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Environmental Physiology and Shelter Engineering

With Special Reference to Domestic Animals

XLIV. STABLE HEAT AND MOISTURE DISSIPATION WITH BEEF CALVES AT TEMPERATURES OF 50° AND 80° F

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Missouri Agricultural Experiment Station and the
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SUMMARY

Ventilation and air conditioning loads which would be attributed to penned beef calves and their bedded area were determined with stable temperatures of 50° and 80° F. Both stable moisture (latent heat) and stable heat (latent plus sensible) loads were determined. They were found to increase with advancing age. The rate of increase was greatest during the first three months of age.

Most analyses were made on a unit weight base to compensate for weight variation among the test animals. Both stable heat and stable moisture then became a decreasing function with respect to advancing calf age.

Stable heat was practically the same at both 50° and 80° F. However, stable moisture at 50° F was only 50 to 60 percent of that at 80° F. The ratio of latent to total heat ranged from 35 to 39 percent at 50° F and 67 to 71 percent at 80° F.

Accumulated litter such as experienced with weekly cleaning was found to increase stable heat and moisture. At 80° F the stable heat and stable moisture were 20 percent greater on the sixth day after cleaning than they were on the first day after cleaning. An air temperature of 50° F reduced this effect by about one-half.

Estimates were made of stable heat and the stable moisture dissipation for each of the three breeds tested (Shorthorn, Brahman, and Santa Gertrudis). On the basis of unit weight, the highest values were obtained prior to 20 weeks of age. Thereafter, the values dropped sharply for several weeks and after 45 weeks began leveling off to a fixed value at 60 weeks which was much the same as with mature animals.

The 80° F air temperatures were found to increase bedding requirements and litter production by about 50 percent above the values obtained at 50° F.

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INTRODUCTION

The design of adequate ventilation or air-conditioning systems for animal stables requires knowledge of the heat and moisture which must be removed by them. Primary considerations in such design calculations are: (1) the heat and moisture dissipated by animals and their bedded area and watering devices and (2) the heat and moisture lost or gained by way of walls, ceiling, and floors. The primary purpose of this report is to present design data concerning the first of these two considerations as they apply to calf housing. These data were obtained with beef calves, under the controlled environmental conditions of the Psychro-energetic Laboratory at the University of Missouri as part of a study of the effect of environment upon calf growth.

DEFINITIONS

Terms which might be confused in this report are defined as follows.

Stable heat refers to the heat dissipated by the animals and their bedded area. It does not include heat from lights, personnel and equipment.

Stable moisture refers only to the moisture dissipated by the animals, their bedded area, and their watering devices.

Animal heat production refers to the heat released through feed utilization and other processes within the animal's body. It was evaluated through the measurement of oxygen consumption with a metabolism apparatus.[1] Not included in such an evaluation is any heat released through anaerobic bacterial action within the rumen. The transfer of the heat produced by the cow to the environment is a major problem in hot-weather housing.

Animal vaporization refers to the total water that is vaporized by the animal. It is a very important means by which an animal dissipates its heat production. At high temperature it is frequently the only avenue of heat transfer available to cattle. It was measured with a hygrometric tent. This was essentially a plastic tent through which a measured volume of air was moved. The difference between the intake and exhaust air-moisture content was measured and used with the air volume to determine animal vaporization. A companion bulletin[2] provides a more complete discussion of this device.

METHODS AND MATERIALS

Experimental Design

The testing program was designed to determine the effects of temperature upon the growth of Shorthorn, Brahman, and Santa Gertrudis calves. These calves were divided into two groups with three calves of each breed within a group. One group was exposed to a constant air temperature of 50° F and the other was exposed to a constant air temperature of 80° F. Duration of the exposure was 13½ months. A temperature of 50° F was considered representative of the winter temperatures within many of the cattle stables in the Northern area of the United States. A temperature of 80° F was considered approximately maximum for near-normal rectal temperatures and growth. Actually, results of the studies have shown that a constant temperature of 80° F was too high for good growth and normal rectal temperatures among the Shorthorn calves.[3] The average relative humidity was 62 percent at 50° F and 54 percent at 80° F. More detailed temperature and humidity information is given in the discussion of test-room conditions.

The heat and moisture picked up by the ventilation system as well as the heat transferred through walls, ceiling, and floor were determined from continuous records of temperature, dew point, and duct air velocity.

Several other measurements were made periodically by various investigators throughout the tests. Most of these involved the determination of physiological reactions such as: weight gains; growth; feed and water consumption; metabolism; animal vaporization rates; skin and rectal temperatures; pulse and respiration rates; blood volume; and thyroid activity. A few spot measurements were made of the patterns of temperature, wind velocity, and light intensity within the test rooms. All physiological and oher measurements were scheduled for minimum disturbance to the calves and to the ventilation exchange data.

Management Practices

Management practices were like those found on many farms where calves are kept in pens within barns. For the first three months the calf pens were cleaned weekly with fresh bedding added daily. Wheat straw and wood shavings were used in a combination which consisted of slightly more than 50 percent straw. Pulverized limestone was dusted on the floor after each thorough weekly cleaning. After the first three months, wet litter was removed once daily. The once-a-week thorough cleaning practice was continued to the end of the tests. Water was available at all times to each pen.

Milk was fed to the calves for the first 4 weeks of test. The calves were fed all the alfalfa hay and grain that they would eat for the first 24 weeks of test. Thereafter the grain ration was reduced to 6 pounds per calf per day with the calves receiving half in the morning and half in the afternoon. The grain ration was a standard mix for calves and was fortified with a Vitamin D supplement.

For purposes of special basal metabolism measurements the calves were fasted for three 32-hour periods. These fasting periods fell near the end of the experiment (during the 11th, 12th, and 13th, months of test).

The Calves

All calves used in these tests were loaned to the laboratory from ranches in Texas and Oklahoma. Their ages at the beginning of the experiment ranged from one to three months. The rates of weight gains were excellent for all except the 80° F Shorthorn calves. (See Table 1).

TABLE 1. AVERAGE WEIGHT (LB./CALF) OF EACH PEN OF CALVES

	Test Room I (50°F)			Test Room II (80°F)		
Date	Pen 1 Shorthorn	Pen 2 Santa Gertrudis	Pen 3 Brahman	Pen 1 Shorthorn*	Pen 2 Santa Gertrudis	Pen 3 Brahman
1954						
Nov. 15	128	138	134	111	138	140
Nov. 30	151	156	154	125	153	158
Dec.	202	213	203	162	204	211
1955						
Jan.	281	286	259	194	277	281
Feb.	351	357	321	232	347	350
Mar.	415	429	387	267	412	416
Apr.	473	493	442	316	473	488
May	527	563	490	362	522	531
June	578	622	540	397	574	568
July	617	667	571	432	613	609
Aug.	654	711	601	465	647	642
Sept.	697	769	643	503	706	673
Oct.	736	810	673	545	740	705
Nov.	771	855	705	573	780	742
Dec.	810	898	734	623	815	772

* Does not include a fourth Shorthorn calf which was in this pen from Nov. 30, 1954, to Mar. 2, 1955.

Calf birth dates ranged from Aug. 7, 1954, to Oct. 3, 1954.
In Test Room I they were approximately as follows: Shorthorn calves - Aug. 7, Aug. 15, and Sept. 28; Brahman - Sept. 18, Sept. 20, and Oct. 3; Santa Gertrudis - Sept. 22, Oct. 1, and Oct. 2.
In Test Room II they were: Shorthorn - Aug. 7, Aug. 28, and Sept. 30; Brahman - Sept. 20, 21, and 29; Santa Gertrudis - Sept. 19, Sept. 22, and Oct. 1.

The 80° F Shorthorn calves were apparently under stress throughout the experiment as their rectal temperatures were generally about 2° F above normal. The hair coats of the 80° F Shorthorn calves were clipped about the third, fifth, and seventh months of test to alleviate heat stress. This temporarily reduced rectal temperatures about 1° F.[1]

A major setback in the growth and feed consumption of the calves occurred when they were dehorned (July 28, 1955—about the ninth month of test).

The Shorthorn and Santa Gertrudis were vaccinated for brucellosis in March of 1955. The 80° F Brahman calves were moved from the laboratory for about 2 hours in June to have their hoofs trimmed.

Facilities

Only minor facility changes were made in the Psychroenergetic Laboratory from those previously reported.[4,5] The cow stanchions and stall dividers were

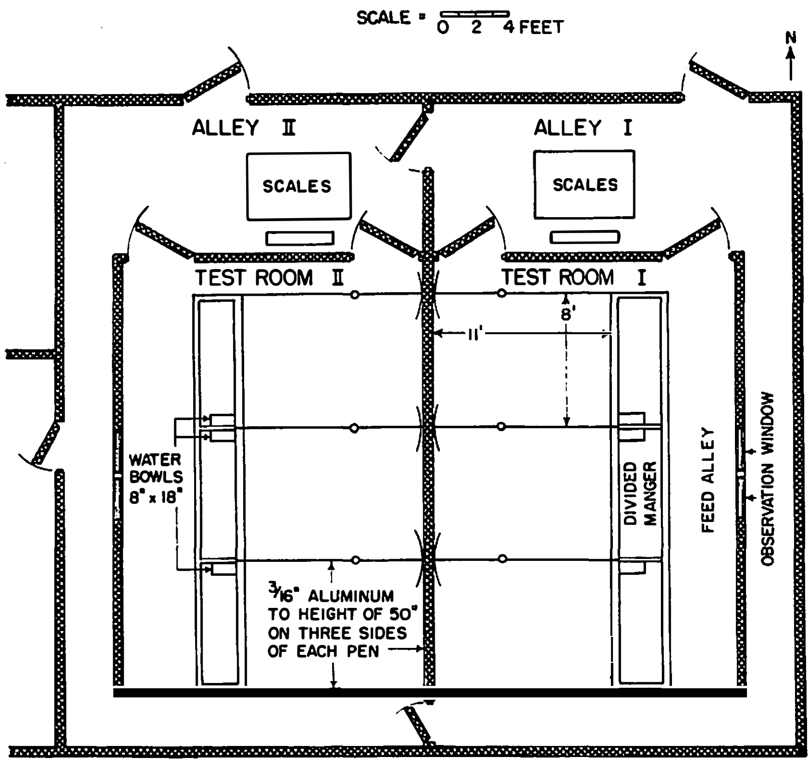

Fig. 1—Floor plan of testing areas within the Psychroenergetic Laboratory. Test Room I was used for the 50° F tests and Test Room II was used for the 80° F tests. The calves were weighed in the alleys. The alleys were maintained at the same temperature as their respective test rooms.

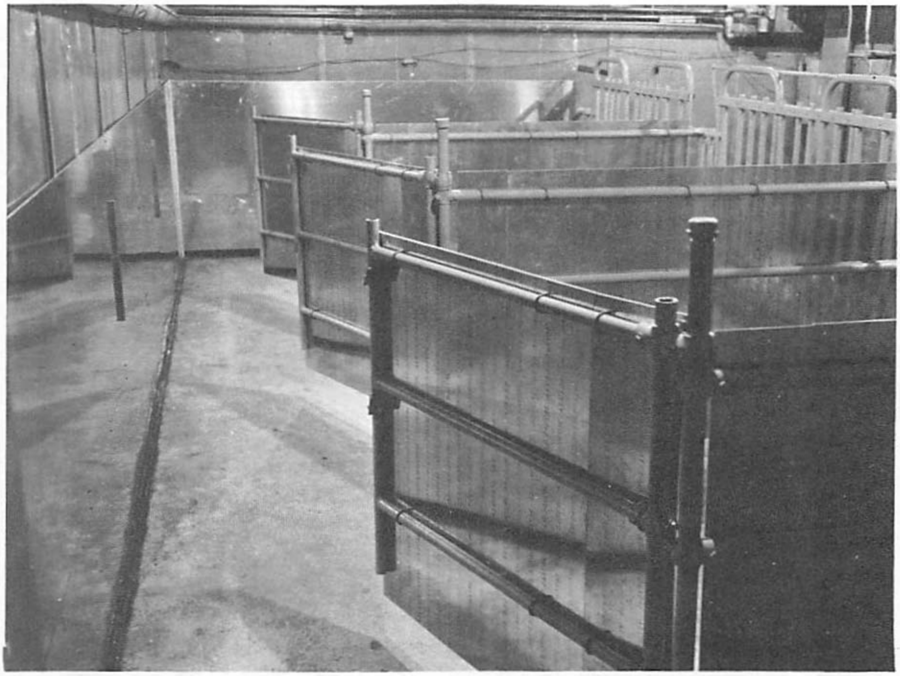

Fig. 2—Photograph of the calf pens within Test Room II. Aluminum, 3/16 inches thick, was placed along the three sides of the pens primarily for the protection of the walls and to isolate one pen from the other more completely. Ventilation air was discharged, horizontally, at near ceiling height from above the feed alley toward the rear wall (from right to left on the picture).

replaced with calf stanchions and partitions. Three pens, each 8 x 11 feet, were constructed in each of the two test rooms as shown in Figure 1. Each pen had three calf stanchions made of one-inch steel pipe. Around the other three sides were placed 3/16-inch-thick aluminum panels which extended from 2 inches above the floor to a height of 50 inches above the floor. Raised wooden mangers were provided for the first three months of test. Thereafter the concrete and steel mangers of previous studies were used.

Water was available at all times from water tanks in which the water level was maintained by a float-operated water valve. The amount of water drunk in each pen and the time it was drunk were continuously recorded. The temperature of the drinking water ranged from about 80° F down to 65° F in the 80° F test room and from about 50° F up to about 60° F in the 50° F test room.

The test-room temperatures and humidities were maintained through refrigerating and/or heating the air used in ventilation. About 950 cubic feet of air per minute was circulated through each test room. About 20 percent of this was fresh air which was preconditioned to test-room temperatures in the outer work alleys. The remaining 80 percent was recirculated air from the test rooms.

Instruments

In general the instruments and controlling devices were the same as used in previous Psychroenergetic Laboratory experiments.[4,5] The psychrometric properties of both the intake and exhaust air were recorded continuously. Ventilation air temperatures were measured with resistance-type instruments. The moisture content of the air was measured with a lithium-chloride dew-point measuring apparatus, a Foxboro Company "Dewcel." Frequent calibration checks of these instruments were made with a sling psychrometer.

Ventilation-duct air velocities were recorded by a recording manometer actuated by a combined-reverse pitot tube in the intake duct. These measurements were checked and average duct velocity traverses were made with a carefully calibrated deflecting-vane-type anemometer, having a probe similar to that of the combined-reverse pitot tube. Air velocities within the test room were measured with a portable hot wire anemometer oriented to record maximum velocity. Light intensities were measured with a General Electric photocell-type light meter with the measuring surface of the light cell horizontal.

Structural heat transfer and storage were estimated from temperatures as detected by 10-junction thermopiles and as recorded by a 16-point recording potentiometer. The pattern of air temperatures among the calves was measured with copper-constantan thermocouples and an automatic-balancing potentiometer.

Test Room Conditions

Exhaust air temperatures and humidities provided the data of test-room conditions (Table 2). During the 13½ months of the 50° F test, the average temperature for each day exceeded 51° F on 21 days and was below 49° F on only 15 days (the highest daily average temperature was 54.6° F and the lowest was 48.0° F). Within the 13½ months of the 80° F test, the average temperatures for each day exceeded 81° F on 39 days and fell below 79° F on 11 days (the highest daily average temperature was 82.0° F and the lowest was 78.6° F). Average dew-point temperatures for each day ranged from 33.3 to 42.0° F in the 50° F room and from 56.7 to 68.5° F in the 80° F room.

The temperature variation within a day was generally less than 2° F from the average temperature for that day. At no time was this deviation greater than 5° F. The humidity control was not as precise as the temperature control and 5° F variations in dew point were observed within several days throughout the tests.

Air-temperature measurements were made at nine equally-spaced positions and at levels of 15, 30, and 48 inches above the floor within each pen. These data show good agreement between exhaust air and pen temperatures. All points were usually within 2° F of the exhaust temperature at any given time. Exceptions to this uniformity of temperatures occurred when measuring temperatures between stanchioned calves. Here the temperatures of the thermocouples were often 2° F higher than might otherwise be measured.

The air temperature within each pen was within 1° F of the temperatures for the other pens in the same test room. Air velocities and light intensities were also found to be uniform among pens. Within each pen, air velocities ranged from 20 to 50 feet per minute with an average value of about 30 feet per minute. Light was provided by six 200-watt incandescent lamps which were automatically switched on at 6 a.m. and off at 6 p.m. A 40-watt light bulb above the middle pen of each room was on at all times. Light intensities with all lights on ranged from 6 to 12-foot candles at positions located 15 inches above the floor within the pens.

A major problem arose in the evaluation of the environment. During the time when litter was removed weekly, the litter temperature would rise as much as 30° F above room temperatures. The possible effect of this heat on the reaction of the calves was recognized and was the principal reason for changing to daily cleaning practices. Actually, the greatest effect would occur when the animals were lying down. Bedded area surface temperatures (dermal radiometer measurements) ranged from 1° F below room temperatures (with the bedding less than 1 inch deep and wet) to 8° F above room temperatures (with the bedding 4 to 6 inches deep and dry). With daily cleaning, average bedded area surface temperatures were about the same as room air temperatures. Feces, urine or animals lying down caused a localized surface temperature increase of a few degrees. Such localized heating was counteracted by 1 to 2° F lower surface temperatures caused by the evaporation of water from wet spots in the bedded area.

The possibility of the aluminum sides of the pens altering the calves environment was investigated briefly through dermal radiometer surface temperature and 8-inch globe thermometer measurements. With the radiometer held two feet from and directed toward the aluminum, values 2 and 3° F above room air temperatures were obtained. For example, one set of data showed an 82.5° F average surface temperature reading for all sides when the air temperature was 80.8° F. The radiometer showed animal skin temperatures to be 95.0°F at the time. Evidently, very little of the animal's radiantly dissipated heat was reflected back to the animal.

Globe thermometer readings were difficult to evaluate because of low air velocities. The data indicate that the mean radiant temperatures behind stanchioned calves were about 3° F above exhaust air temperatures. Most of the radiant heat was assumed to come directly from the calves as the globe was only about 3 feet from the stanchioned calves.

Computations

The method of computing the heat and moisture dissipation was much the same as reported in previous ventilation bulletins of this series.[4, 5] The enthalpy Btu per pound of dry air) and the humidity ratio (pounds water per pound dry air) of test room intake and exhaust air were determined from psychrometric charts[6] by using the daily average air and dew point temperatures as reference points. The difference in the enthalpy as well as in the humidity ratio between the intake and exhaust air was multiplied by the volume of intake air. Intake air represented the entire air exchange as the test rooms were slightly pressurized.

Volume (Q) of intake air was determined from the following formula:

$$Q \text{ pounds of dry air per hour} = C \left(\frac{D}{(1 + W)v} \right)^{0.5}$$

where D = the differential pressure across an industrial type combined-reverse pitot tube as recorded by a slack-diaphragm type recording draft gage,

W = the humidity ratio of intake air,

v = the specific volume (cubic feet per pound of dry air), and

C = a constant.

The constant, C, represents: (1) a constant for the pitot tube and draft gage; (2) an altitude correction factor; (3) the cross-sectional area of the duct; (4) a correction factor for the errors in the draft gage (when present); (5) and a factor of correlation between the center velocity (at the pitot tube) and the average cross-sectional velocity. Variable factors within this constant were checked about once every two months and necessary corrections were made.

The heat and moisture values which were obtained by this method were further adjusted for heat gains and losses from sources other than those directly related to the animal. The heat added by personnel was calculated by using a coefficient of 720 Btu per man per hour.[7] At 50° F the moisture added by each person was estimated at 0.14 pounds of water per hour. At 80° F a rate of 0.51 pounds of water per hour was used. Adjustments for lights and equipment were made according to their power consumption or change in specific heat.

The heat transfer (Btu/hr.) through walls, ceiling, and floor was added (or subtracted if heat was gained) by multiplying the daily average temperature gradient through the walls and ceiling by appropriate coefficients.

Vapor losses or gains through test-room surfaces were considered relatively small. No adjustments were made for them in the stable moisture calculations.

RESULTS

Stable Heat and Moisture Data

Results of the 50° and 80° F stable heat and stable moisture computations are shown in Table 2. In general, both stable heat and stable moisture increased very rapidly from day to day during the first three months of test. For the remaining ten and one-half months, the day-by-day increases were much less. These data were confounded by changing calf weights, rates of daily weight gain, age and a change from a weekly to a daily cleaning practice. This necessitated treating weekly and daily cleaning test periods separately and, in some instances, adjusting stable heat and moisture to a 1000-pound body-weight base.

Figure 3 shows that an adjustment to a 1000-pound body weight base caused stable heat and moisture to become a decreasing function with calf age. The plotted points represent weekly averages of daily calculations. The irregularity of the data until the calves were over 24 weeks of age (particularly at 80° F) reflects the effect of an irregular temperature build-up in the week's accumulation of litter. The sharp change between 45 and 47 weeks of age coincided with the dehorning of the calves but was regarded as a normal physiological reaction as individual metabolic heat production measurements showed this break to occur before dehorning among some animals.

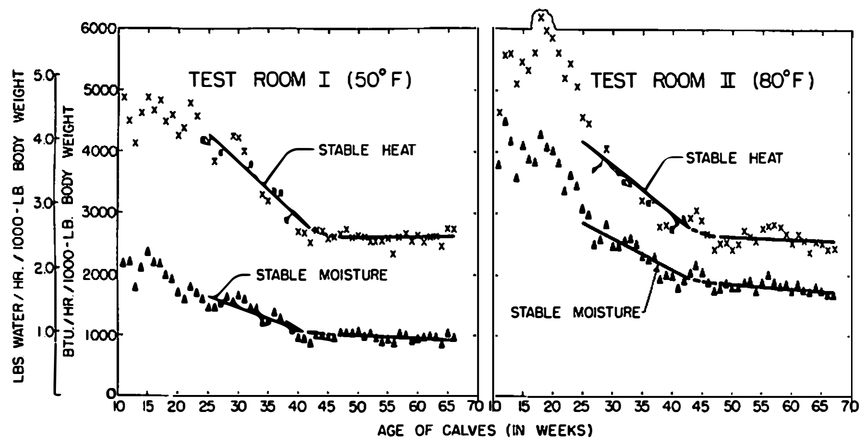

Fig. 3—The stable heat and stable moisture dissipated within 50° and 80° F test rooms using weekly averages of daily ventilation exchange calculations. Each test room housed nine calves, three each of Shorthorn, Brahman, and Santa Gertrudis. Stable moisture may be read on the heat or water scale. A value of 1044 Btu/lb. of water was used to determine the latent heat represented by the stable moisture. Straight line segments of the curves were fitted by a method of least squares.

Figure 3 shows interesting relationships of stable heat and moisture to temperature. The heat dissipation was roughly the same at both 50° and 80° F, particularly if only data taken during the daily cleaning period are considered. However, the stable moisture at 50° F was only between 50 and 60 percent of that at 80° F.

A double scale is provided with Figure 3 so that stable moisture can be read in terms of either latent heat or pounds of water. The relationship of latent to total heat ranged from 35 to 39 percent at 50° F and 67 to 71 percent at 80° F.

Stable Heat and Moisture with Weekly Cleaning

As previously mentioned a temperature "build-up" was noted in the bedded area on successive days after cleaning. These increased bedded-area temperatures were associated with increased stable heat and moisture. Figure 4 shows the effect of accumulated litter, exclusive of the effect of advancing age, on stable heat and moisture during successive days after cleaning.

The effect of advancing age was isolated by determining linear regression equations (of the form $y = a + bt$) for each day of the week. Time (t) in days since the start of tests was used as the independent variable. The plotted points of Figure 4 represent results obtained with $t = 45$ days (about midway through the weekly cleaning tests). These results were considered representative of the entire 90-day testing period. Deviations from these results at other values of "t" were attributed to the scatter among the data and were not significant. Table 3 shows the various values for the regression equation coefficients, "a" and "b", that were used in this analysis.

High air temperatures apparently magnified the effect of a weekly accumulation of litter on stable heat and moisture. At 80° F both stable heat and stable

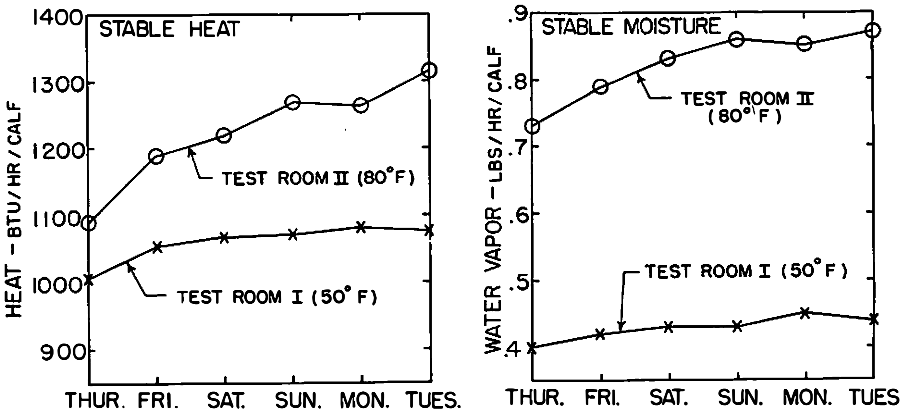

Fig. 4—Stable heat and stable moisture on successive days after weekly cleaning. Thursday was the first day after cleaning. These data were from tests covering the 10 to 25-week period shown in Figure 3 and were adjusted to remove the effect of advancing age.

moisture increased about 20 percent within the week, whereas, at 50° F, stable heat increased only 7 percent and stable moisture increased about 11 percent. These data show the need for daily cleaning of pens in stables where stable heat and moisture are excessive.

Moisture Dissipation from the Bedded Area with Daily Cleaning

The sources of stable moisture were identified as animal vaporization and vaporization from their bedded area. The vaporization of water from the drinking cups was measured and found insignificant. Animal vaporization rates were obtained from companion studies[2] and compared with stable moisture in Figure 5. The ratio of animal vaporization to stable moisture was about 0.53 at 50° F and 0.72 at 80° F. There was only a slight change (a decrease of 0.05) in these ratios as the animals grew from 25 to 67 weeks of age.

The shaded areas between the animal vaporization curves and stable moisture curves are attributed to moisture dissipation from the bedded area. The similarity in sizes of the shaded areas of Figure 5 at both 50° and 80° F indicate that most of the increased stable moisture dissipation at 80° F came from animal vaporization rather than from the bedded area. When the calves were 25 weeks of age the moisture dissipation from the bedded area was 0.75 lb./hr./1000 lb. body weight at 50° F and 0.83 lb./hr./1000 lb. body weight at 80° F. When they were 65 weeks of age the respective values at these two temperatures had decreased to 0.36 and 0.41 lb./hr./1000 lb. body weight. Evidently a change in temperature from 50° to 80° F is practically insignificant relative to its effect on vaporization from the bedded area.

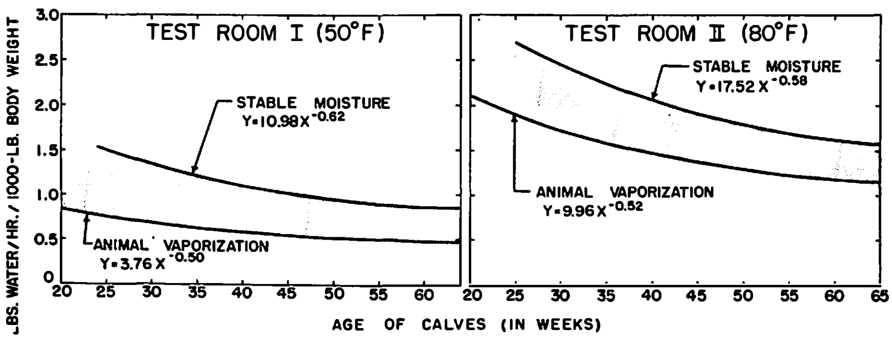

Fig. 5—Animal vaporization rates relative to total stable moisture dissipation rates (with daily cleaning). The shaded area between the two curves represents moisture dissipated from the bedded area. Animal vaporization curves were developed from pooled data of Shorthorn, Brahman, and Santa Gertrudis calves. The stable moisture curves represent the results of fitting a hyperbolic curve to the data of Figure 3. Extrapolations, particularly toward the left of the ages shown, should not be made.

Stable Heat Relative to Animal Heat Production

A comparison of monthly animal heat production rates[1] with monthly average stable heat dissipation rates during the daily cleaning period showed that animal heat production accounted for 92 to 97 percent of the stable heat. For practical purposes the animal heat production of a given breed could be increased by 5 percent in order to develop stable heat prediction curves for that breed.

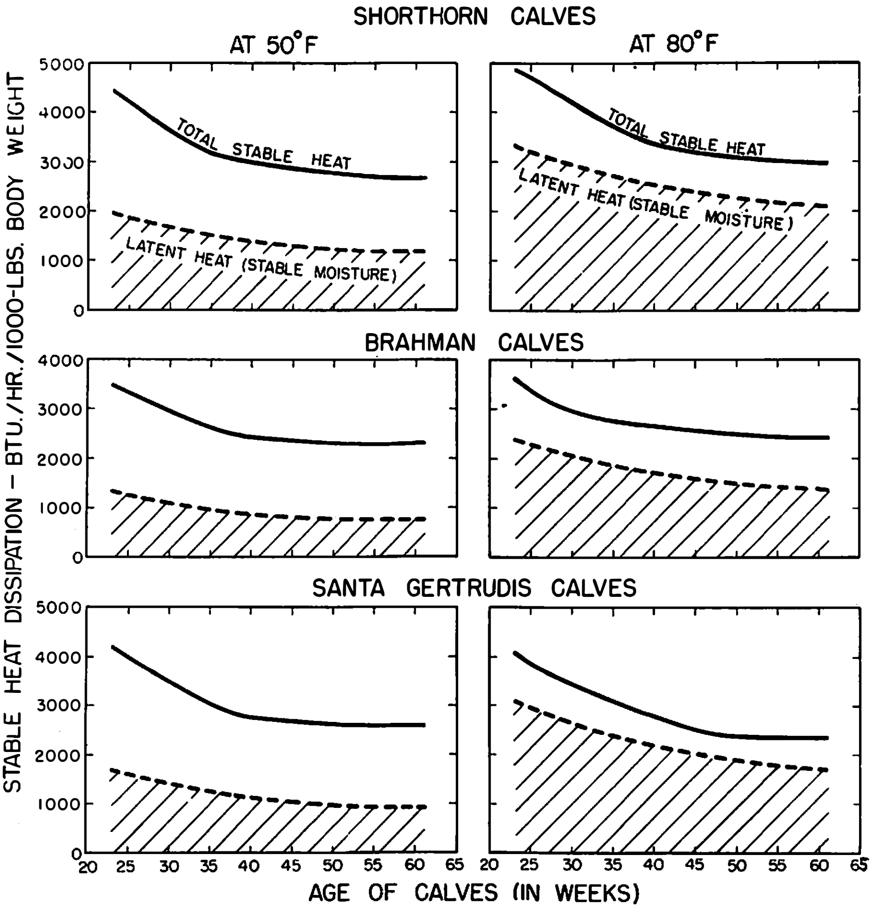

Fig. 6—Predicted rates of stable heat and stable moisture dissipation with daily cleaning for each of the three breeds of calves which were tested, Shorthorn, Brahman, and Santa Gertrudis. These curves would apply to calves which were on a ration that produced excellent weight gains. Extrapolations to the left of these curves should not be made. The latent heat curves represent the sum of the vaporization from the animals and from the bedded area. The total stable heat curves represent the sum of latent plus sensible heat.

Predicted Stable Heat and Moisture for 3 Breeds of Beef Calves

Most applications of these ventilation exchange data involve one breed or the other rather than combinations of breeds; thus it is desirable to provide stable heat and stable moisture data for each breed. As proposed in the preceding paragraph, the animal heat production of each breed tested was increased by 5 percent to provide stable heat data. Estimates of stable moisture for each breed were made by increasing animal vaporization rates of each breed by the amount of stable moisture attributed to the bedded area.

Figure 6 shows the results of the predictions in the form of a stable heat and stable moisture curve for each of the three breeds tested, Shorthorn, Brahman, and Santa Gertrudis. These curves would apply to animals which were making excellent daily weight gains. Actually 30 hours of fasting near the conclusion of these tests caused only about a 40 percent decline in animal heat production.[1]

Animal heat production data indicate that stable heat dissipation per unit body weight would be fairly constant between the ages of 10 and 20 weeks.[1] The respective stable heat dissipation rates (latent plus sensible) for Shorthorn, Brahman, and Santa Gertrudis calves during this period were therefore estimated at 5100, 3800, and 4400 Btu per hour for each 1000 pounds of body weight. These values would apply to both 50° and 80° F temperatures.

It is estimated that stable heat per unit body weight at 60 weeks had reached a fixed value which could be used until maturity. This estimate is based on the tendency for the stable heat curves of Figures 3 and 6 to flatten as the calves reached 60 weeks of age and is further supported by the fact that animal heat production per unit weight of the Brahman calves at 60 weeks is about equal to that produced by Brahman cows during previous experiments.[8]

Litter Production and Bedding Requirements

The weights of the litter removed and the weights of the bedding materials added (a combination of straw, wood shavings, and pulverized limestone) were recorded daily. Since management of the penned calves was much like that found on private farms, it is assumed that these data could be used for estimating bedding requirements. Figure 7 summarizes the results of these measurements in relation to age of the test animals. Results were noted as follows: (1) As was expected, litter production and bedding requirements increased with calf age, the pen size remaining constant; (2) the rate of increase was greatest as the calf age increased from 10 to about 35 weeks, more than doubling within that time; (3) higher stable temperatures (80° F) increased the bedding requirement by roughly 50 percent over the 50° F requirement; (4) the litter production at 80° F was also about 50 percent higher than at 50° F; (5) dehorning when the calves were

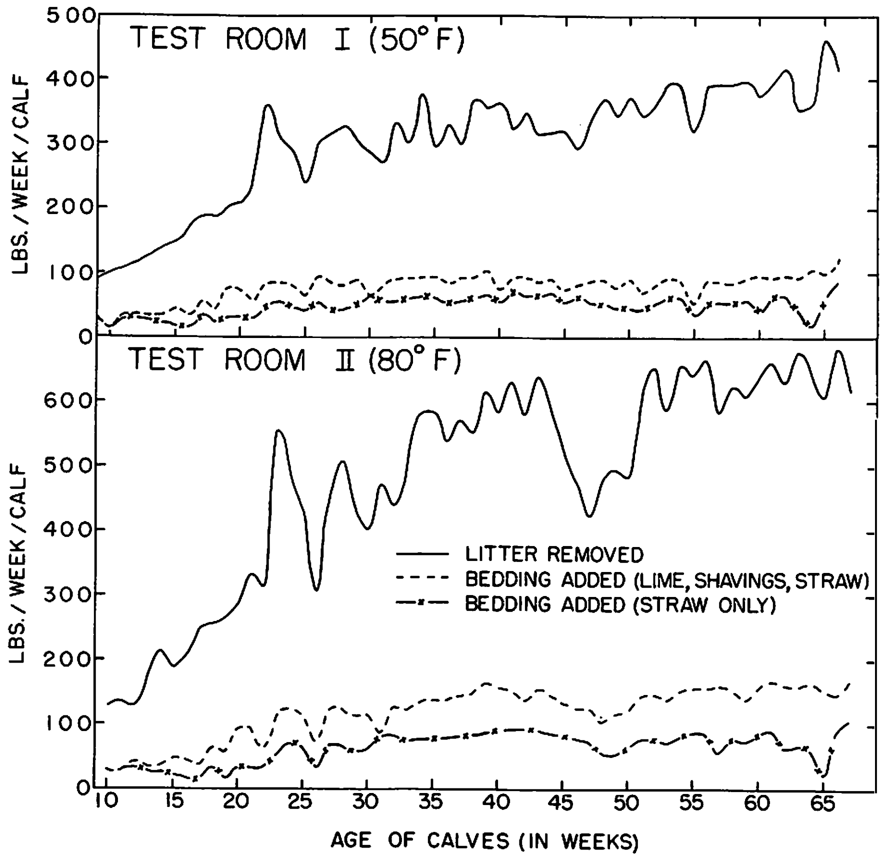

Fig. 7—Litter production and bedding requirements for growing beef calves. Data represent weekly averages of daily measurements from each test room during the 1954-55 growth studies with Shorthorn, Brahman, and Santa Gertrudis calves. No measurements were made of individual pen (and consequently breed) requirements. The herdsman estimated that the Brahman bedding requirements and litter production were slightly less than those for the other two breeds. From 5 to 10 lbs. of pulverized lime were sprinkled on the pen floors of each test room immediately after cleaning. Pens were cleaned weekly until the calves were about 24 weeks of age and daily thereafter.

about 43 weeks of age lowered litter production, particularly in the 80° F room; and (6) weekly cleaning practices that were followed up to the time the calves were about 23 weeks of age seemed to be more economical in regard to bedding requirements and litter production. However, the differences were small.

The most significant result of these tests was that higher stable temperatures increased litter production and bedding requirements for penned beef calves. At

50° F, and as beef calves grew from 10 to 65 weeks of age, bedding requirements increased from about 30 lb./calf/week to about 100 lb./calf/week. At 80° F, they increased from 35 lb./calf/week to about 150 lb./calf/week. Similarly, at 50° F litter production increased from 90 to 400 lb./calf/week and at 80° F increased from 125 to 650 lb./calf/week. Increased water consumption at 80° F was considered a major contributing factor in increased bedding requirements and litter production.

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APPENDIX

TABLE 2. STABLE HEAT (BTU/HR./CALF) AND MOISTURE (LB./HR./CALF) DISSIPATION RATES WITH CORRESPONDING AIR AND DEW POINT TEMPERATURES (°F)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Moisture	Temp.	Dew Point	Heat	Moisture	Temp.	Dew Point
1954								
Nov. 17	---	---	53.7	48.3	---	---	81.6	---
18	---	---	49.9	40.4	348	.32	81.2	64.7
19	---	---	49.4	36.8	499	.38	79.8	61.9
20	---	---	49.3	37.0	540	.42	79.2	59.4
21	---	---	54.6	43.9	588	.48	79.2	60.5
22	627	.27	49.8	37.0	645	.50	79.6	63.7
23	608	.24	49.7	37.5	749	.55	79.6	64.7
24	652	.27	49.7	36.2	608	.48	79.6	61.9
25	666	.23	49.6	36.3	578	.45	79.6	60.8
26	687	.26	49.6	36.0	692	.53	79.4	62.3
27	680	.26	49.6	35.6	680	.54	81.6	64.7
28	737	.32	49.5	35.7	795	.63	80.4	62.9
29	784	.36	49.8	36.6	769	.61	80.2	62.9
30	776	.32	49.7	36.7	938	.71	80.2	63.7
Dec. 1	758	.32	50.1	37.1	796	.63	80.0	64.0
2	766	.33	50.2	36.3	847	.61	78.8	60.1
3	825	.32	51.2	37.8	930	.69	80.2	64.2
4	780	.35	50.4	36.1	867	.68	79.8	63.3
5	713	.30	50.1	36.7	854	.70	80.0	63.5
6	686	.29	50.2	37.6	822	.67	80.6	62.6
7	695	.28	50.2	37.3	962	.72	80.0	65.0
8	691	.24	50.2	37.2	826	.58	79.7	65.4
9	754	.28	50.3	37.8	997	.74	79.2	65.0
10	855	.34	50.4	39.0	929	.64	79.7	65.9
11	841	.35	50.0	38.4	889	.61	79.4	64.3
12	842	.34	50.0	37.5	1072	.68	79.2	64.7
13	780	.33	50.2	37.5	1023	.69	78.6	64.6
14	733	.26	50.2	38.1	950	.64	79.2	66.1
15	602	.22	50.4	37.6	923	.64	79.6	66.0
16	660	.27	50.4	38.2	774	.51	79.2	66.5
17	790	.33	50.0	38.3	828	.54	79.0	63.4
18	858	.37	50.1	37.7	906	.55	79.0	62.2
19	826	.38	50.2	36.1	907	.60	79.8	63.6
20	851	.40	50.4	35.9	943	.64	79.6	64.2
21	854	.36	50.4	37.5	1008	.65	79.8	65.2
22	858	.37	50.4	38.4	656	.54	80.0	64.3
23	831	.37	50.2	39.0	952	.68	79.8	62.9
24	853	.41	50.3	39.2	1055	.77	79.7	63.2
25	997	.42	50.3	38.8	1256	.90	79.7	63.6
26	1030	.41	50.3	39.8	1243	.91	79.8	61.8
27	1082	.48	50.4	41.6	1126	.76	79.6	64.3
28	1077	.46	50.3	38.8	1223	.83	79.7	64.2
29	948	.42	50.2	38.1	840	.58	79.7	62.6
30	900	.45	50.3	38.6	808	.60	79.7	61.9
31	944	.46	50.5	37.8	998	.71	79.7	62.5

TABLE 2 (Continued)

Date	Test Room I (50°F) Heat	Mois- ture	Temp.	Dew Point	Test Room II (80°F) Heat	Mois- ture	Temp.	Dew Point
1955								
Jan. 1	970	.47	50.7	39.0	1182	.81	79.7	64.6
2	1039	.46	50.6	38.9	1197	.79	79.8	64.1
3	1014	.44	52.8	42.1	1195	.79	80.6	67.7
4	981	.45	50.3	40.6	1275	.85	80.2	68.5
5	1040	.44	50.0	39.4	973	.67	80.0	62.4
6	993	.42	49.7	38.9	1033	.69	79.8	59.5
7	1032	.46	50.0	39.0	1190	.76	79.8	63.4
8	1065	.50	50.4	39.1	1285	.80	79.7	65.3
9	1075	.49	50.2	37.9	1325	.84	79.8	63.9
10	1155	.55	50.1	38.3	1430	.91	79.7	64.1
11	1245	.58	50.3	39.2	1466	.92	79.7	64.9
12	1070	.44	50.2	38.4	1241	.82	80.0	61.6
13	1146	.44	50.1	38.0	1206	.81	79.7	63.0
14	1134	.45	50.0	38.2	----	---	80.0	----
15	1119	.48	49.9	38.0	1450	1.01	79.8	62.1
16	1143	.48	49.7	36.5	1538	1.05	79.7	63.0
17	1146	.55	49.9	37.2	1640	1.00	79.8	63.5
18	1163	.50	50.1	37.5	1572	1.03	80.0	63.7
19	1053	.43	49.9	37.4	1156	.80	80.2	62.1
20	1108	.44	50.1	37.8	1218	.86	79.7	62.6
21	----	---	50.0	----	1377	.89	79.7	63.9
22	1150	.48	49.6	39.5	1463	.98	79.4	63.4
23	1148	.48	50.3	38.9	1480	.89	79.2	63.5
24	1202	.52	49.7	38.4	1585	1.05	79.2	64.1
25	1249	.54	49.9	38.8	1648	1.07	79.8	64.8
26	1163	.47	50.0	38.2	1282	.81	79.7	62.2
27	1168	.45	50.0	38.1	1336	.83	79.7	63.2
28	1241	.50	50.0	38.9	----	---	79.7	----
29	1257	.46	49.9	38.5	1415	.95	79.7	64.7
30	1307	.49	49.9	39.2	1554	1.06	79.6	62.1
31	1277	.46	50.0	38.3	1541	1.05	79.4	58.5
Feb. 1	1193	.46	49.8	38.8	1653	1.10	79.6	65.4
2	1138	.40	49.7	37.6	1203	.77	79.7	60.2
3	1125	.41	50.0	38.2	1375	.89	79.8	62.1
4	----	---	50.3	37.0	1458	.92	79.7	62.0
5	1197	.45	50.1	38.7	1528	.98	79.6	62.2
6	1280	.50	50.3	38.9	1677	1.07	79.7	62.4
7	1383	.50	49.8	37.6	1625	1.00	79.7	61.6
8	1409	.55	50.3	37.9	1630	1.02	80.0	62.2
9	1227	.41	50.0	36.4	1309	.87	80.2	59.5
10	1178	.41	49.7	37.3	1354	.78	80.0	59.8
11	1318	.41	50.0	36.6	----	----	80.0	----
12	1427	.47	50.3	38.1	1403	.85	80.0	60.9
13	1286	.42	50.3	36.8	1457	.86	80.0	61.2
14	1352	.47	50.1	36.1	1540	.96	80.6	59.3
15	1475	.49	50.0	35.4	1645	1.04	79.8	59.7

TABLE 2 (Continued)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Moisture	Temp.	Dew Point	Heat	Moisture	Temp.	Dew Point
1955								
Feb. 16	1506	.56	49.8	37.2	1454	.94	79.2	61.1
17	1523	.54	50.1	37.3	1494	.96	79.7	61.2
18	----	---	50.2	37.4	1647	1.01	79.6	62.6
19	1618	.55	50.5	37.8	1748	1.10	79.7	61.5
20	1660	.64	50.3	38.1	1744	1.14	79.8	64.8
21	1684	.60	50.0	36.1	1731	1.12	80.0	62.6
22	1663	.64	50.6	36.7	1761	1.13	80.4	62.5
23	1442	.56	49.6	34.0	1471	1.00	80.0	60.6
24	1473	.50	49.7	33.3	1469	.89	79.7	61.2
25	1497	.52	49.8	34.8	----	----	80.6	59.8
26	1457	.49	50.1	35.9	1444	.99	81.2	60.9
27	1494	.49	49.9	36.6	1512	.98	79.7	63.3
28	1482	.53	49.6	36.9	1481	.97	79.8	64.2
Mar. 1	1470	.52	49.9	36.2	1536	.98	79.6	64.0
2	1467	.53	49.6	34.7	1447	.94	79.7	63.4
3	1450	.52	49.8	34.8	1333	.79	79.4	64.9
4	----	---	49.8	34.9	1463	.93	79.7	64.6
5	1412	.51	49.8	36.1	1533	1.04	81.0	67.2
6	1553	.56	50.4	36.2	1561	.97	80.4	66.2
7	1569	.54	49.9	35.8	1476	.91	80.4	67.1
8	1568	.54	49.8	35.8	1572	.98	79.6	65.0
9	1598	.53	50.5	36.6	1549	.98	79.7	66.4
10	----	.53	49.7	35.6	----	.92	79.4	65.3
11	1430	.47	49.8	35.1	----	----	79.7	60.2
12	1489	.52	49.7	35.7	1573	1.08	79.0	59.4
13	1500	.47	49.9	34.7	1292	.83	79.0	61.5
14	1696	.60	49.5	36.0	1254	.76	79.4	64.1
15	1502	.52	49.4	35.0	1403	.85	80.2	64.6
16	----	----	49.7	----	----	----	79.8	----
17	1318	.51	49.8	34.9	1234	.81	79.7	64.6
18	----	----	49.9	33.8	1174	.75	79.6	63.9
19	1426	.46	49.7	34.7	1174	.75	79.7	63.9
20	1392	.55	50.1	37.2	1399	1.00	79.7	64.5
21	1504	.53	49.8	35.8	1243	.81	79.7	63.7
22	1507	.54	49.8	35.8	1327	.81	78.8	62.9
23	1523	.55	50.0	36.3	----	---	79.6	----
24	1531	.55	49.7	35.6	1382	.94	79.8	63.4
25	1684	.65	49.9	37.0	----	----	79.8	60.6
26	1598	.62	50.1	36.5	1326	.79	79.6	62.0
27	1554	.58	50.6	36.0	1512	1.02	80.2	62.2
28	1692	.65	50.2	35.9	1590	1.06	80.0	62.3
29	1548	.64	49.9	36.1	1293	.82	80.2	62.0
30	1596	.61	50.1	34.7	1504	1.02	79.8	61.4
31	1542	.56	49.9	34.7	1450	.96	79.2	61.2
Apr. 1	----	----	49.6	34.8	1488	.99	79.0	61.5
2	1772	.73	50.5	36.2	1573	1.04	79.2	61.6
3	1727	.67	50.5	37.5	1518	1.03	79.0	61.2
4	1737	.66	50.2	37.3	1543	1.01	79.4	61.6

TABLE 2 (Continued)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Mois-ture	Temp.	Dew Point	Heat	Mois-ture	Temp.	Dew Point
5	1726	.64	49.8	36.3	1497	.98	79.0	61.2
6	1733	.61	49.5	36.1	1504	.95	79.6	61.5
7	1720	.63	49.9	36.7	1339	.85	79.8	62.2
8	1769	.65	50.2	36.7	----	----	79.6	61.3
9	1783	.60	50.4	36.7	1242	.75	79.2	61.8
10	2088	.61	49.9	37.1	1438	.88	78.8	62.6
11	1843	.59	50.1	38.1	1351	.88	78.8	62.1
12	1916	.78	50.6	41.2	1473	.91	78.8	62.4
13	1880	.69	50.1	40.0	1440	.92	78.8	62.5
14	1972	.73	50.1	40.2	1426	.87	78.6	62.3
15	----	----	50.0	----	1447	.96	79.8	62.9
16	1813	.61	50.8	39.6	----	----	79.2	----
17	1859	.65	50.2	38.4	1669	1.08	79.4	65.9
18	1752	.70	51.4	40.7	1577	1.07	79.6	63.2
19	1856	.76	51.3	40.5	1478	1.03	79.7	63.3
20	1809	.73	50.2	40.6	1444	1.01	79.4	62.7
21	1689	.61	50.3	38.8	1396	.98	79.7	63.2
22	1792	.67	50.3	39.5	----	----	79.7	----
23	1851	.71	50.7	40.7	----	----	79.4	----
24	1905	.65	50.8	39.7	1439	.99	79.7	64.4
25	1765	.67	50.9	38.9	1404	1.06	80.8	64.0
26	1814	.63	50.2	37.4	1555	1.10	79.7	62.6
27	1688	.62	50.2	37.8	1451	1.01	79.2	61.2
28	1702	.62	49.8	38.1	1537	1.04	79.7	62.1
29	----	---	49.9	37.2	1565	1.10	79.7	62.6
30	1735	.64	50.1	38.1	1540	1.09	80.2	62.8
May 1	1783	.69	50.4	38.9	1580	1.11	79.7	61.9
2	1869	.68	50.5	39.7	1635	1.12	79.6	61.6
3	1904	.71	51.7	41.1	1578	1.09	79.6	61.6
4	1773	.67	49.7	38.7	1554	1.08	79.2	60.7
5	1710	.64	50.3	40.0	1568	1.10	79.0	61.2
6	1745	.64	50.2	38.7	----	----	79.8	62.6
7	1640	.60	49.8	38.2	1400	.91	79.8	61.8
8	1668	.62	50.4	39.2	1530	1.06	80.4	63.3
9	1624	.57	51.2	39.5	1534	1.12	80.2	63.8
10	1789	.62	50.2	38.0	1506	1.04	79.6	62.6
11	1690	.59	50.3	38.5	1351	.90	79.6	62.2
12	1665	.56	49.7	38.1	1424	.94	79.6	62.1
13	----	---	50.2	40.1	1435	.95	79.7	62.1
14	1503	.52	50.4	40.0	1443	1.00	79.8	62.6
15	1584	.58	50.4	39.2	1476	1.01	79.8	62.4
16	1549	.55	50.6	38.2	1490	1.03	79.6	62.0
17	1628	.59	49.6	36.4	1475	.98	79.2	60.9
18	1688	.62	49.6	37.6	1429	.98	79.4	62.0
19	1597	.63	49.5	37.5	1469	.98	79.0	60.9
20	1673	.61	49.1	36.6	----	----	79.8	60.9
21	----	---	50.0	----	----	----	80.6	----
22	----	----	49.2	----	----	----	79.7	----
23	1604	.70	49.4	39.3	1531	1.06	79.7	64.0
24	1893	.72	49.8	38.9	1605	1.11	79.6	63.8

TABLE 2 (Continued)

Date	Test Room I (50°F)				Test Room II (80°F)			
	Heat	Moisture	Temp.	Dew Point	Heat	Moisture	Temp.	Dew Point
25	1662	.66	50.2	39.2	1485	1.02	79.4	63.3
26	1790	.67	49.7	38.9	1448	.96	79.6	62.8
27	----	---	49.5	38.6	1465	.96	79.6	62.9
28	1867	.66	48.0	37.3	1513	1.01	79.4	62.8
29	1721	.65	50.3	40.4	1519	1.03	80.6	62.3
30	1790	.67	49.4	38.7	1414	1.00	81.6	64.6
31	1814	.71	50.6	40.0	1343	.94	80.2	60.5
June 1	1748	.66	50.3	38.4	1352	.91	79.8	61.8
2	----	---	50.3	----	----	----	79.6	62.6
3	1805	.65	49.8	37.6	----	----	79.7	60.5
4	1704	.59	49.8	37.6	1120	.68	80.0	64.7
5	1787	.62	50.0	38.1	1423	.89	79.8	65.4
6	1540	.63	50.0	38.1	1452	.96	79.8	64.2
7	1600	.60	49.5	37.2	1409	.94	79.4	62.8
8	1653	.61	48.6	35.9	1353	.93	79.4	61.4
9	1505	.60	49.5	37.2	1350	.92	79.7	60.8
10	----	---	49.8	38.5	1319	.91	79.6	60.2
11	1571	.57	50.9	39.6	1322	.91	79.8	60.6
12	1606	.62	50.7	38.9	1408	.93	81.0	62.9
13	1614	.57	49.6	36.4	1466	.96	79.7	62.2
14	----	.56	49.2	36.1	1389	.95	79.8	61.6
15	1636	.59	50.0	37.8	1227	.94	80.0	61.6
16	1844	.59	49.8	37.5	1359	.93	80.0	62.4
17	1761	.60	50.7	38.7	----	----	80.0	60.8
18	1646	.56	50.0	37.1	1385	.88	79.4	61.8
19	1570	.56	51.1	39.2	1372	.90	79.4	62.8
20	1410	.55	52.9	39.9	1409	.93	80.4	64.1
21	1730	.59	50.7	36.6	1431	.90	79.6	63.6
22	1490	.52	49.5	35.7	1304	.79	79.4	65.0
23	1567	.51	49.6	35.4	1346	.78	79.6	64.7
24	----	---	51.6	39.0	1380	.83	79.7	65.0
25	1548	.47	49.9	35.9	1442	.86	79.6	65.2
26	1514	.49	49.9	36.4	1539	.90	79.6	64.6
27	1442	.48	49.7	36.1	1506	.91	79.4	64.6
28	1520	.49	49.5	35.4	1482	.87	79.7	64.4
29	1668	.49	49.3	34.7	1481	.92	79.8	65.3
30	1562	.66	53.2	41.9	1521	.90	79.2	66.8
July 1	1630	.54	51.6	35.9	----	----	79.4	63.2
2	1596	.51	49.9	34.6	1511	.95	79.0	61.8
3	1476	.48	49.8	34.9	1549	1.01	80.0	61.1
4	1432	.40	50.2	34.6	1478	1.02	80.2	61.1
5	1497	.54	50.0	35.5	1560	1.00	79.6	63.3
6	1457	.47	50.1	34.8	1479	.98	79.8	61.6
7	1402	.46	50.1	35.0	1535	1.00	79.6	62.2
8	----	---	50.5	37.6	1553	1.02	80.8	63.0
9	1640	.55	49.6	35.7	1559	1.01	79.8	62.6
10	1579	.54	50.3	36.0	1560	1.11	80.4	63.4
11	1503	.50	50.0	35.1	1543	1.02	79.8	61.7
12	1590	.57	49.5	36.3	1592	1.08	79.8	61.3

TABLE 2 (Continued)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Mois-ture	Temp.	Dew Point	Heat	Mois-ture	Temp.	Dew Point
13	1767	.61	50.0	37.5	1672	1.20	80.4	63.5
14	1707	.58	49.3	36.7	1595	1.08	79.8	63.4
15	1698	.60	50.5	37.8	----	----	80.8	61.1
16	1650	.56	49.9	36.3	1615	1.06	79.8	62.6
17	1756	.60	50.5	37.6	1712	1.12	79.8	62.8
18	1799	.61	49.9	37.4	----	----	79.9	62.3
19	1520	.59	50.3	38.7	1532	1.04	82.0	64.1
20	1668	.59	50.0	38.7	1522	1.05	81.6	64.4
21	----	---	51.1	39.5	1630	1.11	81.4	63.3
22	----	---	50.1	37.7	1468	1.02	81.4	63.5
23	1546	.53	51.8	40.0	1647	1.05	79.8	61.9
24	1593	.52	50.7	38.1	1552	1.01	80.2	61.7
25	1668	.62	50.5	38.4	1564	1.07	80.2	62.4
26	1630	.61	51.0	38.8	1648	1.10	79.4	63.0
27	1623	.62	50.7	37.5	----	----	79.7	61.6
28	----	---	49.9	38.4	----	----	80.4	61.9
29	1524	.51	50.3	38.1	1363	.90	81.2	62.7
30	1541	.55	51.4	39.4	1404	.97	80.6	61.5
31	1579	.51	49.9	37.8	1342	.87	80.0	61.0
Aug. 1	1699	.55	49.0	37.4	1309	.86	80.2	61.5
2	1799	.69	50.2	40.8	1324	.90	79.8	61.9
3	1466	.57	48.7	36.9	1324	.89	79.2	60.8
4	1637	.56	49.4	37.7	1348	.92	79.8	61.2
5	----	---	50.2	----	1362	.98	80.8	62.2
6	1583	.53	52.4	42.5	1329	.97	81.5	62.9
7	1615	.51	48.1	38.5	1439	.92	79.8	60.5
8	1592	.52	48.8	39.2	1360	.88	80.4	60.1
9	1627	.61	49.5	38.0	1385	.87	81.0	60.3
10	1595	.59	49.8	37.7	1322	.91	80.4	60.9
11	1868	.67	49.2	38.4	----	----	81.0	----
12	1711	.66	49.4	37.9	1402	.93	81.0	62.1
13	1816	.65	49.2	38.0	1539	1.03	81.4	63.1
14	1716	.69	50.2	38.5	1500	1.06	80.6	63.2
15	1666	.63	49.7	39.5	1410	1.02	81.2	63.4
16	1860	.63	50.4	39.7	1504	.97	79.8	67.7
17	1783	.62	49.9	40.7	1522	1.03	80.6	65.1
18	----	---	48.8	----	1490	.99	81.0	66.0
19	1756	.66	50.4	40.6	1254	1.02	79.8	65.7
20	1809	.71	50.3	40.1	1455	.99	79.6	65.3
21	1725	.60	50.6	40.4	1492	1.04	79.7	65.7
22	1774	.66	50.2	40.5	1431	1.05	81.6	65.7
23	1563	.63	50.6	41.2	1439	1.04	81.4	64.4
24	1761	.65	49.7	39.8	1352	.92	80.8	63.5
25	1725	.61	50.1	39.9	----	----	80.8	63.6
26	1570	.60	49.6	39.1	1297	.90	80.6	63.6
27	1770	.61	50.5	39.9	1401	.99	79.8	64.2
28	1750	.73	50.8	40.5	1407	.96	79.8	64.6
29	1678	.72	50.5	40.5	----	----	79.8	64.4
30	1713	.64	49.5	38.9	1322	.95	79.2	63.2
31	1740	.62	49.3	38.5	1430	.96	79.8	62.3

TABLE 2 (Continued)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Moisture	Temp.	Dew Point	Heat	Moisture	Temp.	Dew Point
Sept. 1	----	---	49.1	39.7	1534	1.00	79.7	61.4
2	1800	.67	49.6	39.5	1496	1.03	80.2	61.3
3	1822	.67	50.7	40.3	1456	1.01	80.2	61.5
4	1744	.68	50.7	40.3	1564	1.04	80.0	62.2
5	1898	.73	50.8	40.9	1630	1.08	80.8	63.2
6	1818	.71	50.3	40.0	1557	1.10	80.4	63.2
7	1926	.76	49.5	39.8	1613	1.09	79.6	62.1
8	1772	.63	50.3	40.0	1637	.99	79.0	65.4
9	1621	.53	49.7	39.1	----	----	80.4	62.4
10	1585	.54	49.5	38.9	1604	1.06	79.8	63.5
11	1660	.51	49.6	38.5	1671	1.06	79.7	60.7
12	1769	.68	49.2	39.0	1641	1.07	80.0	60.3
13	1773	.68	49.5	38.9	1577	1.07	80.6	61.2
14	1729	.68	50.7	39.7	1560	1.09	80.0	61.3
15	1725	.66	49.2	37.8	1581	1.05	80.0	62.1
16	----	---	49.4	40.3	1525	1.12	80.6	62.6
17	1775	.67	49.8	40.1	1633	1.09	80.8	63.4
18	1651	.63	49.5	38.8	1707	1.17	80.8	63.9
19	1822	.70	49.2	38.0	1855	1.12	81.2	64.6
20	1801	.68	49.0	37.8	1593	1.06	80.4	62.6
21	1769	.59	49.0	37.2	1530	1.02	81.8	63.9
22	1758	.63	49.1	38.1	1532	.97	79.8	62.4
23	1757	.61	49.2	38.1	---	----	80.4	61.2
24	1861	.58	48.8	37.2	1292	.79	82.0	67.0
25	1821	.61	49.0	37.3	1692	1.10	81.4	65.6
26	1891	.65	49.9	38.7	1742	1.10	81.5	64.6
27	1769	.59	49.0	37.1	1730	1.12	80.4	62.0
28	1764	.58	50.8	39.2	1608	1.05	81.2	62.1
29	1714	.59	49.1	37.3	1765	1.10	79.7	61.2
30	----	---	49.5	39.1	1852	1.22	80.0	60.6
Oct. 1	1840	.56	49.2	37.7	1726	1.14	80.8	61.2
2	1779	.59	50.4	38.1	1672	1.11	81.6	63.3
3	1830	.67	51.2	38.9	1741	1.22	82.0	63.5
4	1893	.69	50.2	37.2	1788	1.21	80.2	60.6
5	1872	.65	50.8	37.8	1786	1.23	81.0	62.1
6	----	.62	49.2	36.7	----	1.22	79.7	60.6
7	1980	.64	49.5	37.0	----	----	80.2	58.8
8	1720	.58	49.2	36.7	1842	1.21	81.5	64.3
9	1740	.56	49.5	36.4	1742	1.16	81.0	64.2
10	1844	.63	49.9	37.0	1738	1.15	80.4	62.2
11	1837	.68	50.2	37.2	----	----	----	----
12	1564	.52	48.7	35.8	1891	1.14	78.8	63.2
13	1410	.52	48.9	36.1	1831	1.17	79.6	59.0
14	----	---	49.8	40.9	1787	1.15	79.8	59.4
15	1759	.59	49.4	35.3	1758	1.12	81.5	62.0
16	1766	.63	49.5	34.8	1880	1.19	81.4	63.2
17	1837	.63	49.9	36.4	2043	1.28	81.5	61.1
18	1841	.64	49.3	36.4	2112	1.21	80.6	59.5
19	1928	.68	49.9	37.1	1735	1.09	79.7	58.4

TABLE 2 (Continued)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Mois-ture	Temp.	Dew Point	Heat	Mois-ture	Temp.	Dew Point
20	2080	.90	50.5	40.8	1626	1.06	80.0	59.8
21	2001	.82	50.0	38.1	----	----	81.5	59.8
22	1933	.73	50.3	39.4	1536	1.01	81.5	62.4
23	2030	.73	49.9	39.2	1858	1.08	81.4	63.0
24	1896	.66	49.4	38.0	1910	1.16	81.0	57.8
25	----	---	49.5	36.7	----	----	79.7	56.8
26	1867	.77	49.6	37.6	1773	1.15	80.1	57.9
27	1926	.68	50.0	38.1	1614	1.11	79.4	58.2
28	----	---	49.3	39.1	1722	1.12	79.2	59.5
29	2144	.78	48.9	39.1	1842	1.17	79.8	58.5
30	1885	.68	50.1	38.8	1740	1.18	80.8	59.1
31	2071	.72	50.2	37.9	1615	1.08	79.6	59.5
Nov. 1	2041	.60	49.2	36.1	1566	1.04	80.2	59.3
2	1750	.57	48.8	36.6	1634	1.02	78.8	60.2
3	1908	.66	49.3	37.8	1672	1.10	79.7	59.3
4	1890	.66	49.6	37.4	----	----	80.2	58.2
5	1802	.66	50.6	37.6	1746	1.11	79.8	58.9
6	2027	.71	49.4	36.5	1852	1.23	80.2	58.5
7	2051	.70	49.7	37.3	1748	1.11	79.7	56.7
8	1925	.61	49.3	36.1	1791	1.09	80.0	57.3
9	1867	.64	49.4	38.3	1809	1.23	80.0	58.2
10	2001	.70	49.5	38.2	1838	1.22	79.7	58.1
11	2084	.72	49.8	37.9	----	----	81.4	59.3
12	2018	.71	50.2	39.0	1875	1.26	80.8	60.8
13	2024	.71	49.6	38.9	1786	1.19	80.2	59.9
14	2002	.77	51.3	40.8	1724	1.16	80.0	58.7
15	2083	.72	49.5	37.3	1766	1.18	79.7	58.5
16	1787	.62	49.1	36.9	1713	1.11	80.0	59.7
17	1654	.63	48.8	37.2	1749	1.08	80.0	60.2
18	----	---	50.9	39.9	1812	1.11	80.6	60.3
19	2048	.71	49.8	39.7	1807	1.15	81.2	60.7
20	1862	.71	50.1	39.8	1727	1.19	81.0	61.0
21	2090	.75	49.6	38.9	1616	1.16	80.2	60.8
22	2051	.75	49.5	38.5	1713	1.16	80.2	61.2
23	2033	.69	48.8	37.8	1410	.98	79.7	59.5
24	2045	.70	49.1	36.0	1397	.99	80.6	59.6
25	1979	.71	49.9	35.4	1661	1.12	80.2	60.9
26	2082	.73	49.9	36.6	1845	1.25	81.4	61.6
27	2156	.73	49.6	38.1	1873	1.24	80.6	61.3
28	2117	.71	49.9	38.1	1743	1.19	80.2	62.2
29	2099	.72	49.4	36.7	1786	1.16	80.8	61.9
30	1993	.66	49.9	35.1	1803	1.23	80.0	62.6
Dec. 1	1972	.71	56.0	43.1	1767	1.18	80.2	61.9
2	2024	.72	51.3	35.0	----	----	80.6	60.8
3	2043	.69	50.1	35.6	1830	1.22	79.4	58.8
4	2205	.79	50.2	37.9	1789	1.20	80.0	59.3
5	2019	.71	50.3	37.7	1721	1.15	80.0	60.5
6	2067	.65	49.8	35.4	1707	1.13	80.2	60.6
7	1892	.60	49.5	35.5	1769	1.14	79.6	60.3

TABLE 2 (Continued)

	Test Room I (50°F)				Test Room II (80°F)			
Date	Heat	Moisture	Temp.	Dew Point	Heat	Moisture	Temp.	Dew Point
8	1586	.58	48.9	35.8	1808	1.18	80.6	60.9
9	----	---	49.6	37.0	1837	1.20	80.8	61.2
10	----	---	50.0	40.7	1891	1.23	81.2	61.3
11	----	---	50.5	40.2	1849	1.25	81.2	61.8
12	----	---	49.8	38.7	1865	1.24	81.5	62.0
13	----	---	49.6	37.4	1932	1.18	80.8	61.5
14	2142	.77	49.6	38.1	1537	1.02	79.8	60.6
15	2155	.76	49.4	38.4	1337	.91	79.7	59.5
16	2261	.79	49.7	38.3	----	----	81.4	61.6
17	2270	.75	49.8	38.7	1815	1.22	81.0	61.0
18	2347	.82	50.9	40.4	1970	1.26	81.4	61.6
19	2265	.77	50.7	39.5	1847	1.25	81.2	61.6
20	2315	.84	50.2	39.2	1905	1.27	80.0	60.2
21	2234	.74	50.2	37.8	1795	1.15	79.8	59.9
22	2225	.71	50.5	37.0	1682	1.08	79.7	59.5
23	2163	.74	50.5	37.6	1736	1.10	79.7	59.5
24	2050	.69	49.8	36.9	1747	1.11	79.4	59.9
25	1974	.65	49.6	36.6	1800	1.09	79.7	58.9
26	2161	.70	49.5	36.7	1755	1.15	79.8	59.4
27	2153	.67	49.8	35.8	1672	1.09	80.2	59.0

TABLE 3. COEFFICIENTS FOR THE EQUATION $y = a + bt$ SHOWING RELATIONSHIP OF STABLE HEAT AND MOISTURE (y) TO TIME (t) IN DAYS SINCE THE START OF TESTS. COEFFICIENTS ARE GIVEN FOR EACH SUCCESSIVE DAY AFTER THE DAY OF CLEANING (WEDNESDAY).

Constants	Thurs.	Fri.	Sat.	Sun.	Mon.	Tues.
			Stable Heat - Btu/Hr./1000 Lb. Body Weight			
			at 50°F			
a	5462	5675	5953	5929	5860	5685
b	80.1	85.0	81.6	82.6	86.1	89.1
			at 80°F			
a	6055	6379	7092	7517	7275	7941
b	83.2	95.8	85.9	86.4	90.8	86.3
			Stable Moisture - Lbs. of Water/Hr./1000 Lb. Body Weight			
			at 50°F			
a	2.42	2.75	2.96	2.86	3.07	2.65
b	.026	.022	.020	.023	.022	.029
			at 80°F			
a	4.74	4.89	5.27	5.71	5.45	5.77
b	.040	.048	.047	.045	.048	.046