Overland Training Technical Paper Series

1.1.1

We all talk about it, but how does tire pressure really effect performance?

by Graham Jackson

The best way to understand how reducing tire pressures will increase performance is to look at the increase in contact patch as pressure is reduced. We all know from looking at a flat tire that amount of tire surface contacting the ground increases with reduction in pressure. So how much does the surface area increase at lower pressures? And how low can tire pressures go before the lower pressure itself becomes deleterious? Further we can look at the practical effects of increased contact patch on performance in varied terrain.

This paper will only look at the increase in contact area and its practical implications. The effects on the tire of reduced pressure will be dealt with later.

The data for this paper was gathered from vehicles that attended the Overland Training certification course. The tires represented are heavily weighted towards BFGoodrich, but the same general principles can be applied to any tire on any vehicle. In this case we are assuming that the vehicles all have four wheels as the tested vehicles did, but again, the same principles can be applied to 6x6 or 8x8 overland vehicles. The method of testing was as follows: with the vehicle on a hard surface the tread width was measured, as was the length of the tire section touching the ground. Several assumptions were made; one that the contact patch width would be the same at all tested pressures and would equal the tread width. This was found to be generally true on a hard surface. The sidewall bulge did not contact the ground on any of the tested tires at any of the tested pressures. Obviously on a soft surface like mud or sand, the sidewall bulge may well contact the ground, but this will only increase the contact patch, so the tested method was considered conservative. The second assumption is that the contact patch is a rectangle. In actuality the contact patch is probably an oval, but for ease of measuring and calculating, the rectangle was assumed and this was carried through all the testing on all the tires. The last assumption was that at low pressures the entire width of the tread was in contact with the ground and no cupping of the tread occurred.

Note that all measurements were taken by different people, or groups of people, so while the measuring method was the same for all tires, the details may differ.

The tires tested were:

BFGoodrich MT KM2 285/75R16
BFGoodrich MT KM 255/85R16
BFGoodrich AT KO 265/75R16

Toyo M/T 255/85R16

These represent some common sizes used on light to medium duty truck and SUV style expedition rigs. The pressures used for the measurements were:

Street pressure as used by the owner of the rig (different for each tire)
20psi
10psi
5psi

The data clearly shows the increase in area at reduced pressure:

Contact patch area for one tire(in^2)

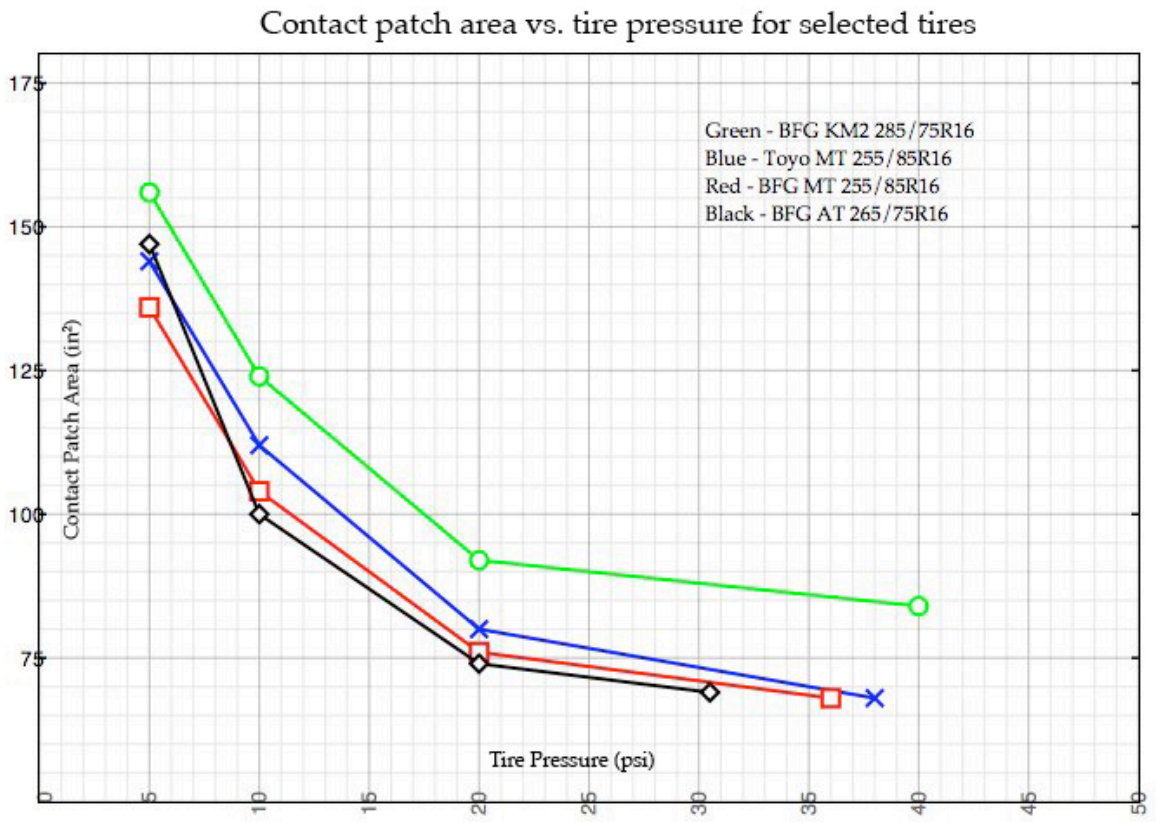
psi	BFG MT KM2 285/75R16	Toyo M/T 255/85R16	BFG MT KM 255/85R16	BFG AT KO 265/75R16
40	84			
38		68		
36			68	
30.5				69
20	92	80	76	74
10	124	112	104	100
5	156	144	136	147

If this is generalized for all tires on the same rig:

Total contact area for four tires (in^2)

psi	BFG MT KM2 285/75R16	Toyo M/T 255/85R16	BFG MT KM 255/85R16	BFG AT KO 265/75R16
40	336			
38		272		
36			272	
30.5				276
20	368	320	304	296
10	496	448	416	400
5	624	576	544	588

Graphing the contact patch area versus the tire pressure shows that the area grows in an exponential fashion as pressure reduces.



In all cases dropping from street pressure to 20psi makes a relatively small impact on contact patch, yet 20psi is what many people consider 'aired down' to be. Going to 10psi and then to 5psi gives a massive increase in area. The BFG AT (All Terrain) stands out as having a particularly significant increase in area from 10psi to 5psi. The Toyo M/T and the BFG MT KM are the same size tire (nominally) but notice the area difference as pressure drops.

Looking at the percent increase in contact patch area for one tire is interesting:

Percent increase in total contact area over street pressure

psi	BFG MT KM2 285/75R16	Toyo M/T 255/85R16	BFG MT KM 255/85R16	BFG AT KO 265/75R16
20	9.5	17.6	11.8	7.2
10	47.6	64.7	52.9	44.9
5	85.7	111.8	100.0	113.0

Perhaps the most telling way to look at this data is to consider how many 'extra' street pressure tires are added at each lower pressure.

Practical number of street pressure tires

psi	BFG MT KM2 285/75R16	Toyo M/T 255/85R16	BFG MT KM 255/85R16	BFG AT KO 265/75R16
20	4.38	4.71	4.47	4.29
10	5.90	6.59	6.12	5.80
5	7.43	8.47	8.00	8.52

Notice that at 20psi in all cases just under a single tire has been added; the Toyo comes out on top adding 0.71 of a street pressure tire. Effects are much more dramatic at lower pressures. At 10psi with the Toyos it will be the same as having 2.59 more street pressure tires under the vehicle, an instant 6x6; at 5psi 4.47 more tires added gives the practical contact patch of an 8x8. In these terms it is easy to see the massive tractive advantage of lowering pressures; what better way to gain traction than to add tires?

The increased contact patch will give benefits in practically all off-road terrain, but will be especially effective in sand. Additionally, increasing the contact patch and hence traction, will greatly reduce tire spin, one of the most environmentally damaging aspects of off-road travel. So consider it to be an immediate conservation tactic; air down as soon as you get off road and reduce impact. In rocky terrain, really low tire pressures will increase the danger of sidewall damage, but in general terms the advantage of low pressures over rocks is more tire deformation than contact patch, and pressures need not be as low as on soft surfaces like sand.

Of course everything is a compromise, and tire pressures cannot be reduced with no detrimental effects. Traveling speed will be the limiting factor on how low pressures can go; as tires flex heat is generated, and flex increases with lower pressure. That will be the subject of a future paper.