This equation is used in conjunction with the time-tolerance chart.

2 A recommended procedure, for predicting the effect of environments other than the ones studied, is to use the existing tolerance chart in conjunction with the following predictive equation:

\[ \Delta q_e = -8.3 + 0.126 t_e - 0.037 t_r + 1.92 V_r \]  \hspace{1cm} (11)

This predictive equation is also presented in graphic form. From these charts, the effective storage index can be computed.

\( q_{\text{effective}} = q_{\text{tolerance chart}} - \Delta q_e \text{(nomograph)} \)  \hspace{1cm} (12)

3 A conservative method for applying the steady exposure data to a transient condition is suggested. This method is based on the division of exposure time into 5-min intervals and a computation is made for the percentage of tolerance time used.

4 The importance of the head, hands, and feet in the overall tolerance picture is emphasized. The partition of the water-loss quantities indicates that more data should be collected on this specific problem.

References


DISCUSSION

H. A. Mauch

The author states in the introduction to his paper that, “It is difficult to justify any extensive program of evaluation on any particular clothing assembly because these assemblies soon become obsolete. Nevertheless, the principle of the ventilating garment is so fundamental that it is the objective of this paper to provide a rational basis for the prediction of thermal tolerance when using an MA-2 ventilating garment with a modified MK-IV antiexposure suit.”

It may be of interest to note that the principle of this ventilating garment is indeed being used or under consideration for a...
number of industrial applications such as environmental protective coveralls, ventilating inserts for hospital beds, car seats and seat covers, hair drying hoods, etc. This makes the author's paper a particularly timely contribution. Ideally, a predictive formula to be used for design purposes in such cases should, however, include additional variables which the author did not need in the specific case he investigated for the Air Force. In particular, the effective clo value of the assembly and the water vapor pressure of the ventilating air may vary. Also, instead of the 8000-ft altitude in the author's experiments, sea level conditions will usually apply.

Since the empirical investigation of the influences of five variables would necessitate a large number of experiments, we derived a predictive formula by a method which combined the empirical and the analytical approach. This method is described in Appendix C of the WADC Report listed by the author as Reference [2]. The formula thus derived yields the Storage Index:

\[ q_s = 0.45 \frac{t_0 - 95}{\text{clo}} + 0.7 - \frac{V_p}{100} (136 - t_v - p_v) \text{ Btu/ft}^2 \text{, hr} \]

in which:
- \( t_0 \) = operative temperature, deg F
- \( \text{clo} \) = mean effective clothing insulation
- \( V_p \) = ventilating air flow, ft\(^3\)/min
- \( t_v \) = temperature of vent air, deg F
- \( p_v \) = water vapor pressure, vent air, mm Hg

The results obtained by applying this formula to the author’s experiments, with \( \text{clo} = 2.15 \) and \( p_v = 5 \) mm Hg, correlate well with the results obtained using the author’s equation (4).  

The formula also illustrates the experimental experience that

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7 Variations of the water vapor pressure of the environmental air can be neglected, if this air is not to be used for ventilation.

8 Experience shows that, for moderate altitude variations, the test results do not change significantly, if the volume flow of the ventilating air is maintained.

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Another interesting rule of thumb suggested by the formula is the fact that one can (roughly) trade one degree F of the temperature of the ventilating air against one mm Hg of its water vapor pressure.

The formula is based on a metabolic rate of 20 Btu/ft\(^2\), hr which applies to the sitting resting position of a subject. If, in a practical case, the actual metabolic rate deviates from this value in either direction, the difference must be added to or subtracted from the \( q_s \) predicted by the formula, before one enters Section IX of Fig. 3 of the author’s paper.

Finally, a word of caution. The author’s predictive equations (9) and (10) for the max heart rate and the Craig Index, respectively, are, strictly speaking, only valid for test durations as used by the author in his experiments and do not apply to arbitrary exposure times.

Author’s Closure

Mr. Mauch’s discussion has emphasized some of the specific limitations of these experiments and this is appreciated. Even though it is an extrapolation of these data it is suggested that the thermal effects of altitude and clothing can be taken care of by use of Fig. 3. However, variation in the water vapor pressure of the air to the ventilated garment is best accounted for by Mr. Mauch’s equation as all of our data were taken at a constant vapor pressure of 0.20-in. mercury.

Another point of clarification concerns the time duration of the experiments. The 120 deg F and 160 deg F exposures were scheduled for two hr, the 200 deg F for one hr, and the 240 deg F for 45 min. Experiments were terminated before these times only when the subject’s heart rate reached 140 beats per min or when the rectal temperature rose to 102 deg F.