

THE PRODUCTION OF A SUITABLE PSYCHROMETRIC CHART
FOR
REFRIGERATION OF COLD ROOMS

by

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INTRODUCTION

The psychrometric chart contained in this thesis has been prepared to eliminate complicated calculations in refrigeration work within the chart's range. This chart is based on what appears to be the best and most recent data available. The temperature range of the chart is from 0° fahrenheit to 100° fahrenheit. Particular attention has been given to the lower temperature portion of the chart with the hope that it will fill a place which has been somewhat neglected.

It is the writer's wish to acknowledge the help obtained from Charles R. Lucas' thesis, "Properties of Steam-Air Mixtures." Also the help and valuable suggestions given by Professor W. R. Woolrich, under whose direction this thesis was prepared.

GENERAL SURVEY OF THE FIELD

There are many psychrometric charts available at the present time but due to changes in steam-air mixture data and the use of lower temperatures there is a place for a new chart. It is the hope of the writer that this chart will fill that place.

GENERAL THEORY

This thesis had no laboratory research work connected with it. Instead, it consisted entirely of calculations to determine points through which curves of the chart were drawn.

The definition of terms accepted as standard for this chart are as follows:

1. Standard barometric pressure is 29.92 inches of mercury.
2. The absolute temperature is t° fahrenheit $+$ 459.64 $^{\circ}$ fahrenheit.
3. Specific volume of air. The weight of one cubic foot of cubic foot of pure air at 32 $^{\circ}$ fahrenheit and 29.92 inches of mercury barometric pressure is 0.080728 pounds per cubic foot. Therefore

$$\frac{pv}{T} = 53.35$$

4. Instantaneous specific heat of air.

$$C_{pa} = 0.24112 + 0.000009 \ t^{\circ} \text{ fahrenheit}$$

5. Instantaneous specific heat of water vapor.

$$C_p = 0.4423 + 0.00018 \ t^{\circ} \text{ F.}$$

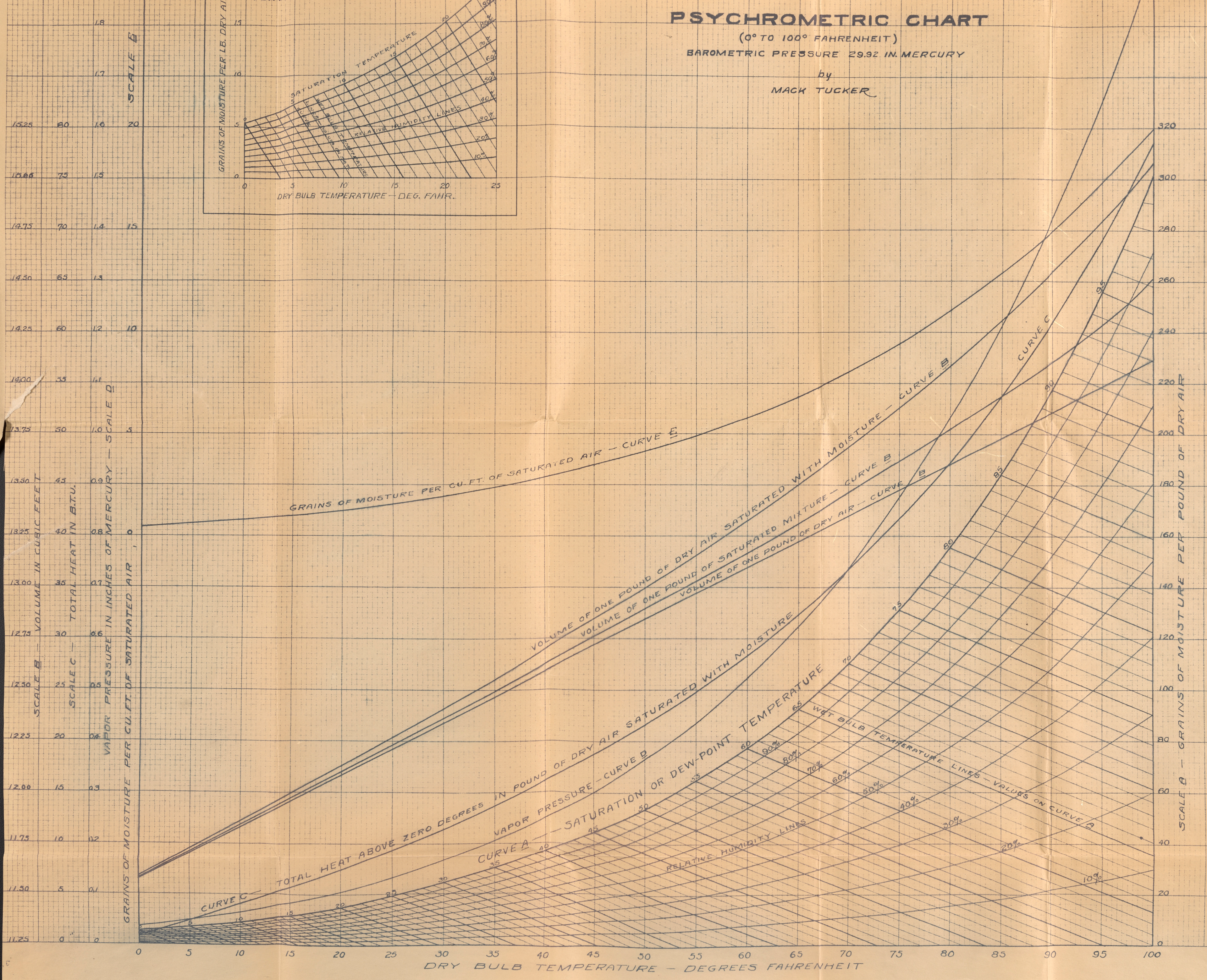
PSYCHROMETRIC CHART

(0° TO 100° FAHRENHEIT)

BAROMETRIC PRESSURE 29.92 IN. MERCURY

by

MACK TUCKER



FORMULAE USED IN CALCULATIONS

1. Partial Saturation Lines.

When the temperature of a definite weight of saturated vapor is increased isobarometrically it is said to be superheated. Its specific volume is increased, in accordance with the law of gases, in direct proportion to the increase of the absolute temperature, while its density is changed in an inverse proportion. $\frac{D_2}{D_1} = \frac{T_1}{T_2}$:

$T_2 - T_1$ is the degree of superheat. If D_2^1 is the density of the saturated vapor at temperature T_2 , then the ratio $\frac{D_2}{D_2^1}$ is said to be the percent of saturation, or more exactly, the percent of isothermal saturation. When these relationships are considered with respect to water vapor in air, this ratio is termed percent of relative humidity, while the densities D_1 , D_2 , D_2^1 , etc., customarily expressed in grains of moisture per cubic foot, are termed absolute humidity.

2. Wet Bulb Temperature Lines.

The diagonal adiabatic lines representing saturation or wet-bulb temperatures, are calculated from the following formula:

$$W = \frac{r^1 w^1 - C_{p_a} (t - t^1)}{r^1 + C_{p_s} (t - t^1)}$$

where:

w^1 is the weight of water vapor contained in one pound of dry air at saturation temperature t^1 .

C_{p_a} is the mean specific heat of air of constant pressure between t and t^1 .

C_{p_s} is mean specific heat of water vapor of constant pressure between temperatures t and t^1 .

t is dry bulb temperature.

t^1 is wet bulb temperature.

r^1 is latent heat of water vapor corresponding to t^1 .

W is weight of water vapor actually contained in one pound of dry air, i.e., it is the ratio of the weight of water vapor to the weight of air in the mixture.

It should be noted that these lines have a slight curvature due to the factor $C_{p_s}(t - t^1)$. As an example, let it be assumed that t is 85° fahrenheit and t^1 is 80° fahrenheit. By solving the above equation for W we find a point on the 80° wet-bulb temperature line.

$$W = \frac{1047.4 \times 0.02226 - (0.24112 + 0.000009 \times 82.5) (85 - 80)}{1047.4 + (0.4423 + 0.00018 \times 82.5) (85 - 80)}$$

$$W = \frac{22.1058115}{1049.68515} = .02106 \text{ pounds per cu. ft.}$$

$$W = .02106 \times 7000 = 147.2 \text{ grains per cu. ft.}$$

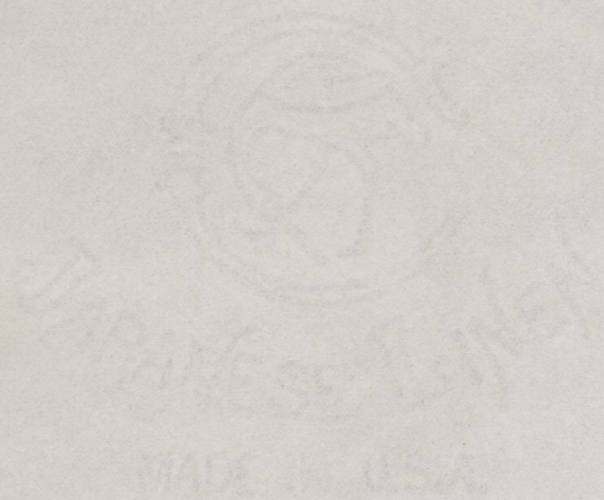
Likewise, other points on the 80° F. wet-bulb temperature line may be determined until sufficient points have been located to draw the line. It may be noted that when the equa-

tion is set equal to zero, i.e., W is zero, the equation is simplified to

$$Cp_a(t - t^1) \approx r^1 w^1$$

or $t \approx \frac{r^1 w^1 - t^1 Cp_a}{Cp_a}$ t in this case being the intercept on the $x - x$ axis.

A P P E N D I X



STEAM-AIR MIXTURE TABLES

Dry Bulb Temperature Deg. Fah.	Grains of Moisture Per Lb. of Dry Air	Grains of Moisture Per Cu. Ft. of Sat. Air	Vapor Pressure In Inches Mercury.
0	5.467	0.472	0.0375
5	7.112	0.606	0.0487
10	9.163	0.772	0.0628
15	11.774	0.982	0.0806
20	15.008	1.237	0.1027
25	19.075	1.555	0.1304
30	24.108	1.943	0.1646
35	30.002	2.380	0.2036
40	36.449	2.868	0.2478
45	44.240	3.442	0.3003
50	53.480	4.113	0.3624
55	64.40	4.895	0.4356
60	77.35	5.804	0.5214
65	92.61	6.855	0.6218
70	110.46	8.069	0.7386
75	131.39	9.46	0.8744
80	155.82	11.06	1.0314
85	184.38	12.89	1.212
90	217.63	14.96	1.421
95	256.34	17.32	1.659
100	301.35	19.98	1.931

STEAM-AIR MIXTURE TABLES (CONTINUED)

Dry Bulb Temperature Deg. Fah.	Volume of 1 lb. of dry air - cu. ft.	Volume of 1 lb. of sat. mixture cu. ft.	Volume of 1 lb. air + vapor to Sat. cu. ft.
0	11.58	11.581	11.590
5	11.70	11.71	11.725
10	11.83	11.84	11.86
15	11.96	11.97	11.995
20	12.09	12.10	12.13
25	12.21	12.24	12.27
30	12.34	12.36	12.41
35	12.47	12.49	12.55
40	12.59	12.63	12.70
45	12.72	12.76	12.85
50	12.84	12.90	13.00
55	12.97	13.08	12.16
60	13.10	13.18	13.33
65	13.22	13.31	13.50
70	13.35	13.47	13.69
75	13.48	13.62	13.88
80	13.60	13.78	14.09
85	13.73	13.94	14.31
90	13.86	14.11	14.55
95	13.98	14.27	14.80
100	14.11	14.52	15.08

STEAM-AIR MIXTURE TABLES (CONTINUED)

Dry Bulb Temperature Deg. Fah.	Total Heat Above 0° F. Contained In 1 lb. of Sat. Mix- ture. B. T. U.	Total Heat Above 0° F. Contained In 1 lb. of dry air plus Vapor to Saturate. B. T. U.
0	0.924	0.963
5	2.328	2.334
10	4.028	4.032
15	5.681	5.691
20	7.434	7.456
25	9.362	9.387
30	11.418	11.477
35	13.629	13.691
40	16.020	16.064
45	18.554	18.682
50	21.370	21.544
55	24.469	24.712
60	27.911	28.235
65	31.772	32.199
70	36.034	36.618
75.	40.825	41.640
80	46.242	47.230
85	52.252	53.623
90	59.033	60.874
95	66.607	69.121
100	75.292	78.548

MADE IN U.S.A.

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APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

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