

HUMIDITY RELATIONS IN ICE AND ELECTRIC
REFRIGERATORS

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Preface

Foods are kept in refrigerators because in them are maintained atmospheric conditions designed to retard spoilage. Foods spoil due to the presence of tiny living growths known as micro-organisms. Three types of these micro-organisms -- bacteria, yeast, and molds -- are the most important and objectionable of all causes of food spoilage. The growth of bacteria, yeast, and molds, like that of all other plants, is influenced by temperature, moisture, and light. This paper, as indicated by the subject, is to deal with the moisture in ice and electric refrigerators.

Survey of the Field and Purpose

Scientists have done much in determining the temperature conditions which will check the growth of bacteria. They have found that milk, fresh meat, poultry, fish, and many fresh fruits and vegetables should be kept at a temperature of 50°F, and preferably less, as a means of checking the growth of such micro-organisms as are responsible for souring and decay. Experiments indicate that 40°F should be the lower limit for the keeping of most foods, while in keeping foods from day to day, temperatures as high as 60°F may prove a decided aid.

The matter of moisture in the atmosphere surrounding foods which are being preserved is also an important one, for food high in moisture will wither or evaporate if the air is too dry, while if excess moisture is present the food will have a musty odor. The moisture in the air is also a factor affecting the rate of growth of bacteria and the heat transfer rate through the refrigerator walls.

A rather thorough survey, by the author, of magazine articles, books, and bulletins indicated that a considerable amount of work and experiment has been done in testing household refrigerators as regards temperatures, heat transfer rates, efficiencies, and temperature variations in different parts of the refrigerator. A test of particular interest was one conducted by Mildred B. Porter of the Bureau of Home Economics upon an ice refrigerator which indicated that both the temperature in the refrigerator and the melt-

ing rate of the ice are linear functions of the room temperature. Readings were only taken after the box had not been opened for some time. Four thermometers used in different parts of the box gave temperature variations as high as 10 degrees when the room was at 90.5°F, tapering off to a difference of 5.5 degrees with the room at 62.4°F.

In all of the tests and experiments reviewed there was not a single case in which the moisture conditions on the inside of the refrigerator were determined. The author, therefore, decided to make a study of humidity conditions in household refrigerators in actual use, and more especially to attempt to trace a relationship between the humidity variations within the refrigerator and the variations within the room in which the refrigerator was located.

Description of Test and Theory

Arrangements were made for conducting tests on two ice refrigerators and four electric refrigerators. In the data and on the curve sheets the ice boxes are indicated by Nos. 1 and 2. No. 3 was formerly an ice refrigerator to which a Frigidare unit had been added; No. 4 a Cavalier electric refrigerator; No. 5 a Jewett electric refrigerator; and No. 6 a Kelvinator. Nos. 4 and 6 were located in the refrigeration laboratory at the University and were being used in tests for determining the latent heats of foods by another student at the same time. The remainder of the refrigerators were in private homes. As planned, the author intended to make fifty humidity determinations on each refrigerator, and for each humidity found for the refrigerator, to determine a corresponding humidity in the room. This plan was carried out, except in the case of the Kelvinator on which only forty determinations were made. In taking readings, whether or not the refrigerator had been recently opened was disregarded since the author was desirous of making the tests under actual operating conditions.

Relative humidity is defined as the ratio of the amount of moisture in the air to the amount of moisture which would be in the air, at the same temperature, if the air were saturated. It is usually determined by means of an instrument called a psychrometer, which merely consists of two thermometers suitably mounted, the bulb of one being covered with a close fitting wick which is moistened with water. If the

air is saturated no evaporation occurs from the wet bulb thermometer and both read the same. However, if the air is less than saturated, evaporation will take place and the wet bulb thermometer will read lower than the dry bulb. The amount of moisture in the air is a function of these temperatures and the difference between them.

There are two types of psychrometers: the "stationary" and the "sling". The latter is whirled through the air at the rate of about 200 r.p.m. and is the more accurate. Knowing the wet and dry bulb temperatures the humidity can be determined from the following formula deduced by Carrier:

$$h = \left[P_w - \frac{(P - P_w)d}{2800 - 1.3t_w} \right] \frac{1}{P_d}$$

In which

h = Relative humidity

P_w = Pressure of saturated vapor at wet bulb temperature, in.

P = Barometric pressure, in.

d = Temperature difference between dry and wet bulb thermometers.

t_w = Wet bulb temperature.

P_d = Pressure of saturated vapor at dry bulb temperature.

To solve for each humidity from this equation would involve considerable arduous calculation. Therefore humidities are usually determined from a psychrometric chart, or a table such as has been reproduced in the back of the report from a table prepared by Prof. W. R. Woolrich.

In the test humidities were determined with two "Tycos"

vest pocket thermometers, one of which was wrapped with a piece of gauze and used as a wet bulb thermometer. Before taking any readings the thermometers were checked to see that they registered together, and both were checked against a standard thermometer. Graduations on the thermometers were every two degrees; it was, therefore, impossible to read accurately closer than a whole degree. Since the thermometers could not be whirled in the refrigerators, they were also kept stationary in making the determinations in the room in order to keep the results consistent.

Since the temperatures vary in different parts of the refrigerator, the thermometers were swung from the same place in each refrigerator for each test, and in a corresponding place in all refrigerators. This point was located in the central portion of the food chamber as is shown by the sketch of Figure 1. Preliminary tests indicated that with the spirit thermometers used that it required about eight minutes for the wet bulb thermometer to drop from room temperature to a temperature of about 40°F as was frequently found in the electric refrigerators.

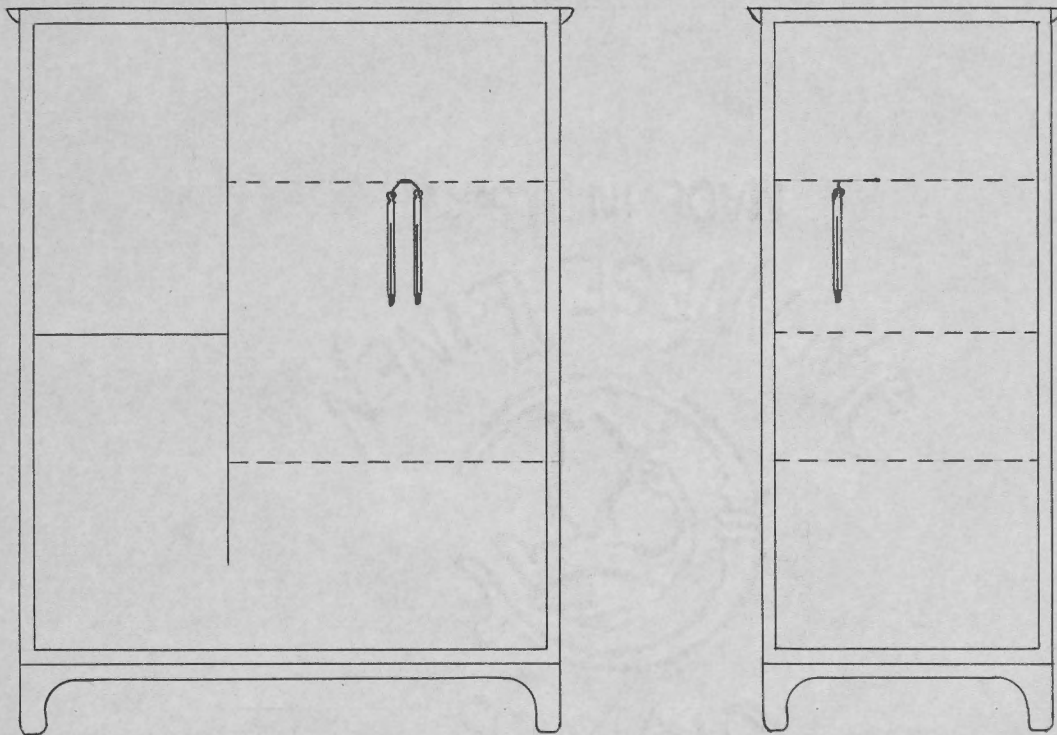


Figure 1

LOCATION OF THERMOMETERS IN REFRIGERATORS

Results and Conclusions

The data as taken is shown on pages 9 to 14. Arithmetic averages of the refrigerator relative humidities in percent follow with corresponding room humidities:

	Refrigerator	Room
Ice Refrigerator #1	75.0	61.2
Ice Refrigerator #2	75.3	55.0
Electric Refrigerator #3	79.0	62.2
Electric Refrigerator #4	76.1	52.7
Electric Refrigerator #5	82.2	61.6
Electric Refrigerator #6	75.4	53.6

While the author had nothing to base his assumption on, he had expected that the ice refrigerators would produce humidities rather higher than those in the electric refrigerators. As indicated by the above data, the contrary was true.

The data as taken was revised, the room humidities being listed in the order of increasing sequence with their corresponding refrigerator humidities. Curves were platted from this revised data with room and refrigerator humidities as co-ordinates, using the average of the refrigerator humidities at each room humidity. Where a room humidity appeared but once, it was disregarded in platting the curves.

On Figures 2 and 3 are platted the points for the ice boxes. It is to be noticed that these points simply appear at random and indicate no relation between refrigerator and room humidities. An uncontrolled factor in the ice boxes is

the melting rate of ice, which, according to tests conducted by Mr. Paul W. Scates at the University of Tennessee, has a decided effect upon humidity. This, no doubt, explains the absence of any relationship between refrigerator and room humidities.

On Figures 4, 5, 6, and 7 are platted values for the humidities in the electric refrigerators with corresponding room humidities. It is to be noted in each of these figures that there is a definite tendency for the refrigerator humidity to vary directly with the room humidity. Some of the points are rather badly off, but when one considers that an error of $\frac{1}{2}$ degree in opposite directions in the reading of each thermometer would result in approximately 6 to 8 percent error in the humidity at refrigerator temperatures, and that no attempt was made to hold room humidities at constant points, it seems only natural that some such false points would creep in.

In conclusion the author wishes to state that he believes a test conducted on a single electric refrigerator located in a room in which humidity might be controlled, with a more accurate device used in the refrigerator for humidity determinations, would reveal but slight variations from a linear relationship between refrigerator and room humidities.

Ice Refrigerator #1

No	Date	Time	Ice in Box	Dry T	Wet T	Rel Hum	Dry T	Wet T	Rel Hum
1	Apr	14:12:15P	100	64	60	79	70	64	72
2	"	14: 5:35P	80	62	60	89	71	64	68
3	"	15: 7:20A	50	57	56	94	65	60	75
4	"	15: 5:30P	75	63	56	64	75	72	87
5	"	16: 9:45A	40	59	57	89	69	61	63
6	"	16: 5:45P	75	61	55	68	69	64	81
7	"	17: 7:35A	50	54	51	82	67	60	66
8	"	17:12:25P	80	60	55	73	76	65	55
9	"	18: 7:15A	40	55	52	82	70	62	64
10	"	18: 5:30P	75	68	62	71	74	66	75
11	"	19:12:20P	100	62	57	74	74	63	54
12	"	19: 3:00P	90	60	55	73	75	65	59
13	"	20: 7:30P	40	58	54	77	70	62	64
14	"	20:12:15P	80	62	58	79	79	66	50
15	"	21:12:15P	85	62	56	69	76	67	63
16	"	21: 5:45P	70	59	56	72	73	66	69
17	"	22:12:15P	90	50	48	87	61	52	54
18	"	22: 4:00P	75	54	51	82	64	55	56
19	"	23: 7:15A	60	46	44	86	54	47	59
20	"	23:12:15P	80	51	49	87	62	52	50
21	"	24: 7:25A	40	47	45	86	58	51	61
22	"	24:12:15P	80	53	50	81	65	58	66
23	"	27:12:15P	90	52	50	87	66	56	53
24	"	27: 5:35P	65	54	51	82	66	57	57
25	"	28: 7:30A	50	47	44	79	58	51	61
26	"	28:12:15P	80	52	49	81	66	54	44
27	"	29:12:20P	60	60	54	68	71	61	56
28	"	29: 5:30P	40	60	54	68	72	62	57
29	"	30: 8:15A	35	56	52	76	65	57	61
30	"	30:12:15P	75	54	52	88	69	62	67
31	May	1: 7:35A	40	49	44	67	65	58	66
32	"	1:12:15P	90	58	54	77	71	64	64
33	"	1: 5:40P	70	56	51	71	79	65	47
34	"	2:10:45A	100	59	52	62	73	66	69
35	"	2: 5:35P	80	58	53	72	75	67	66
36	"	3:12:20P	70	56	52	76	75	63	51
37	"	4: 7:30A	30	52	48	75	67	57	53
38	"	4:12:15P	70	59	54	72	77	66	56
39	"	5:12:20P	80	58	54	77	72	65	69
40	"	5: 5:50P	50	60	56	78	73	63	57
41	"	6:12:20P	80	56	53	82	69	63	72
42	"	6: 5:40P	60	60	56	78	75	68	70
43	"	7:12:15P	80	54	49	70	62	68	79
44	"	7: 5:35P	60	55	51	76	64	56	60
45	"	8:12:15P	90	56	51	71	69	58	51
46	"	9:12:15P	90	54	50	76	78	69	64
47	"	11:12:15P	80	58	53	72	70	62	48
48	"	11: 5:30P	60	57	51	65	77	62	42
49	"	12: 7:40A	50	53	49	75	70	61	59
50	"	12:12:30P	80	56	52	76	69	60	59

Ice Refrigerator #2

No	Date	Time	Ice	Refrigerator				Room			
			in Box	Dry	T:Wet	T:Rel	Hum	Dry	T:Wet	T:Rel	Hum
1	Apr 15	1:00P	40	68	66	90		73	70	86	
2	"	15: 7:05P	25	66	62	80		76	64	52	
3	"	16: 9:30A	15	64	59	74		76	65	55	
4	"	16: 9:30P	8	68	64	80		78	64	46	
5	"	17: 1:00P	50	64	60	79		82	65	60	
6	"	17: 7:30P	40	66	58	61		80	68	54	
7	"	19: 3:00P	25	61	60	94		78	66	53	
8	"	19: 7:00P	20	65	61	80		79	68	57	
9	"	20:12:30P	25	61	58	84		80	66	48	
10	"	20: 5:00P	20	64	59	74		81	68	51	
11	"	21:11:40A	35	59	58	94		72	65	69	
12	"	21: 6:05P	25	62	58	79		79	68	57	
13	"	22: 8:45A	40	57	56	94		70	60	65	
14	"	22: 4:10P	30	59	55	78		77	64	49	
15	"	23: 9:30A	20	52	51	94		67	56	49	
16	"	23: 6:45P	15	58	52	66		70	59	51	
17	"	24: 2:30P	35	53	50	81		70	59	51	
18	"	24: 7:45P	25	62	56	69		74	62	50	
19	"	27:12:25P	35	58	54	77		75	64	55	
20	"	27: 7:05P	25	60	54	68		78	62	40	
21	"	28:10:05A	25	54	52	88		69	58	51	
22	"	28: 5:30P	20	60	56	78		75	60	41	
23	"	29: 3:20P	50	60	55	73		80	65	44	
24	"	29: 7:25P	40	62	56	69		79	63	41	
25	"	30:12:45P	25	58	53	72		78	66	53	
26	May	1: 1:10P	60	57	52	71		76	66	59	
27	"	1: 7:40P	50	59	56	83		77	66	56	
28	"	2:10:30A	80	56	52	76		75	66	63	
29	"	2: 7:30P	70	52	49	81		78	70	67	
30	"	3:11:45A	60	55	50	70		73	64	61	
31	"	3: 6:00P	40	59	52	62		79	62	37	
32	"	4: 1:30P	70	58	52	66		83	68	46	
33	"	4: 8:45P	50	60	54	68		76	68	67	
34	"	5:10:10A	70	54	50	76		73	65	65	
35	"	5: 4:15P	50	58	53	72		77	67	60	
36	"	6:11:15A	50	56	52	76		73	64	61	
37	"	6: 6:00P	40	61	54	63		82	72	62	
38	"	7: 9:40A	30	58	50	56		71	64	68	
39	"	7: 4:45P	20	58	53	72		73	62	53	
40	"	8:12:30P	70	52	48	75		73	61	50	
41	"	8: 8:45P	60	56	52	76		77	68	63	
42	"	9:11:45A	40	58	53	72		75	63	51	
43	"	9: 5:40P	40	59	54	72		80	71	64	
44	"	10:11:50A	40	58	51	61		75	62	48	
45	"	10: 5:55P	30	58	54	77		77	64	49	
46	"	11: 2:00P	25	60	54	68		78	65	50	
47	"	11: 7:00P	20	59	54	72		79	66	50	
48	"	12:10:10A	40	58	54	77		76	67	63	
49	"	12: 6:40P	30	60	56	78		79	66	50	
50	"	14: 8:10P	20	62	56	69		76	66	59	

Electric Refrigerator #3

No	Date	Time	Refrigerator				Room			
			Dry	T:Wet	T:Rel	Hum	Dry	T:Wet	T:Rel	Hum
1	Apr	15: 7:35A:	61	58	84		66	63	85	
2	"	15: 7:35P:	60	56	78		76	67	63	
3	"	16: 7:45A:	54	51	82		69	63	72	
4	"	16: 8:30P:	52	45	57		76	64	44	
5	"	#17: 1:15P:	54	45	48		79	64	44	
6	"	17: 8:00P:	55	52	82		75	63	51	
7	"	18: 7:35P:	58	56	88		71	63	64	
8	"	18: 7:05P:	56	52	76		76	64	44	
9	"	20: 7:45A:	54	51	82		71	62	60	
10	"	20: 4:10P:	50	44	61		74	65	61	
11	"	21: 7:40A:	50	48	87		69	61	63	
12	"	21: 5:15P:	52	51	94		72	64	65	
13	"	22:12:30P:	52	51	94		70	62	64	
14	"	22: 6:00P:	52	50	87		70	61	59	
15	"	23: 7:45A:	53	51	87		71	60	52	
16	"	23: 6:15P:	50	44	61		75	64	55	
17	"	24: 7:45A:	52	49	81		70	59	51	
18	"	24: 3:15P:	50	46	74		78	67	57	
19	"	26: 8:40A:	54	52	88		75	66	63	
20	"	26: 5:50P:	51	47	74		71	60	52	
21	"	#28: 7:45A:	48	47	93		71	60	52	
22	"	28: 1:45P:	50	46	74		73	65	65	
23	"	29: 7:40A:	50	48	87		65	55	52	
24	"	29: 5:50P:	49	48	93		76	69	70	
25	"	30: 8:40A:	50	48	87		73	60	46	
26	"	30: 9:10P:	50	47	80		75	69	74	
27	May	1: 1:40P:	49	46	80		73	67	73	
28	"	1: 7:15P:	53	50	81		80	73	72	
29	"	2: 9:55A:	50	46	74		73	62	53	
30	"	2: 8:00P:	52	49	81		78	70	67	
31	"	4: 7:45A:	48	44	73		72	63	61	
32	"	4: 5:30P:	49	45	73		75	66	63	
33	"	5: 9:45A:	52	48	75		73	70	86	
34	"	5: 3:30P:	52	48	75		74	65	63	
35	"	6:10:45A:	51	48	80		75	69	74	
36	"	6: 4:40P:	52	49	81		79	73	72	
37	"	7:12:45P:	49	46	80		73	68	78	
38	"	7: 8:10P:	50	47	80		74	66	65	
39	"	8:11:15A:	50	48	87		71	65	72	
40	"	8: 8:00P:	49	46	80		74	65	61	
41	"	9:11:15A:	52	48	75		71	66	77	
42	"	9: 6:00P:	54	50	76		80	71	64	
43	"	10: 7:00P:	54	48	64		78	66	63	
44	"	#11: 1:15P:	50	47	80		76	65	55	
45	"	12: 9:45A:	50	46	74		72	60	49	
46	"	12: 9:30P:	45	42	78		75	64	55	
47	"	13: 7:30A:	49	46	80		72	63	68	
48	"	13: 6:15P:	49	47	87		77	69	67	
49	"	14: 7:45A:	49	47	87		77	69	67	
50	"	14: 5:45P:	51	49	80		74	64	58	

Note: # indicates defrosted on this date.

Electric Refrigerator #4

NO	Date	Time	Refrigerator				Room			
			Dry	T:Wet	T:Rel	Hum	Dry	T:Wet	T:Rel	Hum
1	Apr 15	10:05A	39	36	75		67	60	66	
2	" 15	4:45P	45	41	72		74	70	82	
3	" 16	9:10A	46	44	86		71	62	60	
4	" 16	4:00P	44	40	71		77	74	87	
5	" 17	10:35A	42	38	69		74	61	43	
6	" 17	3:00P	48	45	79		74	64	58	
7	" 18	11:45A	43	38	63		68	62	71	
8	" 18	5:00P	56	53	82		75	65	59	
9	" 20	11:00A	45	41	72		78	69	64	
10	" #20	3:05P	46	44	86		74	65	61	
11	" 22	9:30A	55	52	82		77	63	46	
12	" 22	3:30P	46	44	86		72	57	38	
13	" 23	9:10A	49	45	73		83	65	37	
14	" 23	12:05P	53	50	81		74	58	36	
15	" 24	10:05A	47	45	86		77	62	42	
16	" 24	3:50P	46	42	72		76	63	49	
17	" 27	10:10A	46	43	79		56	44	34	
18	" 27	4:50P	49	44	67		76	58	32	
19	" 28	4:30P	49	46	80		78	57	25	
20	" 29	10:15A	47	45	86		79	63	41	
21	" 29	4:30P	50	46	74		76	57	29	
22	" 30	9:15A	45	42	78		74	61	47	
23	" 30	4:00P	44	43	93		68	58	54	
24	May 1	10:15A	43	40	78		75	65	59	
25	" 1	2:15P	44	42	85		77	67	60	
26	" 2	9:15A	44	43	93		77	69	67	
27	" 2	5:00P	52	50	87		80	70	61	
28	" 4	10:15A	44	40	71		78	67	57	
29	" 4	5:00P	48	46	86		78	68	60	
30	" #5	9:15A	44	42	85		76	69	70	
31	" 5	3:00P	48	46	86		74	69	78	
32	" 6	10:10A	49	46	80		79	70	64	
33	" 6	3:45P	50	48	87		77	68	63	
34	" 7	4:00P	56	51	71		78	64	46	
35	" 9	10:45A	55	53	88		78	70	67	
36	" 11	10:25A	52	48	75		77	60	36	
37	" 11	5:20P	54	47	59		76	62	48	
38	" 12	9:15A	56	50	65		83	66	40	
39	" 12	8:30P	44	40	71		78	65	50	
40	" 13	9:15A	54	47	59		74	61	47	
41	" 13	5:30P	49	45	73		75	61	44	
42	" 14	9:15A	54	48	64		76	63	48	
43	" 14	4:45P	58	53	72		78	65	50	
44	" 15	9:00A	57	50	60		77	65	62	
45	" 15	4:15P	56	51	71		74	63	54	
46	" #16	10:30A	55	51	76		78	64	46	
47	" 18	8:30A	58	53	72		78	67	57	
48	" 18	5:00P	58	53	72		81	69	54	
49	" 19	10:00A	58	53	72		81	69	54	
50	" 19	5:00P	58	54	77		80	65	44	

Note: # indicates defrosted on this date.

ELECTRIC REFRIGERATOR #5

No	Date	Time	Refrigerator			Room			
			Dry T	Wet T	Rel Hum	Dry T	Wet T	Rel Hum	
1	Apr 21	11:30A	60	58	89	73	65	65	
2	" 21	7:00P	55	53	88	74	69	78	
3	" 22	8:30A	50	48	87	71	62	60	
4	" 22	7:00P	52	50	87	75	61	44	
5	" 23	9:45A	48	47	93	74	63	54	
6	" 23	5:20P	48	46	86	70	54	33	
7	" 24	1:10P	43	41	85	74	62	50	
8	" 24	7:15P	48	42	60	74	60	43	
9	" #27	12:20P	54	52	88	74	60	43	
10	" 28	10:35A	41	40	92	70	58	48	
11	" 28	9:10P	46	44	86	72	58	42	
12	" 29	10:35A	43	42	92	75	63	48	
13	" 29	8:00P	46	45	93	70	60	55	
14	" 30	11:45A	53	51	87	72	63	61	
15	May 1	1:50P	46	43	79	76	68	67	
16	" 1	8:00P	49	48	93	78	70	67	
17	" 2	11:00A	46	44	86	75	66	63	
18	" 2	5:45P	44	41	78	79	70	64	
19	" 3	3:30P	42	41	92	75	68	70	
20	" 4	12:55P	38	37	91	75	69	74	
21	" 5	10:30A	42	41	92	75	69	74	
22	" 5	4:30P	44	40	72	72	66	73	
23	" 6	11:50A	46	44	86	74	68	73	
24	" 6	5:10P	47	45	86	76	71	78	
25	" 7	10:05A	45	43	86	75	68	70	
26	" 7	5:50P	47	44	79	70	62	64	
27	" 8	12:05P	46	44	86	79	70	64	
28	" 8	5:00P	48	46	86	75	64	55	
29	" 9	9:30A	44	41	78	67	60	66	
30	" 9	5:45P	48	45	79	74	68	73	
31	" 10	12:45P	47	43	72	80	66	48	
32	" 10	5:30P	46	44	86	70	61	59	
33	" 11	12:45P	45	42	78	76	69	70	
34	" 11	7:00P	58	50	56	74	67	69	
35	" 12	10:25A	44	42	85	75	68	70	
36	" 12	5:40P	45	43	86	68	61	67	
37	" 13	9:40A	50	47	80	77	65	52	
38	" 13	5:00P	46	44	86	78	69	64	
39	" 14	9:45A	48	44	73	76	67	63	
40	" 14	7:00P	50	47	80	75	66	63	
41	" 15	9:30A	47	45	86	75	67	66	
42	" 15	4:45P	49	46	80	79	68	57	
43	" 16	5:00P	47	44	79	77	68	63	
44	" 18	12:45P	47	42	65	82	72	62	
45	" #19	12:40P	47	43	72	76	66	59	
46	" 19	7:00P	52	47	69	79	58	57	
47	" 21	10:30A	42	39	77	71	64	68	
48	" 21	7:15P	42	40	85	75	64	55	
49	" 22	11:30A	41	38	76	75	69	74	
50	" 22	6:00P	45	42	78	73	67	73	

Note: # indicates defrosted on this date.

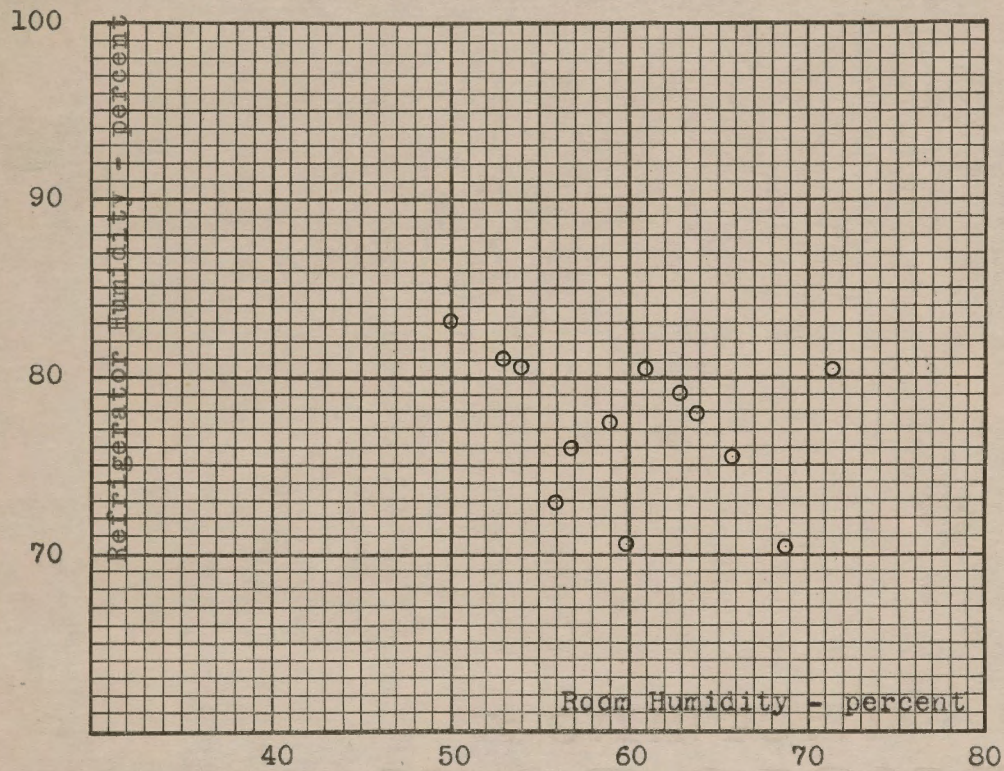
ELECTRIC REFRIGERATOR #6

No	Date	Time	Refrigerator				Room			
			Dry T	Wet T	Rel Hum		Dry T	Wet T	Rel Hum	
1	Apr 28	9:30A	42	37	52		78	63	43	
2	" 28	4:30P	40	36	68		78	57	25	
3	" 29	10:15A	42	41	92		79	63	41	
4	" 29	4:30P	41	38	76		76	57	29	
5	" 30	9:15A	40	38	84		74	61	47	
6	May 1	10:15A	38	37	91		75	65	59	
7	" 1	2:15P	35	34	90		77	67	60	
8	" #2	9:15A	36	35	91		77	69	67	
9	" 2	5:00P	38	37	91		77	68	63	
10	" 4	10:15A	36	34	82		78	67	57	
11	" 4	5:00P	37	36	91		78	68	60	
12	" 5	9:15A	37	36	91		76	69	70	
13	" 5	3:00P	35	34	90		74	69	78	
14	" 6	10:10A	36	34	82		79	70	64	
15	" 6	3:45P	36	34	82		77	68	63	
16	" 7	9:15A	51	50	94		78	67	57	
17	" 7	4:00P	55	49	64		78	64	46	
18	" 12	8:30A	43	40	78		78	65	50	
19	" 13	9:15A	44	39	63		75	62	48	
20	" 13	5:30P	49	45	73		75	61	44	
21	" 14	9:15A	47	42	65		76	63	48	
22	" 14	4:45P	45	42	78		78	65	50	
23	" #15	9:00A	49	45	73		77	65	52	
24	" 15	4:15P	48	45	79		74	63	54	
25	" 16	11:30A	44	42	85		78	64	46	
26	" 18	8:30A	62	56	69		78	67	57	
27	" 18	5:00P	43	39	70		81	69	54	
28	" 19	10:00A	54	49	70		75	63	51	
29	" 19	5:00P	48	45	79		80	65	45	
30	" 20	10:10A	49	42	55		77	71	74	
31	" 20	3:45P	45	41	72		77	69	67	
32	" 21	9:15A	44	41	78		77	63	46	
33	" 21	3:00P	36	32	64		80	67	51	
34	" 22	9:00A	40	37	75		77	66	56	
35	" 22	4:00P	35	31	63		71	65	72	
36	" 23	8:15A	35	32	72		68	55	42	
37	" 25	10:10A	35	34	90		76	66	48	
38	" 25	3:30P	35	33	81		80	69	57	
39	" 26	9:15A	37	36	91		75	63	51	
40	" 26	2:30P	38	36	83		68	58	54	

Note: # indicates defrosted on this date.

LABORATORY

DATE

FIG. NO. 2

TITLE:-

ICE REFRIGERATOR #1

INTERPRETATION OF CURVES

LABORATORY

DATE



FIG. NO. 3

TITLE:-

ICE REFRIGERATOR #2

INTERPRETATION OF CURVES

LABORATORY

DATE

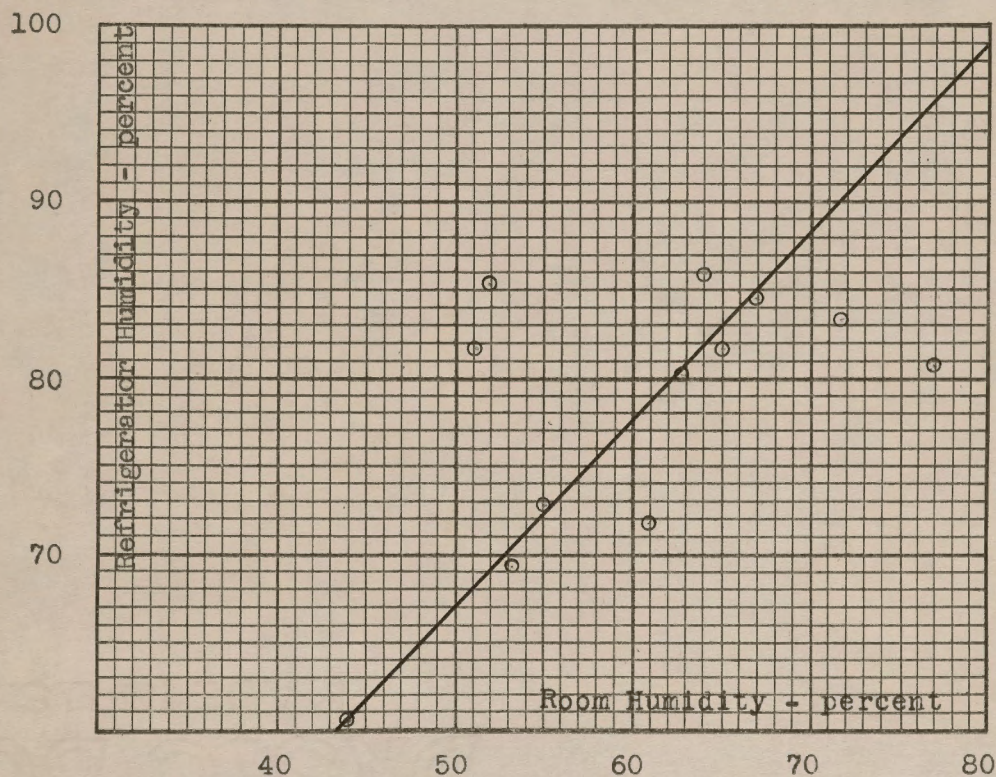


FIG. NO. 4

TITLE:-

ELECTRIC REFRIGERATOR #3

INTERPRETATION OF CURVES

LABORATORY

DATE

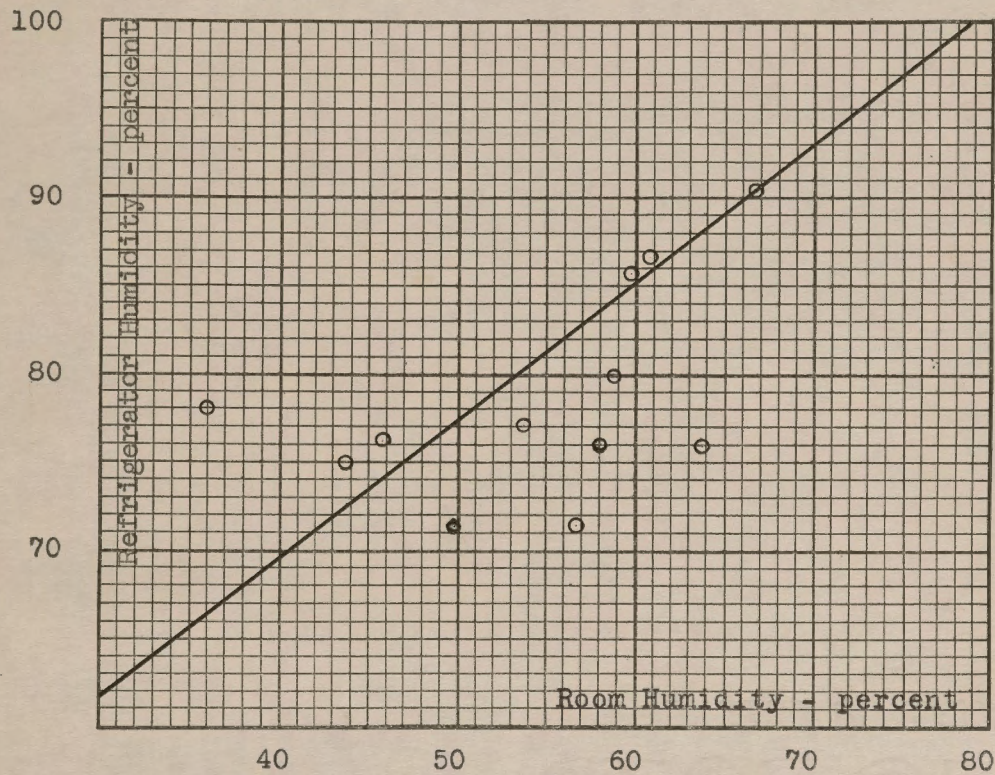


FIG. NO. 5

TITLE:-

ELECTRIC REFRIGERATOR #4

INTERPRETATION OF CURVES

LABORATORY

DATE

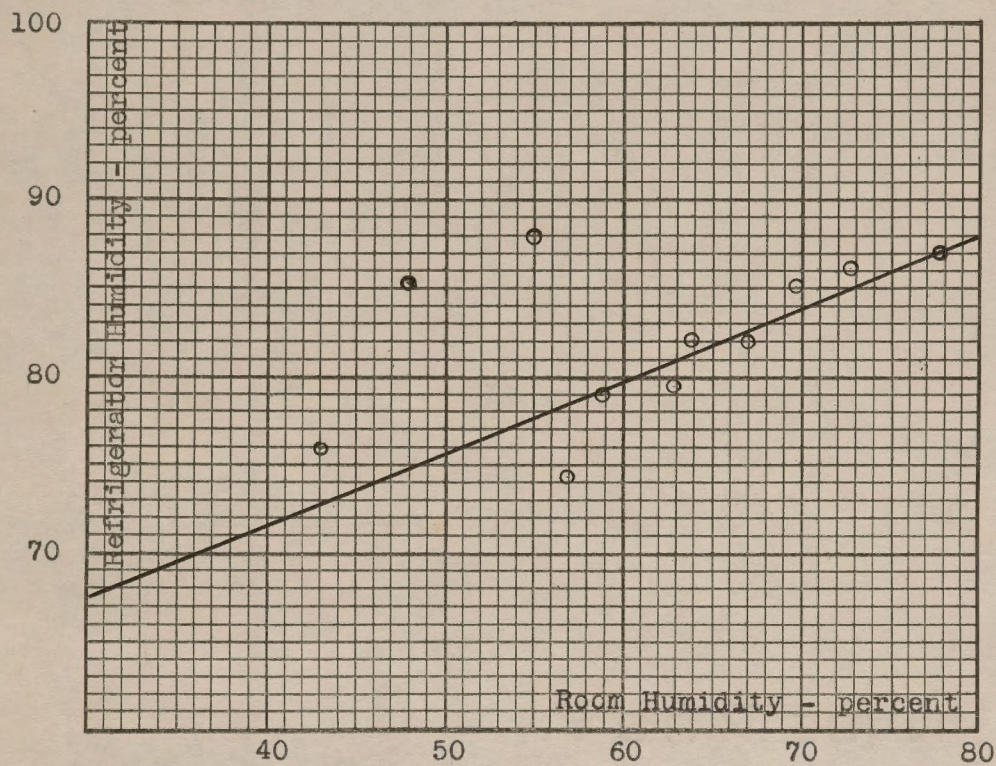


FIG. NO. 6

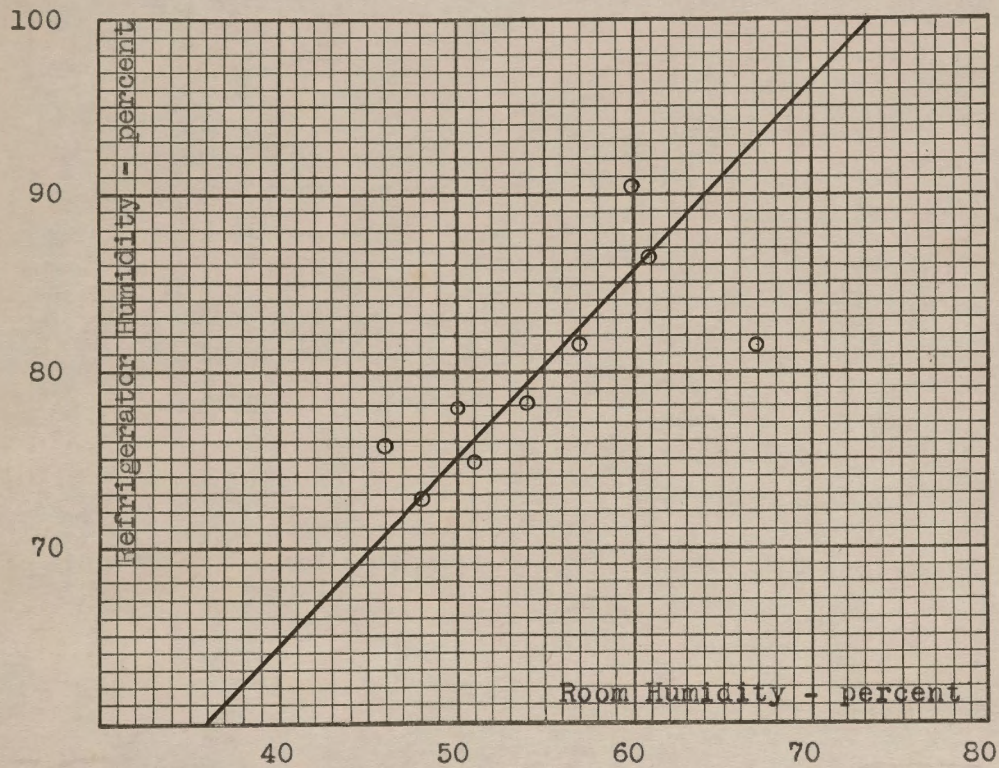
TITLE:-

ELECTRIC REFRIGERATOR #5

INTERPRETATION OF CURVES

LABORATORY

DATE

FIG. NO. 7

TITLE:-

ELECTRIC REFRIGERATOR #6

INTERPRETATION OF CURVES

LABORATORY

DATE

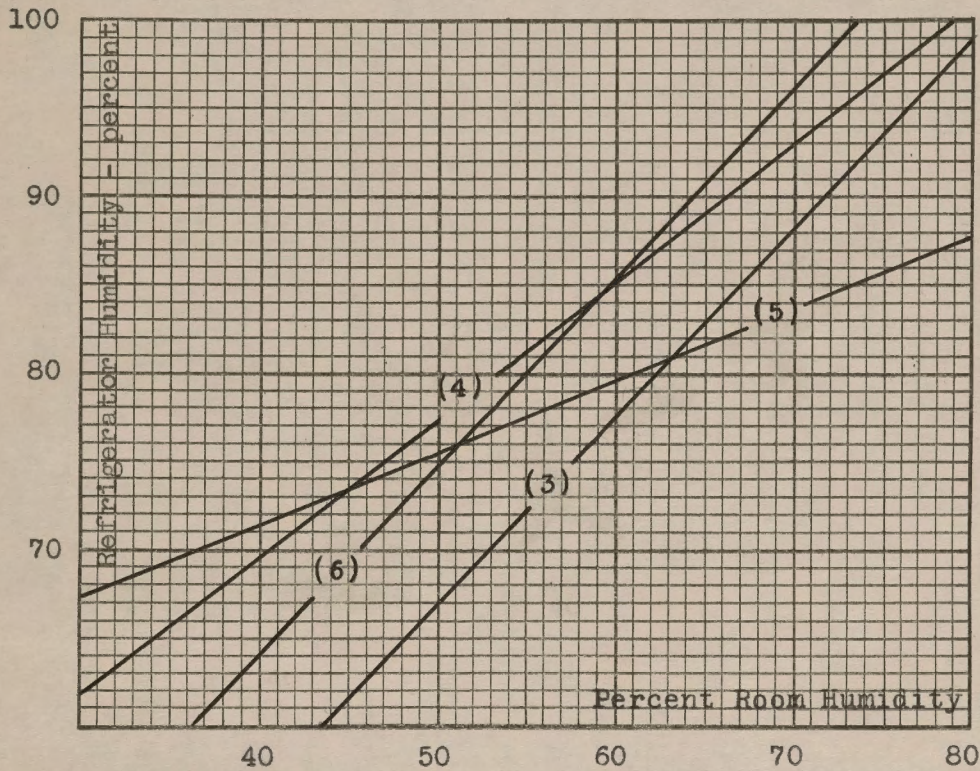


FIG. NO. 8

TITLE:-

ALL ELECTRIC REFRIGERATORS

INTERPRETATION OF CURVES

- Curve (3) - Refrigerator #3
- Curve (4) - Refrigerator #4
- Curve (5) - Refrigerator #5
- Curve (6) - Refrigerator #6

48	93	86	79	73	66	60	54	47	41	35	29	23	18	12	7	1					48
49	93	87	80	73	67	61	55	48	42	37	31	25	20	14	9	3					49
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5					50
51	94	87	80	74	68	62	56	50	44	39	34	28	23	18	12	7	2				51
52	94	87	81	75	69	63	57	51	46	40	35	29	24	19	14	9	4				52
53	94	87	81	75	69	63	58	52	47	41	36	31	26	21	16	11	6				53
54	94	88	82	76	70	64	59	53	48	42	37	32	27	22	17	12	8	3			54
55	94	88	82	76	70	64	59	54	49	43	38	33	29	24	19	14	10	5			55
56	94	88	82	76	71	65	60	55	50	44	39	34	30	25	20	16	11	7	2		56
57	94	88	82	77	71	65	60	56	51	45	40	36	31	26	22	17	13	9	4		57
58	94	88	83	77	72	66	61	56	51	46	41	37	32	27	23	18	14	10	6	1	58
59	94	89	83	78	72	67	62	57	52	47	42	38	33	29	24	20	16	11	8	3	59
60	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21	17	13	9	5	60
61	94	89	84	78	73	68	63	58	54	49	44	40	35	31	27	22	18	14	11	7	61
62	94	89	84	70	74	69	64	59	54	50	45	41	36	32	28	24	20	16	12	8	62
63	95	89	84	79	74	69	64	60	55	50	46	42	37	33	29	25	21	17	14	10	63
64	95	90	84	79	74	70	65	60	56	51	47	43	38	34	30	26	22	18	15	11	64
65	95	90	85	80	75	70	66	61	56	52	48	44	39	35	31	27	24	20	16	13	65
66	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	29	25	21	17	14	66
67	95	90	85	80	75	71	66	62	58	53	49	45	41	37	33	30	26	22	19	15	67
68	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	31	27	23	20	16	68
69	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	32	28	24	21	18	69
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	29	25	22	19	70
71	95	90	86	81	77	72	68	64	60	56	52	48	45	41	37	33	30	27	23	20	71
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	34	31	28	24	21	72
73	95	91	86	82	78	73	69	65	61	57	53	50	46	42	38	35	32	29	25	22	73
74	95	91	86	82	78	73	69	65	61	58	54	50	47	43	39	36	33	29	26	23	74
75	96	91	87	82	78	74	70	66	63	59	55	51	48	44	41	38	34	31	28	25	75
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42	38	36	32	29	26	76
77	96	91	87	83	79	74	71	67	63	60	56	52	49	46	42	39	36	33	30	27	77
78	96	91	87	83	79	75	71	67	64	60	57	53	50	46	43	40	37	34	31	28	78
79	96	91	87	83	79	75	71	68	64	60	57	54	50	47	44	41	37	34	31	29	79
80	96	91	87	83	79	75	72	68	64	61	57	54	51	48	44	41	38	36	32	29	80
81	96	92	88	84	80	76	72	68	64	61	58	54	51	48	45	42	39	36	33	30	81
82	96	92	88	84	80	76	72	69	65	62	58	55	52	49	46	43	40	37	34	31	82
83	96	92	88	84	80	76	72	69	65	62	59	56	52	49	46	43	40	37	34	31	83
84	96	92	88	84	80	76	73	70	66	63	59	56	53	50	47	44	41	38	35	32	84
85	96	92	88	84	80	77	73	70	66	63	60	57	53	50	47	44	41	38	36	33	85
86	96	92	88	85	81	77	74	70	67	63	60	57	53	51	48	45	42	39	37	34	86
87	96	92	88	85	81	77	74	71	67	64	61	57	53	51	48	45	42	40	37	34	87
88	96	92	88	85	81	77	74	71	67	64	61	58	54	52	49	46	43	41	38	35	88
89	96	92	88	85	81	78	74	71	68	64	61	58	54	52	49	46	43	41	38	36	89
90	96	92	89	85	81	78	75	71	68	65	62	59	55	53	50	47	44	42	39	37	90
91	96	92	89	85	81	78	75	71	68	65	62	59	56	53	50	47	44	42	39	37	91
92	96	92	89	85	82	78	75	71	69	65	62	59	56	54	51	48	45	43	40	38	92
93	96	93	89	85	82	78	75	72	69	66	63	60	56	54	51	48	45	43	40	38	93
94	96	93	89	86	82	78	75	72	69	66	63	60	57	54	52	49	46	44	41	39	94
95	96	93	89	86	82	79	75	72	69	66	63	60	57	55	52	49	46	44	41	39	95
96	96	93	89	86	82	79	76	72	70	67	64	61	57	55	53	50	47	45	42	40	96
97	96	93	89	86	82	79	76	73	70	67	64	61	58	56	53	50	47	45	42	40	97
98	96	93	89	86	83	79	76	73	71	67	64	62	59	57	54	52	48	46	43	41	98
99	96	93	89	86	83	79	76	74	71	68	65	62	59	57	54	53	49	47	44	42	99
100	96	93	90	86	84	80	77	74	73	70	67	64	61	58	56	53	51	48	46	43	100

[illegible]

RELATIVE HUMIDITY IN PERCENT AT DIFFERENT DRY BULB
AND WET BULB READINGS

Degrees of Wet Bulb Below Dry Bulb Temperature

Degrees of wet bulb below dry bulb temperature																																						
Dry Bulb	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Dry Bulb	
0	67	33																																			0	
1	68	36	3																																		1	
2	70	39	9																																		2	
3	71	42	13																																		3	
4	72	44	17																																		4	
5	73	47	20																																		5	
6	74	49	23																																		6	
7	75	51	26	2																																	7	
8	76	53	29	6																																	8	
9	77	55	32	9																																	9	
10	78	56	34	13																																	10	
11	79	58	37	16																																	11	
12	80	59	39	19																																	12	
13	80	61	43	23	4																																13	
14	81	62	44	26	8																																14	
15	81	63	46	28	11																																15	
16	82	65	48	31	14																																16	
17	83	67	50	33	17	1																															17	
18	84	68	52	36	20	5																															18	
19	84	69	54	38	23	9																															19	
20	85	70	55	40	26	12																															20	
21	85	70	56	42	28	15	1																														21	
22	86	71	58	44	31	17	4																														22	
23	86	72	59	46	33	19	7																														23	
24	87	73	60	47	35	22	10																														24	
25	87	74	61	49	37	25	13	1																													25	
26	87	75	63	51	39	27	16	4																													26	
27	88	75	64	52	41	29	19	7																													27	
28	88	76	65	54	43	32	21	10																													28	
29	88	77	66	55	44	34	23	13	2																												29	
30	89	78	67	56	46	36	26	16	6																												30	
31	89	78	68	58	47	38	28	18	9																												31	
32	89	79	69	59	49	39	30	20	11	2																											32	
33	89	80	70	60	50	41	32	22	14	5																											33	
34	90	81	71	62	52	43	34	25	16	8																											34	
35	90	81	72	63	54	44	36	27	18	11	3																										35	
36	91	82	73	64	55	46	38	29	21	13	5																										36	
37	91	82	74	65	57	48	40	31	23	15	8																										37	
38	91	83	75	66	58	50	42	33	25	17	10	2																									38	
39	92	83	75	67	59	51	44	35	27	20	13	5																									39	
40	92	84	75	68	60	52	45	37	29	22	15	7																									40	
41	92	84	76	69	61	54	46	39	31	24	17	10	3																								41	
42	92	85	77	69	62	55	47	40	33	26	19	12	5																								42	
43	92	85	78	70	63	56	48	40	35	28	21	14	8	2																							43	
44	93	85	78	71	63	56	49	43	36	30	23	16	10	4																							44	
45	93	86	78	72	64	57	51	44	38	31	25	18	12	6																							45	
46	93	86	79	72	65	58	52	45	39	32	26	20	14	8	2																						46	
47																																						47

Dry Bulb	1	2	3
0	67	33	
1	68	36	3
2	70	39	9
3	71	42	13
4	72	44	17
5	73	47	20
6	74	49	23
7	75	51	26
8	76	53	29
9	77	55	32
10	78	56	34
11	79	58	37
12	80	59	39
13	80	61	43
14	81	62	44
15	81	63	46
16	82	65	48
17	83	67	50
18	84	68	52
19	84	69	54
20	85	70	55
21	85	70	56
22	86	71	58
23	86	72	59
24	87	73	60
25	87	74	61
26	87	75	63
27	88	75	64
28	88	76	65
29	88	77	66
30	89	78	67
31	89	78	68
32	89	79	69
33	89	80	70
34	90	81	71
35	90	81	72
36	91	82	73
37	91	82	74
38	91	83	75
39	92	83	75
40	92	84	75
41	92	84	76
42	92	85	77
43	92	85	78
44	93	85	78
45	93	86	78
46	93	86	79

APPENDIX A

Table of Relative Humidities

Degrees of Wet Bulb Below Dry Bulb Temperature

Dry		Degrees of wet bulb below dry bulb temperature																																				Dry	
Bulb	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Bulb		
0	67	33																																				0	
1	68	36	3																																			1	
2	70	39	9																																			2	
3	71	42	13																																			3	
4	72	44	17																																			4	
5	73	47	20																																			5	
6	74	49	23																																			6	
7	75	51	26	2																																		7	
8	76	53	29	6																																		8	
9	77	55	32	9																																		9	
10	78	56	34	13																																		10	
11	79	58	37	16																																		11	
12	80	59	39	19																																		12	
13	80	61	43	23	4																																	13	
14	81	62	44	26	8																																	14	
15	81	63	46	28	11																																	15	
16	82	65	48	31	14																																	16	
17	83	67	50	33	17	1																																17	
18	84	68	52	36	20	5																																18	
19	84	69	54	38	23	9																																19	
20	85	70	55	40	26	12																																20	
21	85	70	56	42	28	15	1																															21	
22	86	71	58	44	31	17	4																															22	
23	86	72	59	46	33	19	7																															23	
24	87	73	60	47	35	22	10																															24	
25	87	74	61	49	37	25	13	1																														25	
26	87	75	63	51	39	27	16	4																														26	
27	88	75	64	52	41	29	19	7																														27	
28	88	76	65	54	43	32	21	10																														28	
29	88	77	66	55	44	34	23	13	2																													29	
30	89	78	67	56	46	36	26	16	6																													30	
31	89	78	68	58	47	38	28	18	9																													31	
32	89	79	69	59	49	39	30	20	11	2																												32	
33	89	80	70	60	50	41	32	22	14	5																												33	
34	90	81	71	62	52	43	34	25	16	8																												34	
35	90	81	72	63	54	44	36	27	18	11	3																											35	
36	91	82	73	64	55	46	38	29	21	13	5																											36	
37	91	82	74	65	57	48	40	31	23	15	8																											37	
38	91	83	75	66	58	50	42	33	25	17	10	2																										38	
39	92	83	75	67	59	51	44	35	27	20	13	5																										39	
40	92	84	75	68	60	52	45	37	29	22	15	7																										40	
41	92	84	76	69	61	54	46	39	31	24	17	10	3																									41	
42	92	85	77	69	62	55	47	40	33	26	19	12	5																									42	
43	92	85	78	70	63	56	48	40	35	28	21	14	8	2																								43	
44	93	85	78	71	63	56	49	43	36	30	23	16	10	4																								44	
45	93	86	78	72	64	57	51	44	38	31	25	18	12	6																								45	

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 warrent its acceptance as a prerequisite to the degree for which it has been submitted. It is to be 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 was submitted.

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