HOW HUMID IS YOUR DAY?

Many of us have wondered what the effects of humidity really are when we go fly. Some of its aspects are obvious, and all are negative – but by **how much**? Performance charts for landings, for example, say that they are predicated on a dry paved surface, and there is usually a correction for grass (DRY short grass) strips. But how much do we correct if the grass is damp, from either dew in the morning or rain during the day? The answer most of us instructors give is, "It will take more space, and if the grass strip is even close to marginal length to begin with, go somewhere else!" And that is certainly good advice!

We all also know, when dealing with Density Altitude (DA), anything that decreases the oxygen content in the air will decrease performance. Our two most standard references for that are temperature and pressure. We all learned that higher temperatures will make the air less dense, and that decreases in pressure (as in altitude) will also make the air less dense. Our performance charts are, after all, based on a "standard day" as the baseline, and then we adjust for temperature and pressure differences (both standard and non-standard). The performance charts themselves accomplish some of that, and "corrections" notes that we must apply to the figures we get from the charts also do some. And then there is our good old friend – "interpolation"! Most of us struggled with that one when we were first learning how to read performance charts, and with the advent of some of the newer calculators, the math we did has become old fashioned – but still true.

But, what about…….Humidity?

What IS a standard day? "*Standard day conditions* means standard ambient conditions as described in the United States Standard Atmosphere 1976, (i.e., temperature=15 °C, specific humidity=0.00 kg H20/kg dry air, and pressure=101325 Pa.)"

OR – 59F and 29.92" and **0% humidity** (emphasis mine), at Sea Level.

The fact is that we all know, because we were taught it, that humidity displaces oxygen in the air mass, thus making it less dense – and performance will….decrease. "How much?" your student asks, and we mostly fumble for an answer – which often sounds like the wet grass answer, "if the field is that marginal, and the humidity is high, don't go." And, with luck, our student nods their head in "understanding", and asks nothing further.

Have you ever wondered how much? Or, how you might answer the questions with something other than a general evasion? There is certainly nothing within any of the PIM's (Pilot Information Manuals) or POH's (Pilot Operating Handbooks) to help us out on this one, and none of the aircraft manufacturers that I have ever seen have a "humidity chart" available.

While reading a quiz article, in another publication, by Barry Schiff, he asked a question that he had gotten from another pilot, and the answer to the question gave reference to a humidity calculator on the web and an answer that, "The effect of humidity can be greater than is generally appreciated." I thank Barry for that answer, because it sent me to the web site to do some additional investigation. I had a basic question, which was – Is there some general guideline that I can give students about the effects of humidity on performance that is quantifiable? The answer is….yes, but….

I went to the site (https://www.beaufort.usmc.mil/weather/wx_calculators.htm - **NOTE** - this website is no longer available to the public – it was taken down by the military.) and found several calculators there that are, at least, interesting. Included is a calculator for Density Altitude with inputs for altitude, air temperature (in F), altimeter setting (in inches), and humidity. There is the printed caveat that, "**This calculator is for educational purposes only and should not be used for flight planning.**" So, we still don't have an "approved" source of information, but it IS a source. Lacking one put out by anyone else, however, it can surely be used to come up with some answers as to the humidity effects – which we already know are not in our favor.

I will spare you all the numbers that I ran through the calculator, as you can go to the calculator yourself, or, better yet, with your students, to see for yourself what various combinations of numbers will do. But, several general concepts emerged quite quickly. I did my numbers for sea level, 3000 feet, and 5000 feet, using temperatures from 60 F (approximately standard for sea level) to 100 F, and using only standard altimeters (as a constant).

The results for the temperature changes at all altitudes were as expected – DA went up as temperature went up (we all know that) and did so with greater effect as altitude went up. You are saying, "We knew that too, so tell us something we didn't know."

What was surprising to me was that humidity did make the DA go up (we knew that) but more so at lower altitudes and higher temperatures. In other words, the percentage increase in DA (and thus decrease in performance) due to humidity was greater at lower altitudes than higher ones, and also at higher temperatures than lower ones – neither of which are particularly intuitive. For example, at sea level and 80^{o} F, the density altitude went up 3.2% for every 10% of humidity increase, to a total of just over 32% at 100% humidity. The same approximate range was true each for 90^{o} and 100^{o} degrees. For example, on a nice hot and humid flat land day of 90^{o} degrees and 90% humidity, the dry DA of approximately 1978 feet increases to almost 2500 by humidity alone. And, on a 100^{o}/100% day, one of those summer swelterers, DA goes from a dry 2584 to 3410 – almost a 1000 foot increase in DA, and decrease in performance, that does not appear in the charts!

At 3000 feet, the range was from about .65%/10% at 60^{o} to 1.4%/10% at 100^{o} for 6.5% and 14.5% decreases in performance respectively at 100% humidity. At 3000', a

90^{o}/90% day would have a dry DA of 5625 and the wet DA of 6288, and on the 100^{o}/100% day the dry DA would be 6216 and the wet DA would be 7115. At 5000 feet, the ranges were between .42% and 1.1%/10% of humidity at 60^{o} and 100^{o}, with a range of 4.2% to 11% respectively for 100% humidity. The 90^{o}/90% dry DA would be 8046 and the wet DA would be 8607, with the 100°/100% ranging from a dry DA of 8627 to a wet DA of 9580. Again, almost 1000 feet not shown on the chart, and in an already highly degraded performance condition by temperature alone.

While the increase in the numbers at the higher altitudes may not look or sound nearly as bad as the ones at sea level, one must remember that those decreases are being applied to performance that is already significantly degraded due to our normal two DA calculations – temperature and altitude – to begin with, and thus the results can be devastating if not considered.

So what DO we tell our students? Since the caveat says we cannot use the figures for flight planning, I would suggest two things:

1) Humidity can further decrease performance from 11% at the higher altitudes to as much as 32% at lower altitudes – above and beyond the effects of temperature and altitude alone. (This takes the highest values, and when we are calculating performance, I would rather not "split hairs".)

2) Give them the web site or, better yet, go there with them on a computer, put in the numbers, and let them see for themselves. Do practical scenarios. It does, for example, get really hot in AZ but with less humidity, and it does get really warm in the Southeast and Midwest WITH high humidity.

And, then give them the rule that we have all used for ages of aviation, "If the airport is that marginal, for either take-off or landing, without the humidity applied, then **just don't go!**"

Here is a site that IS up - http://wahiduddin.net/calc/calc_da.htm - it is the work of Richard Shelquist, and it uses Dew Point to get to the same point. If you are interested in the math of it, go to http://wahiduddin.net/calc/density_altitude.htm, and read to your heart's content. But remember: **This calculator is for educational purposes only and not to be used for flight planning!**

Now you will have some numbers to back you up – even if they are "**for educational purposes only"**. That's certainly "educational" enough to convince me!

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Have a SAFE day!