THE HUMISERY AND OTHER MEASURES OF SUMMER DISCOMFORT

by

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1. INTRODUCTION

Westerner: "I've been in temperatures near 100 degrees many times back home, but I've never been hotter than I am visiting your 90 degree weather."

Easterner: "It's not the heat, it's the humidity."

The Easterner in this conversation is attempting to explain the Westerner's discomfort by telling why it feels so much hotter than it is. The Easterner's explanation is fairly reasonable as far as it goes, but of course, it does not provide a measurement. How does the Westerner feel in the Easterner's weather? Suppose it is 90 degrees with a dew point of 77 degrees Fahrenheit (relative humidity, 66 percent)? Does it feel like 95°F, 100°F, 105°F?

A number of attempts have been made to provide such an estimate similar to the way the wind chill provides an estimate of winter discomfort (see Section 3 below). Unfortunately, although the wind chill is firmly established with the public, none of the summer measures have gained anything of the wind chill's general acceptance. It is appropriate to examine the reasons for this situation.

2. WHY THE WIND CHILL INDEX WORKS

Perhaps the strongest appeal of the wind chill index is its intuitive fit with experience. When the wind chill index is -50°F, people feel cold even with heavy clothing. Another characteristic of the wind chill is its simplicity to the public. It is a number that is always lower than the temperature and is identical with the temperature at low wind speeds. A final characteristic is its use of all the factors which both prevail over populated areas and which contribute to discomfort. In this case, there are two: temperature and wind. Perhaps if any of the summer discomfort measures had the same characteristics, they would be equally acceptable to the public.

3. THE SUMMER INDICES

Various summer discomfort measures have been proposed since at least the 1920's.

Figure 1. Humisery Index Adjustment Due to Humidity

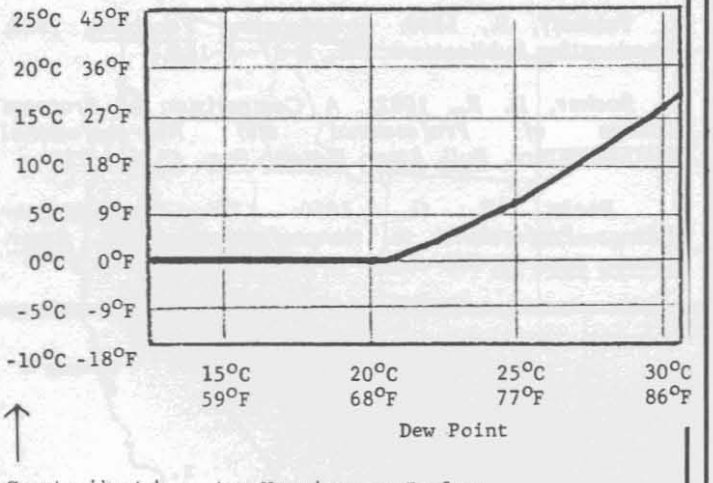


Figure 2. Humisery Index Adjustment Due to Wind

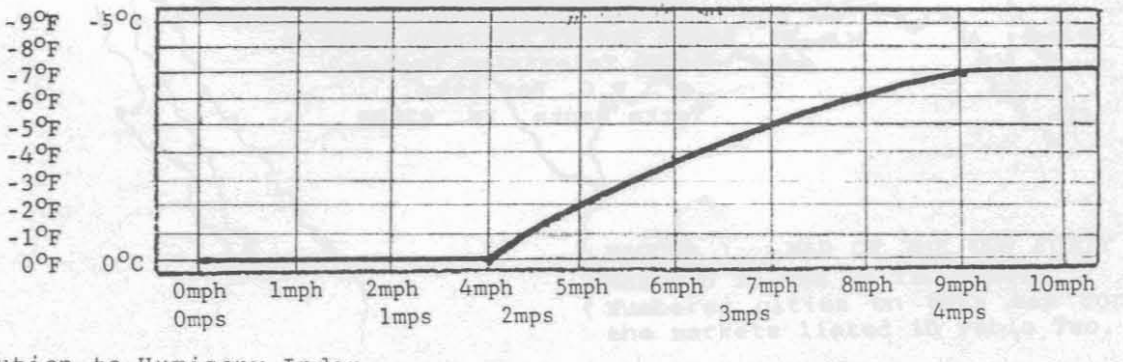
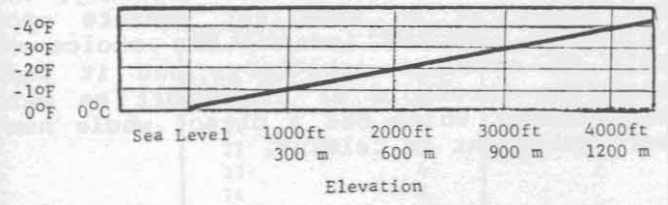


Figure 3. Humisery Index Adjustment Due to Elevation



Considering them one at a time, they are the "temperature-humidity index" (2), the "apparent temperature" (3), and the "Humiture" (4). Comparing them against the "wind chill" index standard will give some idea of their nature.

3.a The Temperature-Humidity Index

This index was the result of experiments which attempted to establish what combinations of heat and humidity gave equivalent feelings of discomfort. Perhaps the greatest barrier to acceptance is its lack of intuitive fit with experience. This index is set up such that at 70°F, few people are uncomfortable and at 80°F, nearly everybody is uncomfortable. The necessity of a double translation from index to percentage of people feeling uncomfortable to personal feeling of discomfort is a severe handicap. The index also does not consider wind or elevation. It continues to register, declining even at very low dew points, way outside the range of usefulness.

3.b The Apparent Temperature

The apparent temperature is the result of experiments and judgments about discomfort based on clothing and physiology. The index also predicts heat stress risk. The intuitive fit of this index is very good; however it does not have a base and thus the apparent temperature occasionally drops below the actual temperature.

A somewhat lesser problem is that apparent temperature is strongly based on relative humidity, a notoriously variable parameter. For example, in the case of the humid day previously noted (90°F temperature, 77°F dew point), a 1 degree decline in temperature will, at that dewpoint, cause more than a 1 percent increase in relative humidity. Because of its variability, relative humidity is considered a poor factor for use in calculating indices.

3.c The Humiture Index

This index also provides a good intuitive fit with discomfort but suffers from the same lack of basis as does the apparent temperature. Its most striking feature is its computational simplicity. One equation of humiture is that it is equal to temperature plus dew point minus 65°F (or 18° Celsius). It frequently is less than temperature, however, and perhaps more seriously, it also continues to decline even at very low dew points. Wind and elevation are not considered in this index.

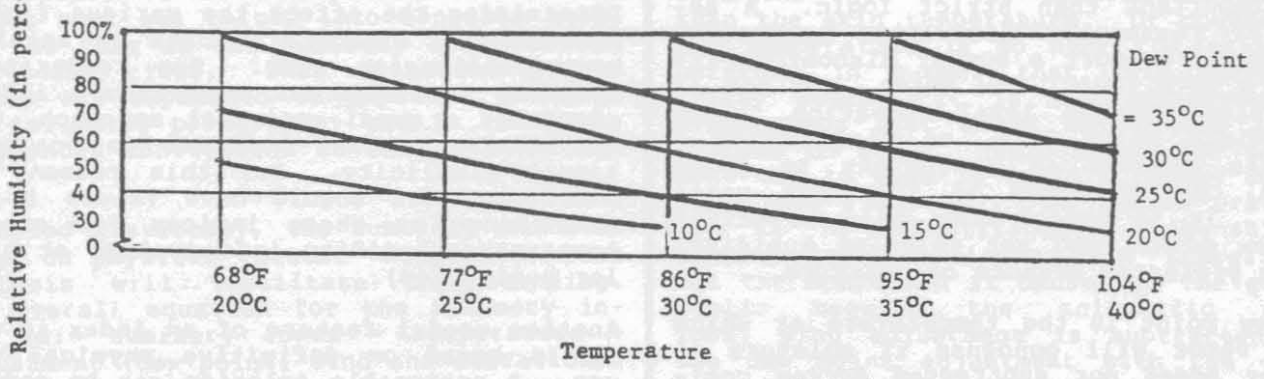
Notwithstanding these minor weaknesses, it must be admitted that each of these indices gives information about heat and humidity that is no less meaningful than the wind chill index. Indeed, it may be only a lack of a strong public education campaign that is keeping the indices out of general practice.

Nonetheless, considering in detail all the factors that make the wind chill acceptable, and applying them to the summer discomfort index, we should be able to produce a better notion of what an acceptable summer discomfort index should be like. I shall call this newly developed product the humisery index.

4. A NEW SUMMER INDEX - HUMISERY

Intuitively, a summer discomfort index should be in the 80s, 90s and 100s as people get more and more uncomfortable (when

Figure 4. Relationship of Temperature, Dew Point and Relative Humidity

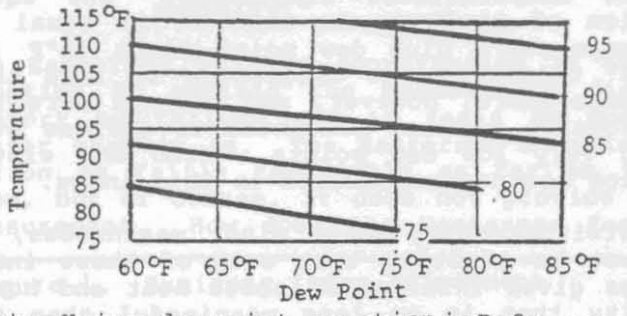


Note: Valid at 1000mb only, but relatively close at 950 mb.

working within the Fahrenheit scale). The index should also be higher as the air becomes more humid, stagnant or thicker (the last with lower elevation). Although shade conditions, clothing, pollution, physiology, and physical activity also influence discomfort, such factors vary so widely between individuals and within short distances that they cannot be used in an index.

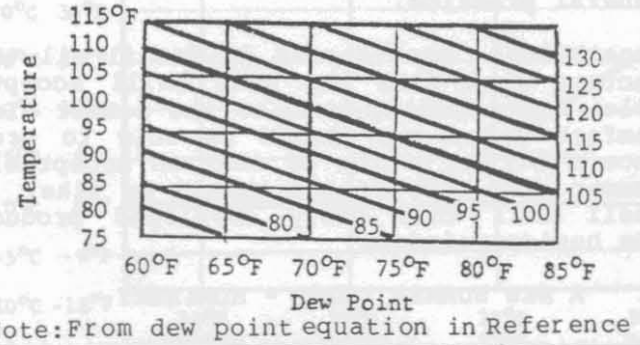
Determining a good base for a summer discomfort index must, of necessity be somewhat arbitrary or judgmental. The wind chill uses a 4 mph wind speed as its base, for example. Since 4 mph is a reasonable

Figure 5. Discomfort (Temperature-Humidity)



Note: Using dew point equation in Reference 2

Figure 6. Humiture



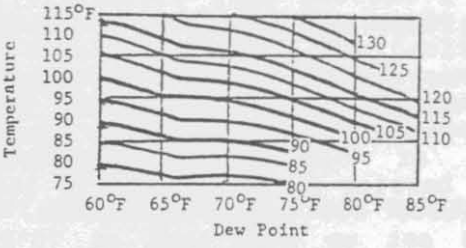
Note: From dew point equation in Reference 4.

brisk walking speed, then logically the wind chill index should actually be warmer than the air temperature when the wind is under 4 mph. The fact that it is not shows that a firm base line is perhaps more important than strict logic. A series of reasonable base line parameters that would support a summer discomfort index are 68°F (20°C) dew point, a 4 mph (2 mps) wind and sea level elevation. Thus dew points below 68°F, or winds below 4 mph are treated as equivalent to these values, as explained in the next paragraph. It is useful once more to stress why dew point, and not relative humidity, is the preferred measure of moisture.

The dew point is the temperature at which water vapor will condense if moisture is neither added nor subtracted during cooling. Over the course of a summer day, the dew point is unlikely to change much except in the unusual case of a swift frontal passage. Because of its stability, the dew point is an excellent measure upon which to base an index. The choice of 68°F is somewhat arbitrary, but it does seem the threshold of discomfort as well as a number which has a direct whole number equivalent in Celsius.

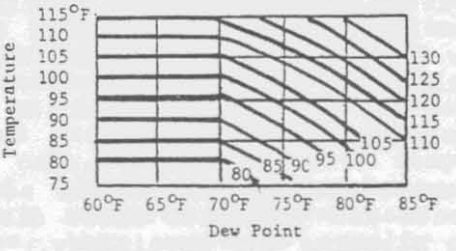
The 4 mph wind choice parallels the wind chill index wind speed base. The sea level elevation choice is defined on the basis that much of the population worldwide lives fairly close to that level.

Figure 7. Apparent Temperature



Base on Figure 1 of Reference 3 and interpolation and conversion to dew point valid at sea level and 5.6 mph wind.

Figure 8. Humisery



From Figure 1-3 of this paper, valid at sea level and 5.6 mph wind.

Now that the base line of the humisery index has been chosen, the next matter is to detail the effects of conditions that represent more discomfort than the base lines.

Determining the effect the various factors have on the discomfort index is surely a most challenging task. The temperature-humidity and apparent temperature indices represent a quasi-empirical approach, with the humiture being modified for calculational simplicity. For this reason, the humisery index should have values in the same range as these indices (or similar temperature-humidity index values at similar humiseries).

Another useful feature of an index is that it is based on definitive physical values. A reasonable relation can be made to the rise in equivalent temperature (the