The Importance of Cool Inlet Air to an early Esprit

By Bill Galbraith

Let's start off with a couple equations:

Approximate horsepower at other than measured condition[i]:

$$HP = HP_{std} \bullet (\sigma - 0.1) / 0.9$$

Where σ is the density ratio = density / $density_{std}$

So, what are typical air densities at different temperatures. This table shows them[ii]:

Temp °F	Density (lb/ft^3)
30	0.081
40	0.080
50	0.078
60	0.076
70	0.075
80	0.074
90	0.072
100	0.071
120	0.069
140	0.066
150	0.065
200	0.060
250	0.056
300	0.052
400	0.046
500	0.041
600	0.038

So, for an example, let's assume that Lotus measured the output of the 907 engine on a 60 deg day, and got 160 HP. What happens when it is cooler outside, let's say on a cold morning, at 40°F.

$\sigma = 0.080 / 0.076 = 1.053$

$HP = 160 \bullet (1.053 – 0.1) / 0.9$

$= 169.4$ horsepower

Okay, so this is why we like to drive on cool days.

What happens on a hot day, say 90°F.

$\sigma = 0.072 / 0.076 = 0.947$

$HP = 160 \bullet (0.947 – 0.1) / 0.9$

$= 150.6$ horsepower

Okay, not too bad. However, this is assuming that the air that the engine is receiving is at the ambient temperature.

Now, what about those guys running an S1 with an engine cover, but no fresh air inlet. The carburetors are sucking in hot air from under the engine cover. I'm not sure how hot this air is, but let's look at some examples.

In the air is 200°F,

$\sigma = 0.060 / 0.076 = 0.789$

$HP = 160 \bullet (0.789 – 0.1) / 0.9$

$= 122.4$ horsepower, or 76.5% of nominal horsepower

Is the air under the engine cover hotter than 200°F? I'll bet it is, since that area isn't ventilated. Is it 300°F?

$\sigma = 0.052 / 0.076 = 0.684$

$HP = 160 \bullet (0.684 – 0.1) / 0.9$

$= 103.8$ horsepower, or 65% of nominal horsepower

So, do you see the importance of having cool air ducted into your engine?

Let's look at another factor. You tuned the mixture to be optimal when the engine was fairly cool, with the engine cover off, so the engine is breathing in relatively cooler air. With the cover on and the engine ingesting air that is only 68% the density of the air from when it was tuned, your engine is now running rich. Performance also degrades. The amount of degradation is left as homework for the reader.

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[i] Source: Aeronautical Vestpocket Handbook, United Technologies Pratt & Whitney, August 1986

[ii] Source: http://www.engineeringtoolbox.com/air-temperature-pressure-density-d_771.html