Send to Dick Dosler
Gtash

Comparison of BOTSBALL and WBGT Heat Stress Indices*

by

James H. Botsford
Howard Engineering Company
Bethlehem, PA 18017

1. Validation of index by published *scientific* studies of physiological heat stress: BOTSBALL; no. WBGT; no.

2. Number of published definitions of index: BOTSBALL; one. WBGT; five, all different.

3. Correlation with other heat stress indices: BOTSBALL; excellent. WBGT; excellent, in latest form.

4. Proposed heat exposure limits published: BOTSBALL; yes. WBGT; yes.

5. Acceptance by heat stress "experts": BOTSBALL; poor. WBGT; good.

6. Acceptance by users: BOTSBALL; good. WBGT; poor.

7. Commercial availability of basic instruments: BOTSBALL; good, in stock at 2 U. S. and 4 foreign locations, listed in Thomas Register and safety equipment directories. WBGT; no suppliers known.

8. Cost of basic instruments: BOTSBALL; $65. WBGT; $100 up.

9. Calculations necessary: BOTSBALL; no. WBGT; yes, formulas require 3 to 5 mathematical operations.

10. Cost and delivery of direct-reading instruments: BOTSBALL; $65, from stock. WBGT; $960 to $995, from stock to 8 weeks.

11. Reliability of direct-reading instruments: BOTSBALL; good. WBGT; unknown.

12. Variability in design and construction of instruments: BOTSBALL; none. WBGT; great, effects of variations on consistency of readings unknown.

13. Size of instruments: BOTSBALL; 2½ x 8½". WBGT; about 6"x12"x18" minimum.

14. Weight of instruments: BOTSBALL; 12 ounces. WBGT; several pounds.

15. Portability of instruments: BOTSBALL; good. WBGT; fair.

* Presented to Physical Agents Committee of American Conference of Governmental Industrial Hygienists on May 22, 1977.

16. Ruggedness of instruments: BOTSBALL; good. WBGT; poor.

17. Time required to obtain one reading in unchanging thermal environment: BOTSBALL; 5 minutes maximum. WBGT; 20 minutes minimum.

18. Reliability of data obtained by personnel with brief training: BOTSBALL; good. WBGT; questionable to poor.

19. Graphic recording of variation of index with time: BOTSBALL; easily accomplished. WBGT; easily accomplished with direct-reading instruments only.

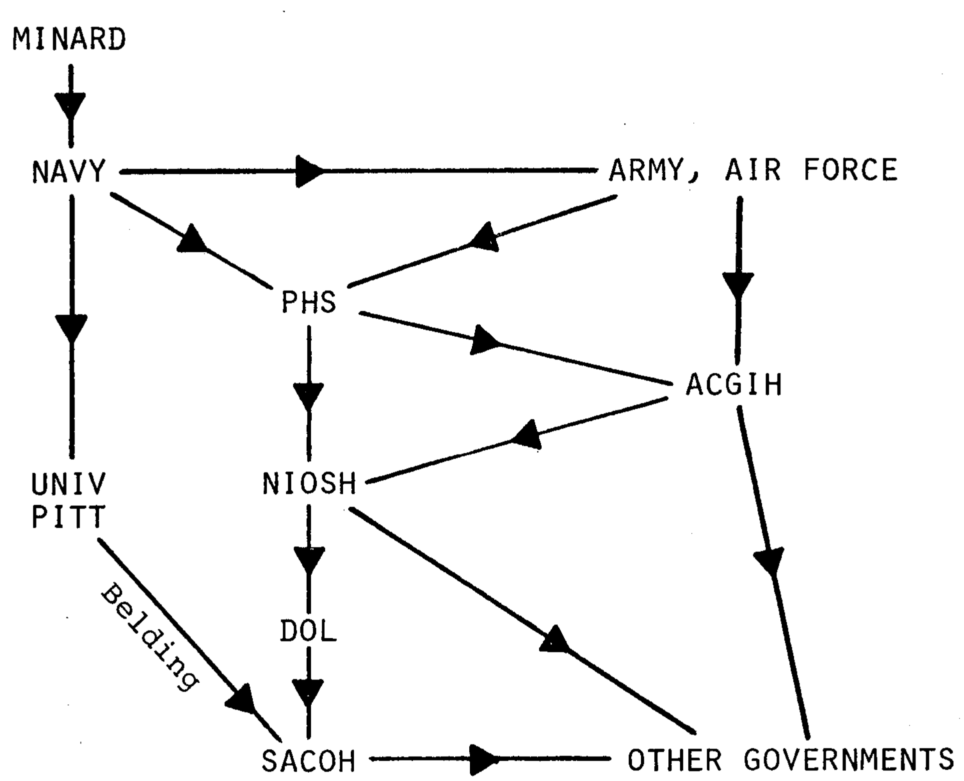
20. Possibility of constructing a wearable heat dosimeter: BOTSBALL; good. WBGT; impossible.

21. Suitability of instruments for general field use: BOTSBALL; good, usable anywhere. WBGT; poor, unusable in many places.

22. Number of instruments in use: BOTSBALL; over 2000 worldwide. WBGT; unknown but probably fewer.

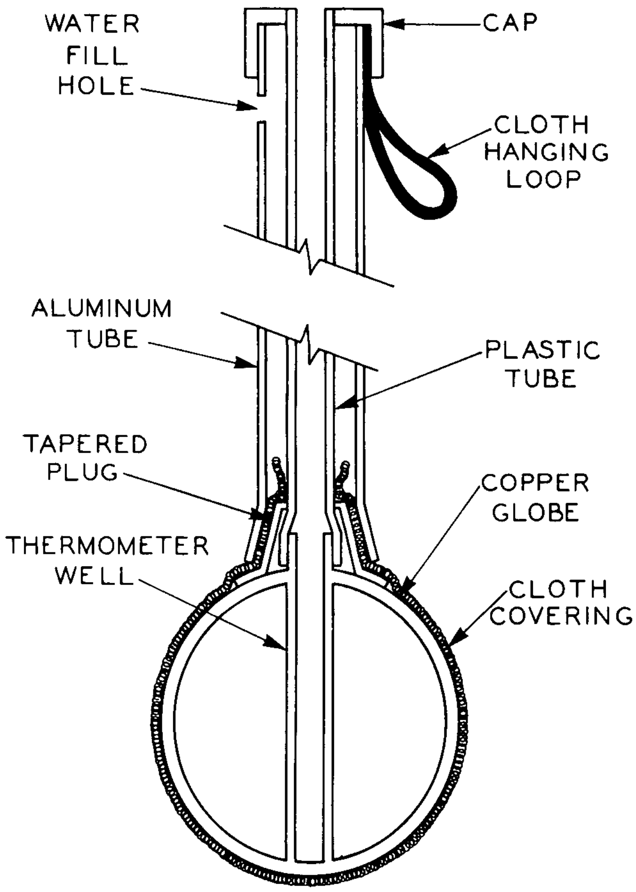
23. Possibility of achieving heat stress limitation goal: BOTSBALL; good. WBGT; poor to impossible.

WBGT FAMILY TREE



OPERATING INSTRUCTIONS AND PARTS LIST FOR THE BOTSBALL THERMOMETER

The BOTSBALL Thermometer, formerly called the Wet Globe Thermometer, is a new instrument which combines air temperature, humidity, wind and thermal radiation into a single reading that is related to human responses in a meaningful way[1]. It consists of a 2⅜ inch hollow copper sphere that is painted black and covered with a double layer of black cloth. The cloth covering is continuously moistened by water seeping from the aluminum reservoir tube attached to the globe. The stem of a dial thermometer passes through a plastic tube along the centerline of the water reservoir tube and into the globe to sense its temperature. Details of construction are shown in the sketch below.



PRINCIPLES OF OPERATION

When placed in a hot area, the globe is warmed by the surrounding air and by heat radiated from hot surfaces. It is also cooled by evaporation according to the wind and humidity. The wet globe reaches an equilibrium temperature when these heating and cooling effects come into balance. The BOTSBALL Temperature indicated by the dial thermometer provides a direct physical measure of the thermal environment.

Any change in air temperature, humidity, wind or thermal radiation that causes the BOTSBALL Temperature to rise will increase human discomfort or stress. Conversely any change in these conditions that lowers the BOTSBALL Temperature will alleviate discomfort or stress. Thus, the BOTSBALL Temperature provides an excellent index of human responses to heat.

RELATIONS TO OTHER INDICES

Several different environmental heat indices are in use and the BOTSBALL Temperature has been found to correlate very well with all of them[2]. Somewhat different relations among these indices are found in laboratory studies as compared to workplace studies; the latter are deemed more suitable for practical applications.

Two of the more commonly used heat stress indices are ET (Effective Temperature) and WBGT (Wet Bulb-Globe Temperature). The relations of these indices to BOTSBALL Temperatures according to NIOSH workplace studies[3] are expressed in the equations below.

$$\begin{aligned} ET &= 1.25B - 17.4 \quad (°F) \\ &= 1.25B - 5.2 \quad (°C) \\ WBGT &= .0118B^2 - 0.560B + 54.9 \quad (°F) \\ &= .0212B^2 + 0.192B + 9.5 \quad (°C) \end{aligned}$$

where B is the BOTSBALL Temperature.

OPERATING PROCEDURE

To use the BOTSBALL Thermometer, first fill the plastic squeeze bottle with water but not above the "fill line" shown on each side. Distilled water is recommended to avoid deposition of solids normally dissolved in tap water on the cloth covering of the globe. Put the cap on the mouth of the bottle airtight to prevent leakage. When the cap is properly sealed, squeezing the bottle will cause water to flow from the spout.

Take the globe assembly out of the plastic bag. Save the bag and wire closure for storing the thermometer after use. Use the squeeze bottle to fill the water reservoir of the globe assembly through the fill hole in the side of the reservoir tube near the top.

Make sure the cloth covering of the globe is wetted thoroughly by rubbing drops of water from the squeeze bottle into the cloth with the fingers or by dipping the globe in water. Also, make sure that the part of the cloth cover gathered inside the reservoir tube is thoroughly wetted by gently pulling the reservoir tube upward away from the globe to allow water to flow out of the reservoir through this stricture.

To measure the BOTSBALL Temperature, hang the globe assembly in the desired location with a string or wire attached to the hanging loop at the top of the water reservoir. The temperature of the wet globe will come to equilibrium with unchanging thermal surroundings within 5 minutes. In a stable thermal environment, equilibrium has been reached when no change in the reading of the dial thermometer occurs in one minute. Check occasionally to make sure the cloth is wet over the whole surface of the globe.

Water seepage from the reservoir to the globe may be adjusted to keep the globe wet under all evaporative conditions without excessive dripping. To increase water flow, pull the reservoir tube away from the globe gently with a slight twisting motion; to decrease water flow, push them together.

If the BOTSBALL Thermometer will be in continuous use for long periods, a siphon should be provided to keep the reservoir filled. Attach one end of the small plastic tube furnished with the Thermometer to the spout of the squeeze bottle and push the other end of the tube through the fill hole to the bottom of the reservoir. Suspend the thermometer and squeeze bottle at the same height. To start the siphon, squeeze the bottle until water runs out of the reservoir fill hole and then vent the pressure in the bottle by loosening the bottle cap.

The dial thermometer may be withdrawn from the wet globe assembly and replaced by the probe of a recording thermometer if a continuous record of the BOTSBALL Temperature is desired. The sensitive portion of the probe must lie entirely within the globe for accurate readings.

If the BOTSBALL Thermometer is suspended from a vibrating support, water seepage from the reservoir will be excessive. To prevent such rapid drainage of the reservoir, install a thin rubber band as a link in the suspension to prevent the vibrations from reaching the thermometer.

The error of the dial thermometer is initially less than 1°F which can be maintained indefinitely with proper care. Rough handling or dropping the thermometer can enlarge the error. The error of the dial thermometer should be checked periodically by comparison with another thermometer known to be accurate.

If the BOTSBALL Thermometer is used in magnetic fields strong enough to attract a steel tool held in the hand with noticeable force, an error of 2 or 3°F in the reading of the dial thermometer might result. For such applications, the BOTSBALL Thermometers with magnetic shielding should be used.

After using the BOTSBALL Thermometer, store it in the plastic bag it arrived in gathering the top tightly around the reservoir tube with the wire closure provided. This procedure will keep the globe wet and ready for immediate use on the next occasion.

INTERPRETATION OF READINGS

Working in hot environments can cause dehydration, muscle cramps, exhaustion and collapse. No heat exposure standards have been established to avoid these effects but several organizations have made recommendations.

The American Industrial Hygiene Association recommended maximum values of WBGT for persons not in direct sunlight[4]. These maxima were converted to BOTSBALL Temperatures using the equations above and are shown in Table I.

Table I. Maximum BOTSBALL Temperatures for persons not in direct sunlight based on the recommendations of the American Industrial Hygiene Association[4].

Exposure Time	Rest or Sedentary[(a)]		Moderate Work[(b)]		Heavy Work[(c)]	
	°F	°C	°F	°C	°F	°C
Continuous Daily Work[(d)]	83.2	28.5	80.3	26.8	75.6	24.2
Intermittent Work-Rest[(e)]						
3 Hours	86.0	30.0	82.5	28.1	78.8	26.0
2 Hours	87.3	30.7	83.9	28.8	80.3	26.8
1 Hour	90.0	32.2	86.7	30.4	83.2	28.5
30 Minutes	94.3	34.6	90.6	32.6	86.7	30.4
20 Minutes	97.2	36.2	93.7	34.3	90.0	32.2

(a) sitting, desk work
(b) standing, light or moderate work at machine or bench
(c) intermittent heavy lifting, pulling, climbing
(d) eight hours per day with 10 minutes rest per hour
(e) work periods alternated with one-hour rest periods under cooler conditions

The Physical Agents Committee of the American Conference of Governmental Industrial Hygienists has proposed limits for occupational heat exposures[5]. Their limits were expressed in terms of WBGT also and are shown after conversion to BOTSBALL Temperatures in Table II.

Table II. Maximum BOTSBALL Temperatures derived from the recommendations of the American Conference of Governmental Industrial Hygienists[5].

Work-Rest Regimen	Work Load Light		Moderate		Heavy	
	°F	°C	°F	°C	°F	°C
Continuous work	80.4	26.9	75.8	24.3	73.2	22.9
75% Work — 25% Rest	81.2	27.3	77.6	25.4	74.6	23.7
50% Work — 50% Rest	82.3	27.9	79.6	26.4	77.5	25.3
25% Work — 75% Rest	83.3	28.5	81.9	27.7	80.4	26.9

Another heat exposure limit has been proposed by the National Institute for Occupational Safety and Health[6]. They recommend that the average ET not exceed 80.5°F based on the work of Lind which they convert to a WBGT of 79°F using the relationship established by Minard. According to the equations above, the NIOSH limit would correspond to an average BOTSBALL Temperature of 78.3°F. For women, an average temperature 3°F lower is recommended.

The Standards Advisory Committee on Heat of the Occupational Safety and Health Administration has made recommendations for controlling occupational heat exposures[7]. These recommendations included upper limits expressed in terms of WBGT which have been translated into the BOTSBALL Temperatures of Table III using the equations above.

Table III. Maximum BOTSBALL Temperatures based on recommendation of the OSHA Standards Advisory Committee on Heat[7].

Metabolic rate	Air Velocity up to 300 fpm		Air Velocity 300 fpm or more	
	°F	°C	°F	°C
200 KCal/hr or less	80.3	26.8	83.2	28.5
201 to 300 KCal/hr	77.2	25.1	81.0	27.2
over 300 KCal/hr	74.8	23.8	78.8	26.0

The BOTSBALL Thermometer is also useful for gauging discomfort under torrid conditions. Most people will be uncomfortable when the BOTSBALL Temperature exceeds 70°F or at lower temperatures when they are physically active. When body activity is insufficient to cause sweating, the globe may be left dry to provide a better index of comfort. In this method of use, the reading will not be influenced by humidity which, in the absence of sweating, has little effect on discomfort.

Although the BOTSBALL Thermometer was developed to evaluate heat stress in hot work places, users are exploring other applications. Some of these are rating performance of heating and air conditioning systems, measuring and reporting weather conditions, evaluating heat conditions in the military services, studying effects of heat on plants and animals, establishing wage premiums for hot work, assessing process drying conditions, surveying evaporative cooling possibilities and monitoring heat conditions at athletic events. There is, as yet, insufficient experience with these applications to suggest proper interpretations of readings.

PARTS LIST

The BOTSBALL Thermometer is supplied in a kit containing the wet globe assembly, a special dial thermometer inserted into the wet globe assembly, a plastic squeeze bottle for filling the water reservoir, a siphon tube for providing continuous water feed and literature including operating instructions. Part numbers for these items are shown below.

No. 80 BOTSBALL Thermometer Kit, Fahrenheit Scale
No. 81 Special Dial Thermometer, Fahrenheit Scale
No. 82 BOTSBALL Wet Globe Assembly
No. 83 Plastic Squeeze Bottle
No. 84 BOTSBALL Literature Package
No. 85 BOTSBALL Thermometer Kit with Magnetic Shielding, Fahrenheit Scale
No. 86 BOTSBALL Wet Globe Assembly with Magnetic Shielding
No. 87 Plastic Siphon Tube
No. 90 BOTSBALL Thermometer Kit. Celsius Scale
No. 91 Special Dial Thermometer, Celsius Scale
No. 92 BOTSBALL Thermometer Kit with Magnetic Shielding, Celsius Scale

REFERENCES:

1. Botsford, J. H.: A Wet Globe Thermometer for Environmental Heat Measurement, Amer. Ind. Hyg. Assoc. J. 32:1 (1971).
2. Brief, R. S. and R. G. Confer: Comparison of Heat Stress Indices, Amer. Ind. Hyg. Assoc. J. 32:11 (1971).
3. D. Sundin, F. Dukes-Dobos, R. Jensen and C. Humphreys: Comparison of the ACGIH TLV for Heat Stress with Other Heat Stress Indices, paper presented at American Industrial Hygiene Conference, San Francisco (1972).
4. Heating and Cooling for Man in Industry, American Industrial Hygiene Association, Akron, Ohio (1970).
5. Threshold Limit Values for Physical Agents, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio (1972).
6. Occupational Exposure to Hot Environments, National Institute for Occupational Safety and Health, Cincinnati, Ohio (1972).
7. Recommendations for a Standard for Work in Hot Environments, OSHA Standards Advisory Committee on Heat, U.S. Department of Labor (1974).

HOWARD ENGINEERING COMPANY
3456 ALTONAH ROAD
BETHLEHEM, PA. 18017

(Revised September, 1975)

APPLICATIONS OF THE BOTSBALL THERMOMETER*

by

James H. Botsford
HOWARD ENGINEERING COMPANY
3456 Altonah Road
Bethlehem, Pennsylvania 18017

The BOTSBALL Thermometer is a simple instrument developed for evaluating the physiological stress of environmental heat. It consists of a copper sphere 6 centimeters in diameter that is painted black and covered with a double layer of black cloth. The cloth covering is continuously moistened by water seeping from the aluminum reservoir tube attached. The stem of a dial thermometer passes along the center-line of the water reservoir tube and into the copper globe to sense its temperature.

When the BOTSBALL Thermometer is placed in a hot area, the wet globe is warmed by the surrounding air and by heat radiated from hot surfaces. It is also cooled by evaporation according to the wind and humidity. Within five minutes, the BOTSBALL Thermometer reaches an equilibrium temperature which provides a direct physical measure of the thermal environment.

The BOTSBALL Thermometer is really a simple model of man. Any change in air temperature, humidity, wind or thermal radiation that causes the BOTSBALL Temperature to rise will increase human discomfort or stress. Conversely, any change in these conditions that lowers the BOTSBALL Temperature will alleviate discomfort or distress. Thus, the BOTSBALL Temperature furnishes an excellent index of human responses to heat. It actually indicates the comprehensive environmental temperature that controls man's heat exchange with his surroundings.

The instrument was originally called the Wet Globe Thermometer but this name was abandoned because of the widespread confusion of the Wet Globe Temperature it indicated with the Wet Bulb-Globe Temperature index. As readings of the two devices differed by approximately 7°F over the important range, the confusion had to be eliminated. So the nickname BOTSBALL given to the instrument by my colleagues was adopted in favor of the proper, but confusing, scientific name.

The new instrument was first described in May of 1969 at the American Industrial Hygiene Association meeting in Denver, Colorado. That paper reported an excellent correlation between the readings of the BOTSBALL Thermometer and all other heat stress indices. As all reliable measures of the same quantity must necessarily correlate highly with each other, the BOTSBALL was thusly shown to be a good measure of environmental heat stress.

Because of the great interest shown in the new thermometer, it was made available commercially in the summer of 1969. Use of the BOTSBALL Thermometer grew from that time until, at the end of 1975, there were over 1400 BOTSBALLS used in government, industry and educational organizations throughout the United States and 21 foreign countries. Interest continues to grow as over 300 BOTSBALLS have been ordered so far in 1976.

It seemed likely to me that there were many novel applications of the BOTSBALL Thermometer since it had been supplied not only to industrial hygiene and safety personnel, but to users in the diverse fields of meteorology, agronomy, animal husbandry, industrial engineering, athletics, the armed forces and possibly others I do not know of. To gain information on these applications, over 300 BOTSBALL owners were sent a request for information. Some of the responses received will be described here.

*Presented at the American Industrial Hygiene Association meeting in Atlanta, Georgia on May 20, 1976.

The most commonly reported application of the BOTSBALL Thermometer was for evaluation of environmental heat in the workplace as might be expected. But these were not all routine. Richard C. Ramberg of the U. S. Department of Agriculture studied the BOTSBALL as a monitor of heat stress in forest firefighting. The BOTSBALL Temperature was one of 15 factors singled out for study to determine how each affected the rate of progress in quelling forest fires by constructing what he called a "fireline." These factors, which included the pulse rates of crewmen, were checked every half-hour during 48 fires over a two-year period. BOTSBALL readings were averaged by the usual time-weighting method. A multiple regression analysis showed that the BOTSBALL Temperature accounted for a larger percentage of variation in fire fighting efficiency than any other factor. BOTSBALL Temperatures above 72°F were almost always associated with high firefighter pulse rates. Mr. Ramberg recommended that the rest breaks be extended as necessary to allow pulse rates to drop to 100 beats per minute or less.

Another BOTSBALL user reported that a similar study was conducted in a foundry where it was the practice to furnish an extra metal-pouring crew for relief of heat stress during the hottest weather. The main objective of that study was to develop a method whereby the foreman could make a scientific determination of when the extra crew was needed. Heat stress conditions including pulse rates and oral temperatures were monitored inside the foundry. Simultaneous BOTSBALL readings were taken outside. From an analysis of the data accumulated, it was determined that, when the BOTSBALL Temperature measured in the sunshine on the foundry roof reached 65°F or higher, the extra crew should be brought in to relieve the others periodically. This is an interesting example of how the BOTSBALL was calibrated to a particular situation in order to provide management with a simple aid to decision-making.

Many BOTSBALL users had correlated its readings with other heat measures, especially WBGT. All found excellent correlations. Vince Ciriello and Stover Snook of Liberty Mutual Insurance Company showed that these excellent correlations could be made even better if consideration was limited to a particular type of environment. In classifying thermal environments, the factors considered were either low or high thermal radiation, low or high wind velocity and low, moderate or high humidity. When these qualitative evaluations of the surroundings were made along with the BOTSBALL reading, the standard error of estimating WBGT could be reduced to 1/2°F or less corresponding to correlation coefficients of 0.996 to 0.999.

In the regulatory area, the BOTSBALL Thermometer has found applications also. The State of Wisconsin incorporated in its tunneling and shafting code a set of occupational heat exposure limits expressed in terms of readings obtained with the BOTSBALL Thermometer. The limits were those recommended by Brief and Confer.

In the Canadian Province of British Columbia, occupational heat exposure regulations are in the process of development now. The limits proposed are those recommended for air velocities under 300 feet per minute by the OSHA Standards Advisory Committee on Heat. They are expressed in terms of WBGT and the BOTSBALL Temperature also.

Belgium has recently established occupational heat exposure standards which state that "The maximum temperature of the working area must be measured with a wet globe thermometer or any other means to measure the effective temperature."

While the BOTSBALL Thermometer is finding regulatory uses in other countries, it has been shunned at the Federal level here in the United States. Why? The reason is that NIOSH has arbitrarily determined that WBGT will be the unit of heat stress measurement utilized in this country to the exclusion of all others. This decision was not a scientific one as NIOSH would like us to believe. The decision was really political. Let me tell you what happened.

After extensive literature review, NIOSH determined that the studies of Lind provided the best basis for establishing heat standards. In his research, Dr. Lind measured the Effective Temperature of the experimental environment. Based on his work, NIOSH selected an Effective Temperature limit of 80½°F.

NIOSH then declared Effective Temperature to be impractical of measurement and substituted WBGT. This was an arbitrary judgment because many professionals were then determining Effective Temperature and are continuing to do so. The selection of WBGT was purely a political move to avoid upsetting the established governmental use of WBGT in the armed forces.

In selecting WBGT for NIOSH, Dr. Francis Dukes-Dobos was also showing professional courtesy to his fellow physician David Minard who had established use of WBGT in the armed forces. And in converting Effective Temperature to WBGT, Dr. Dukes-Dobos naturally selected the relationship developed by Dr. Minard. Using Minard's 25-point curve determined under outdoor military training conditions for establishing heat standards in indoor industry could hardly be called scientific with a straight face.

As one of the consultants selected to review the NIOSH criterion document on heat, I pointed out to Charles H. Powell, then Assistant Director of Research and Standards Development in NIOSH, that the BOTSBALL Temperature correlated as well with Effective Temperature as did WBGT according to the data of Brief and Confer. I suggested that NIOSH duplicate the work of Brief and Confer to determine whether the clumsy and unpopular WBGT was a sufficiently more accurate predictor of Effective Temperature to justify its selection over the much more practical BOTSBALL Thermometer.

Actually NIOSH had already done this analysis as it was reported on by Dr. Dukes-Dobos and his colleagues at the meeting of the American Industrial Hygiene Association in San Francisco in mid-1972. They reportedly found, as others had, that the relationship of BOTSBALL Temperature to WBGT was excellent. This work was never published. In addition NIOSH suppressed their finding of the good correlation of the BOTSBALL reading with Effective Temperature. I was able to obtain a poor copy of their data showing this relationship which was marked "confidential communication" clearly indicating the intent to suppress the facts. Whenever Dr. Dukes-Dobos is asked about the correlations of BOTSBALL Temperature with other heat stress indices, he always fails to recall these curves from his own studies and answers that he knows of no correlation.

Having heard that NIOSH maintained an Equipment Testing and Certification Laboratory in Morgantown, West Virginia, I wrote the Director, Robert H. Schutz, asking whether the BOTSBALL Thermometer could be certified. He replied "We do not have a certification program encompassing this type of instrumentation nor is one planned in the foreseeable future. Neither has such a program existed in the past; consequently we have not certified <u>any</u> heat measuring devices." Not even WBGT?

A reply to this inquiry was also received from Elliott S. Harris, Director of NIOSH's Division of Laboratories and Criteria Development in Cincinnati. Dr. Harris said of WBGT that "We do not feel at this time that there is sufficient evidence to prove any other index more accurate in predicting physiological response to heat exposure". In making this officious pronouncement, Dr. Harris stupidly excluded Effective Temperature which was the fundamental scale on which the proposed NIOSH limits were based.

Then Dr. Harris went on to criticize the NIOSH data relating BOTSBALL readings to WBGT by picking a point where data scatter indicated WBGT readings differing by 15°F corresponded to the same BOTSBALL reading. Dr. Harris concluded sanctimoniously that "Such an error could not be tolerated either from the workers safety or compliance standpoint." Dr. Harris was, however, willing to overlook the fact that Dr. Minard's 25-point data, which NIOSH chose to translate Effective Temperature into WBGT, showed just as much scatter as he later found it expedient to declare intolerable!

I wrote a letter complaining about these shenanigans to Edward J. Baier, Deputy Director of NIOSH. Incredibly, he responded saying "I have checked into your allegation of arbitrary conduct in the development of the NIOSH heat stress criteria document. I have found nothing to indicate improper or arbitrary conduct by NIOSH personnel." He went on to say "While not 'adopted' NIOSH has recommended WBGT" and I'd like someone to explain that double-talk to me. He concluded that "Providing heat stress limits in terms of Effective Temperature as you suggest would be inconsistent with the results of the criteria document review process and would serve no purpose other than to permit a variety of measurement techniques (notably the Botsball) to be used." These responses show that Mr. Baier has decided to overlook the NIOSH bungling I have described and force the impractical result upon us.

Here we are confronted with a scientific decision made by bureaucrats. There is no word to describe it so I've combined one — scientcratic. There is also no word to describe bureaucracy's response to criticism of such antics. So I've taken the sylables left over from the first combination and formed another word — bureauific.

Now I do not accept Ed Baier's decision to "cover-up" NIOSH deficiencies and "stonewall it" in defense of criticism. I do not believe others will accept it either. So I'm exposing his conduct to public questioning by means of this paper and in other ways. He apparently learned little from Watergate so I'll do my best to teach him something about Waterball!

The industrial hygiene profession does not have to sit still while NIOSH stuffs WBGT down its throat. Industrial hygienists who are opposed should protest. Those who have correlated heat measures with WBGT have really made the wrong correlation. WBGT is a secondary measure; Effective Temperature is the primary unit. These data should be reworked to show the relations with Effective Temperature and be re-published in that form. In this way, the NIOSH blunder of selecting the impractical WBGT index can be brought to light and rectified.