1

What is the purpose of an evaporative cooling system?

- The purpose of an evaporative cooling system is to maintain a house temperature of 30°C or lower during hot weather


2

It is not…

- To maintain an actual house temperature in the seventies…

- which in most poultry growing areas of the U.S./world is not possible.

3

Or…

- to totally eliminate heat stress

- Rather to keep heat stress to manageable levels so that performance is minimally affected during hot weather.

4

Because the fact is no matter how good an evaporative cooling system is, there will be days when our birds will get hot…

- we just want to keep those days/hours to a minimum.

5

6

As water evaporates into the air, heat is air essentially "removed" from the air…

- In fact, for every liter of water we can evaporate into the air…
- 2,200 Btu's of heat is essentially "removed" from the air.
  - Same amount of heat as produced by 75, 2.2 kg chickens
- As heat is "removed" the temperature of the air decreases.

7

The greater amount of water you can evaporate…

- the greater the amount of heat "removed" from the air,
- the greater the reduction in air temperature.

8

How much water you can evaporate into the air depends on how much water is already in the air:

- Dryer air (low RH):
  - Can hold more water and therefore has a higher potential for cooling

9

How much water you can evaporate into the air depends on how much water is already in the air:

- Dryer air (low RH):
  - Can hold more water and therefore has a higher potential for cooling

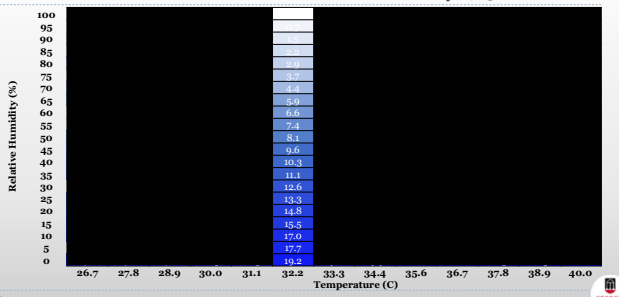
- Humid air (high RH):
  - Can hold less water and therefore has a lower potential for cooling

10

There are charts that illustrate the maximum amount of cooling that can be produced through the evaporation of water into the air

11

Maximum amount cooling produced through the evaporation of water into the air as a function of relative humidity @ 32°C



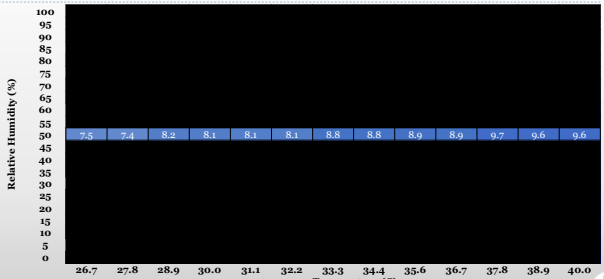
12

Air temperature also has an effect on the amount of water you can evaporate

- Warmer air can hold more water than cooler air therefore evaporative cooling is more effective at higher air temperatures

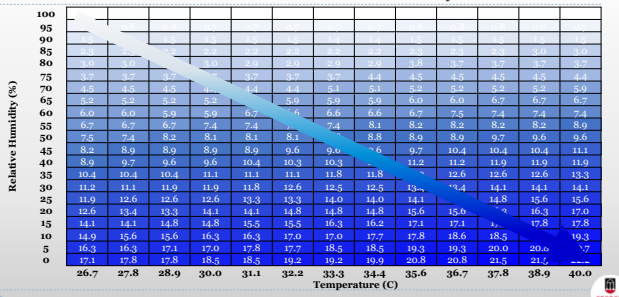
13

Maximum amount of cooling produced through the evaporation of water in to the air as a function of temperature



14

Maximum amount of cooling produced through the evaporation of water into the air as a function of relative humidity



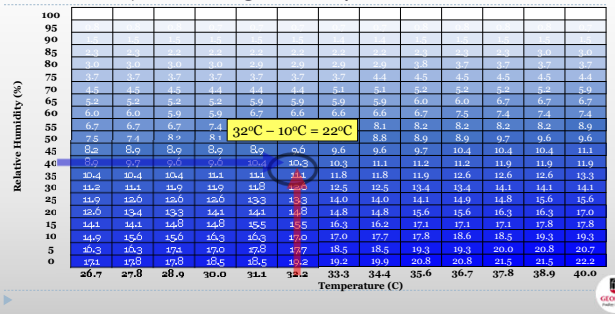
15

From this chart we can determine the maximum temperature reduction that can occur using evaporative cooling

- For instance, when it is 32°C and 40% RH

16

For instance, when it is 32°C and 40% RH



17

The chart can be modified to show air lowest achievable air temperature possible through the use of evaporative cooling

18

So instead of this…

Relative Humidity (%)	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
100													
95													
90													
85													
80													
75	3.7	3.7	3.7	3.7	3.7	3.7	3.7	4.4	4.5	4.5	4.5	4.5	4.4
70	4.5	4.5	4.5	4.4	4.4	4.4	5.1	5.1	5.2	5.2	5.2	5.2	5.9
65	5.2	5.2	5.2	5.2	5.9	5.9	5.9	5.9	6.0	6.0	6.7	6.7	6.7
60	6.0	6.0	5.9	5.9	6.7	6.6	6.6	6.6	6.7	7.5	7.4	7.4	7.4
55	6.7	6.7	6.7	7.4	7.4	7.4	7.4	8.1	8.2	8.2	8.2	8.2	8.9
50	7.5	7.4	8.2	8.1	8.1	8.1	8.8	8.8	8.9	8.9	9.7	9.6	9.6
45	8.2	8.9	8.9	8.9	8.9	9.6	9.6	9.6	9.7	10.4	10.4	10.4	11.1
40	9.0	9.7	9.7	9.7	9.7	10.3	10.3	11.1	11.2	11.2	11.9	11.9	11.9
35	10.4	10.4	10.4	11.1	11.1	11.1	11.8	11.8	11.9	12.6	12.6	12.6	13.3
30	11.2	11.1	11.9	11.9	11.8	12.6	12.5	12.5	13.4	13.4	14.1	14.1	14.1
25	11.9	12.6	12.6	12.6	13.3	13.3	14.0	14.0	14.1	14.9	14.8	15.6	15.6
20	12.6	13.4	13.3	14.1	14.1	14.8	14.8	14.8	15.6	15.6	16.3	16.3	17.0
15	14.1	14.1	14.8	14.8	15.5	15.5	16.3	16.2	17.1	17.1	17.1	17.8	17.8
10	14.9	15.6	15.6	16.3	16.3	17.0	17.0	17.7	17.8	18.6	18.5	19.3	19.3
5	16.3	16.3	17.1	17.0	17.8	17.7	18.5	18.5	19.3	19.3	20.0	20.8	20.7
0	17.1	17.8	17.8	18.5	18.5	19.2	19.2	19.9	20.8	20.8	21.5	21.5	22.2

Temperature (C)

19

We get this

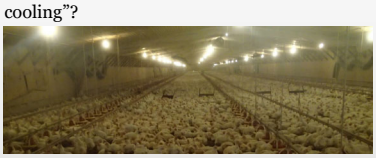
Relative Humidity (%)	26.7	27.8	28.9	30.0	31.1	32.3	33.3	34.5	35.5	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9	30.0	31.1	32.3	33.3	34.5	35.5	36.7	37.8	38.9	40.0
95	25.9	27.0	28.1	29.3	30.4	31.6	32.6	33.7	34.8	35.9	37.0	38.1	39.3
90	25.2	26.3	27.4	28.5	29.6	30.8	31.9	33.0	34.1	35.2	36.3	37.4	38.5
85	24.4	25.5	26.7	27.8	28.9	30.1	31.1	32.2	33.3	34.4	35.5	35.9	37.0
80	23.7	24.8	25.9	27.0	28.2	29.4	30.4	31.5	31.8	33.0	34.1	35.2	36.3
75	23.0	24.1	25.2	26.3	27.4	28.6	29.6	30.0	31.1	32.2	33.3	34.4	35.6
70	22.2	23.3	24.4	25.6	26.7	27.9	28.2	29.3	30.4	31.5	32.6	33.7	34.1
65	21.5	22.6	23.7	24.8	25.2	26.4	27.4	28.5	29.6	30.7	31.1	32.2	33.3
60	20.7	21.8	23.0	24.1	24.4	25.7	26.7	27.8	28.9	29.2	30.4	31.5	32.6
55	20.0	21.1	22.2	22.6	23.7	24.9	25.9	26.3	27.4	28.5	29.6	30.7	31.1
50	19.2	20.4	20.7	21.9	23.0	24.2	24.5	25.6	26.7	27.8	28.1	29.3	30.4
45	18.5	18.9	20.0	21.1	22.2	22.7	23.7	24.8	25.9	26.3	27.4	28.5	28.9
40	17.8	18.1	19.3	20.4	20.7	22.0	23.0	23.3	24.4	25.5	25.9	27.0	28.1
35	16.3	17.4	18.5	18.9	20.0	21.2	21.5	22.6	23.7	24.1	25.2	26.3	26.7
30	15.5	16.7	17.0	18.1	19.3	19.7	20.8	21.9	22.2	23.3	23.7	24.8	25.9
25	14.8	15.2	16.3	17.4	17.8	19.0	19.3	20.4	21.5	21.8	23.0	23.3	24.4
20	14.1	14.4	15.6	15.9	17.0	17.5	18.5	19.6	20.0	21.1	21.5	22.6	23.0
15	12.6	13.7	14.1	15.2	15.6	16.8	17.0	18.2	18.5	19.6	20.7	21.1	22.2
10	11.8	12.2	13.3	13.7	14.8	15.3	16.3	16.7	17.8	18.1	19.3	19.6	20.7
5	10.4	11.5	11.8	13.0	13.3	14.6	14.8	15.9	16.3	17.4	17.8	18.1	19.3
0	9.6	10.0	11.1	11.5	12.6	13.1	14.1	14.5	14.8	15.9	16.3	17.4	17.8

Temperature (C)

20

But…

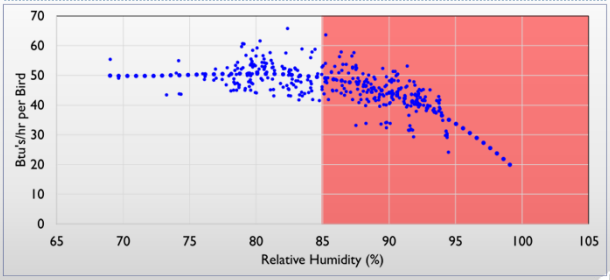
- Do we really want the "lowest achievable" air temperatures when using evaporative cooling"?



- To achieve **maximum** amount of evaporative cooling we would have to evaporate the **maximum** amount of water into the air resulting in a relative humidity of 100%
  - This will actually increase heat stress.

21

Respiratory heat loss Vs. Relative humidity



22

Do we really want the "lowest achievable" air temperatures when using evaporative cooling"?

- Can actually increase bird heat stress.
- No moisture removal from litter

23

This is why we use pads that are only about 75% efficient at saturating the air with moisture

24

So instead of getting 22°C…

Relative Humidity (%) \ Temperature (C)	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.5	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9	30.0	31.1	32.3	33.3	34.5	35.5	36.7	37.8	38.9	40.0
95	25.9	27.0	28.1	29.3	30.4	31.6	32.6	33.7	34.8	35.9	37.0	38.1	39.3
90	25.2	26.3	27.4	28.5	29.6	30.8	31.9	33.0	34.1	35.2	36.3	37.4	38.5
85	24.4	25.5	26.7	27.8	28.9	30.1	31.1	32.2	33.3	34.4	35.5	35.9	37.0
80	23.7	24.8	25.9	27.0	28.2	29.4	30.4	31.5	31.8	33.0	34.1	35.2	36.3
75	23.0	24.1	25.2	26.3	27.4	28.6	29.6	30.0	31.1	32.2	33.3	34.4	35.6
70	22.2	23.3	24.4	25.6	26.7	27.9	28.2	29.3	30.4	31.5	32.6	33.7	34.1
65	21.5	22.6	23.7	24.8	25.2	26.4	27.4	28.5	29.6	30.7	31.1	32.2	33.3
60	20.7	21.8	23.0	24.1	24.4	25.7	26.7	27.8	28.9	29.2	30.4	31.5	32.6
55	20.0	21.1	22.2	22.6	23.7	24.9	25.9	26.3	27.4	28.5	29.6	30.7	31.1
50	19.2	20.4	20.7	21.9	23.0	24.2	24.5	25.6	26.7	27.8	28.1	29.3	30.4
45	18.5	18.9	20.0	21.1	22.3	22.7	23.7	24.8	25.9	26.3	27.4	28.5	28.9
40	17.8	18.1	19.3	20.4	20.7	22.0	23.0	23.3	24.4	25.5	25.9	27.0	28.1
35	17.3	17.4	18.5	18.9	20.0	21.3	21.5	22.6	23.7	24.1	25.2	26.3	26.7
30	15.5	16.7	17.0	18.1	19.3	19.7	20.8	21.9	22.2	23.3	23.7	24.8	25.9
25	14.8	15.2	16.3	17.4	17.8	19.0	19.3	20.4	21.5	21.8	23.0	23.3	24.4
20	14.1	14.4	15.6	15.9	17.0	17.5	18.5	19.6	20.0	21.1	21.5	22.6	23.0
15	12.6	13.7	14.1	15.2	15.6	16.8	17.0	18.2	18.5	19.6	20.7	21.1	22.2
10	11.8	12.2	13.3	13.7	14.8	15.3	16.3	16.7	17.8	18.1	19.3	19.6	20.7
5	10.4	11.5	11.8	13.0	13.3	14.6	14.8	15.9	16.3	17.4	17.8	18.1	19.3
0	9.6	10.0	11.1	11.5	12.6	13.1	14.1	14.5	14.8	15.9	16.3	17.4	17.8

25

We get this with a 75% efficient system

Relative Humidity (%) \ Temperature (C)	27	28	29	30	31	32	33	34	36	37	38	39	40
100	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
95	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	37.2	38.3	39.4
90	25.6	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9
85	25.0	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	36.7	37.8
80	24.4	25.6	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0	36.1	37.2
75	23.9	25.0	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4	35.6	36.7
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4	30.6	31.7	32.8	33.9	35.0	35.6
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4	30.6	31.7	32.8	33.3
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	30.6	31.7	32.8
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9	30.0	31.1	31.7
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9	30.0	31.1
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	30.0
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3

26

Is a pad cooling efficiency of 75% good enough to meet our cooling goal?

- Will we be able to maintain a temperature of 30°C or lower during hot weather?

27

What weather conditions would cause a problem for us? Prevent us from obtaining our goal?

Relative Humidity (%) \ Temperature (C)	27	28	29	30	31	32	33	34	36	37	38	39	40
100	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
95	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	37.2	38.3	39.4
90	25.6	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9
85	25.0	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	36.7	37.8
80	24.4	25.6	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0	36.1	37.2
75	23.9	25.0	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4	35.6	36.7
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4	30.6	31.7	32.8	33.9	35.0	35.6
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4	30.6	31.7	32.8	33.3
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	30.6	31.7	32.8
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9	30.0	31.1	31.7
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9	30.0	31.1
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	30.0
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3

28

15 cm pad – Ideal outside conditions

Relative Humidity (%) \ Temperature (C)	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9										
95	26.1	27.2	28.3	29.4									
90	25.6	26.7	27.8	28.9									
85	25.0	26.1	27.2	28.3	29.4								
80	24.4	25.6	26.7	27.8	28.9								
75	23.9	25.0	26.1	27.2	28.3	29.4							
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4						
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9						
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4					
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4				
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9				
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9			
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9		
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3

29

15 cm pad – Dangerous outside conditions

Relative Humidity (%) \ Temperature (C)	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9	30.0	31.1								
95	26.1	27.2	28.3	29.4	30.6								
90	25.6	26.7	27.8	28.9	30.0	31.1							
85	25.0	26.1	27.2	28.3	29.4	30.6							
80	24.4	25.6	26.7	27.8	28.9	30.0	31.1						
75	23.9	25.0	26.1	27.2	28.3	29.4	30.6	31.1					
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4	30.6					
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	31.1				
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4	30.6	31.1			
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4	30.6			
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	30.6		
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9	30.0	31.1	
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9	30.0	31.1
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	30.0
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3

30

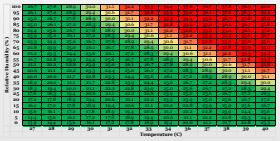
15 cm pad – Deadly outside conditions

Relative Humidity (%)	Temperature (C)												
	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
95	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	37.2	38.3	39.4
90	25.6	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9
85	25.0	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	36.7	37.8
80	24.4	25.6	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0	36.1	37.2
75	23.9	25.0	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4	35.6	36.7
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4	30.6	31.7	32.8	33.9	35.0	35.6
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4	30.6	31.7	32.8	33.3
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	30.6	31.7	32.8
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9	30.0	31.1	31.7
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9	30.0	31.1
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	30.0
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3

31

Dangerous outside conditions

- Do not worry too much about these situations because:
  - They tend to be rare and short lived
    - a few hours during a day…a few times a year
  - Do not necessarily result in serious drops in bird performance IF…
    - the evaporative cooling system is properly designed and maintained!
    - you have sufficient wind speed!
    - the birds are evenly distributed throughout a house!



32

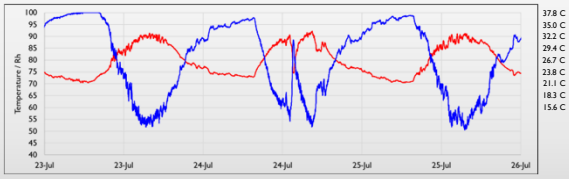
What do you do on a day when incoming air temperature is going to be 32°C or higher (Deadly outside conditions)?

Relative Humidity (%)	Temperature (C)												
	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
95	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	37.2	38.3	39.4
90	25.6	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9
85	25.0	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	36.7	37.8
80	24.4	25.6	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0	36.1	37.2
75	23.9	25.0	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4	35.6	36.7
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4	30.6	31.7	32.8	33.9	35.0	35.6
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4	30.6	31.7	32.8	33.3
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	30.6	31.7	32.8
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9	30.0	31.1	31.7
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9	30.0	31.1
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	30.0
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3

33

You don't have to worry about it…

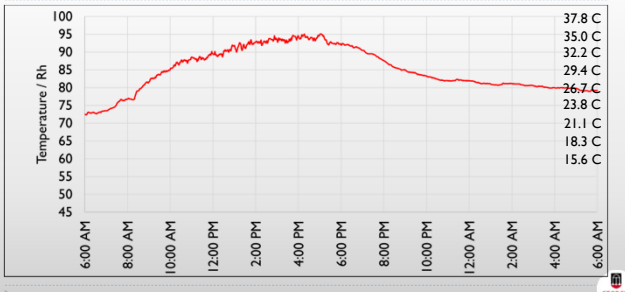
- Because the outdoor conditions required to generate an incoming air temperature above 32°C do not occur in nature



- Due to the inverse relationship between temperature and relative humidity.

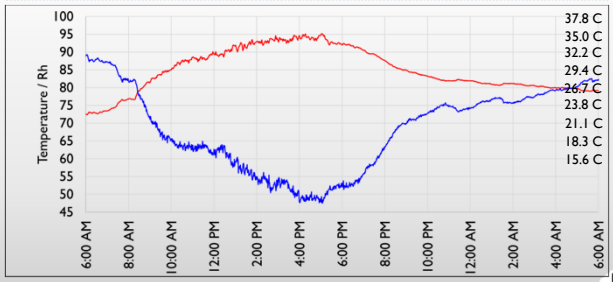
34

As temperature increases over the course of the day…



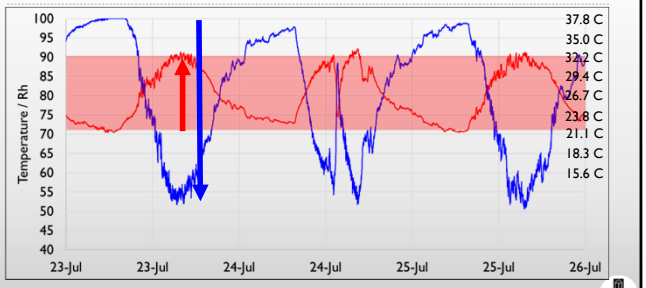
35

relative humidity decreases



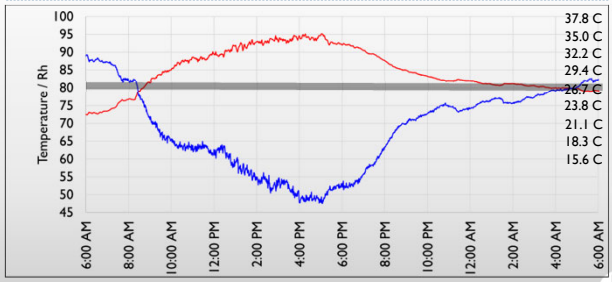
36

For every 10°C the outside air temperature increases, the outside RH will be cut in half



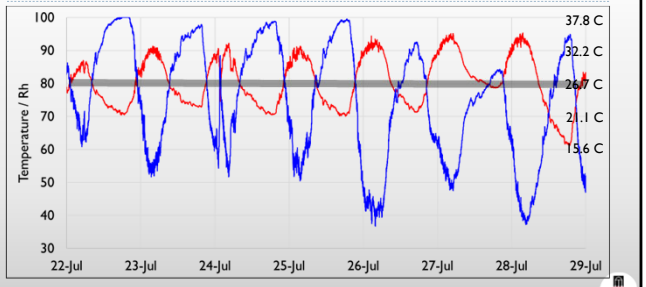
37

The cross-over tends to occur at 27°C – 80% RH



38

The cross-over tends to occur at 27°C – 80% RH



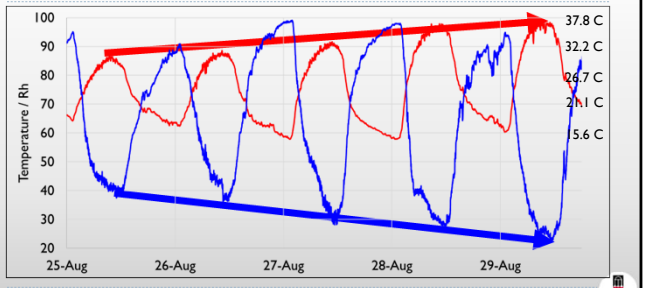
39

Relationship between outside temperature and RH

- Hotter days tend to be drier than cooler days

40

Hotter days tend to be drier than cooler days



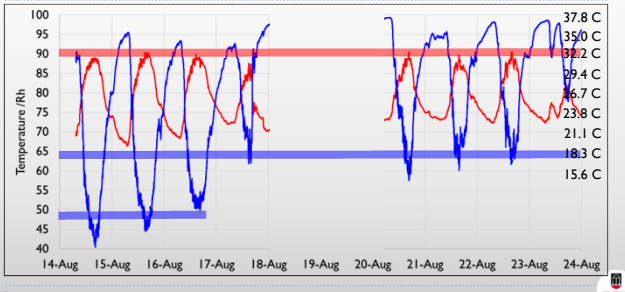
41

That being said

- Some days are more humid than others…

42

32°C days with different levels of RH



43

But at any given temperature…

- The variation in relative humidity tends to be relatively minimal in most poultry growing locations.

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Typically, around 30% variation

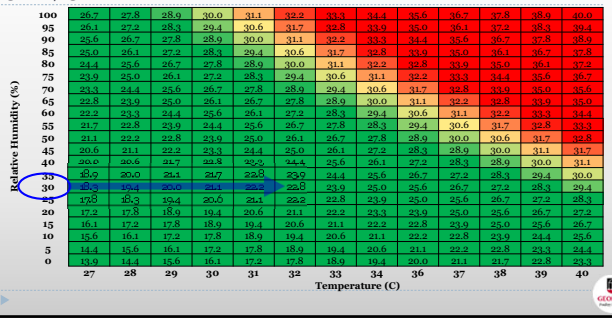
- For instance…32°C, 30% (very dry day) vs. 32°C, 60% (very humid day)

45

Though 30% difference in RH may not seem like much, but it can make a big difference in cooling!

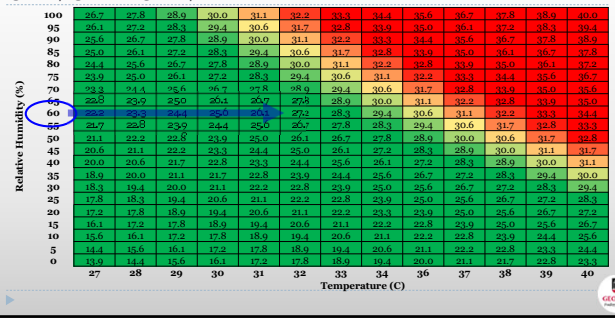
46

Incoming air temperature with 15 cm pad system 32°C / 30%



47

Incoming air temperature with 15 cm pad system 32°C / 30% vs 32°C / 60%



48

But in some climates, with rainy and dry seasons, it can vary 40% or more

- For example…32ºC, 10% vs. 32ºC, 60%

- ….but the vast majority of poultry are grown in" humid" climates

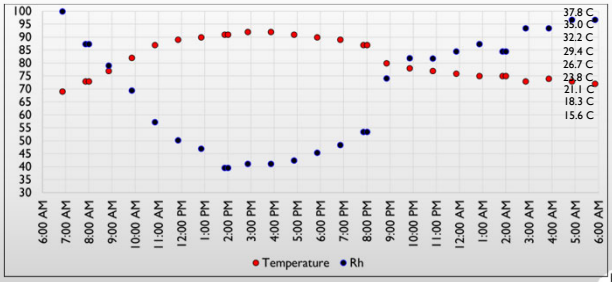
49

To better understand the relationship between temperature, RH and evaporative cooling…

- It is may be better to graph relative humidity vs. temperature

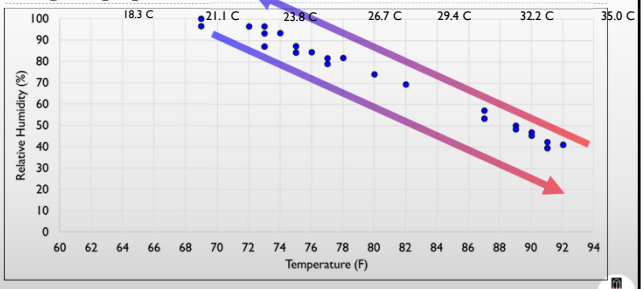
50

So instead of a graph like this for a 24-hour period…



51

We get a graph that looks like this



52

Athens, Georgia – 2018
(Hourly temperature and RH)

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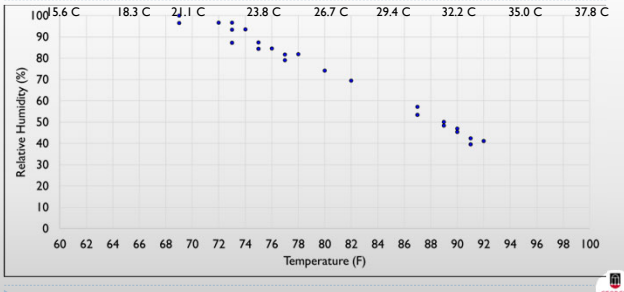
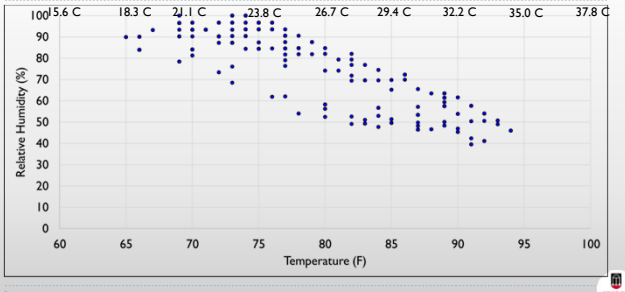
July 10, 2018



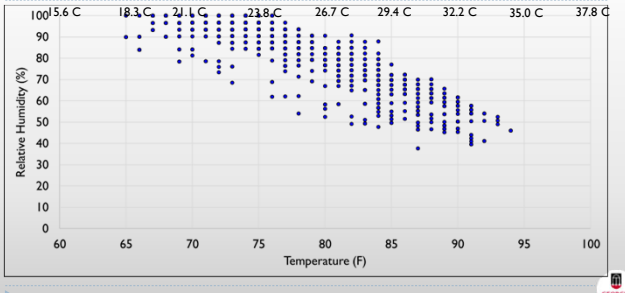
54

July 7 – 13, 2018



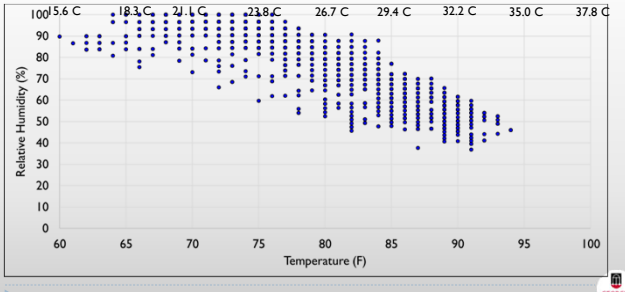
55

July 2018



56

July - August 2018



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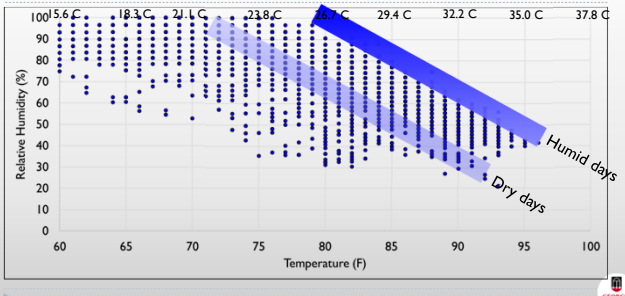
June - September 2018



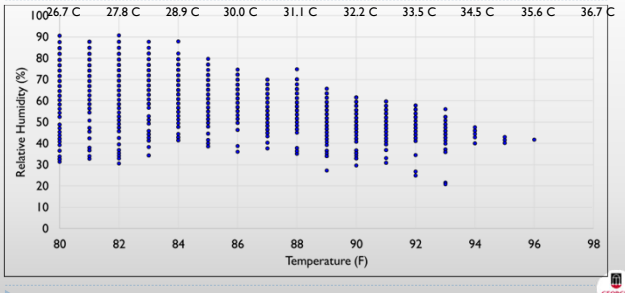
58

Can we meet our evaporative cooling system goals in Athens, Georgia during the summer 2018?

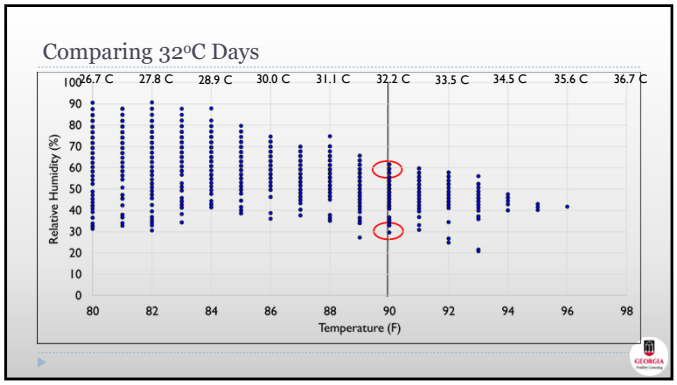
- Namely to maintain a house temperature 30°C or lower

59

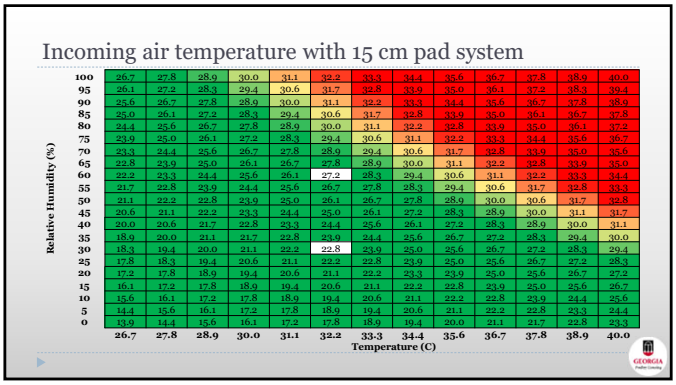
Let's just look at all days where outside temperature is 27°C or higher



60



61



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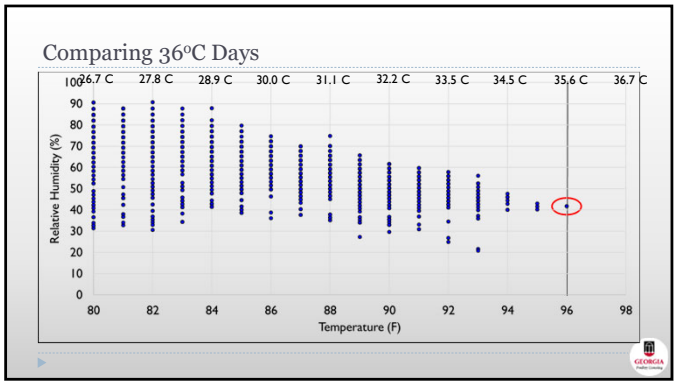
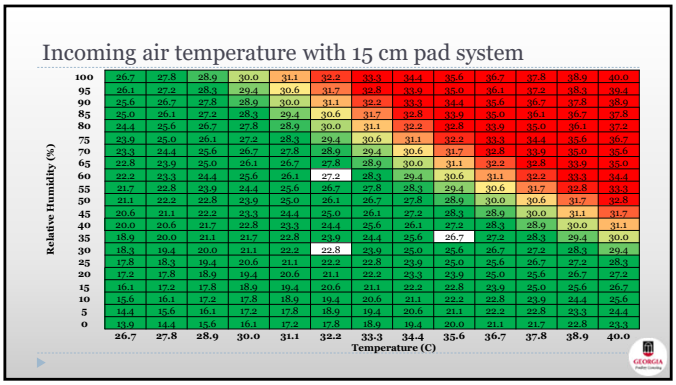
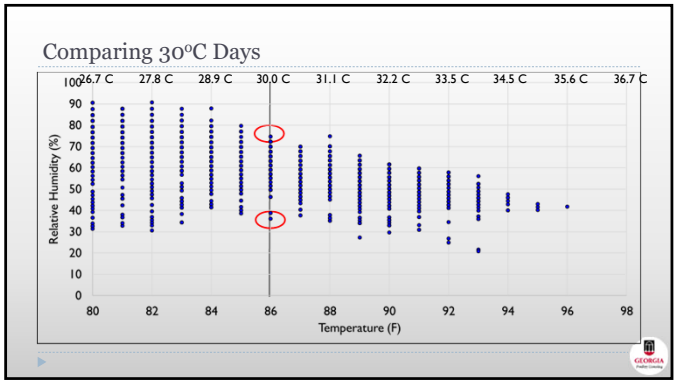


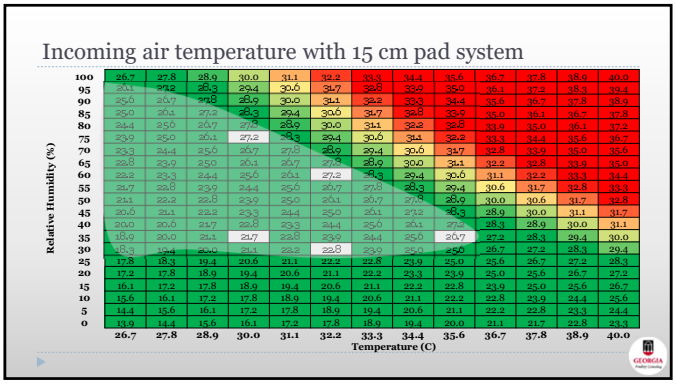
63



64



65

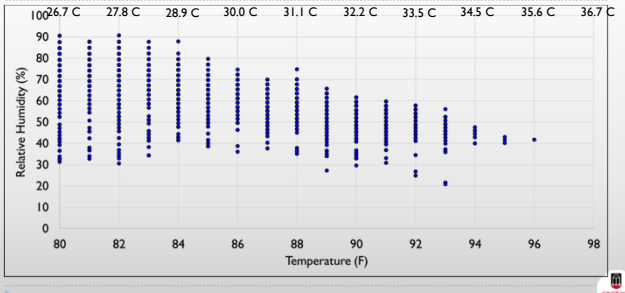


66

There is an easier way to determine how a pad system will perform over the course of a summer

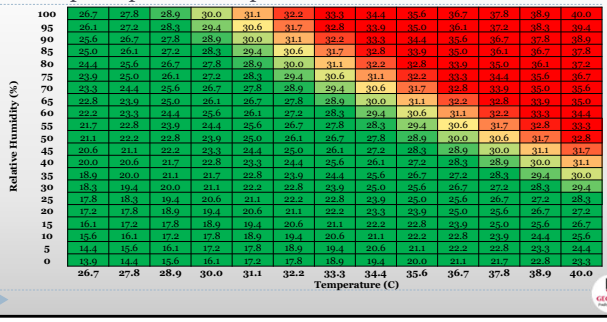
67

Take this graph…



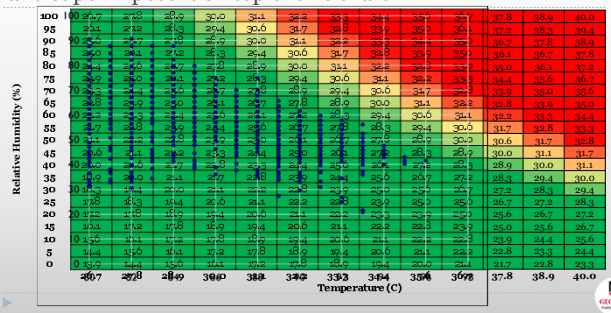
68

and superimpose it on top of this chart



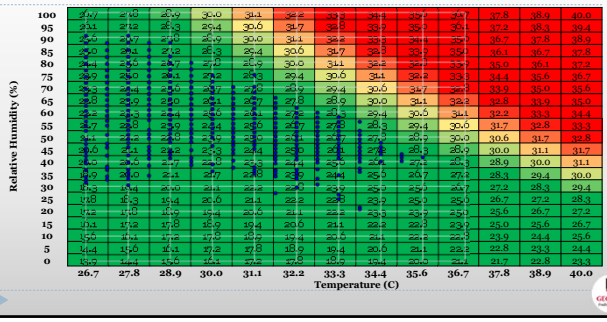
69

and superimpose it on top of this chart



70

and look for occurrences where incoming air temperature 30°C or warmer



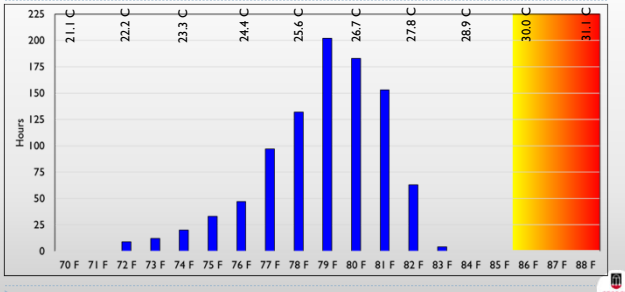
71

Or another way would be to look at times when the outside temperature is 27°C or higher…

- and create a histogram of incoming air temperatures if a pad was in use

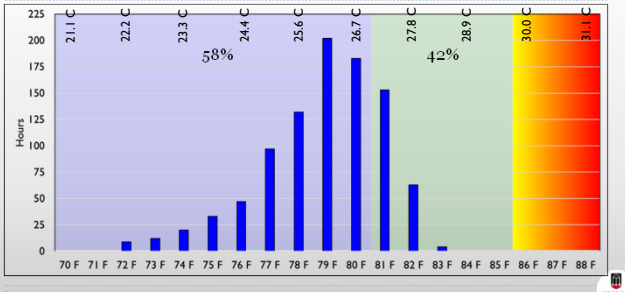
72

Histogram of incoming air temperature when outside temperatures are 27°C or higher



73

Histogram of incoming air temperature when outside temperatures are 27°C or higher

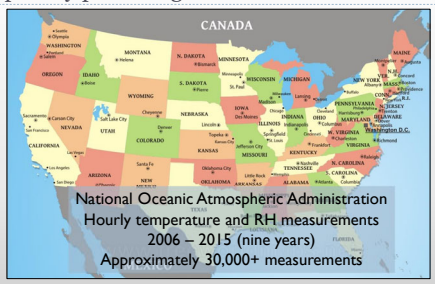


74

Will this relationship hold true for all locations?

75

Various poultry producing locations in the U.S.



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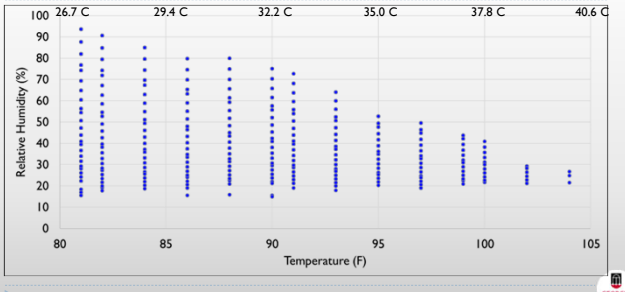
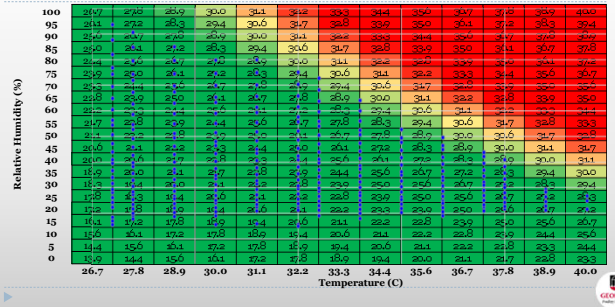
Gadsden, AL (2006 – 2015)
9 years of weather data



77

Gadsden, AL (2006 – 2015)



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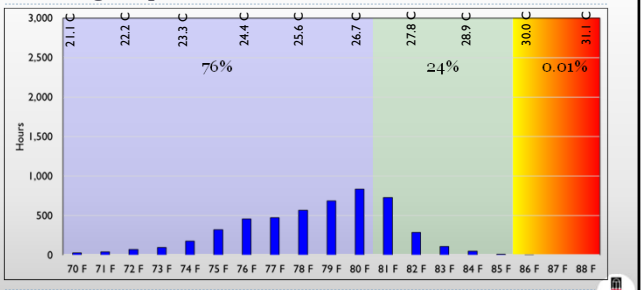
Incoming temperature distribution



Florence, SC (2006 – 2015)

Relative Humidity (%)

	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
100	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0
95	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	37.2	38.3	39.4
90	25.6	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9
85	25.0	26.1	27.2	28.3	29.4	30.6	31.7	32.8	33.9	35.0	36.1	36.7	37.8
80	24.4	25.6	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0	36.1	37.2
75	23.9	25.0	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4	35.6	36.7
70	23.3	24.4	25.6	26.7	27.8	28.9	29.4	30.6	31.7	32.8	33.9	35.0	35.6
65	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	31.1	32.2	32.8	33.9	35.0
60	22.2	23.3	24.4	25.6	26.1	27.2	28.3	29.4	30.6	31.1	32.2	33.3	34.4
55	21.7	22.8	23.9	24.4	25.6	26.7	27.8	28.3	29.4	30.6	31.7	32.8	33.3
50	21.1	22.2	22.8	23.9	25.0	26.1	26.7	27.8	28.9	30.0	30.6	31.7	32.8
45	20.6	21.1	22.2	23.3	24.4	25.0	26.1	27.2	28.3	28.9	30.0	31.1	31.7
40	20.0	20.6	21.7	22.8	23.3	24.4	25.6	26.1	27.2	28.3	28.9	30.0	31.1
35	18.9	20.0	21.1	21.7	22.8	23.9	24.4	25.6	26.7	27.2	28.3	29.4	30.0
30	18.3	19.4	20.0	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3	29.4
25	17.8	18.3	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7	27.2	28.3
20	17.2	17.8	18.9	19.4	20.6	21.1	22.2	23.3	23.9	25.0	25.6	26.7	27.2
15	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	25.0	25.6	26.7
10	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.9	24.4	25.6
5	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.6	21.1	22.2	22.8	23.3	24.4
0	13.9	14.4	15.6	16.1	17.2	17.8	18.9	19.4	20.0	21.1	21.7	22.8	23.3
	26.7	27.8	28.9	30.0	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40.0

Temperature (C)