this.

When the roading costs are included there is a considerable increase in benefit at the lower pressure.

It is important that :

- Each forest owner analyses the effect on his own road system.
- Each truck owner monitors the effect of changing tyre pressure to verify that real life matches the trends shown in the handbooks.
- Each truck owner operators his tyres in accordance with the manufacturer's recommendations.

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