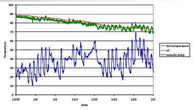
Broiler House Heating System Design Requirements

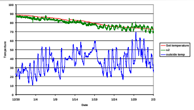
Why is controlling the environment important?

- In order to maximize bird performance and health you must be able to control the environment within a poultry house.
  - air temperature
  - air quality
  - air movement
  - light



Why is controlling the environment important?

- The more control you have over these variables, the more control you will have over bird performance.



To control air temperature, quality, movement and light...

- Heating system
- Ventilation system

Not just any heating system will do…

In order to be successful, a heating system must meet certain objectives

Heating system objectives:

1) Provide a minimum air temperature of 90°F…
   - on the coldest day of the year …
   - with day-old-chicks
   - while at the same time providing good air quality.

Heating system objectives:

2) Minimum floor temperature of 90°F
   - Ideally with areas of the house having significantly warmer floor temps (+110°F)

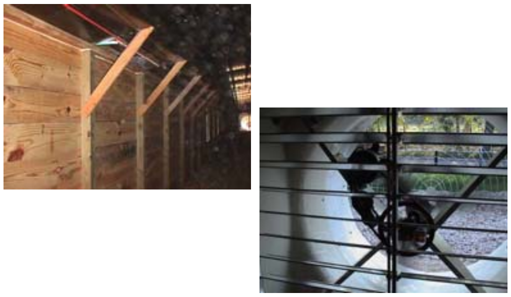
Heating system objectives:

3) Energy efficient

Heating system objectives:

4) Relatively easy to manage and maintain

Our ventilation system also has to meet certain objectives…

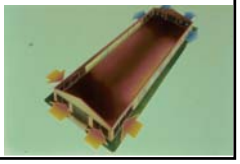


Ventilation system objectives:

1) To provide sufficient fresh air to the house to maintain proper air quality without causing excessive bird chilling.

Ventilation system objectives:

2) To provide sufficient fresh air to control house temperature
   - cold to moderate weather
   - hot weather



Ventilation system objectives:

1) To provide sufficient fresh air to the house to maintain proper air quality without causing excessive bird chilling.
2) To provide sufficient fresh air to control house temperature
3) To accomplish objectives #1 and #2 with a minimum of energy use.

With these objectives in mind, we can now start to design a heating/ventilation system for a broiler house

- Heating system
  - How do we determine what we need?

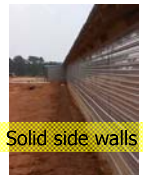
There are basically four heating system design methods:

1) Experience
2) Chicks per brooder
3) Btu's per square foot
4) Heat balance

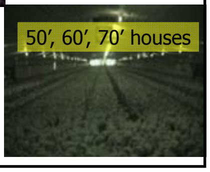
Heating system design methods:
1) Experience

- Based on experimentation in the past
- Usually ok, unless something changes
  - house construction

House changes



House changes



Heating system design methods:
1) Experience

- Based on experimentation in the past
- Usually ok, unless something changes
  - house construction
  - house location
  - type of heating system

Heating system design methods:
2) Chicks per brooder/furnace

- Typically based off of experience
  - Same potential problems
    - House changes
    - Type of brooder changes
    - etc
- An additional problem is that bird density is not a constant…

Heating system design methods:
2) Chicks per brooder/furnace

- Example: 1,200 chicks/brooder
  - 40′ x 500′ = 20,000 sq ft.
- Densities range from 0.6 to 0.9
  - 0.6 = 33,300   0.9 = 22,000
  - 0.6 = 28 brooders   0.9 = 18 brooders

Heating system design methods:
2) Chicks per brooder/furnace

- Radiant brooder specifications
  - 2,000 – 3,000 chicks brooder
- 0.6 = 17 brooders   0.9 = 11 brooders
- 0.6 = 11 brooders   0.9 = 8 brooders

Heating system design methods:
3) Btu's per square foot

- May not take into account different type of heat sources

Heating system design methods:
4) Heat balance…is the proper method

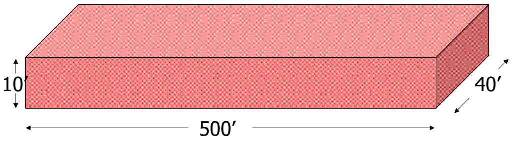
- Calculate how much heat is lost from the poultry house each hour…then replace it.

Heating a poultry house

- Filling up a house with hot air is not the problem…

For example, let's say we have a 40′ x 500′ broiler house

- Volume to fill with hot air
  - Width x length x average side wall height
  - 40′ x 500′ x 10′ = 200,000 cubic feet of air

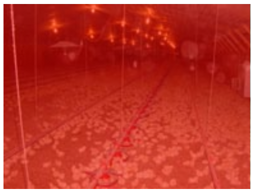


Calculating time to heat the air in the house…

- A single furnace produces 1,200 ft^3/min of air with a temperature of 500°F.
- We can calculate the time required to fill the house with 500°F air by simply taking the volume of the house and dividing by 1,200
  - 200,000 cubic feet / 1,200 cfm = 166 min
  - = 3.6 hours

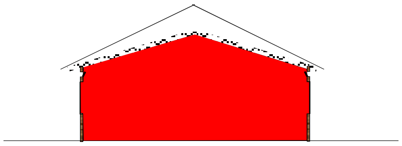
Heating a poultry house

- Filling up a house with hot air is not the problem…
- Keeping it filled is!



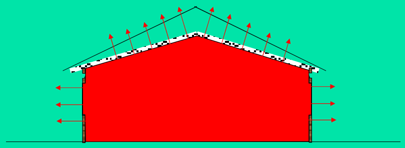
Poultry house heat loss

- Heat flows from warm to cold

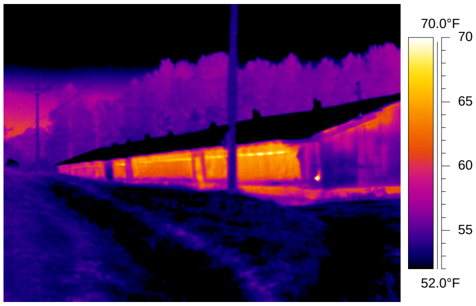


Poultry house heat loss

- Heat flows from warm to cold

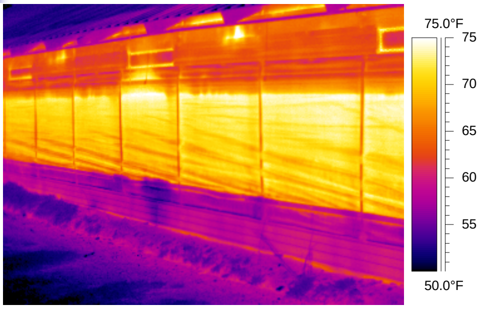


Thermal image of broiler house



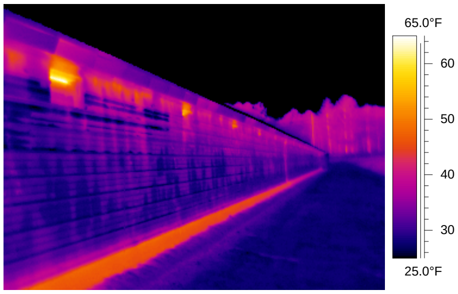
Curtain-sided House

(outside temp = 50ºF, inside 85ºF)

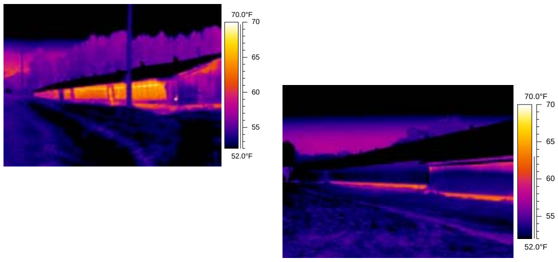


Totally enclosed house

(outside temp=25ºF, inside temp=85ºF)



Curtain-sided vs. Solid sided

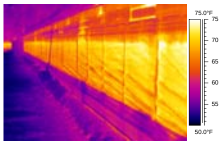


To determine how much heat a house needs…

- We have to determine the **rate** that heat is leaving the house through …
  - House surfaces:
    - ceiling
    - side walls
    - end walls
    - curtains
  - Ventilation
  - Leakage

Heat Loss Rate Through House Surfaces

- How quickly heat leaves through a wall depends on:
  - The size (length, height and thickness) of the wall
  - Temperature difference across the wall
  - Insulation value of the wall components (R-value)



Calculating wall and ceiling heat loss rates

- Heat = (Area / R-Value) x Temp. Diff.
  - The larger the wall area the greater the heat loss rate.
  - The higher the R-Value the slower heat will leave the house.
  - The greater the temperature difference across the wall or ceiling, the faster heat will leave the house.

House heat loss example:

- 40′ x 500′ broiler house
- 8′ side wall (2 x 6′s)
- 4′ curtain
- dropped ceiling (3 1/2″ of fiberglass)

First, we are going to calculate heat loss rate through building surfaces:

- Ceiling
- Side walls
- End walls
- Curtains

Ceiling heat loss rate

- Heat = (Area / R-Value) x Temp. diff.

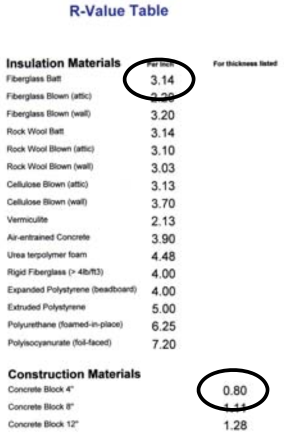
  - Area = W x L
  - = 40.5′ x 500′
  - = 20,250 ft^2
  - R-Value = ?

Determining insulation values

- Reference books
  - ASHRAE Handbook of Fundamentals (“Bible”) (American Society of Heating, Refrigerating & Air-Conditioning Engineers)
  - Midwest Plan Service
  - Etc.
- Insulation manufacturers
  - caution
- Internet (The Mother of All Knowledge)

Materials ……

- that “trap” air have high thermal R values (like the feathers of a down jacket)
- that are good electrical conductors have poor R-values (metals, water, etc.)
- that are dense (masonry, stone, wood, etc.) have poor R-values.



R-Value Table

Insulation Materials	Per Inch	For thickness listed
Fiberglass Batt	3.14	
Fiberglass Blown (attic)	2.20	
Fiberglass Blown (wall)	3.20	
Rock Wool Batt	3.14	
Rock Wool Blown (attic)	3.10	
Rock Wool Blown (wall)	3.03	
Cellulose Blown (attic)	3.13	
Cellulose Blown (wall)	3.70	
Vermiculite	2.13	
Air-entrained Concrete	3.90	
Urea terpolymer foam	4.48	
Rigid Fiberglass (> 4lb/ft3)	4.00	
Expanded Polystyrene (beadboard)	4.00	
Extruded Polystyrene	5.00	
Polyurethane (foamed-in-place)	6.25	
Polyisocyanurate (foil-faced)	7.20	
Construction Materials		
Concrete Block 4"		0.80
Concrete Block 8"		1.11
Concrete Block 12"		1.28

Brick 4" common		0.80
Brick 4" face		0.44
Poured Concrete	0.08	
Soft Wood Lumber	1.25	
2" nominal (1 1/2")		1.88
2x4 (3 1/2")		4.38
2x6 (5 1/2")		6.88
Cedar Logs and Lumber	1.33	
Sheathing Materials		
Plywood	1.25	
1/4"		0.31
3/8"		0.47
1/2"		0.63
5/8"		0.77
3/4"		0.94
Fiberboard	2.64	
1/2"		1.32
25/32"		2.06
Fiberglass (3/4")		3.00
(1")		4.00
(1 1/2")		6.00
Extruded Polystyrene (3/4")		3.75
(1")		5.00
(1 1/2")		7.50
Foil-faced Polyisocyanurate (3/4")		5.40

(1")		7.20
(1 1/2")		10.80
Siding Materials		
Hardboard (1/2")		0.34
Plywood (5/8")		0.77
(3/4")		0.93
Wood Bevel Lapped		0.80
Aluminum, Steel, Vinyl (hollow backed)		0.61
(w/ 1/2" Insulating board)		1.80
Brick 4"		0.44
Interior Finish Materials		
Gypsum Board (drywall 1/2")		0.45
(5/8")		0.56
Paneling (3/8")		0.47
Flooring Materials		
Plywood	1.25	
(3/4")		0.93
Particle Board (underlayment)	1.31	
(5/8")		0.82
Hardwood Flooring	0.91	
(3/4")		0.68
Tile, Linoleum		0.05

Ceiling heat loss rate

- Heat = (Area / R-Value) x Temp. diff.
  - Area = W x L
  - = 40.5’ x 500’
  - = 20,250 ft^2
  - R-Value = ?

R-values

- 3 1/2” fiberglass = 12

Ceiling heat loss rate

- Heat = (Area / R-Value) x Temp. diff.
  - Area = W x L
  - = 40.5’ x 500’
  - = 20,250 ft^2
  - R-Value = 12
  - Temp Diff. = outside temp - inside temp

Ceiling heat loss

- Heat = (Area / R-Value) x Temp. diff.

  - Area = L x W
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  - Temp Diff. = outside temp - inside temp

Heating system objectives:

1) Provide a minimum air temperature of 90°F…
   - on the coldest day of the year …
   - with day-old-chicks
   - while at the same time providing good air quality.

Ceiling heat loss rate

- Heat = (Area / R-Value) x Temp. diff.

  - Area = L x W
  - = 40.5′ x 500′
  - = 20,250 ft^2
  - R-Value = 12
  - Temp Diff. = outside temp – 90°F

Heating system objectives:

1) Provide a minimum air temperature 90°F
   - on the coldest day of the year …
   - with day-old-chicks
   - while at the same time providing good air quality.

Design outside temperatures

- From weather service historical data or the ASHRAE Handbook of Fundamentals
  - 99% design Winter Dry-Bulb temperature (the low temp exceeded only 1% of the hours during December, January & February)
  - Safety factor, subtract 10°F

Outside design temperature data

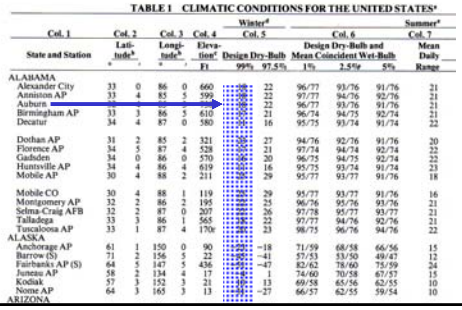


TABLE 1 CLIMATIC CONDITIONS FOR THE UNITED STATES[a]

Col. 1	Col. 2		Col. 3		Col. 4	Winter[d] Col. 5		Col. 6			Summer[e] Col. 7
State and Station	Latitude[b]		Longitude[b]		Elevation[c]	Design Dry-Bulb		Design Dry-Bulb and Mean Coincident Wet-Bulb			Mean Daily Range
	°	′	°	′	Ft	99%	97.5%	1%	2.5%	5%	
ALABAMA											
Alexander City	33	0	86	0	660	18	22	96/77	93/76	91/76	21
Anniston AP	33	4	85	5	599	18	22	97/77	94/76	92/76	21
Auburn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18	22	96/77	93/76	91/76	21
Birmingham AP	33	3	86	5	610	17	21	96/74	94/75	92/74	21
Decatur	34	4	87	0	580	11	16	95/75	93/74	91/74	22
Dothan AP	31	2	85	2	321	23	27	94/76	92/76	91/76	20
Florence AP	34	5	87	4	528	17	21	97/74	94/74	92/74	22
Gadsden	34	0	86	0	570	16	20	96/75	94/75	92/74	22
Huntsville AP	34	4	86	4	619	11	16	95/75	93/74	91/74	23
Mobile AP	30	4	88	2	211	25	29	95/77	93/77	91/76	18
Mobile CO	30	4	88	1	119	25	29	95/77	93/77	91/76	16
Montgomery AP	32	2	86	2	195	22	25	96/76	95/76	93/76	21
Selma-Craig AFB	32	2	87	0	207	22	26	97/78	95/77	93/77	21
Talladega	33	3	86	1	565	18	22	97/77	94/76	92/76	21
Tuscaloosa AP	33	1	87	4	170r	20	23	98/75	96/76	94/76	22
ALASKA											
Anchorage AP	61	1	150	0	90	−23	−18	71/59	68/58	66/56	15
Barrow (S)	71	2	156	5	22	−45	−41	57/53	53/50	49/47	12
Fairbanks AP (S)	64	5	147	5	436	−51	−47	82/62	78/60	75/59	24
Juneau AP	58	2	134	4	17	−4	1	74/60	70/58	67/57	15
Kodiak	57	3	152	3	21	10	13	69/58	65/56	62/55	10
Nome AP	64	3	165	3	13	−31	−27	66/57	62/55	59/54	10
ARIZONA											

Design outside temperatures

- From weather service historical data
  - 99% design Winter Dry Bulb temperature
  - Safety factor, subtract 10°F
- Gainesville, Georgia
  - 99% design temperature = 21°F
  - Design outside temp = 21°F – 10°F = 11°F
  - Let's round it to 10°F = 10°F

Ceiling heat loss rate

- Heat = (Area / R-Value) x Temp. diff.

  - Area = L x W
  - = 40.5′ x 500′
  - = 20,250 ft^2
  - R-Value = 12
  - Temp Diff. = 10°F – 90°F

Ceiling heat loss rate
(3 1/2″ of fiberglass)

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 40.5′ x 500′
  - = 20,250 ft^2
  - R-Value = 12
  - Temp Diff. = 10°F – 90°F
  - = -80°F
- Heat = (20,250 ft^2 / 12) x -80°F
- = -135,000 Btu/hr

Heat loss rate through building surfaces:

- Ceiling = -135,000 Btu/hr

We have to replace this heat or house temperature will decrease

We burn propane to offset this heat loss..

- Burning one gallon of propane produces 92,000 Btu of heat.
  - conventional brooders burn 0.33 gals/hr
    - produces 30,000 Btu/hr
  - radiant brooders burn 0.43 gals/hr
    - produces 40,000 Btu/hr
  - furnaces burn 2.2 gals/hr
    - produces 200,000 Btu/hr

Replacing ceiling heat loss

- To offset the 135,000 Btu/hr of heat loss through the ceiling, we need ….
  - 4.5 conventional brooders
  - 3.4 radiant brooders
  - 0.7 furnaces

What happens when we increase ceiling insulation?

Ceiling heat loss rate
(6" of fiberglass)

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 40.5' x 500'
  - = 20,250 ft^2
  - R-Value = 21
  - Temp Diff. = 10°F - 90°F
    - Heat = (20,250 ft^2 / 21) x -80°F
- = -77,142 Btu/hr
- (57% decrease)

Ceiling hourly heat loss

- To replace heat loss from the ceiling, we need ….
  - 4.5 conventional brooders
  - 3.4 radiant brooders
  - 0.7 furnaces

How does heat loss change if the house has an open ceiling?

Ceiling heat loss
(open ceiling)

- Open ceiling will cost more to heat
- But not because of an increase in volume of air that we need to heat.

How does heat loss change if the house has an open ceiling?

Increased surface area

How does heat loss change if the house has an open ceiling?

Lower R-value

Ceiling heat loss rate
(open ceiling)

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 42′ x 500′
  - = 21,000 ft^2
  - R-Value = 5
  - Temp Diff. = 10°F - 90°F
- Heat = (21,000 ft^2 / 5) x (- 80°F)
- = -336,000 Btu/hr
- about a 250% increase

Ceiling hourly heat loss

- To replace heat loss through the ceiling, we need ….
  - 4.5 conventional brooders
  - 3.4 radiant brooders
  - 0.7 furnaces

Calculating heat loss through building surfaces:

- Ceiling
- Side walls
- End walls
- Curtains

Side wall heat loss rate

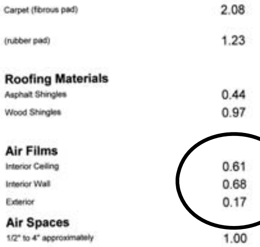
- Heat = (Area / R-Value) x Temp. diff.
  - Area = L x W
  - = 4′ x 500′ x 2
  - Temp Diff. = outside temp - inside temp
  - = 10°F – 90°F
  - R-Value = ?

R-values

- 2″ x 6″ wall with metal: R = 4

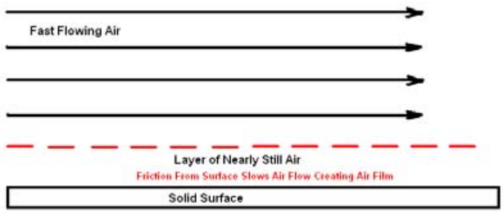
Brick 4" common		0.80
Brick 4" face		0.44
Poured Concrete	0.08	
Soft Wood Lumber	1.25	
2" nominal (1 1/2")		1.88
2x4 (3 1/2")		4.38
2x6 (5 1/2")		6.88
Cedar Logs and Lumber	1.33	
Sheathing Materials		
Plywood	1.25	
1/4"		0.31
3/8"		0.47
1/2"		0.63
5/8"		0.77
3/4"		0.94
Fiberboard	2.64	
1/2"		1.32
25/32"		2.06
Fiberglass (3/4")		3.00
(1")		4.00
(1 1/2")		6.00
Extruded Polystyrene (3/4")		3.75
(1")		5.00
(1 1/2")		7.50
Foil-faced Polyisocyanurate (3/4")		5.40

1.5” X 1.25 ≈ 2



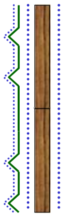
Carpet (fibrous pad)	2.08
(rubber pad)	1.23
Roofing Materials	
Asphalt Shingles	0.44
Wood Shingles	0.97
Air Films	
Interior Ceiling	0.61
Interior Wall	0.68
Exterior	0.17
Air Spaces	
1/2" to 4" approximately	1.00

The insulation value of an air film is caused by the friction induced by a surface on moving air ….



2” x 4” wall R- Value

(0.2+ 0.7+ 2+ 0.7 ≈ 4)

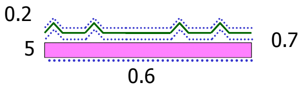


R-value is approximately = 4

Technically….

- 3 ½ of fiberglass, R =12
- Plus air films
  - 0.6 ceiling interior
  - 0.2 exterior
- 12.8 - 12
  - Will not make a big difference in heat flow
- 1” board insulation in the ceiling, R= 6.5

Open ceiling R- Value



R-value approximately = 6.5
(0.2+0.7+5+0.6≈6.5)

Ceiling heat loss rate
(open ceiling)

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 42′ x 500′
  - = 21,000 ft^2
  - R-Value = 6.5
  - Temp Diff. = 10°F - 90°F
- Heat = (21,000 ft^2 / 6.5) x (- 80°F)
- = -258,500 Btu/hr

Ceiling heat loss rate
(open ceiling)

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 42′ x 500′
  - = 21,000 ft^2
  - R-Value = 5
  - Temp Diff. = 10°F - 90°F
- Heat = (21,000 ft^2 / 5) x (- 80°F)
- = -336,000 Btu/hr

Side wall heat loss rate

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 4′ x 500′ x 2
  - = 4,000 ft^2
  - R-Value = 4
  - Temp Diff. = 10°F - 90°F
- Heat = (4,000 ft^2 / 4) x -80°F
- = -80,000 Btu/hr

Heat loss rate through building surfaces:

- Ceiling = -135,000 Btu/hr
- Side wall = -80,000 Btu/hr

Calculating heat loss rates through building surfaces:

- Ceiling
- Side walls
- End walls
- Curtains

R-values

- 2″ x 6″ wall with metal, R=4

End wall heat loss rate

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 9.5′ x 40′ x 2
  - = 760 ft^2
  - R-Value = 4
  - Temp Diff. = 10°F - 90°F
- Heat = (760 ft^2 / 4) x -80°F
- = -15,200 Btu/hr

Heat loss rate through building surfaces:

- Ceiling = -135,000 Btu/hr
- Side wall = -80,000 Btu/hr
- End wall = -15,200 Btu/hr

Calculating heat loss rates through building surfaces:

- Ceiling
- Side walls
- End walls
- Curtains

R-values

- Side wall curtain R= 1.5

Curtain

- Around 0.2 – 0.3
- Plus air films
  - 0.7 interior
  - 0.2 exterior
- Approximately 1.5

Curtain heat loss rate

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 4′ x 500′ x 2
  - = 4,000 ft^2
  - R-Value = 1.5
  - Temp Diff. = 10°F - 90°F
- Heat = (4,000 ft^2 / 1.5) x – 80°F
- = -213,333 Btu/hr

Heat loss through building surfaces:

- Ceiling = -135,000 Btu/hr
- Side wall = -80,000 Btu/hr
- End wall = -15,200 Btu/hr
- Curtain = -213,333 Btu/hr

Total heat loss through building surfaces:

- Ceiling = -135,000 Btu/hr
- Side wall = -80,000 Btu/hr
- End wall = -15,200 Btu/hr
- Curtain = -213,333 Btu/hr
- Total = -443,533 Btu/hr

Half House brooding

Half House brooding

- Ceiling is cut in half
- Curtains are cut in half
- Side walls are cut in half
- End wall is cut in half
  - Brooding curtain must be added

Heat loss rates through building surfaces:

- Ceiling = -135,000 Btu/hr
- Side wall = -80,000 Btu/hr
- End wall = -15,200 Btu/hr
- Curtain = -213,333 Btu/hr

Heat loss rates through building surfaces:

- Ceiling = -67,500 Btu/hr
- Side wall = -40,000 Btu/hr
- End wall = -7,600 Btu/hr
- Curtain = -106,667 Btu/hr

Heat loss rates through building surfaces:

- Ceiling = -67,500 Btu/hr
- Side wall = -40,000 Btu/hr
- End wall = -7,600 Btu/hr
- Curtain = -106,667 Btu/hr
- Brood Curtain = ?

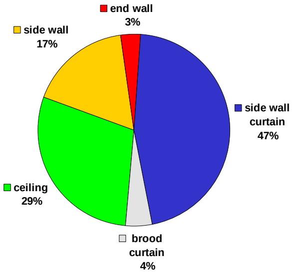
Brood curtain heat loss rate

- Heat = (Area / R-Value) x Temp. diff.
  - Area = 9.5′ x 40′
  - = 380 ft^2
  - R-Value = 1.5
  - Temp Diff. = 50°F - 90°F
- Heat = (380 ft^2 / 1.5) x – 40°F
- = -10,133 Btu/hr

Heat loss rates through building surfaces:

- Ceiling = -67,500 Btu/hr
- Side wall = -40,000 Btu/hr
- End wall = -7,600 Btu/hr
- Brd. Curt. = -10,133 Btu/hr
- Curtain = -106,667 Btu/hr
- Total = -231,900 Btu/hr

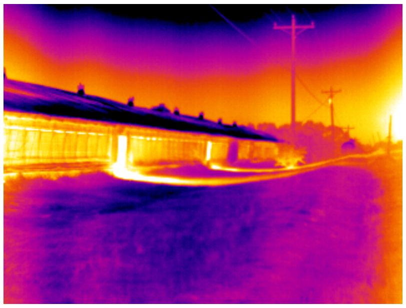
Broiler house surface heat loss



Heating requirement

- 231,900 Btu/hr
  - 7.7 Conventional brooders (30,000 Btu/hr)
  - 5.8 Radiant brooders (40,000 Btu/hr)
  - 1.2 Furnaces (200,000 Btu/hr)

Ventilation



House heat loss

- House surfaces:
  - ceiling
  - side walls
  - end walls
  - curtains
- Ventilation
- Leakage

Ventilation and leakage

- You have to replace heat which is exhausted through ventilation and leakage.

Ventilation and leakage

- Heat = Cfm air flow x Temperature difference
  - Cfm air flow = ?
  - Temp Diff. = outside temp. - inside temp.

Ventilation and leakage

- How much fresh air entering a house depends on:
  - timer fan settings
    - ammonia
    - moisture
    - etc.
  - leakage
    - house tightness
    - wind speed

Ventilation and leakage

- How much ventilation and leakage?
- 20,000 cfm 30 sec on per 5 minutes is 2,000 cfm average ventilation rate. Add 1,000 cfm to cover leakage due to wind and infiltration (no fans).
- Avg. ventilation and leakage is about 3,000 cfm or 3,000cfm/10,000 sqft = .3 cfm/sqft
- Less for tight house, more for loose house
- Range might be from .25 to .35 cfm/sqft

Ventilation and leakage

- Heat = Cfm air flow x Temperature difference
  - assume 0.3 cfm per square foot of floor space
    - Approximately 60% is for the chicks, 40% leakage
      - must plan for the house becoming looser over time.
      - must plan for high ammonia

Ventilation and leakage

- Heat = Cfm x Temperature difference
  - Cfm = 40’ x 250’ x 0.3 cfm/sq. ft. floor
  - = 3,000 cfm

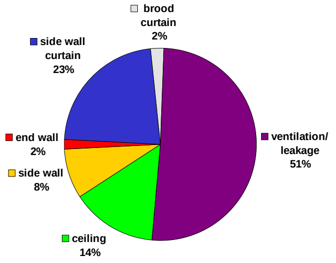
Ventilation and leakage

- Heat = Cfm air flow x Temperature diff.
- Heat = 3,000 cfm x (10°F - 90°F)
- = -240,000 Btu/hr

Heat loss rates through building surfaces and ventilation

- Ceiling = -67,500 Btu/hr
- Side wall = -40,000 Btu/hr
- End wall = -7,600 Btu/hr
- Brood curt = -10,133 Btu/hr
- Curtain = -106,167 Btu/hr
- Ventilation = -240,000 Btu/hr
- Total = -471,900 Btu/hr

Broiler house heat loss



Heating system design

- Once you know how much heat is lost on the coldest day with chicks, you know how much heat you have to add to maintain the desired house temperature and therefore the number or brooders or furnaces can be calculated:
  - # of brooders = heat loss / brooder output
  - # of furnaces = heat loss / furnace output

Calculating the number of brooders, radiant brooders, furnaces required

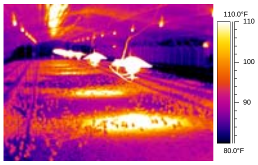
- Total Heat Loss = 471,900 Btu/hr
  - brooders = total heat loss / brooder output
  - = 471,900 / 30,000
  - = 15.7 = 16
  - rad. brooders = total heat loss / brooder output
  - = 471,900 / 40,000
  - = 11.8 = 12
  - furnaces = total heat loss / furnace output
  - = 471,900 / 200,000
  - = 2.4

Required number of brooders or radiant brooders

- The calculated value is the rate of heat required to keep the house at the desired air temperature.

Required number of brooders or radiant brooders

- Keep in mind that this does not necessarily mean that you have the desired amount of floor space covered with radiant heat.



Furnaces

Required number of furnaces

- Because of safety, spacing requirements and lack of radiant heat...calculated furnace numbers should typically be increased by approximately 75%
  - Furnaces = Calculated x Safety Factor
  - = 2.35 x 1.75
  - = approximately four

Heating system requirement approximations

- You can calculate the heat loss rate for all your houses to determine brooder or furnace numbers:
  - takes a fair amount of time
  - necessary for similar houses
    - i.e., houses of same construction but different lengths
- You can express heating system requirements in terms of Btu/ft^2

Heat loss rates through building surfaces and ventilation:

- Ceiling = -67,500 Btu/hr
- Side wall = -40,000 Btu/hr
- End wall = -7,600 Btu/hr
- Brood Curt. = -10,133 Btu/hr
- Curtain = -106,667 Btu/hr
- Ventilation = -240,000 Btu/hr
- Total = -471,900 Btu/hr

Heating system requirement per square foot

- Btu/ft^2 = 471,900/ (40’ x 250’)
- = 47.2 Btu/ft^2
- Heating system requirement for a typical dropped ceiling, curtain-sided house is approximately ……
  - 50 Btu/ft^2

Keep in mind this is for 40’ wide curtain-sided house

Heating system requirements for the nonbrooding end?

Heating system requirements for the nonbrooding end?

- Do not need as much heat in the nonbrooding end because:
  - lower desired house temperatures at 14 to 21 days.
  - ventilation and leakage typically does not increase much when you first go to full house.
  - birds start producing a significant amount of heat.

Heating system requirements for the nonbrooding end

- In the past most people installed about half the number of brooders/furnaces in the nonbrooding end which were installed on the brooding end.

But….

- Many people are turning out at 7 – 10 days.
- Keeping warmer temperatures the first couple of weeks.
- Therefore, you should strongly consider installing at least 65% of the heating capacity in rear of the house as you do in the brooding end.

Summary

- Heating System Design is More Complex Than We First Imagine
- Location, Type of Heat, and Floor Coverage Are Three Important Factors
- House Tightness(Leakage) and House Insulation Are Two Major Factors That Greatly Influence the Amount Of Heat Needed.