

Ventilation Management

通风管理

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Ventilation Management 通风管理



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–Why Ventilation is Important

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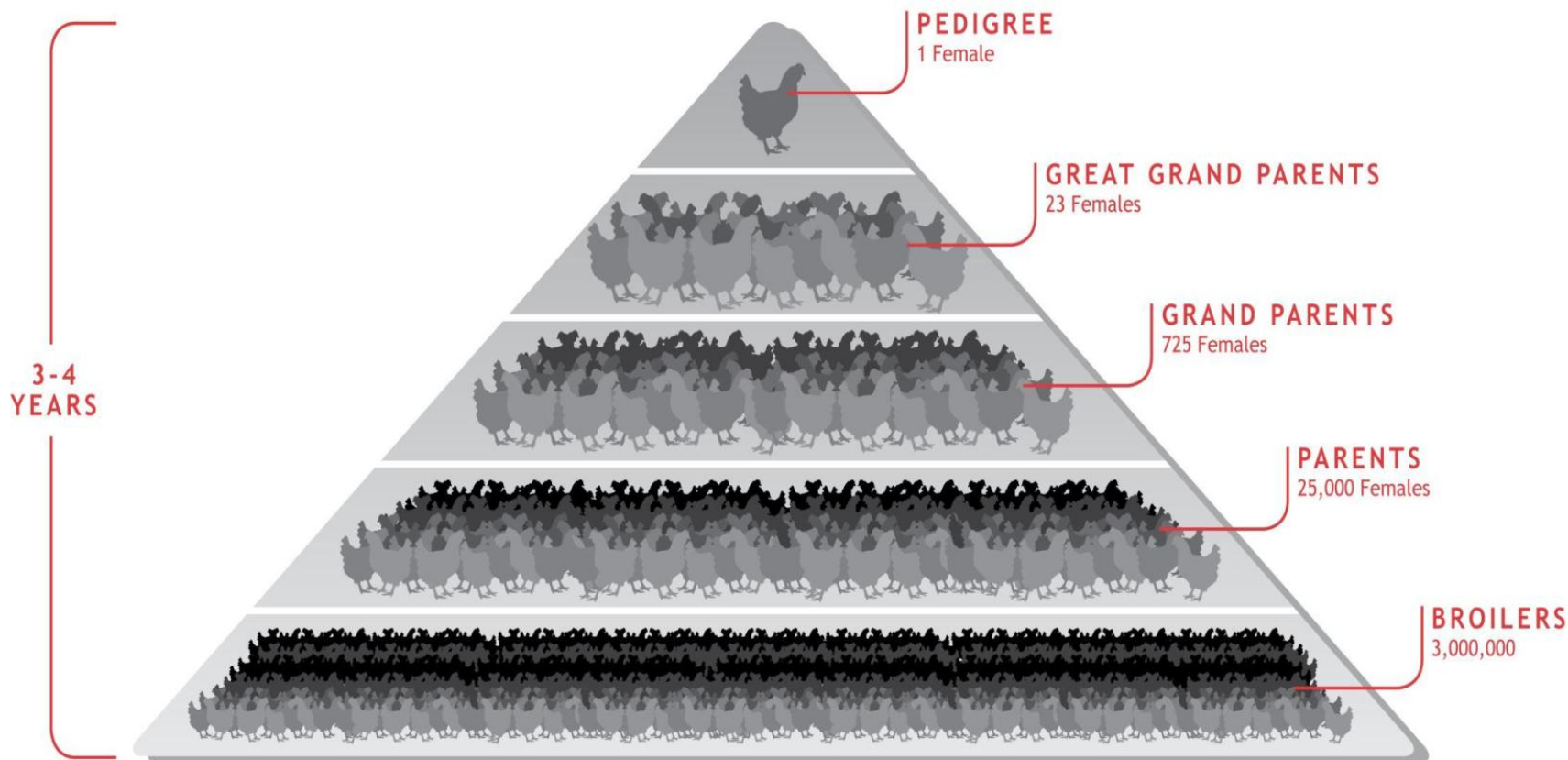


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Why Ventilation is Important 通风管理的重要性



Pedigree Production Pyramid 原种生产金字塔





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Why Ventilation is Important 通风管理的重要性



Pedigree Selection Process 育种选种

Selection Technologies 选择技术

Phenotype Selection

表型选择



Feed conversion

料肉比



Ultrasound

超声波



Lixiscopes

低强X光显像仪



- Each bird needs to go through 600+ different kinds tests & Assessments to be selected. 每只原种鸡的选种要经历600多项检查和测试





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Why Ventilation is Important 通风管理的重要性



Selection Objectives 育种的目的

Cobb500™ Improvements in SR Broiler 42 Days of Age



Trait	1980	1990	2000	2010	2020
Wgt (g)	1135	1588	2042	2495	2948
Wgt (lb)	2.50	3.50	4.50	5.50	6.50



Trait	1980	1990	2000	2010	2020
FCR	2.40	2.22	2.02	1.82	1.62



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Ventilation Management 通风管理

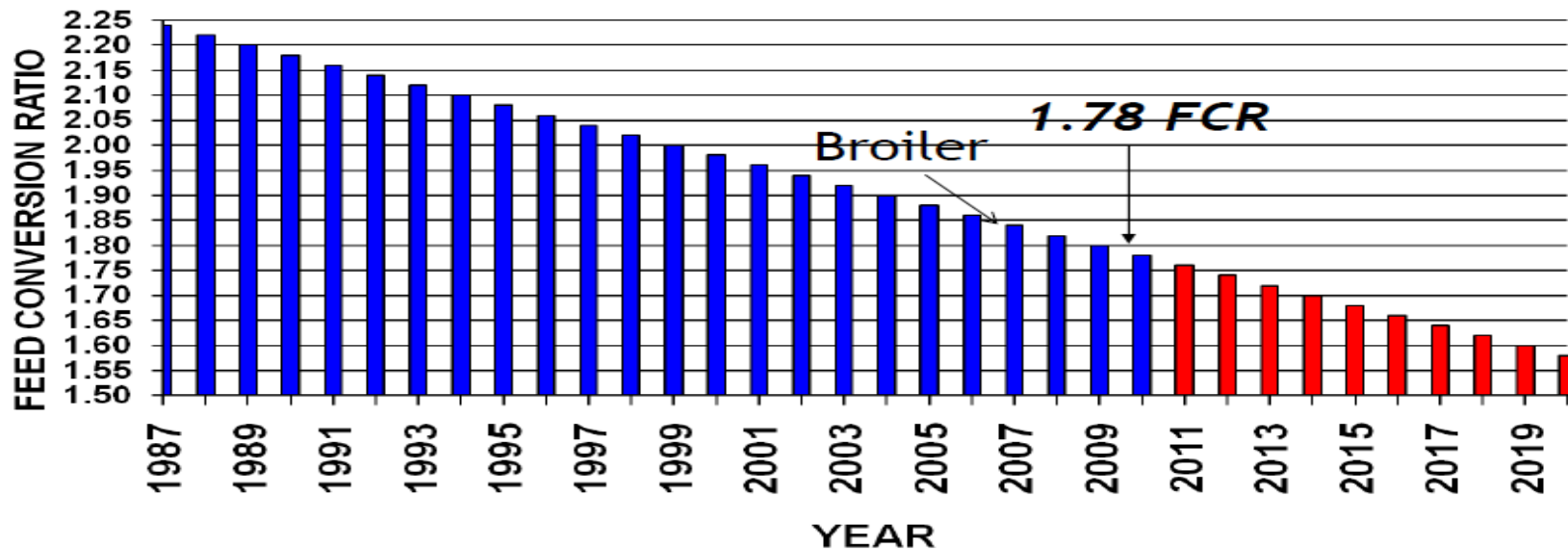


Selection Objectives 育种的目的

Cobb500™ Pedigree Improvements in FCR at 42 days (2585 kg, 5.7 lbs)



Genetic improvement: -.02 to -.025 per year



Cobb World Leader



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Why Ventilation is Important

通风管理的重要性



Why Ventilation is Important

通风管理的重要性

- 育种的不断进展，鸡只新陈代谢的加快，料肉比的不断降低对种鸡饲养管理的均匀度和体重控制带来很大的冲击，对饲养管理的要求将越来越高；现代化，集约化的种鸡饲养对养殖设备的自动化，精确化和耐久性的依赖程度也将越来越高。----肉种鸡饲养管理
- 育种的不断进展，鸡只新陈代谢的加快会让种蛋的蛋胚产生更多的热量，种鸡受精率的不断提高，也会有更多的受精蛋在出雏器里产生热量；如果种鸡超重，特别是上下高峰时体重管理掌握不好，造成种蛋过大也会造成蛋胚产生更多的热量，所以对孵化器，出雏器温度的实时监控管理以及通风降温对保障鸡苗质量至关重要！ ---孵化管理
- 日增重的大幅提高，饲养周期的缩短使得育雏和前期增重的重要性越来越突出。-----育雏&肉鸡饲养管理
- 新陈代谢的加快和日增重的大幅提高将导致肉鸡产生更多的热量，排出更多的水分，现代化集约化的肉鸡养殖模式养殖密度越来越高，饲养周期的缩短，日饮食量的增加对通风管理的要求也越来越高。做好生物安全，鸡舍通风和饲养管理是取得良好养殖成绩的基本保障。---生物安全&通风管理



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Minimum Ventilation 最小通风



1. Minimum ventilation
1. 最小通风



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Minimum Ventilation 最小通风



1. Minimum ventilation principles 最小通风原则
2. How to manage incoming cold air 怎么管理进来的冷空气
3. Inlet management 进风小窗管理
4. Minimum ventilation calculation example 举例计算最小通风
5. Some key management ideas 一些关键的管理理念



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What is Minimum Ventilation?

什么是最小通风



- Operates IF house Temp. Below SET POINT.
操作条件：鸡舍温度。低于目标。
- 5 Minute Cycle Timer 五分钟一个定时循环
- Responsible for **AIR QUALITY** 为空气质量负责
- Provide the required **OXYGEN** 提供所需的氧气
- **Moisture removal** 水分移掉
- **Air Speed < 0.2m/s** 空气速度 < 0.2米/秒
- Minimum run time: 60s - for air and heat distribution 最低运行时间：60秒 – 将空气和热量进行分布
- 请注意以上的排序



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Example: fan off time & its effect on CO₂ & RH levels

举例：风机停止时间和对二氧化碳及湿度的影响



Fan Off Time 风机停止时间	CO ₂ ppm 二氧化碳浓度	RH % 相对湿度
0 min	2,200ppm	35%
1	2,250	36
2	2,350	38
3	2,500	41
4	2,700	45
5	2,950ppm	50%
6	3,250	56
7	3,600	63
8	4,000ppm	71%
9	4,450	80
10 min (分钟)	4,950ppm	90%

Source: J. Donald - AU



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Chicks in Groups - WHY?

鸡只簇团-为什么？





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Effects of High CO₂ Levels

高二氧化碳的影响



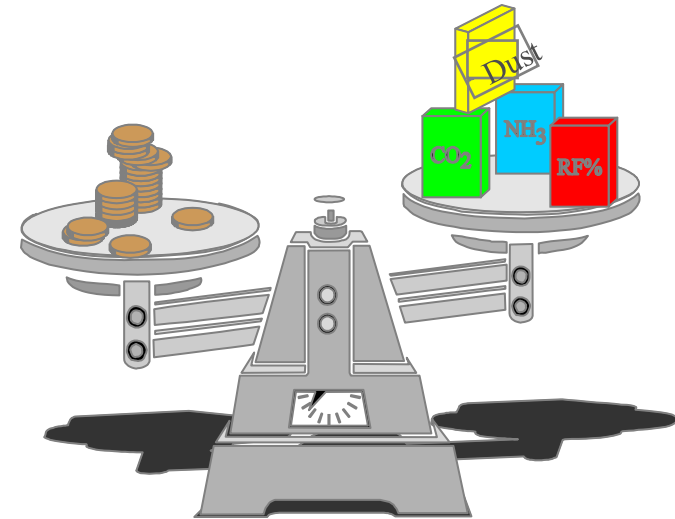
1. **Reduce Activity / 活动减少**
2. **Reduced feed & water Intake / 采食饮水减少**
3. **Increased dehydration / 脱水增加**
4. **Lower weight gain / 低增重**
5. **Increased incidence or right ventricular failure-later in life (Ascites) / 增加后期腹水的发生率**





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Answer: CO₂ High > 3000ppm
答案：二氧化碳高 > 3000ppm



- O₂ > 19.5%
- CO₂ < 0.3% OR 3000ppm
- CO < 10ppm
- NH₃ < 10ppm
- Dust < 3.4 mg/m³



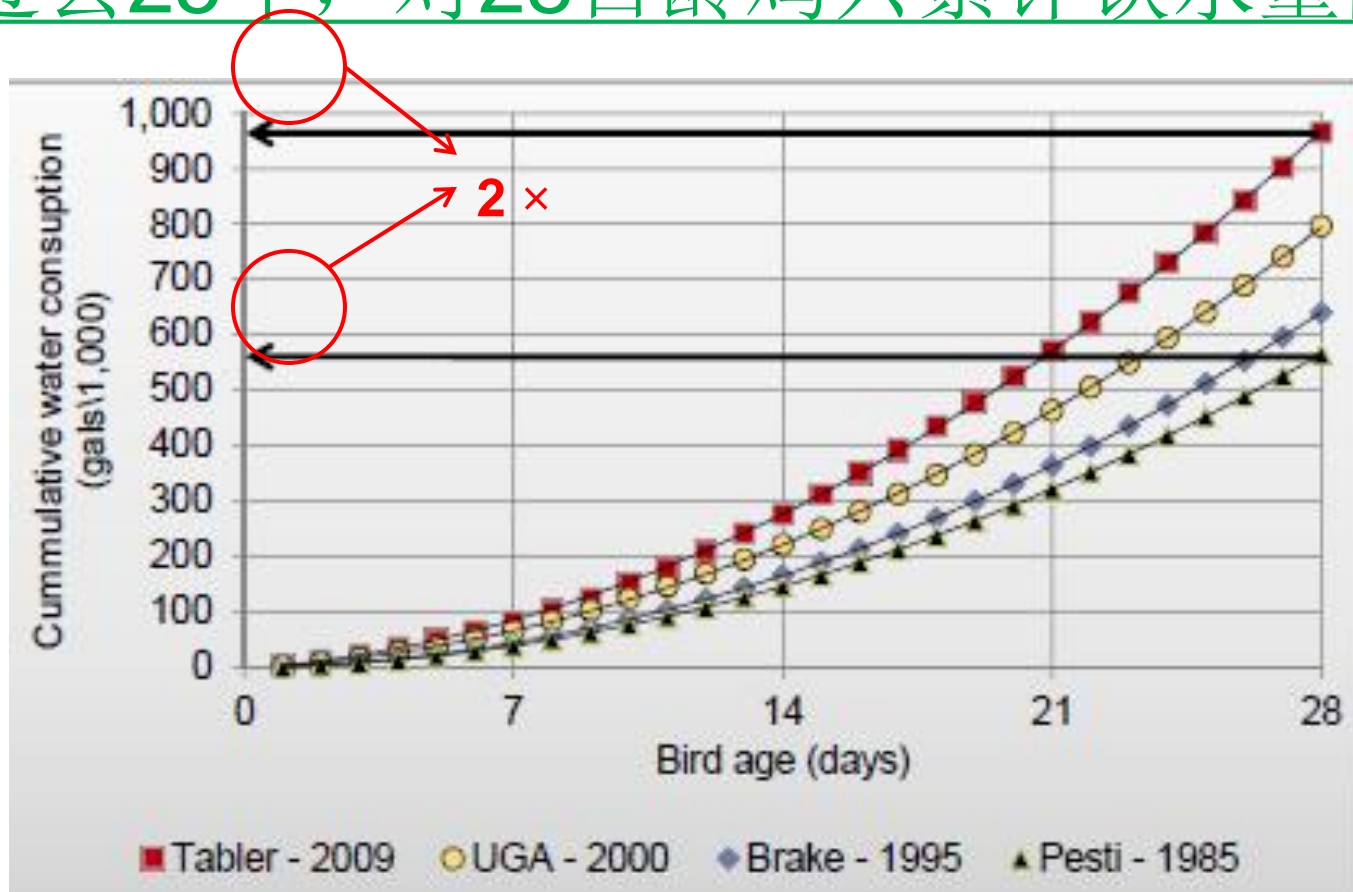
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Minimum Ventilation 最小通风



Cumulative water consumption @ 28 days in
the past 25 years

过去25年，对28日龄鸡只累计饮水量的统计



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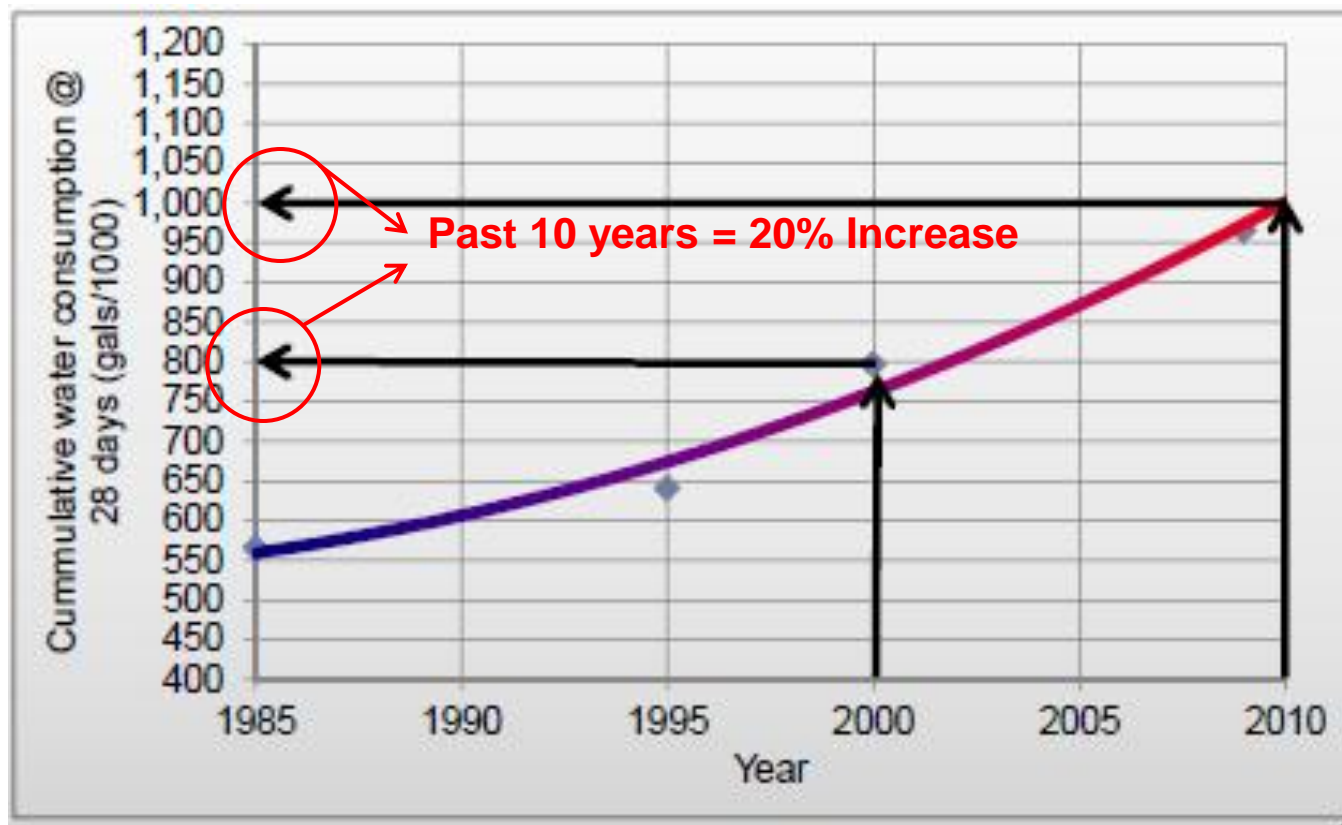
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Minimum Ventilation 最小通风



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Minimum Ventilation

最小通风

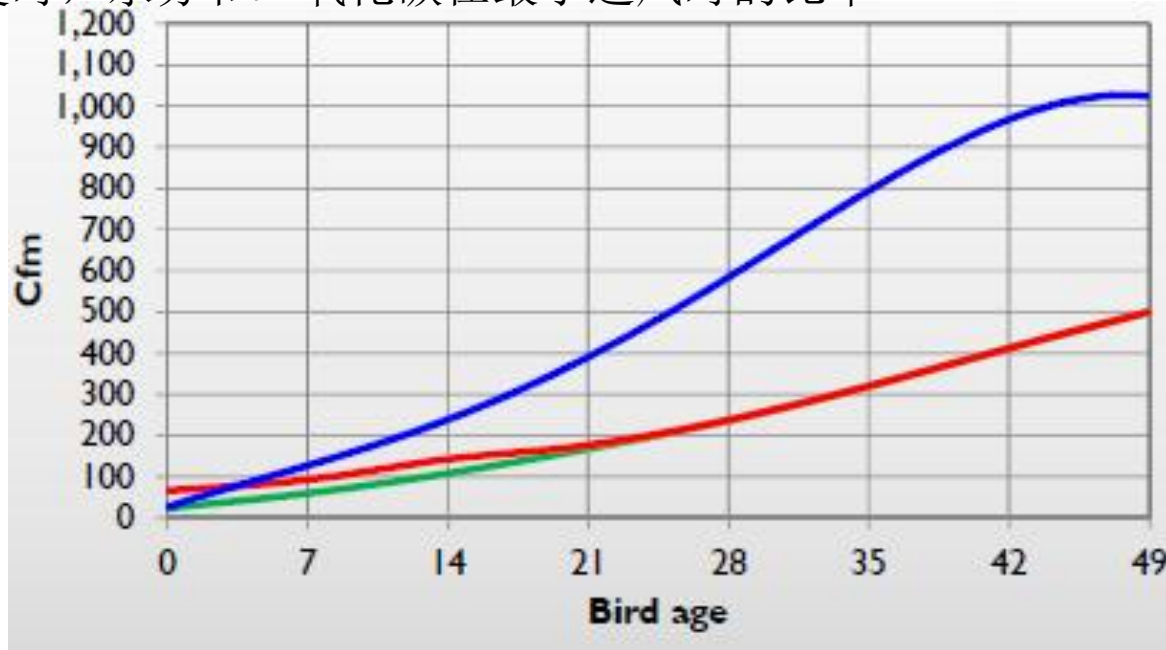


CO₂ is most likely to only be an issue in the 1st 7 days of the flock!

二氧化碳的影响最有影响前7天日龄的鸡群

Comparing Moisture & CO₂ Minimum Ventilation rates @ 5°C outside Temperature

户外5度时，水分和二氧化碳在最小通风时的比率



氨气是我们养殖最大的敌人，氨气的形成和影响？

— Bird CO₂ — Bird + Brooder CO₂ — Moisture Removal

鸡产生二氧化碳 / 鸡+加热器产生二氧化碳 / 移出的水分



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Moisture Control 水分控制

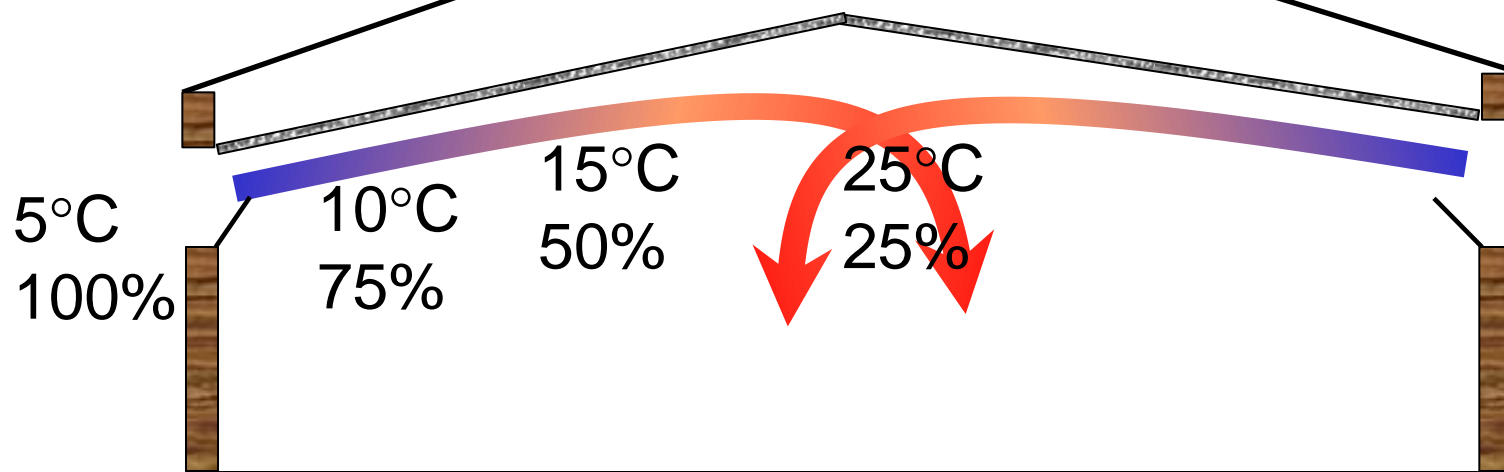


How to Condition Cold 100% humidity air? 怎样调节冷空气中100%的湿度

Keep air close to ceiling 让空气靠近天花板

Maximise heating of incoming air

& maximise moisture holding capacity 让进来的冷空气充分的混合，使吸水能力最大化



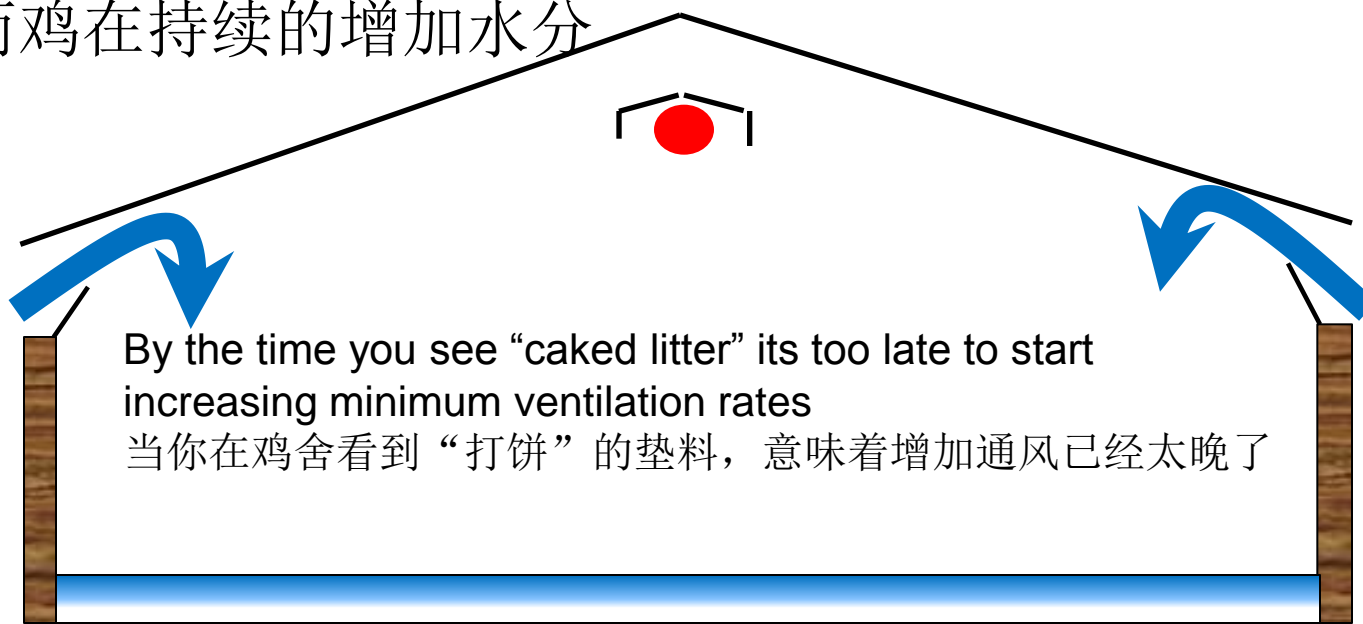


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Managing Litter Moisture 垫料水分控制



- Litter is like a sponge!
- 垫料就像一块海绵！
- A sponge with limited water holding capacity.
- 海绵的吸水能力有限！
- Birds are constantly adding moisture
- 而鸡在持续的增加水分





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Minimum Ventilation 最小通风



2. How to manage incoming cold air
2. 怎样管理来的冷空气



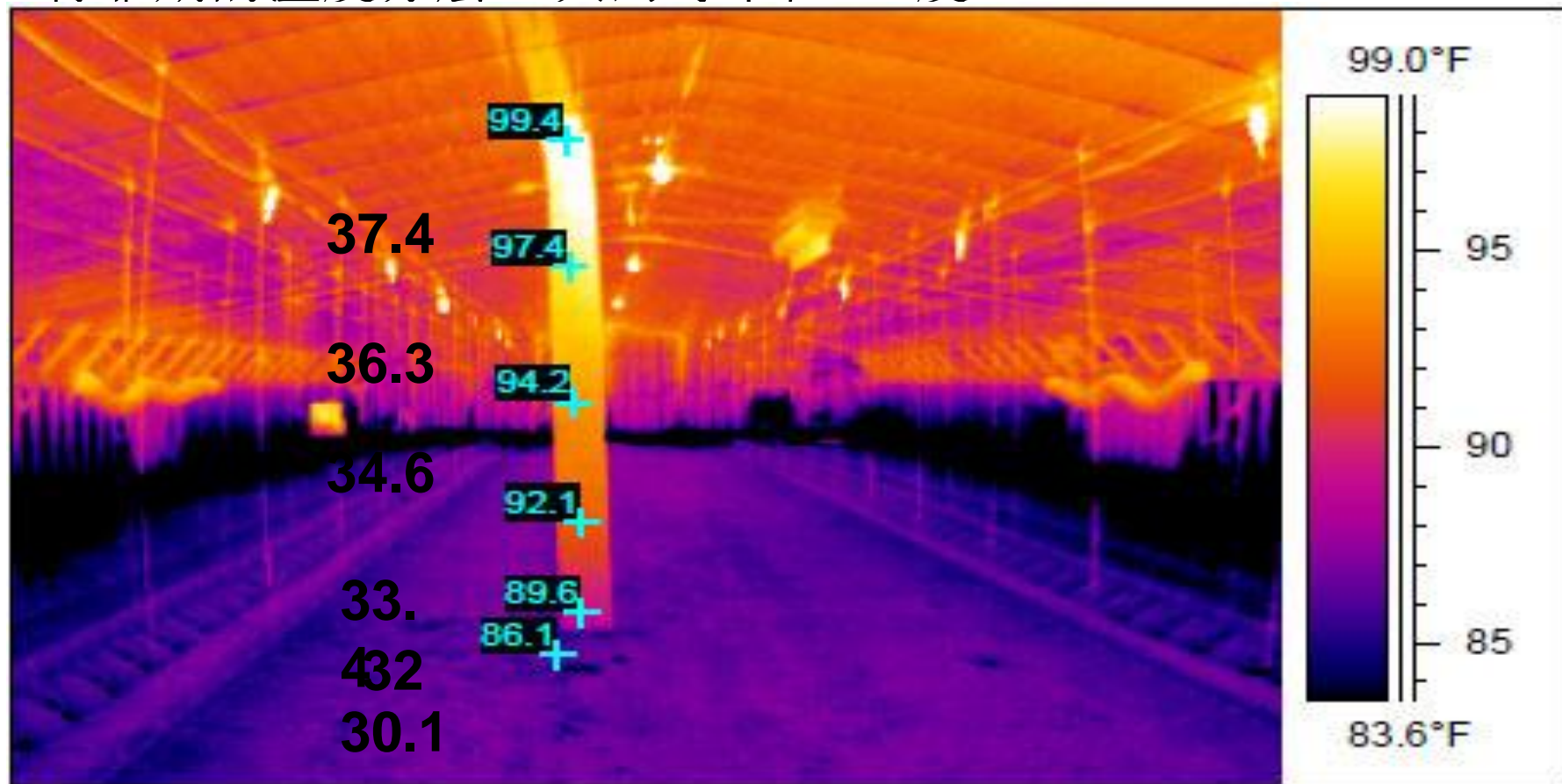
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Temperature Stratification

温度分层



Stratification during brooding – about 2-6°C per m
育雏期的温度分层 – 大约每米在2-6度

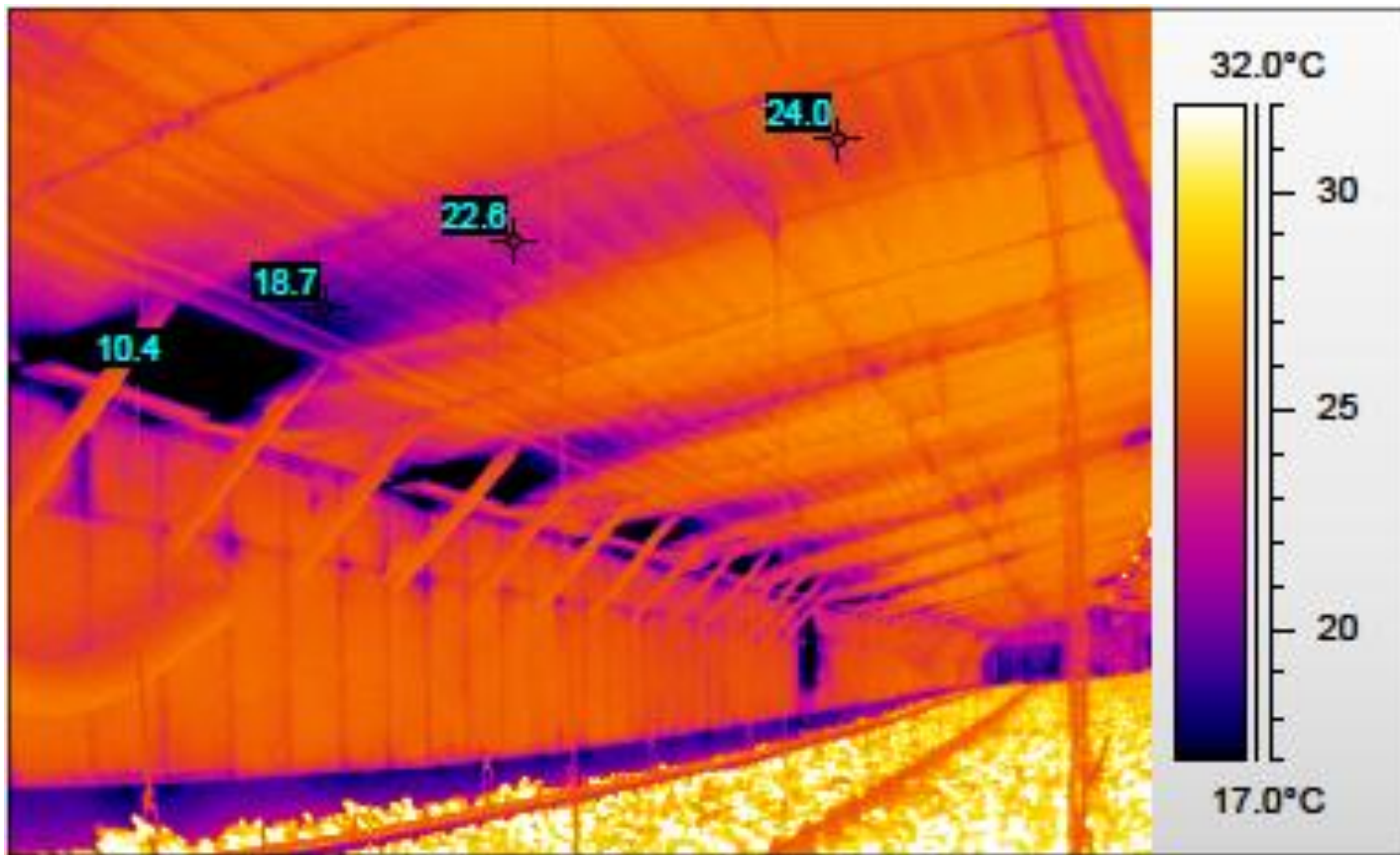




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Conditioning Incoming Air

进来的空气情况



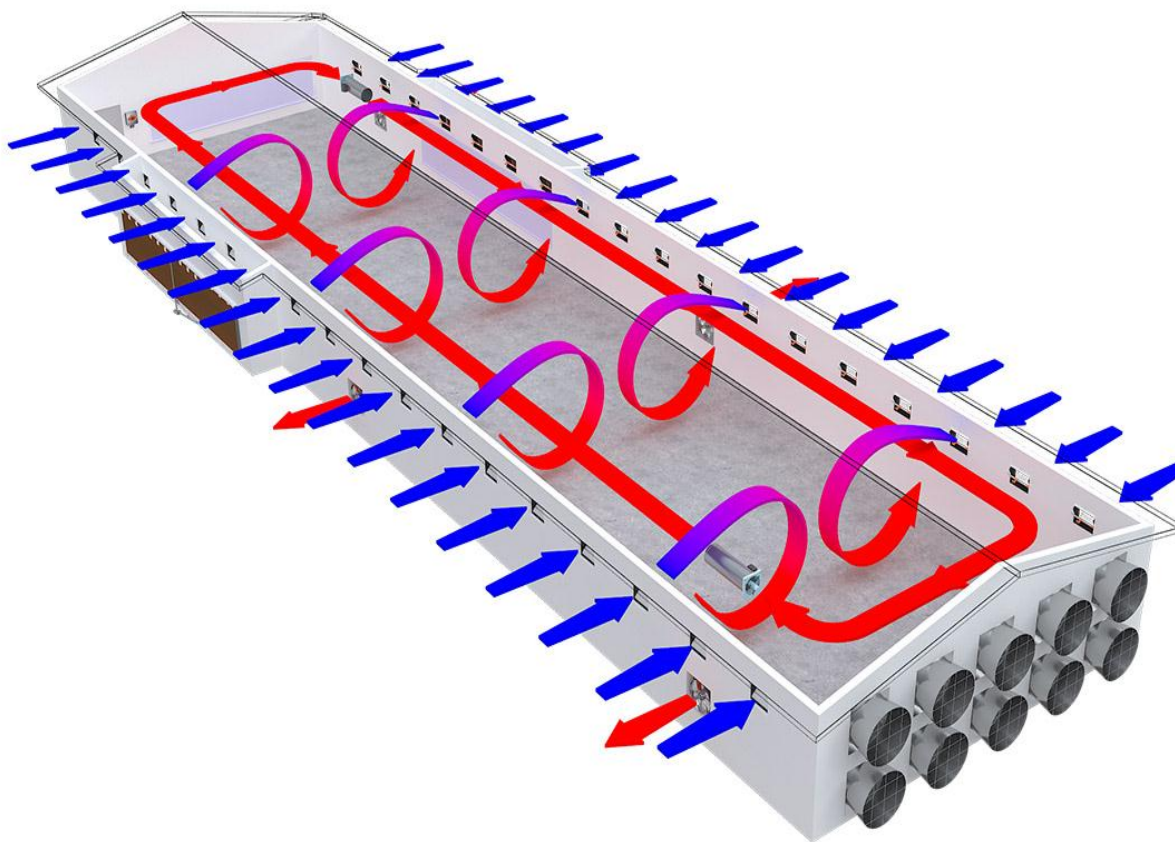
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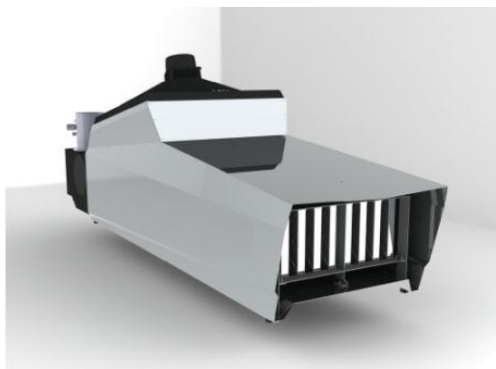
Conditioning Incoming Air

进来的空气情况



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Heating system 加热系统



笼养系统更加建议使用直接对空气进行加热的加热器

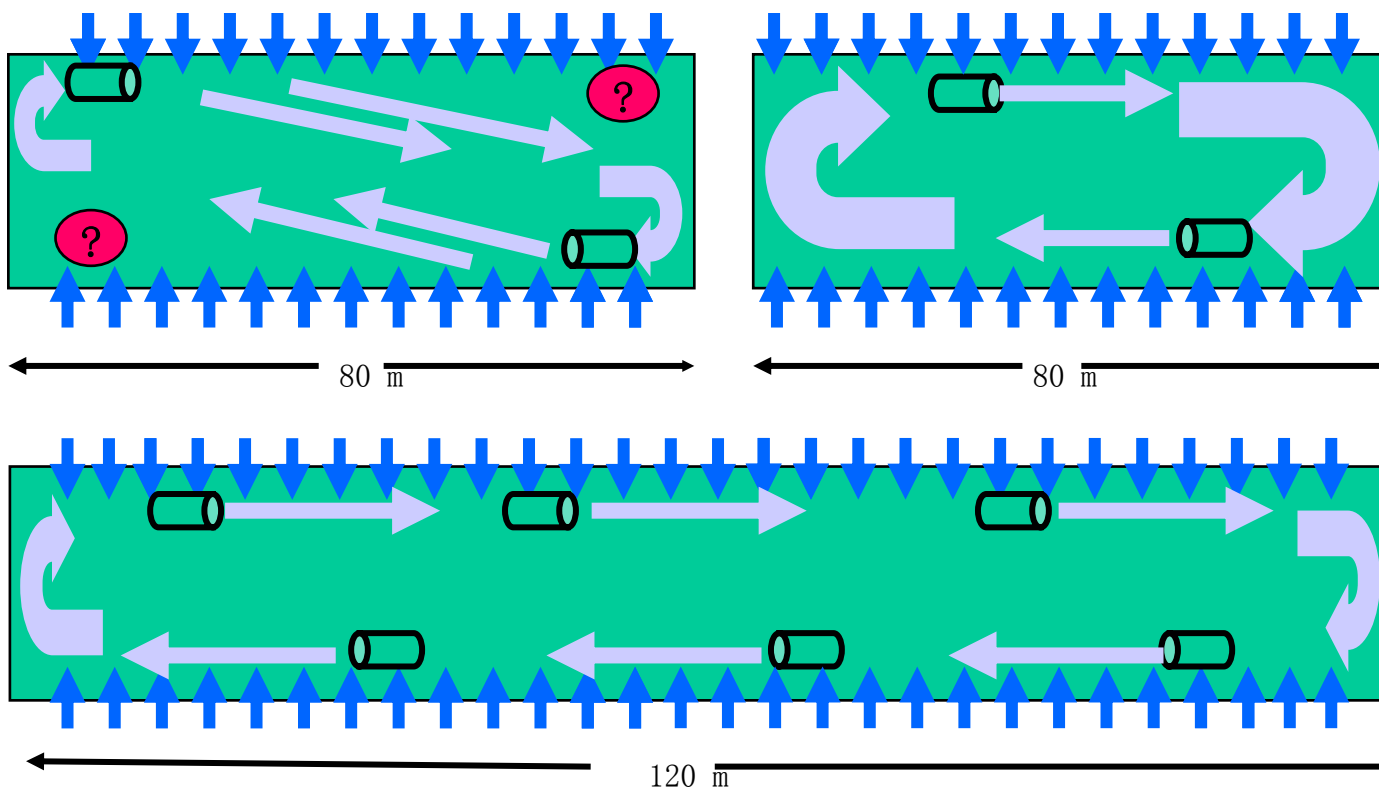


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Heating system 加热系统

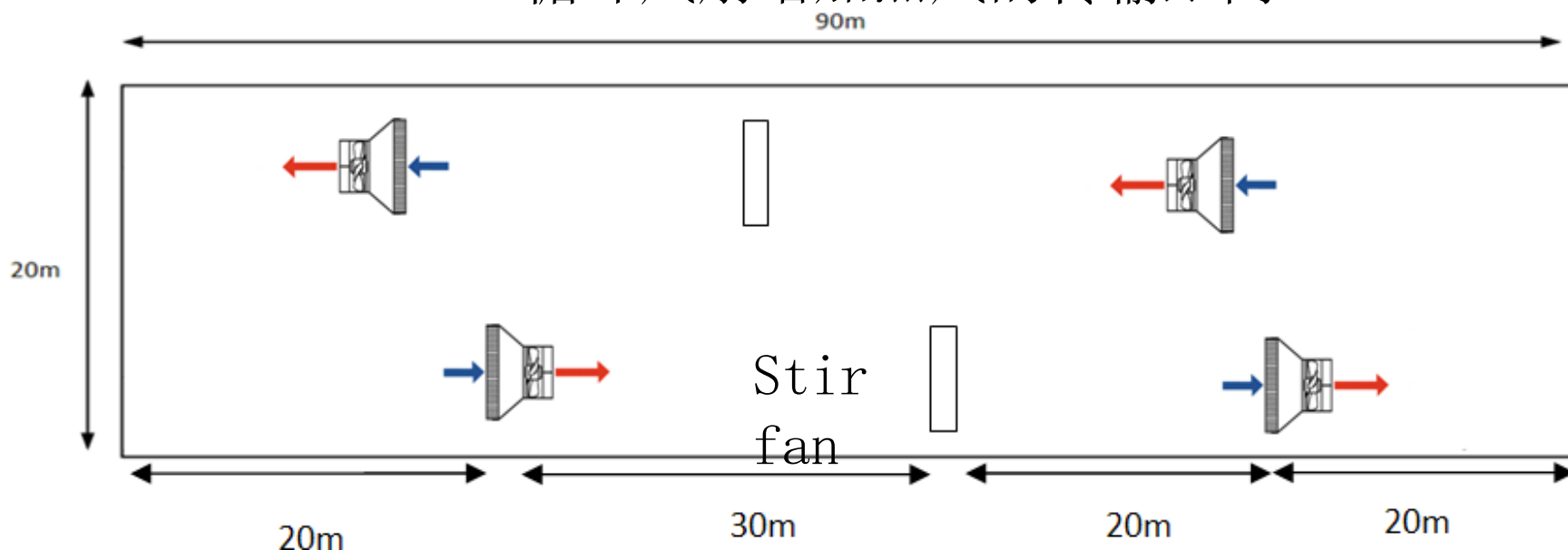
所以才有了这样的加热器排布设计



第一时间预热房舍最冷的部分

Heating system 加热系统

循环风扇增加热风的传输距离



虽然在这里强调了供暖的重要性，是为了保障目标温度。
但是大家一定要注意，最小通风是保障鸡只生存的最小通风量，与温度无关！
问题：保证最小通风量的同时保障不了温度怎么办？

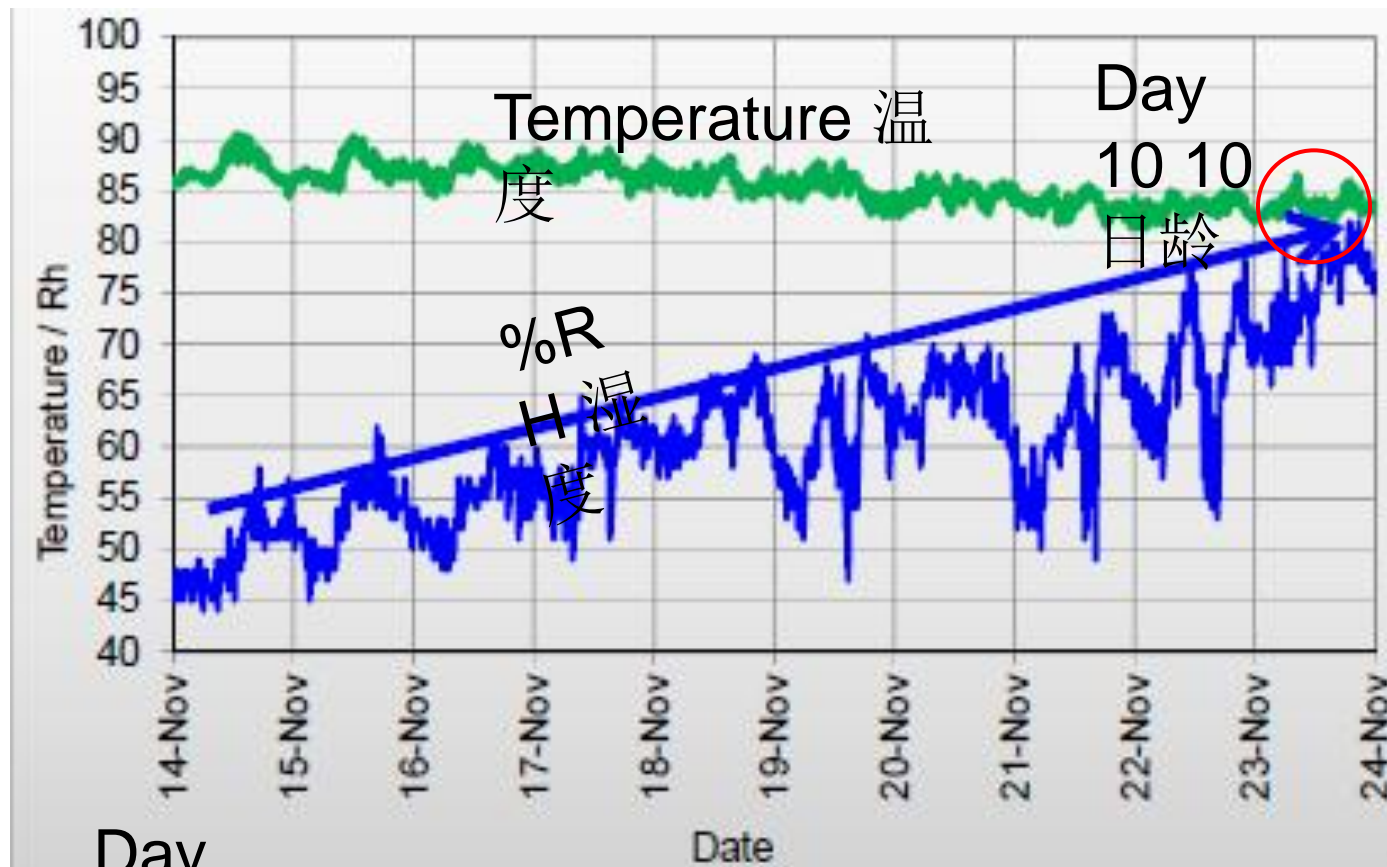


Example of Litter Moisture Build-Up

例子：垫料中水分的构成



RH% should be managed below 60%
相对湿度需要控制在60%以下



Day
0



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Water Consumption – 24,000 birds

饮水消耗- 2.4万只鸡

Approximate Daily Water Consumption – 24000 birds

2万4千只鸡大约每天消耗的水量

<u>Week 周</u>	<u>litres/Day 升/天</u>
1	980
2	1800
3	3111
4	4590
5	6000
6	7100
7	7500



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Approximate Water Added To House – 24000 Birds 2万4千只鸡在鸡舍内大约增加的水分



Source: M. Czarick -- UGA



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How to keep floors dry?

怎样保持地面干燥?

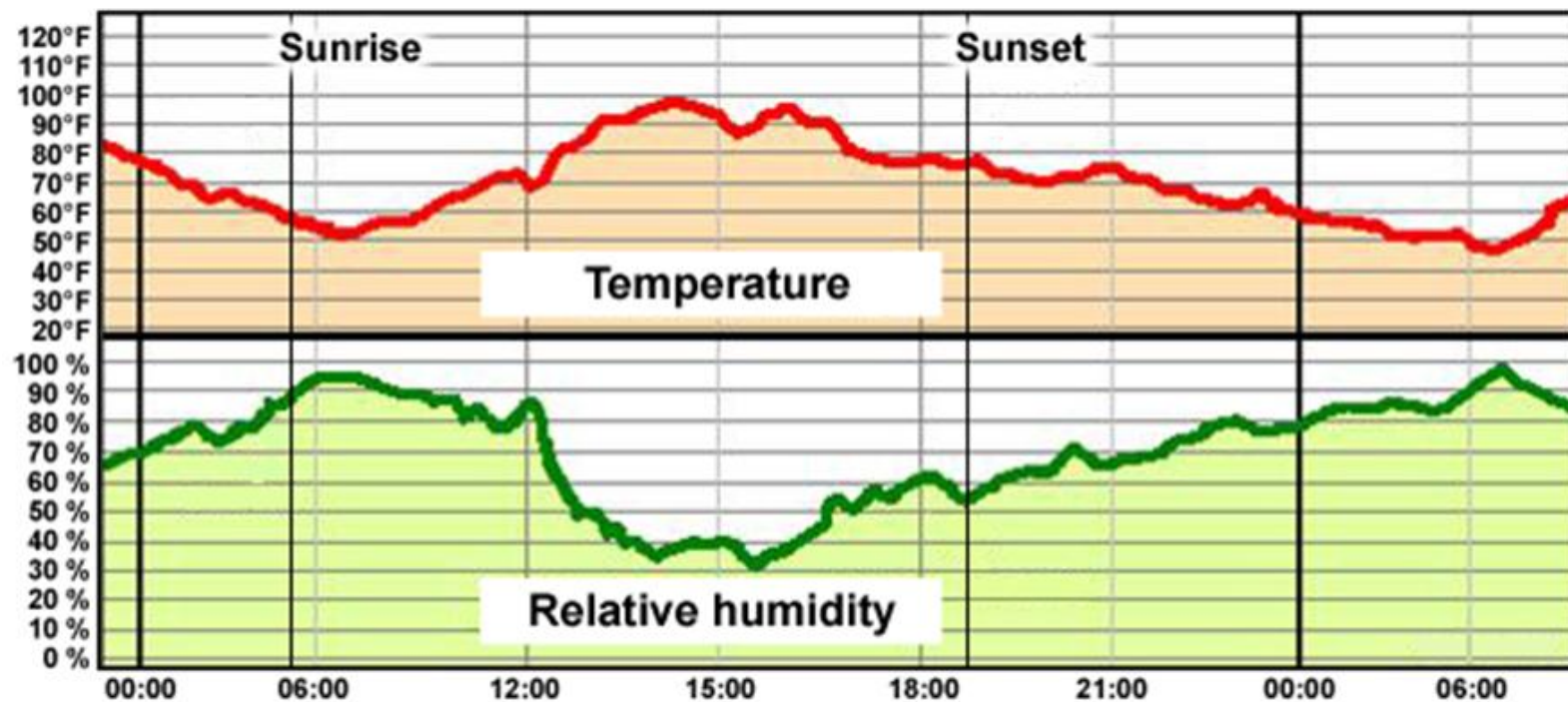
- ❖ Reduce Humidity!
- ❖ 降低湿度!
- ❖ 1°C increase = 5%RH reduction
- ❖ 每升高1度=相对湿度降低5%
- ❖ Heated air expands & holds more moisture.
- ❖ 热空气的扩散和增加吸水能力
- ❖ Take advantage of higher temp & low RH days!
- ❖ 利用好温度高和湿度低的天气!

Winter Minimum Ventilation Challenge?

冬季最小通风的挑战?



Temperature and Relative Humidity



Michael Baker



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%RH When Heated to 30°C

当加热到30度时的相对湿度



Saturated Cold Air饱和的冷空气

Ambient °C 环境温度	H ₂ O (g/m ³) 水（克/每立方米）	%RH 相对湿度	New %RH @ 30°C 30度时新的湿度
0	4.86	100	15%
3	5.98	100	19%
5	6.84	100	22%
7	7.81	100	25%
10	9.49	100	30%
12	10.78	100	34%
15	13.02	100	41%
20	17.66	100	56%

What Pressure & Airspeed?

压力和风速?



General Rule: 基本规则

1ft²/750cfm or 1m²/229m³/min

1 平方英尺 / 750 立方英尺 或是 229立方米/每分钟

House width (m) 鸡舍宽度 (米)	Pascal's/inH ₂ O (帕) 压力	Air speed m/s (fpm) 风速 米/秒	Distance air travels (m/ft) 空气流动距离
10	8 (0.03)	3.5m/s (700fpm)	5.0m/16ft
12	10 (0.04)	4.0m/s (800fpm)	6.0m/20ft
15	15 (0.06)	5.0m/s (1000fpm)	7.5m/25ft
18	20 (0.08)	6.35m/s (1200fpm)	9.0m/30ft
21	25 (0.1)	7.5m/s (1470fpm)	10.5m/35ft
24	35 (0.15)	8.0m/s (1600fpm)	12.0m/40ft



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Negative Pressure Ventilation

负压通风

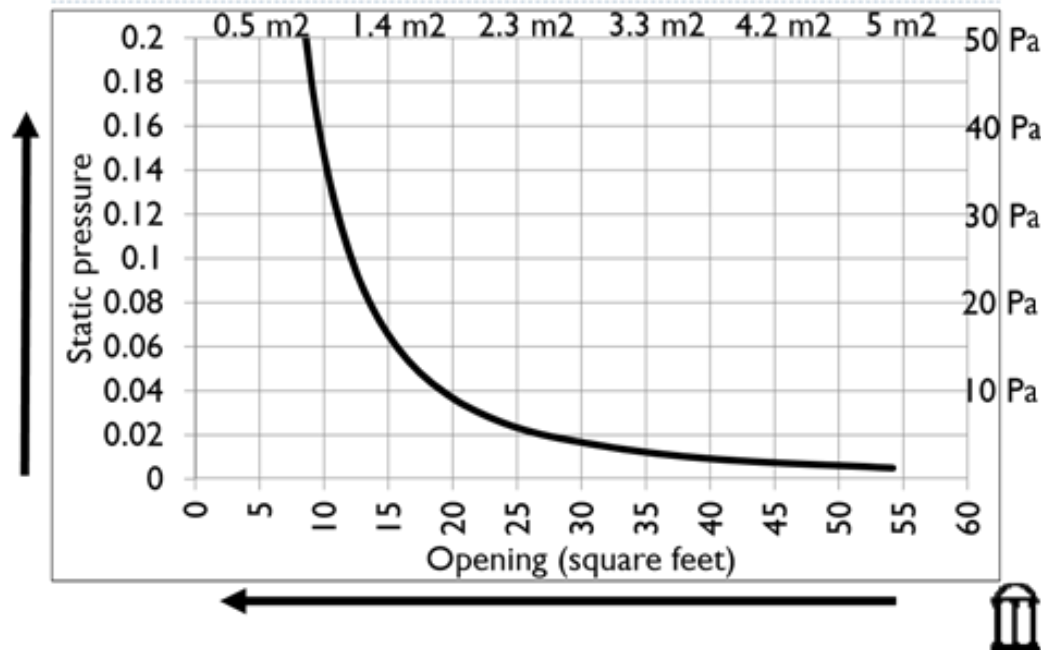


The negative pressure is determined by the amount of inlet opening available to the fan:

负压由风机匹配的进风小窗的开启量决定的

Less opening = more pressure 开口小 = 压力大

More opening = less pressure 开口大 = 压力小



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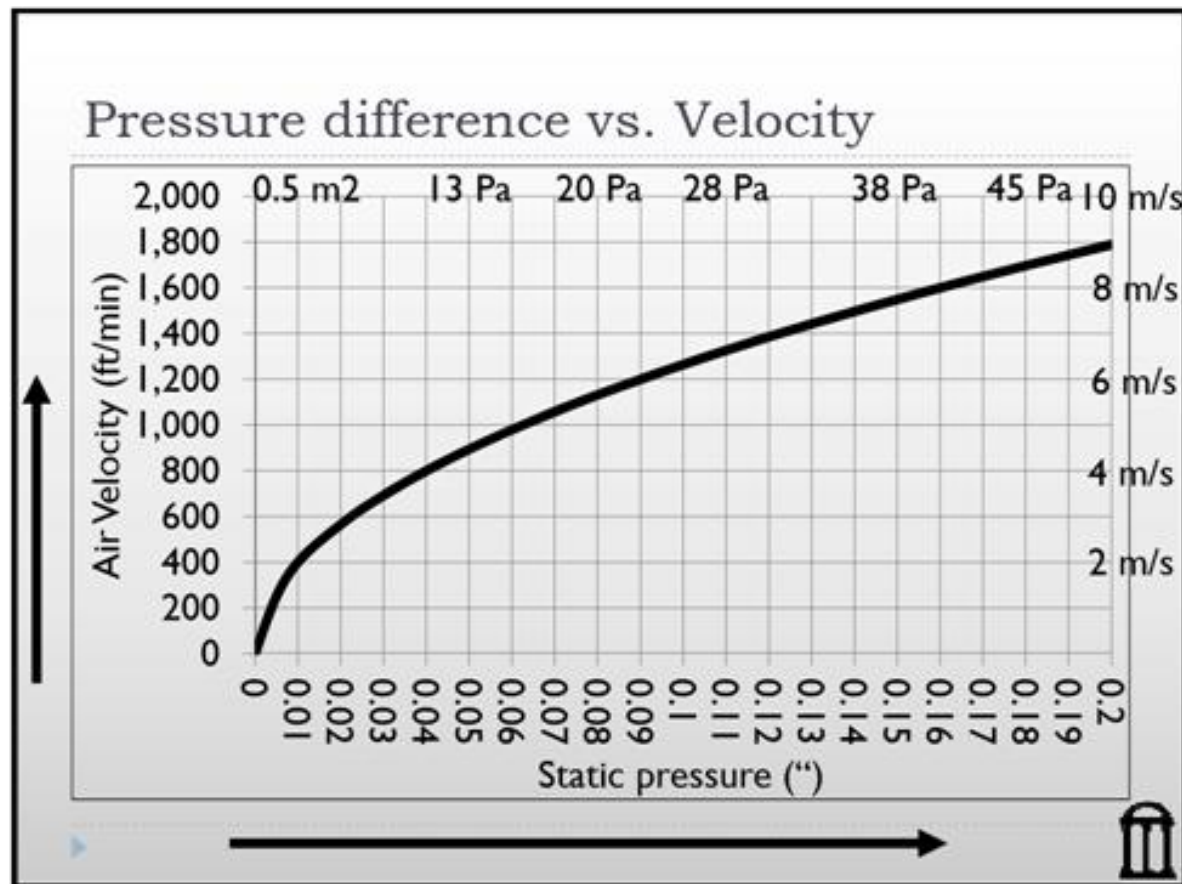


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Negative Pressure Ventilation 负压通风



Relationship between pressure & velocity:
压力和风速之间的关系:



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Test sealing of your house

检测鸡舍的密闭性



How well sealed is the house? 鸡舍的密闭性如何?

TEST: 检测

- All inlets closed
- 所有的风门关闭
- 1 × 120cm Fan (2 × 90cm) ON
- 1*120cm的大风机开启 (2*90cm)
- or 34000m³/h (20 000cfm)
- 或者3.4万立方米/小时 (2万立方英尺)
- Static pressure of 37.5 Pascals or 0.15"
- 负压37.5帕, 或是0.15
- ***If pressure < 25 Pascals or 0.10" then the house is leaking very badly.***
- ***如果压力小于25帕或是0.1, 预示鸡舍密闭性很差***
- **1cfm per 1ft² floor area or 0.28m³/min per 1m²**
- **1立方英尺每分钟/ 每平方英尺 或者 每平方米0.28立方米/分钟每平方米**





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Leaks Area VS Static Pressure

漏风面积对负压的对比



OLD 之前		UPGRADED 更新		NEW 新的	
0.01"	5.6m ²	0.11"	1.4m ²	0.21"	0.75m ²
0.02"	4.1m ²	0.12"	1.3m ²	0.22"	0.7m ²
0.03"	3.3m ²	0.13"	1.2m ²	0.23"	0.65m ²
0.04"	2.6m ²	0.14"	1.1m ²	0.24"	0.6m ²
0.05"	2.3m ²	0.15"	1.0m ²	0.25"	0.55m ²
0.06"	2.0m ²	0.16"	1.0m ²	0.26"	0.5m ²
0.07"	1.9m ²	0.17"	0.9m ²	0.27"	0.45m ²
0.08"	1.7m ²	0.18"	0.9m ²	0.28"	0.4m ²
0.09"	1.6m ²	0.19"	0.8m ²	0.29"	0.35m ²
0.10"	1.5m ²	0.20"	0.8m ²	0.30"	0.3m ²
“VERY LEAKY” 漏风严重		TIGHT 密闭性		VERY TIGHT 密闭性极佳	





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House sealing 房舍密封

如何评估房舍的密闭性？



关闭所有的进气口，密封所有的风机，只留下一台大排量风机启动此台风机，得到的负压值越大，房舍密封性越好。

House sealing 房舍密封

如何评估房舍的密闭性？

▶ 特定漏风面积=

$$\frac{(0.24 \text{ 测试风扇的性能} / \text{房舍地面面积})}{\sqrt{\text{静压}}}$$

- ▶ 测试风扇排风量 = (34,000 – 50,000 立方米每小时)
- ▶ 房舍地面面积 = 平方米
- ▶ 静态压力 = 帕斯卡

House sealing 房舍密封

如何评估房舍的密闭性？

举例：

12米宽*96米长的房舍，测试风机排量35000m³/h，测得负压36Pa

$$\begin{aligned}\text{漏气面积} &= (0.24 * 35000 / (12 * 96)) / \sqrt{36} \\ &= (8400 / 1152) / 6 \\ &= 7.29 / 6 \\ &= 1.22 \text{ 平方米}\end{aligned}$$

此房舍的漏气面积约为1.22平方米



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Leaks Area VS Static Pressure

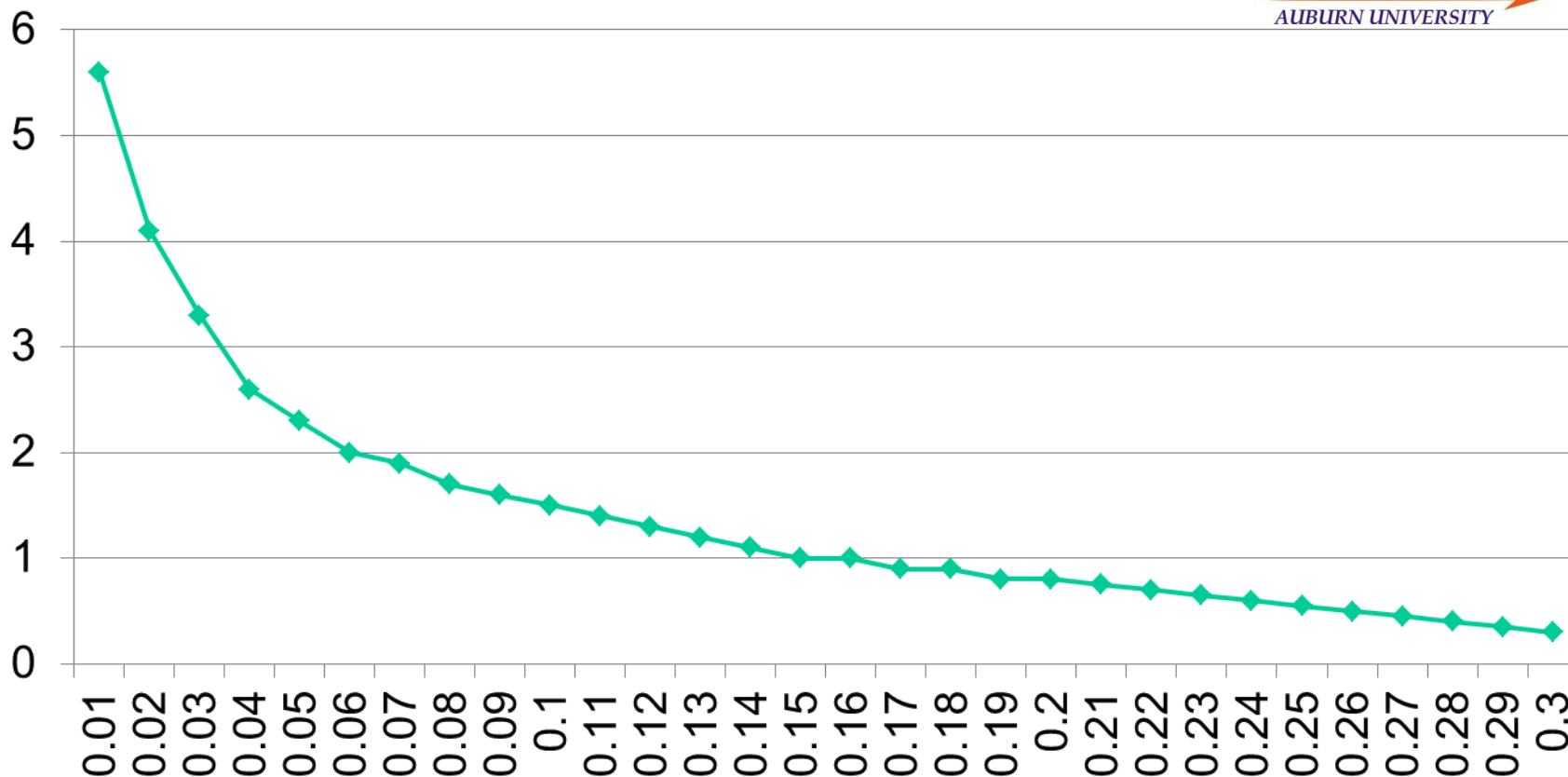
漏风面积和负压对比




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Leakage Area (m²)

NPTC
National Poultry
Technology Center
AUBURN UNIVERSITY



How to Find Leaks

怎样检查漏风处



1. Thermal cameras 热成像摄影机
2. Dust accumulation 粉尘堆积情况
3. Condensation clouds – inside our outside 冷凝 – 屋内，屋外
4. Smoke emitters 烟雾弹测试



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Minimum Ventilation 最小通风



3. Inlet Management 3. 进风小窗的管理



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Minimum Inlet Opening?

最小进风小窗的开口?



Traditional Galvanised Side Wall Inlet:

传统的镀锌侧墙进风小窗:

- 4 – 5cm opening needed 需要打开4-6厘米



Recessed “European Style” Inlet:

镶嵌式的“欧洲风格”进风小窗:

- 3 – 4cm opening needed 需要打开3-4厘米



Galvanised Ceiling Inlet:

镀锌的屋顶进风小窗:

- 3 – 4cm opening needed 需要打开3-4厘米



Surface Mounted Ceiling Inlet:

吸顶安装的天花板进风小窗:

- 3cm opening needed 需要打开3厘米





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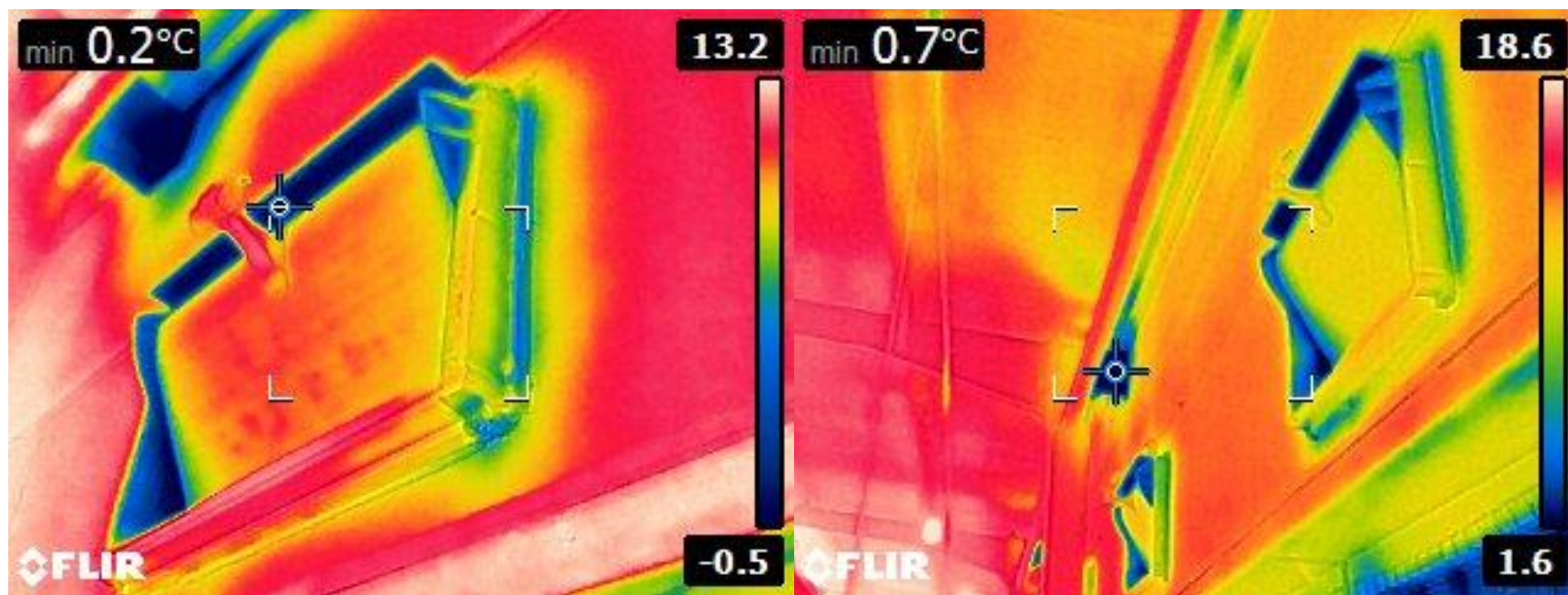
Note 注意



For the no smooth roof house, the inlets guiding plate is very important.
对于屋顶不平滑的房舍，可调节的小窗挡板是非常重要的。
而且大荷兰人的侧风窗的开启是由8毫米的不锈钢杆来开启关闭的



较好的绝热密封度





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Inlet Distribution 进风小窗的分布



1. Temperature and air quality uniformity is primarily determined by inlet distribution not fan distribution

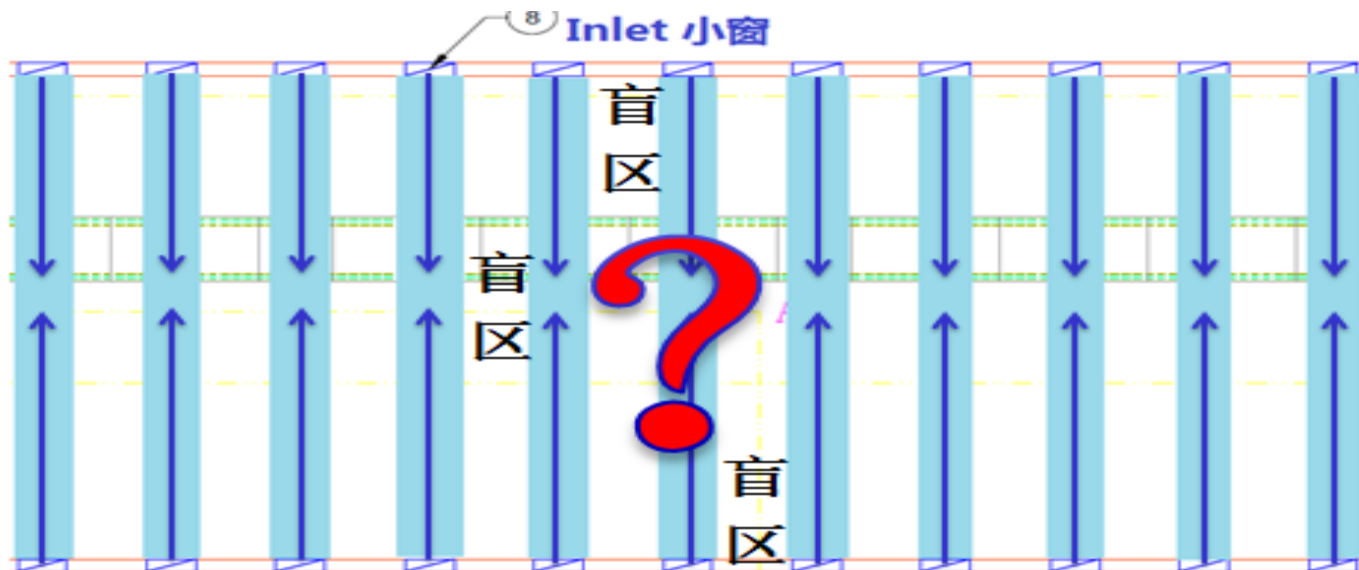
温度和空气质量首先是由进风小窗分布决定的而不是风机的分布决定

2. Air quality for the bird is determined by how far it is from an inlet!

空气质量是有鸡只和进口小窗的和之间的距离决定的

Air quality is determined by how many & how well the inlets are distributed

空气质量是和进风小窗的数量及是否均匀分布决定的



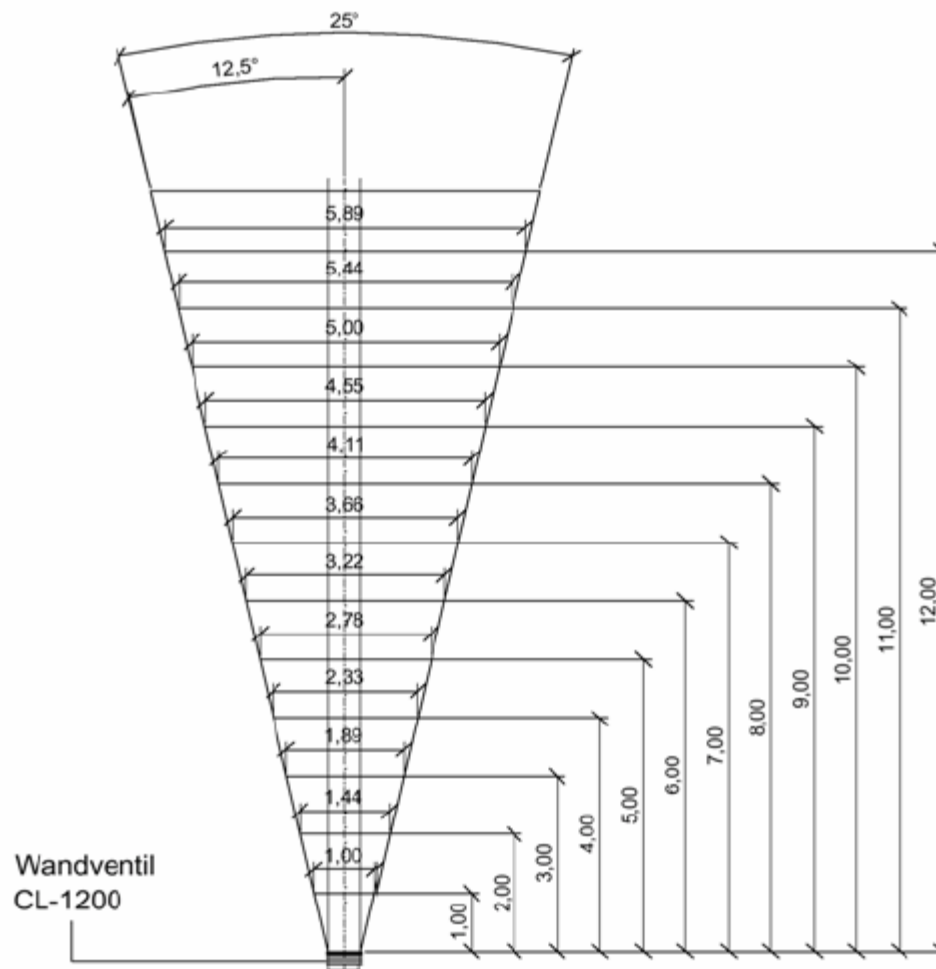
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单个小窗的覆盖宽度



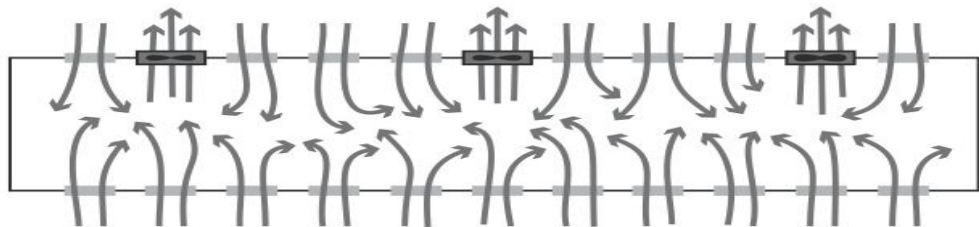
Is Fan Placement Critical?

风机的点位很重要吗?



General Rule: 基本规则:

- A very “tight” house
- 鸡舍的密闭性至关重要
- Fan placement is of some importance, BUT: 风机的定位是重要, 但是:
 - Inlet design/placement is far more important to maintain a good environment
 - 进风小窗的设计和定点才是保持好环境的重点
 - **80% of ventilation design is inlet design & placement**
 - 80%的通风设计在进风小窗和它们的布点上
 - 20% is exhaust fan selection & placement!
 - 20%的设计在大风机和选择定点上



Same opening size...same air flow

cfm = velocity × area

**相同的开启面积, 相同的气流CFM
= 速度*面积**



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Minimum Ventilation 最小通风



4. Minimum Ventilation Calculation

4. 最小通风的计算



Comparing Minimum Ventilation Rates: 20,000 birds

最小通风比例的对比：2万只鸡



Age 日龄	Typical USA Min Vent. Rates (cfm per bird) 典型的美国最小进风 比率（立方英尺/鸡）	Typical USA Min Vent. m ³ /hr 典型的美国最小进风 （立方米/时）	Cobb Timer: ON: OFF (min) 科宝 定时器 开 / 关（分）	Cobb Air Exchange m ³ /hr 科宝空气交换 立方米/时
0	0.10	3398m ³ /hr	1ON : 4OFF	4,140m ³ /hr
7	0.25	8496	1.5ON : 3.5OFF	6,210
14	0.35	11895	2ON : 3OFF	8,280
21	0.50	16992	2.5 : 2.5	10,350
28	0.65	22090	3 : 2	12,420
35	0.70	23789	3.5 : 1.5	14,490
42	0.80	27188	4 : 1	16,560



Week 1 第一周

2. Cycle Run Time – 20,000 birds:

循环运行时间 – 2万只鸡

□ Start – 0.1cfm/bird (Typical US program) = $0.1 \times 20,000 = 2000\text{cfm}$ (3400m³/h)

开始 – 0.1cfm/鸡（典型的美国程序）= $0.1 \times 2\text{万} = 2\text{千CFM}$ （3400立方米/时）

□ **Install** 2 × 36” or 900mm fans with capacity of 10,000cfm (17000m³/h) each or 20,000cfm (34000m³/h)

安装 2*36或是900mm的风机，单个容量为1万cfm(1万7立方米/时)

□ On Time = min vent rate ÷ fan capacity × 300s
 = $2000 \div 20,000$ (3400m³/min ÷ 34000m³/min)
 = 10% On Time OR 30s (5min cycle)

定时 = 最小进风小窗的比例/风机容量*300秒 = $2000/20,000 \times (3400\text{立方米/秒} / 34000\text{立方米/秒}) = 10\%$ 的开启时间 或是 30秒（5分钟一个周期）



Week 2 第2周

2. Cycle Run Time – 20,000 birds:

循环运行时间 – 2万只鸡

□ Start – 0.25cfm/bird (Typical US program) = $0.25 \times 20,000 = 5000\text{cfm}$ (8500m³/h)

开始 – 0.25cfm/鸡（典型的美国程序）= $0.25 \times 2\text{万} = 5000\text{CFM}$ （8500立方米/时）

□ **Install** 2 × 36" or 900mm fans with capacity of 10,000cfm (17000m³/h) each or 20,000cfm (34000m³/h)

□ 安装 2*36或是900mm的风机，单个容量为1万cfm(1万7立方米/时)

□ On Time = min vent rate ÷ fan capacity × 300s
 = $5000 \div 20,000$ (8500m³/min ÷ 34000m³/min)
 = 25% On Time OR 75s (5min cycle)

定时 = 最小进风小窗的比例/风机容量*300秒 = $5000/20,000 \times (8500\text{立方米/秒} / 34000\text{立方米/秒}) = 25\%$ 的开启时间 或是 75秒（5分钟一个周期）



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How Many Minimum Ventilation Fans?

多少最小通风风机?



How many fans on the timer cycle?

定时器开启时，需要多少风机

1. Timer Fan Capacity: 定时风机的容量

- ☐ maximum of 2cfm per ft² floor area
- ☐ 平养地面，最大每英尺2cfm
- ☐ OR maximum of 0.61m³/min per m² floor area
- ☐ 或者平养地面，最大0.61立方米/分钟
- ☐ OR Air exchange capability 5min
- ☐ 或者空气的交换能力在5分钟

- ☐ When birds are young – only 1cfm per ft² of timer fan should be used 当小鸡时 – 应该仅使用1cfm每立方英尺的定时风机
 - ☐ OR 0.30m³/min per m² floor area
 - 或者平养地面每平方米0.3立方米/分

- ☐ Older birds this will be increased gradually to 2cfm per ft² floor area 平养地面鸡长大时，需要逐步增加到2cfm每平方英尺
 - ☐ OR 0.61m³/min per m² floor area
 - 或者平养地面每平方米0.61立方米/分



Example: Typical USA Minimum Ventilation Operation?



Example: 20000 chicks – 1860m² or 20,000ft²:

例子：2万只鸡 – 1860平方米或是2万平方英尺

1. Timer Fan Capacity Installed?: 需要安装定时风机的容量?

- ☐ 1cfm/ft² floor area 平养地面 1cfm/平方英尺
- ☐ OR 18.3m³/h/m² floor area 或是18.3立方米/时/平方
- ☐ Operated on timer cycle 使用定时循环
- ☐ Fans needed: 20,000cfm or (34000m³/h) = 2 × 36" or 2 × 900mm fans 需要的风机：2万cfm（3万4立方米/时）= 2* 36 " 或是2*900mm的风机

- If partial house brooding – recommend using full capacity, unless brood curtain is air tight!
如果部分或半舍育雏 – 建议全部侧排都启用，除非育雏帘密封严密！
- Leave some inlets open in non-brood end. Reduces the amount of cold air entering brood chamber.
- 把非育雏区域的末端一些进风小窗打开。减少冷空气进入育雏区域



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Minimum Ventilation
最小通风



5. Some Key Management Ideas

5. 一些关键的管理理念



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Minimum Ventilation Operation?

最小通风操作?



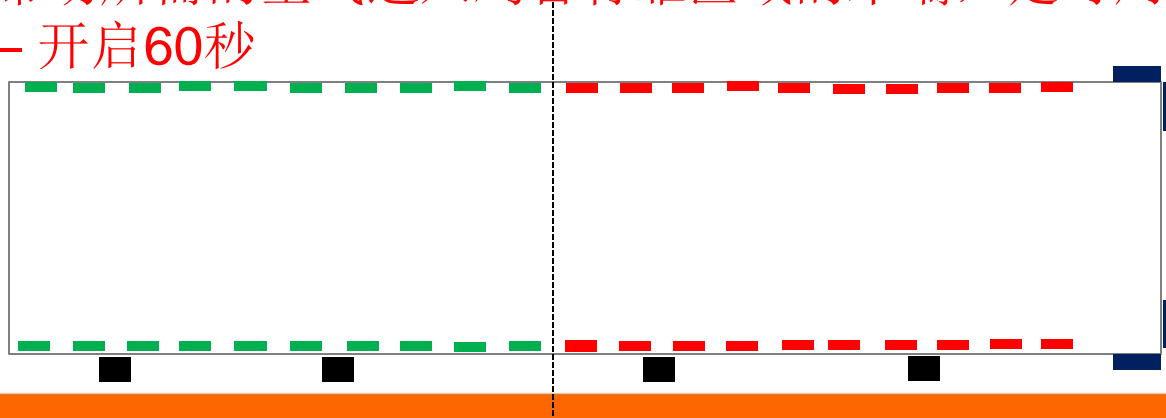
Operation:操作:

- ☐ Turn on 1 fan in both brooding & non brooding ends. 在育雏和非育雏区域的末端各开一个风机
- ☐ Check inlet opening & airflow 检查进风小窗的开口和气流
- ☐ Adjust static pressure if needed 如有必要调整负压

NOTE: If inlets are open on both ends of the house – brood & non-brood:

注意: 如果鸡舍两端的进风小窗都开得话 – 育雏或是非育雏区域:

- ☐ To bring the desired amount of air into the brooding end, timer cycler would be doubled – 60s ON
- ☐ 带动所需的空气进入鸡舍育雏区域的末端，定时周期需要增加双倍 – 开启60秒





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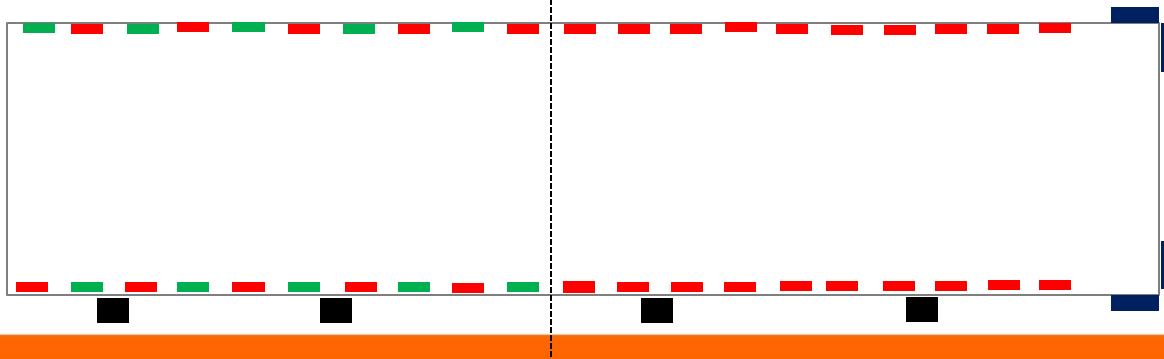
Minimum Ventilation Operation?

最小通风操作?



Leaky House Operation: 漏风的鸡舍操作:

- ❑ Lock ½ of inlets on brood end to create enough opening. 在育雏末端关掉1/2进风小窗的，保证开口充足
- ❑ Using more than 1cfm/ft² for minimum ventilation will result in increased variations in air temperature
- ❑ 使用超过1cfm/平方英尺的最小通风将增加温度的差异
- ❑ House temperatures will drop 鸡舍内温度降下降
- ❑ Use as few fans as possible – **don't "shock" the house!**
尽量使用几个风机- 不要让鸡舍产生剧烈变化





Using Tunnel Fan For Minimum Ventilation? 在最小通风时使用隧道风机？



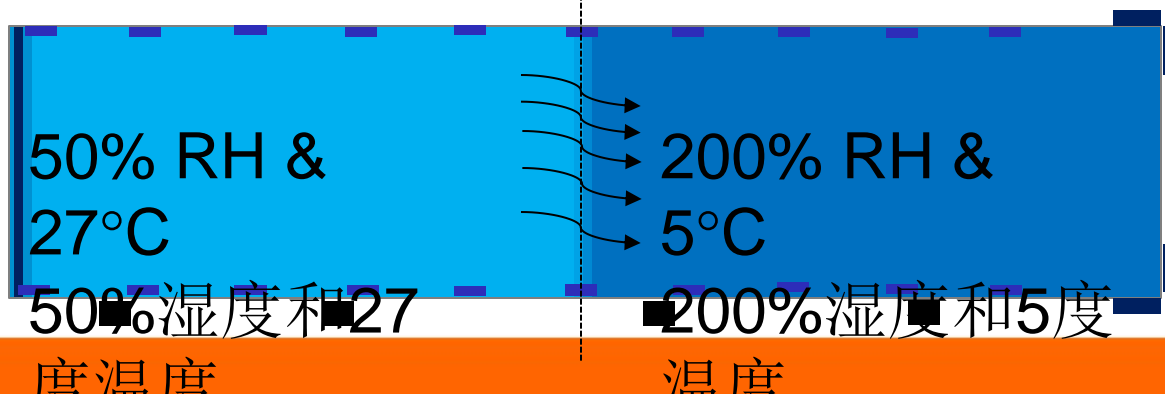
Significant Condensation: 显著的冷凝现象:

- ❑ Ventilating with a tunnel fan during cold weather
– transport water to fan end of house

在寒冷的天气使用隧道风机 – 将水分带到鸡舍末端的风机口

- ❑ Wet litter due to condensation

由于冷凝，潮湿的垫料出现





Key Points 关键点



Minimum ventilation charts provide a general starting point

最小通风表格提供了基本的起始点.

• They do not account for the following: 他们没有将以下点计算在内

1. House temperature & RH 室温和湿度
2. Outside temperature & RH 外界温度和湿度
3. Drinker system and its management 水线系统和管理
4. Fan efficiencies at pressure 风机在压力下的效率

Target humidity: 50% - 65% 目标湿度: 50-65%

• Above 70% will result in wet litter 超过70%将导致垫料潮湿

• Below 50% dusty & potentially chilled chicks!
低于50%会导致灰尘多, 鸡只可能受冷

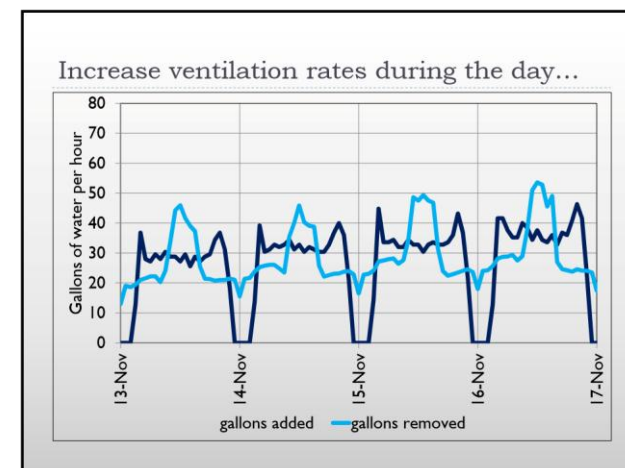
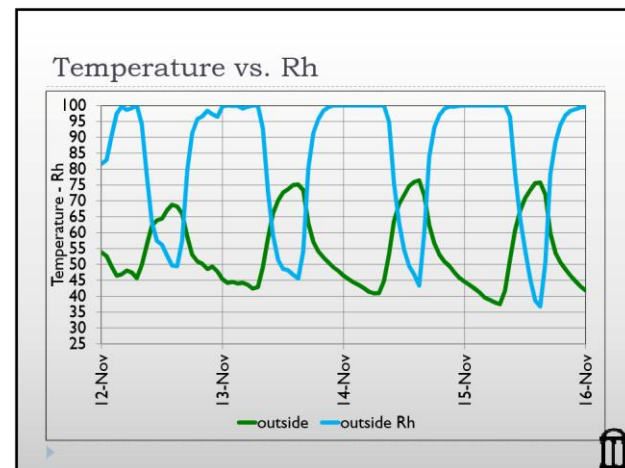
Monitor RH daily – an experienced grower will keep the RH between 50 – 60/65%

每天检测湿度 – 有经验的养殖者会将湿度控制在50%-65%之间

• Daytime vs. Nighttime 白天和夜夜间

❑ Ventilate more on sunny days to compensate for nights!

❑ 晴天多通风来补偿夜里的通风





What should you hear and see in the chicken house? 在鸡舍应该听到或是看到什么？



Chick behavior 鸡只的行为

- Chicks should always be doing the following 鸡只需要一直进行以下活动
 - ❑ Some **eating** 一些鸡采食
 - ❑ Some **drinking** 一些鸡饮水
 - ❑ Some **resting** 一些鸡休息
 - ❑ Some **playing** 一些鸡玩耍
 - ❑ **Evenly spread** throughout the house 均匀分布在鸡舍
 - ❑ *You should hear the birds before you open the door* 你应该在打开鸡舍门前听到鸡的声音
 - ❑ Day 1 -14 - the chicken house should be too warm for the farmer - if not than the temperature is likely too low for the chicks. 1-14日龄的鸡舍温度，应该给养殖者自身的感觉是太暖，如果不是，那么对鸡而言，温度就太低



What should you hear and see in the chicken house?
在鸡舍应该听到或是看到什么？





What should you hear and see in the chicken house?

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在鸡舍应该听到或是看到什么？





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Presentation Outline:

大纲:



1. House design – key considerations
鸡舍的设计 – 需考虑的关键点
2. Transitional ventilation
过渡通风
3. Basics of Bird Heat Transfer
鸡只热量转移的基础
4. House Heat Transfer – key house design considerations
鸡舍热量转移 – 鸡舍设计的关键注意点
5. Tunnel Ventilation - key house design considerations
隧道通风 – 鸡舍设计的关键注意点
6. Managing evaporative Cooling Systems
水帘制冷系统的管理
7. Evaporative cooling maintenance
水帘的维修保养



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Minimum Ventilation 最小通风



1. House Design – key considerations
1. 鸡舍的设计 – 需考虑的关键点



1. Heat Balance Considerations & Calculations / 热平衡考虑和计算

- ❖ Maximum bird heat to be removed – density
- ❖ 鸡只数量最多时需要移出的热量 – 密度
- ❖ Heat load on house – hottest day of year
- ❖ 鸡舍的热负荷 – 一年中最热的天气
- ❖ Geographic & historic weather considerations
- ❖ 地理和历史气象条件的考虑
- ❖ Heat transfer characteristics of all building surfaces.
- ❖ 建筑表面热量转换的特征

2. Air Exchange Considerations & Calculations 空气交换考虑和计算

- ❖ Design Max Acceptable ΔT from end to end.
- ❖ 可接受最大量的设计，鸡舍前端到后端的温差
- ❖ Calculation of Airflow Necessary to Achieve Design.
- ❖ 设计鸡舍需要根据气流

Note: Fan power will be very similar regardless of bird size, BUT Air Speed will vary
提示：根据鸡只的大小设计风机的容量是很相似的，但是气流的速度却是不同的



3. Wind speed Considerations & Calculations 风速考虑和计算

- ❖ Design wind speed for size & type of birds
- ❖ 根据鸡只的大小和品种设计风速
- ❖ Fan selection to satisfy wind speed & exchange rate requirement
- ❖ 风机需要根据风速和空气交换率要求来选择
- ❖ Adequate electric supply!
- ❖ 供电能力需满足!

4. Evaporative Cooling Considerations & Calculations 制冷系统的考虑和计算

- ❖ Need depends on location and weather patterns
- ❖ 取决于地理位置和天气情况
- ❖ Types of cooling systems & their performance
- ❖ 制冷系统的类型和它们的性能
- ❖ Calculation for maximum installed airflow design
- ❖ 计算安装好后最大的空气流动
- ❖ Calculation for maximum water needs!
- ❖ 计算最大的用水需求

What is the Goal of Hot Weather Ventilation?



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炎热天气通风的目标?



1. Heat removal from the house – house tightness will play an integral role / 将热量移出鸡舍 - 密闭的鸡舍将发挥重要的作用
2. Heat removal from the birds – the role of air speed or wind chill / 将热量移出鸡舍 - 空气速度和风冷效应
3. Temperature reduction of the incoming air – role of evaporative cooling. / 进入鸡舍的空气温度降低 – 制冷系统的角色



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Minimum Ventilation 最小通风



2. Transition Ventilation 2. 过渡通风



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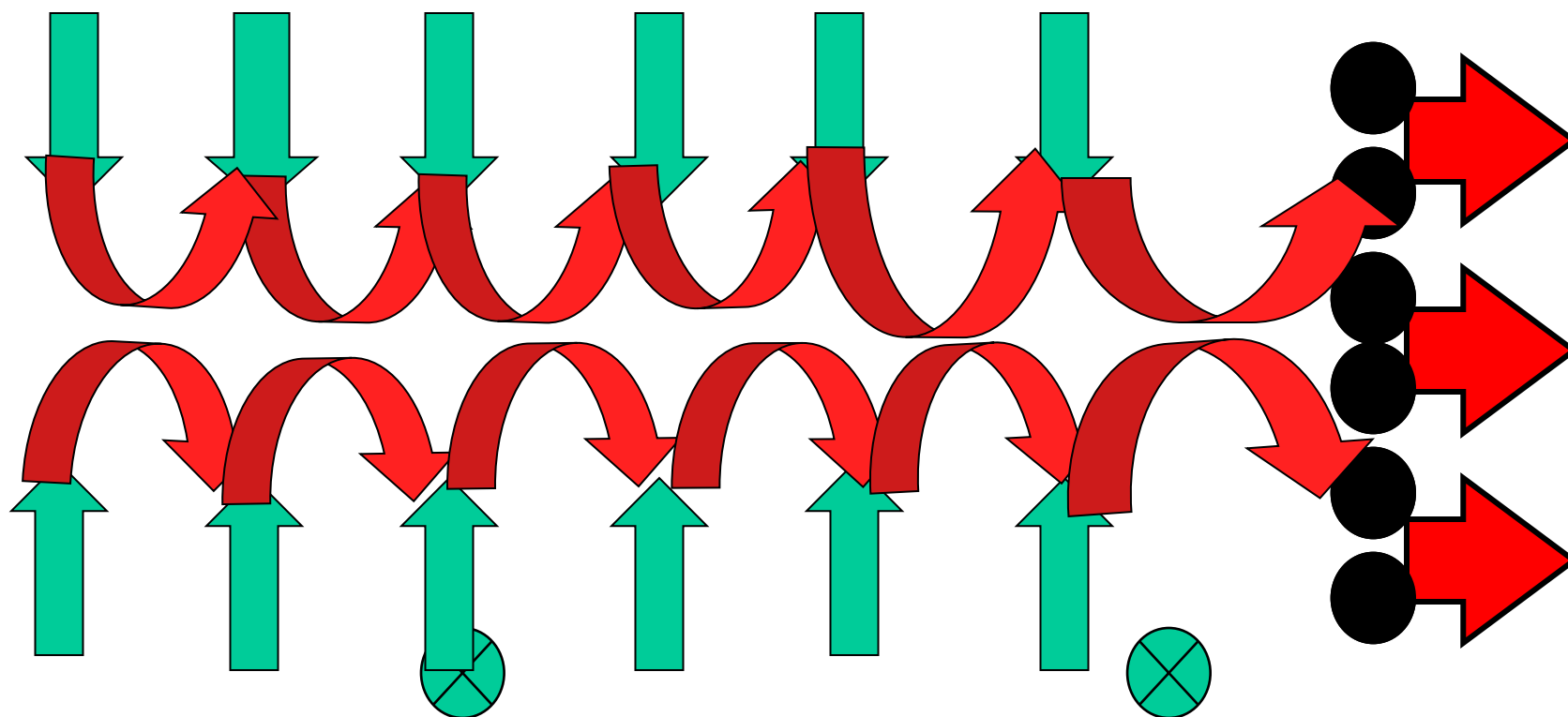
Transitional Ventilation? 过渡通风



- ❑ Use 40 – 50% of 1.2m fans in the gable end of the house & all side wall inlets
- ❑ 使用40-50%的1.2m的山墙风机，侧墙使用进风小窗
- ❑ Air exchange: **2-3min**
- ❑ 空气交换：**2-3分**
- ❑ Airspeed: 25% of full tunnel : **0.5 – 0.8m/s**
- ❑ 空气速度：25%的隧道通风 **0.5-0.8米/秒**



Transition Ventilation 过渡通风



- Even Air Distribution 空气均匀分布
- Increased Air Exchange 增加空气交换
- Limited Air Speed 有限的风速



3. Basics of Bird Heat Transfer

3. 鸡只热量转移的基础

How a bird releases surplus heat?

鸡只怎样释放出多余的热量



If a broiler cannot get rid of all the heat it is producing...

如果鸡只不能将所产生的热量全部释放出来...

- ❖ Body temperature will increase,
- ❖ 鸡只的体温将会上升
- ❖ Feed consumption will decrease,
- ❖ 饲料的采食将会下降
- ❖ Growth rate will decrease,
- ❖ 生长的速度将会下降
- ❖ **FCR will increase,**
- ❖ **料肉比将会增加**
- ❖ Eventually mortality will increase
- ❖ 最终死亡率上升

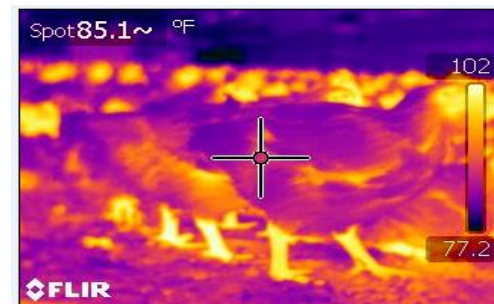
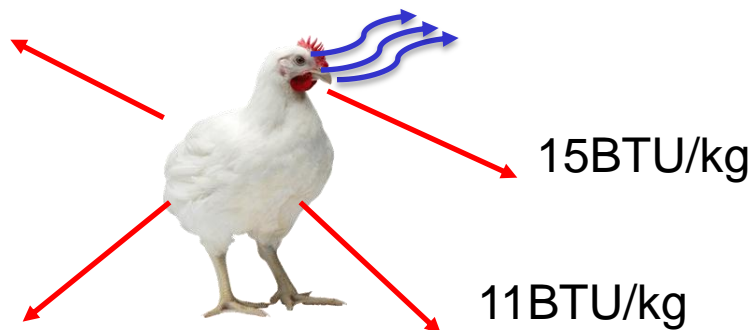
How a bird releases heat?

鸡只怎样释放热量?



A bird releases excess body heat in 2 ways: 鸡只通过两种途径将体内过多的热量释放出来:

1. To the air around it – Sensible Heat – **11BTU/kg or 5BTU/l** / 通过周围的空气 – 体表热量 – 11BTU/公斤 或者 5BUT/磅
 - ❖ The cooler the air the greater the amount of heat loss. The warmer the air, the smaller the amount of heat loss
 - ❖ 空气越凉爽，热能散热越大。空气越暖，热能的散热越小。
2. Through evaporation of moisture from respiratory system – Latent Heat – **15BTU/kg or 7BTU/lb** / 通过呼吸道排出水分 – 内在热量 - 15BTU/公斤 或者 7BUT/磅
 - ❖ the amount of heat a bird loses through the evaporation of moisture off of its respiratory system depends on the relative humidity of the air it breathes
 - ❖ 鸡只通过呼吸道蒸发出去的水分取决于所吸进去的空气的湿度





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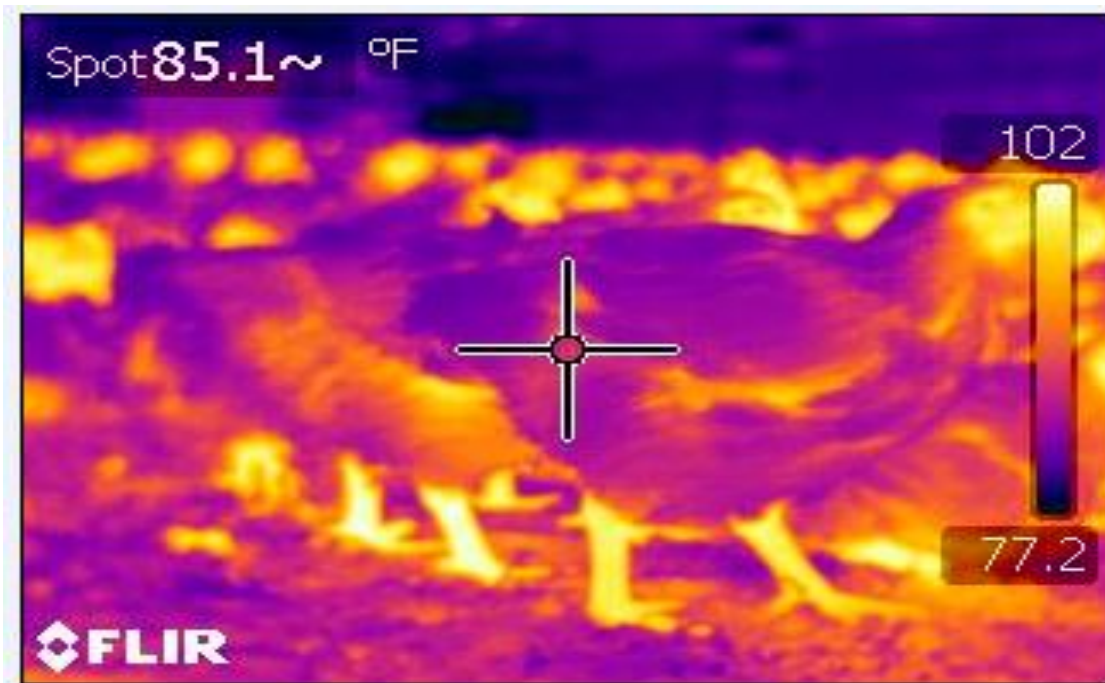
3 Areas Where Broilers Release Heat

肉鸡可以通过三个部位散热



3 Areas on birds where they release sensible heat:
鸡只可以通过以下三个部位进行散热

1. Head, 头
2. Legs, 腿
3. Under wing 后翅膀





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Sensible Heat Release

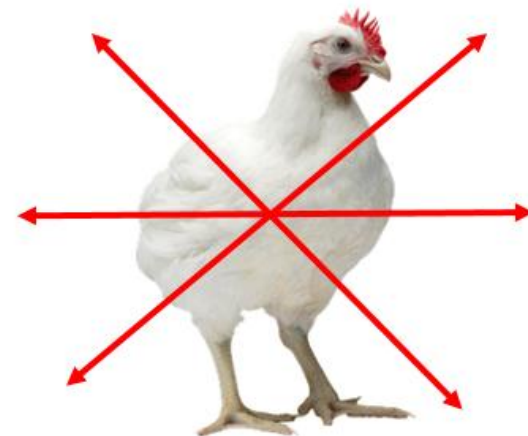
体表热释放



Broiler is essentially “Air Cooled”

肉鸡的本质是“通过空气的流动来冷却”

- ❖ Air velocity shifts heat loss potential - increases sensible heat loss.
- ❖ 空气的流动速度改变散热能力— 增加体感散热
- ❖ Latent heat loss through evaporation – panting - energy is used leading to increased FCR & lower ADG.
- ❖ 通过蒸发热量 – 喘气 – 能量被用来散热，会增加料肉比和低的日增重



11BTU/kg or 5BTU/lb



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Heat Release: 热量释放:



❖ Daily Feed consumption

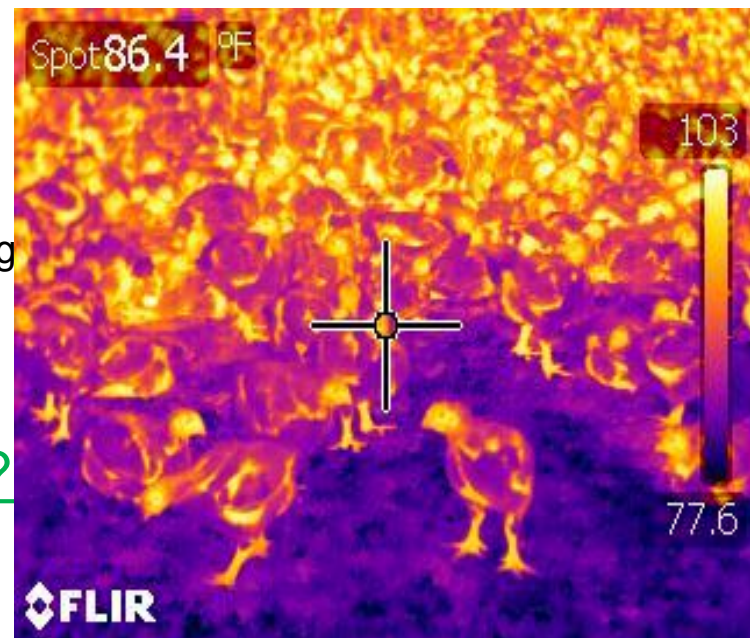
❖ 每日饲料消耗

- ❖ Broilers consume **264** calories per kg of body weight.
- ❖ 肉鸡每公斤体重日消耗**264**卡路里的能量每天
- ❖ Humans should consume **55** calories per kg of body weight
- ❖ 人类每公斤体重需要消耗**55**卡路里的能量每天

❖ How does a broiler use this energy?

❖ 肉鸡怎样使用这些能量

- ❖ Roughly 25% of the energy is used to power the basic functions of life:
- ❖ 粗略计算**25%**的能量用于生存活动
 - ❖ Grow, move around, breath, pumping blood, maintain body temperature, etc.
 - ❖ 生长, 移动, 呼吸, 血液循环, 保持体温, 等等
- ❖ 75% is giving off as metabolic heat – heat a bird needs to get rid of in order to survive!
- ❖ 75%的能量通过代谢排出 – 鸡存活的需要排出这些热量





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Heat Release Example: 热量释放例子:



2.2 Kg broiler: 2.2公斤的肉鸡

- ❖ 21°C & 50% Rh /
- ❖ 21度和50%的相对湿度
- ❖ producing 60 Btu/h OR 17W/h
- ❖ 产生60BTU或是17w/时

Heat Partitioning: 热量区分

1. 25 Btu/h (7W/h) to surrounding air 40%
25Btu/时 (7W/时) 40%到周围空气
1. 35 Btu/h (10W/h) - evaporation respiratory tract 60%
2. 35Btu/时 (10W/时) 60%呼吸道蒸发



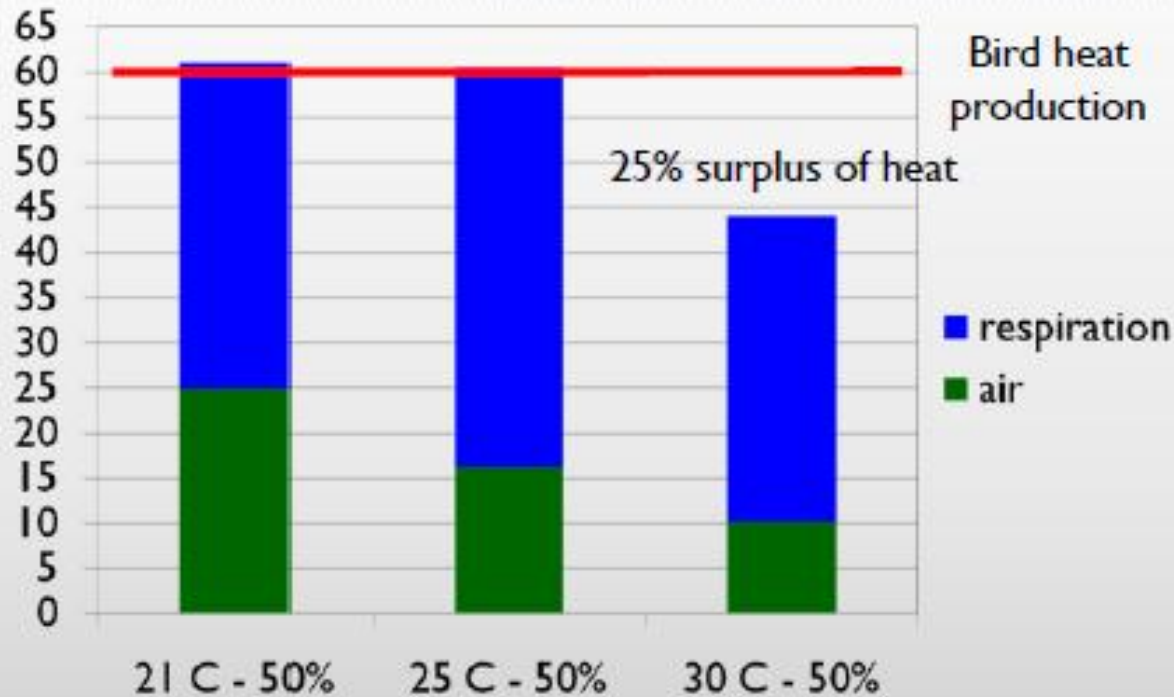
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Heat Release Example 50% RH: 50% 相对湿度时的热量释放



No Air Speed 没有风速

Heat loss from a 2.2 Kg broiler



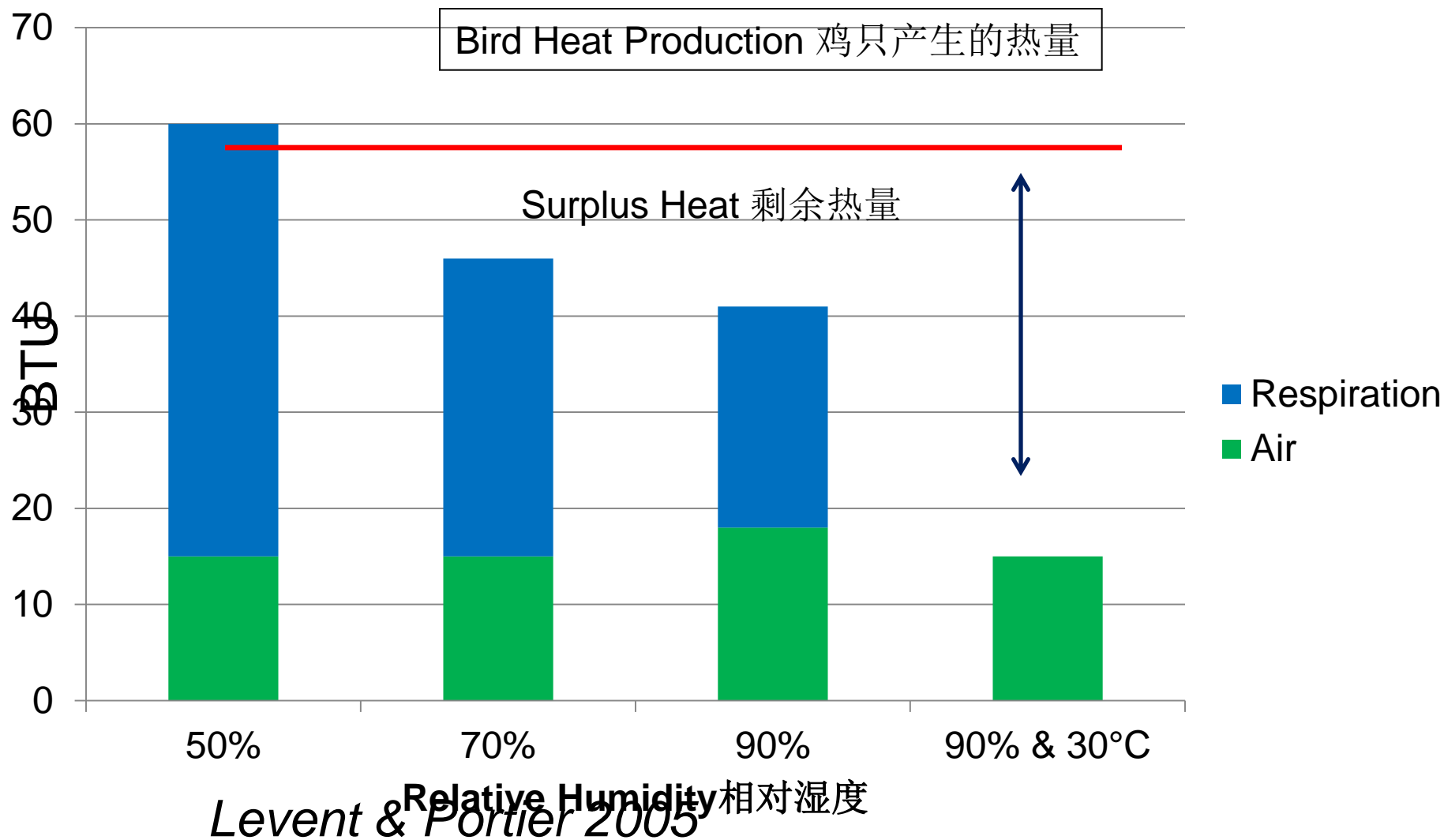
The University of Georgia

College of Agricultural and Environmental Sciences
Cooperative Extension



Heat loss (BTU's/h) from 2.26kg broiler @ 25°C – Still Air

25度静风时，2.26公斤的肉鸡散热（btu/时）

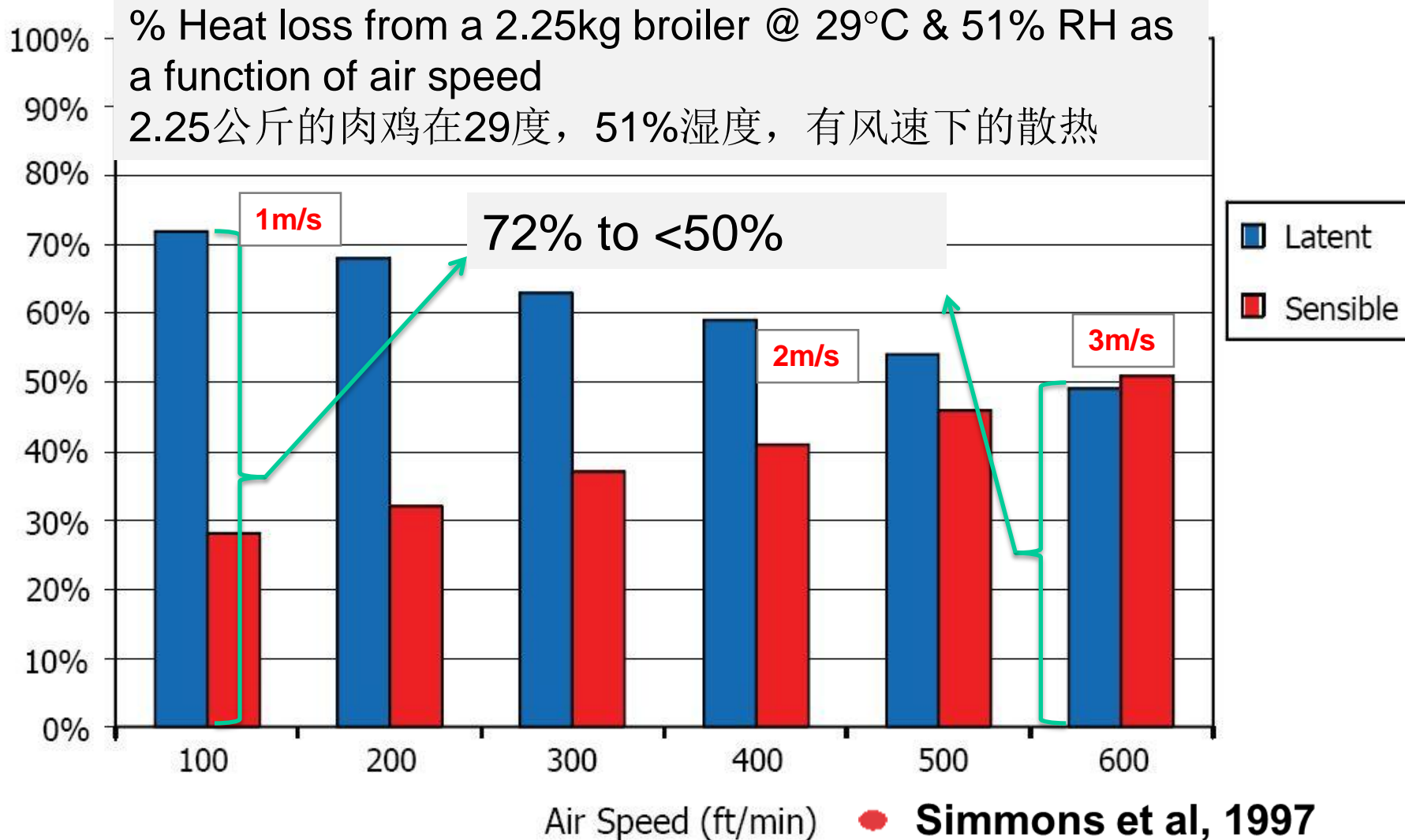




Big Dutchman.

Heat Loss & Air Speed

散热和风速





Big Dutchman.

Heat Loss & Air Speed

散热和风速



Without airspeed evaporative cooling is potentially dangerous and as air velocity increases, the importance of relative humidity to a bird decreases

如果没有风速，制冷系统的使用存在潜在的风险。一旦风速增加，相对湿度对鸡只的重要性将会降低。

If the temperature of the air moving over a bird is equal to its body temperature essentially no heat will be lost to the air. It is not an either/or situation. A producer needs to utilize both air movement and evaporative cooling during hot weather to keep birds comfortable and productive.

如果在有空气流动的情况下，室温等于鸡只的体温，本质上讲，鸡只不会将热量散出去。这不是一个非此即彼的情况。生产者需要利用空气流动和蒸发制冷系统在炎热的天气里让保持鸡只保持舒适，从而高效生产。

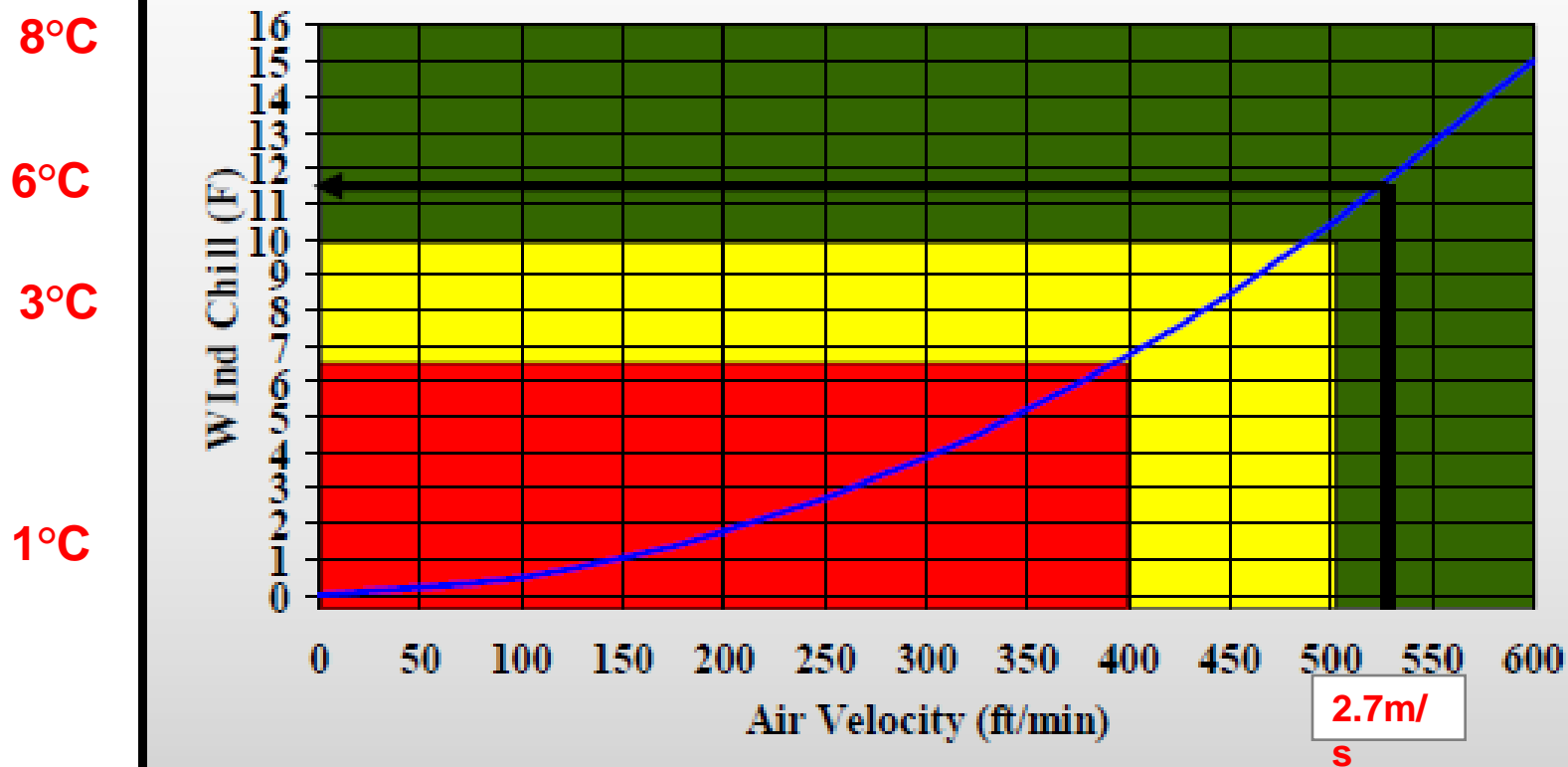


Big Dutchman.

Wind Chill At 29°C 29度时的风冷作用



Wind-chill effect at 85°F





Big Dutchman.

Wind Chill Effect – Effective Temperature

风冷作用 – 实感温度



- Any wind-chill curve is an estimation!!
- 任何的风冷曲线图都只是个预估！！
 - Effective temperature (what a bird perceives the temperature to be) is a function of:
 - 实感温度（什么是鸡只的实感温度）的是：
 1. Air temperature 空气温度
 2. RH 相对湿度
 3. Bird Age 鸡只日龄
 4. Stocking Density 存栏密度
 5. Wind Speed 风速
 6. Amount of radiant Heat – roof or side walls 辐射热的量 – 屋顶和侧墙
- **As a result it is very difficult to come up with a chart/formula that accurately predicts effective temperature!**
- 很难做出一个图表或是公式来准确的预测实感温度！



Big Dutchman.

Heat Release 1.8m/s
散热：1.8米/秒

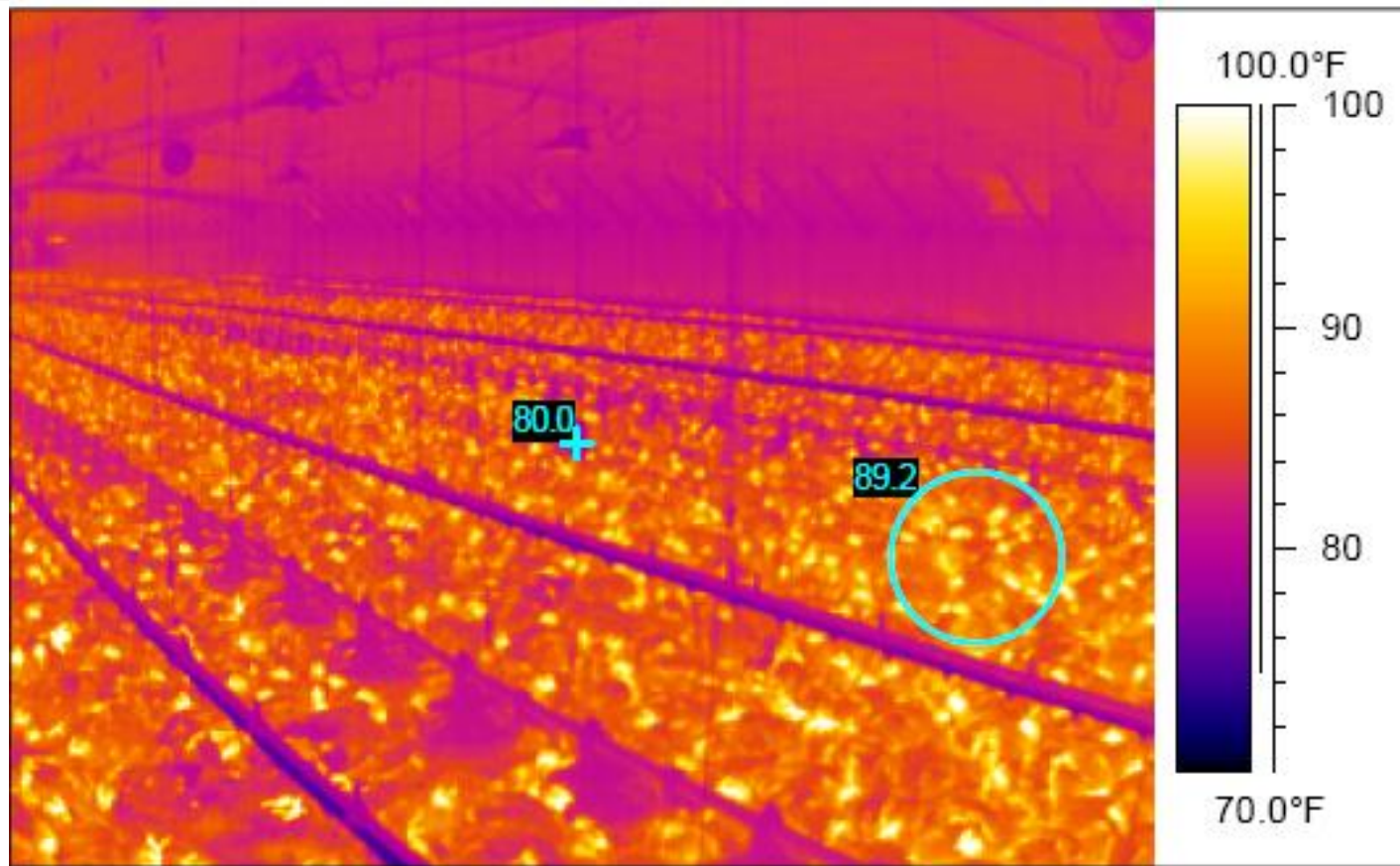


Figure 4. Tunnel-ventilated Broiler House (350 ft/min).



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Big Dutchman.

Heat Release 2.8m/s
散热：2.8米/秒

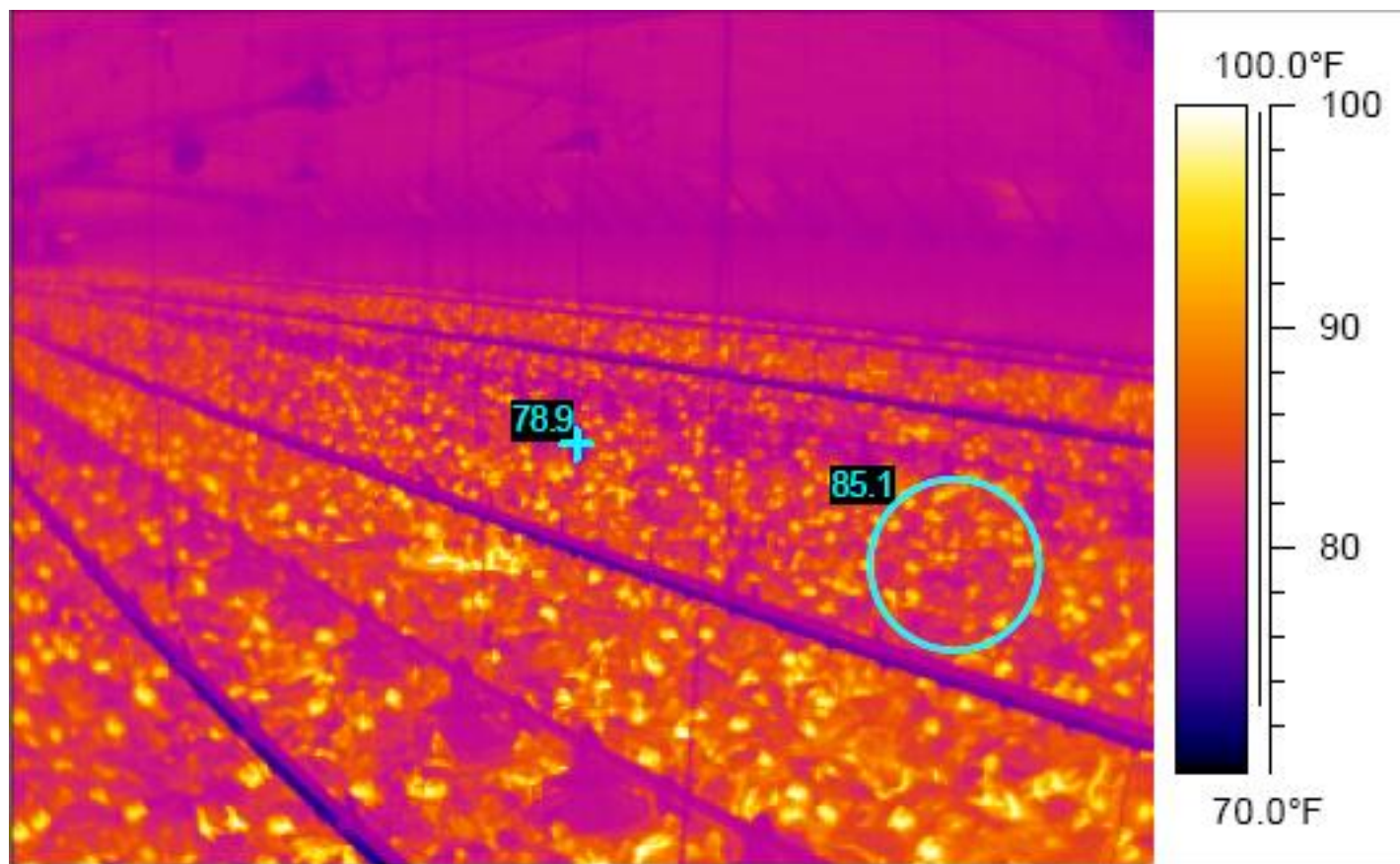


Figure 3. Tunnel-ventilated Broiler House (550 ft/min).



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Big Dutchman.

Minimum Ventilation
最小通风



4. House Heat Transfer

– key house design concepts

4. 鸡舍热量转移 – 鸡舍设计的重点



Big Dutchman

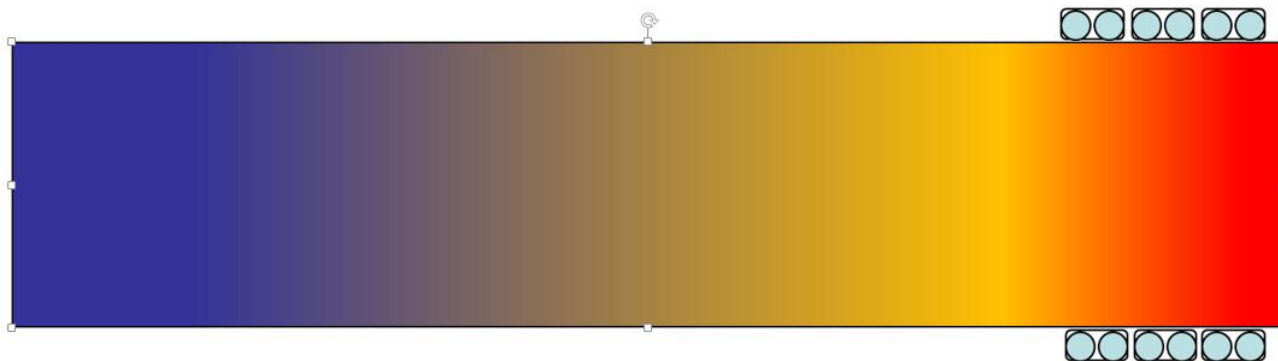
How much does the air heat up?

空气中增加了多少的热量



Depends on: 取决于:

1. Amount of heat added to the air in a house 鸡舍内增加到空气中多少热量
 - ❖ *the more heat added to the house, the hotter the house will be*
 - ❖ 增加到鸡舍的热量越多，鸡舍内就会越热
2. How quickly we exchange the air in the house. 鸡舍内空气的交换速度有多快
 - ❖ *the faster the air exchange rate, the cooler a house will be*
 - ❖ 空气的交换速度越快，鸡舍内就会越凉爽





Big Dutchman.

What Air Exchange Rate?

什么是空气的交换率



We need to make sure we put in enough fans to keep the temperature uniform from end to end.

我们要确保风机数量足够，保证鸡舍内从前到后温度均匀。

A properly insulated tunnel house should have a minimum tunnel fan capacity of:

一个密闭性良好的隧道通风鸡舍需要在隧道通风时风机的最小通风量达到：

1. 9 - 11 cfm/ft² 9-11 立方英尺/平方英尺
2. 165 - 210 m³/m² 165-210 立方米/平方米

This will typically insure a maximum temperature differential of 2.8°C

这是把最大温差控制在2.8度的基本要求

But may not provide enough air speed to cool the birds

但是有可能不能提供足够的风速来给鸡只降温

How to calculate proper air exchange rate?

怎样计算合适的空气交换率?



Big Dutchman



The air in a poultry house is warmed by the heat entering the house through the...

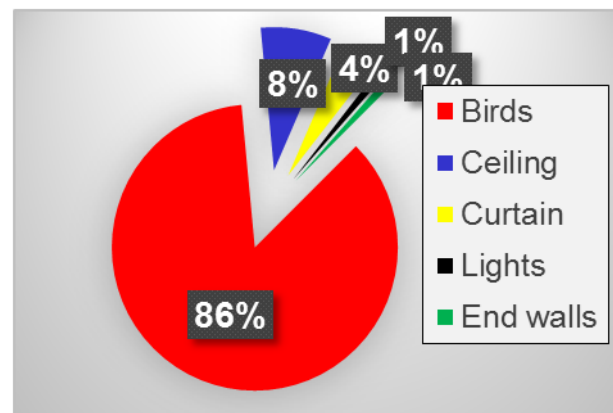
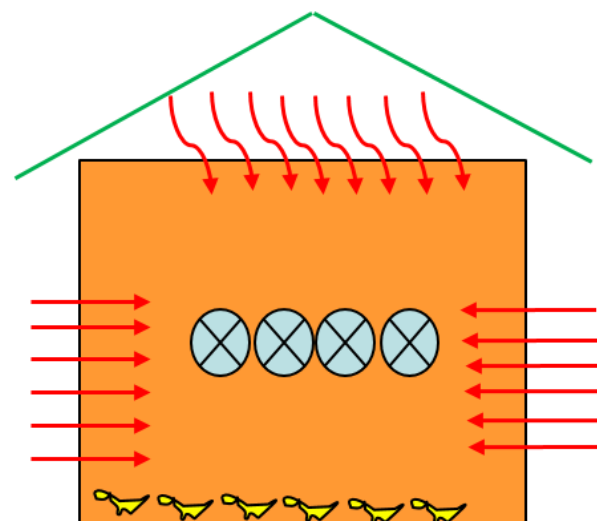
鸡舍内的空气会通过以下的途径变热

1. Ceiling 天花板
2. side walls 侧墙
3. end walls 两端墙体
4. Curtains 卷帘

As well as heat produced by the...

同时还会通过以下方式变热

1. Birds 鸡只
2. Lights 光线





How to calculate the air exchange rate?

怎样计算空气交换率?



$$\text{Total Fan Capacity} \left(\frac{\text{m}^3}{\text{h}} \right) = \frac{\text{Total Heat Added} (\text{kW} \times 3600)}{\Delta T^{\circ}\text{C} (T_{\text{Inlet End}} - T_{\text{Fan End}})} \times 1.2$$

所有风机的容量（立方米/时）= 总共增加的热量（千瓦*3600）/ 温差（进风口末端温度-风机末端温度）*1.2

$$\text{Total Fan Capacity} (\text{cfm}) = \frac{\text{Total Heat Added} \left(\frac{\text{BTU}'s}{\text{h}} \right)}{\Delta T^{\circ}\text{F} (T_{\text{Inlet End}} - T_{\text{Fan End}})} \times 1.089$$

所有风机的容量（立方英尺）= 总共增加的热量（BTU/时）/ 温差（进风末端温度-风机末端温度）*1.089

The accepted ΔT for a modern broiler house is 5°F or 2.8°C

一个现代化的鸡舍可接受的温差在华氏5度，摄氏2.8度



Big Dutchman.

Minimum Ventilation
最小通风



5. Tunnel ventilation – key design concepts

5. 隧道通风- 关键的设计理念



Big Dutchman.

Tunnel Ventilation? 隧道通风?



- ❖ All 1.2m fans in the gable end of the house
- ❖ 所有1.2米的风机都装在山墙端
- ❖ Airspeed: 2.5 – 3.5m/s
- ❖ 风速: 2.5-3.5米/秒
- ❖ Air exchange < 0.75min
- ❖ 空气交换 < 0.75分钟

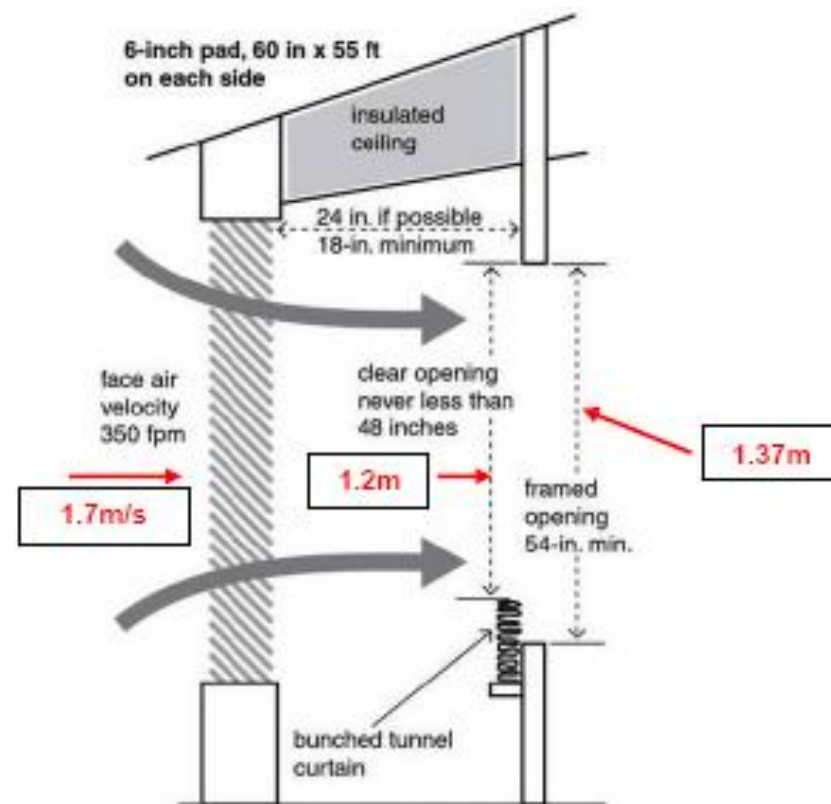




Big Dutchman

Tunnel Inlet Design

隧道进风小窗的设计



Tunnel Door Design

隧道风门的设计



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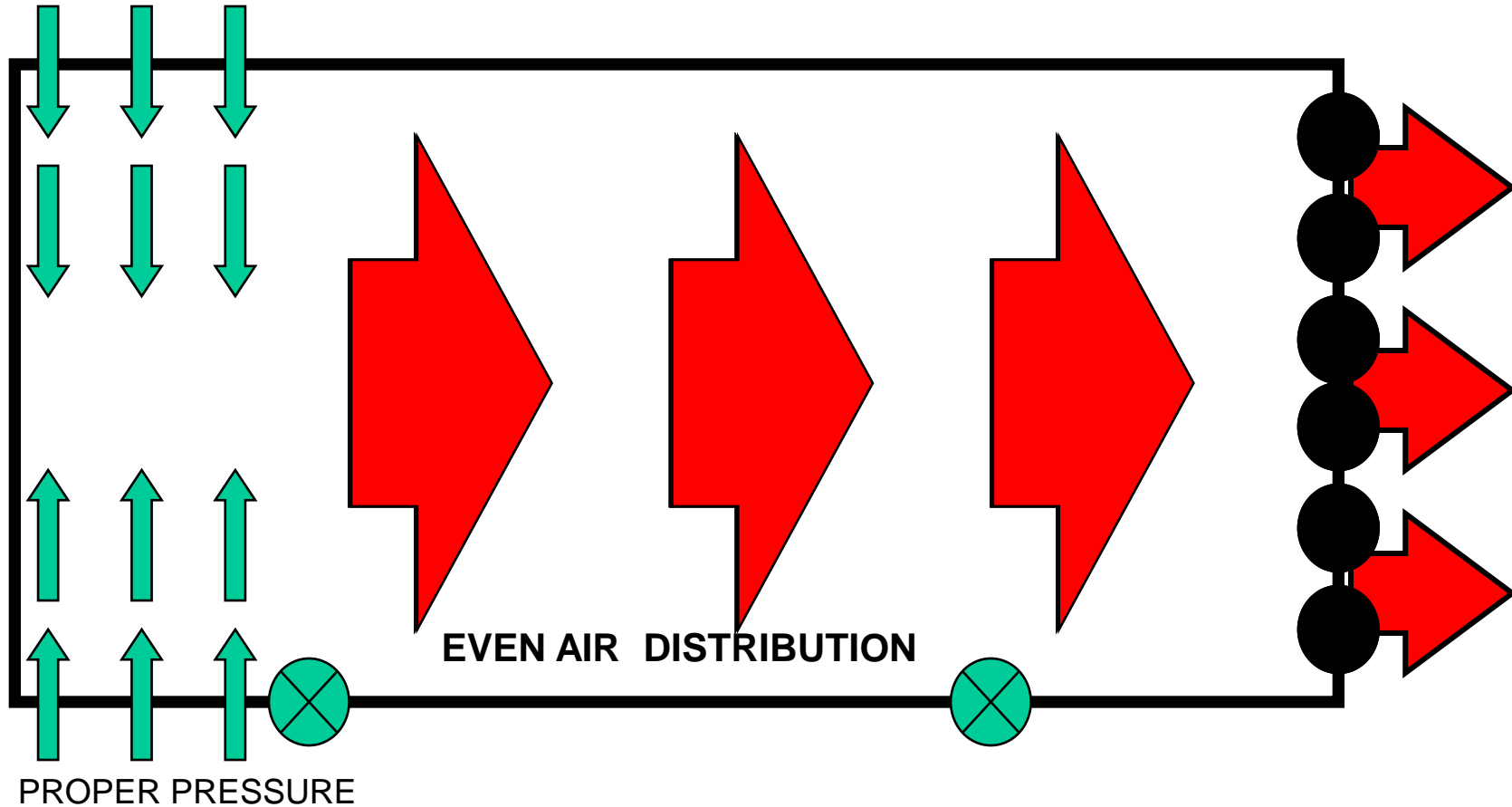


Tunnel Ventilation - Hot Weather

隧道通风- 炎热的天气



PROPER PRESSURE





Big Dutchman

Typical Working Pressures

典型工作时的鸡舍压力



- Center of house: 0.13" – 32pa
- 鸡舍中间: 0.13" - 32帕



- Fan end: 0.17" – 42pa
- 风机末端: 0.17" -42帕





Big Dutchman

Why measure static pressure at the fans?



为什么要测量风机处的负压?

When we measure the static pressure at the fan end of the house...

当我们测量风机末端的负压时...

- We are actually measuring the total of the amount of work it takes to...
- 我们实际上是在测量鸡舍内整体的情况...
 - Pull the air through the pads, 通过水帘进入的空气
 - then through the tunnel doors, 通过隧道风门进入的空气
 - into the cross-section of the house, 到房子的横截面
 - then down to the end of the house. 然后到鸡舍末端

Each action requires work (measured in pressure) of the fans

每个动作都需要风机的工作(检测的压力)

Do all houses have a similar pressure drop from pads to fans?



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所有的鸡舍从水帘到风机的压力相似吗？

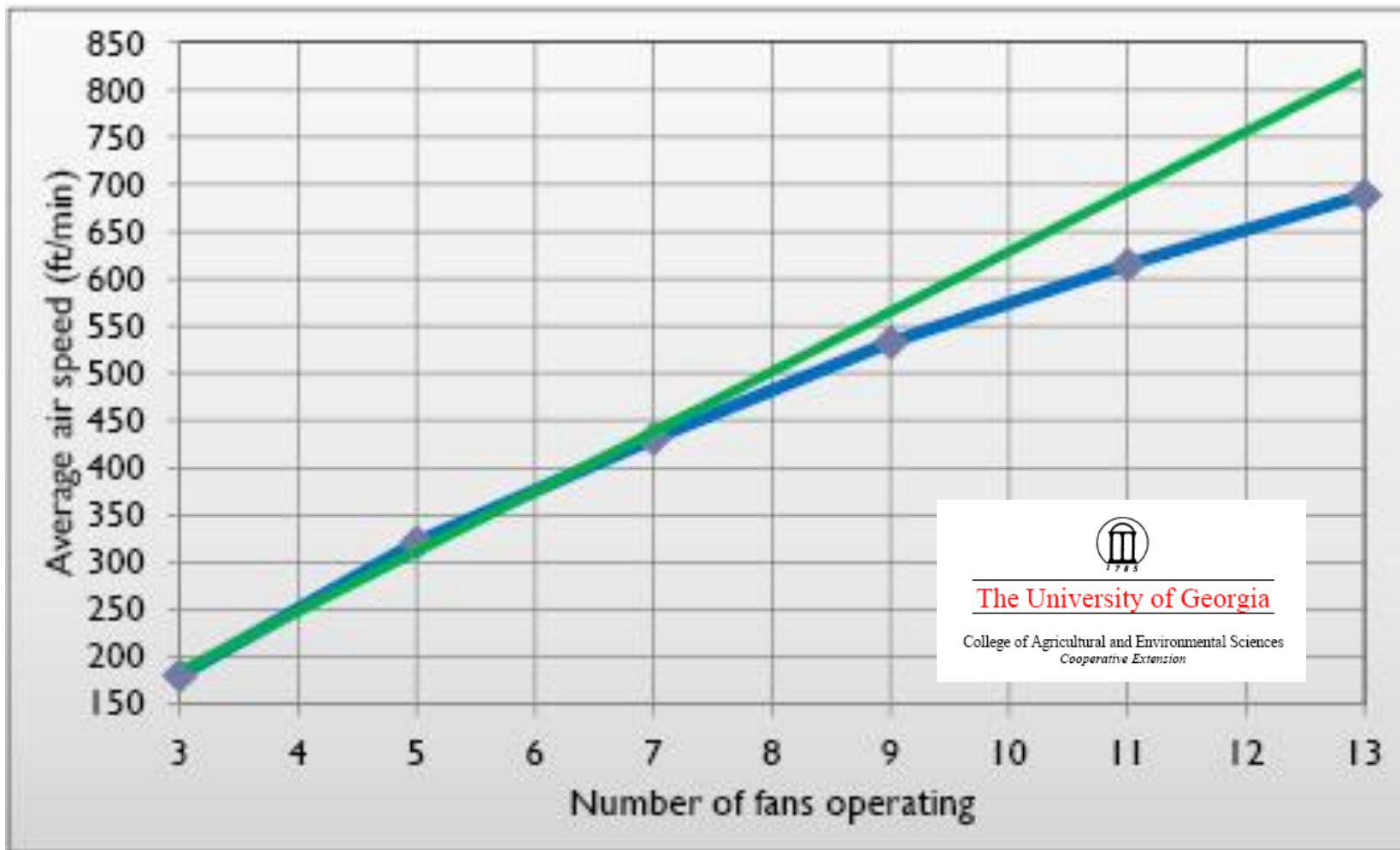
- Large pressure changes primarily occur in high air velocity houses.
- 当鸡舍内的风速很高时会造成大的压力变化
- Due to a law of physics discovered by **Daniel Bernoulli** in the early 1700's
- 根据Daniel Bernoulli在17世纪早期的物理发现的规律
 - Pressure increases with the square of velocity
 - 每平方米内的风速会影响压力的增加
 - if you **double** the velocity of a fluid in a pipe, the pressure/work required to move the fluid through the pipe increases **4 ×**
 - 如果你在管道内将流体速度增加两倍，管内将所需的压力/（工作）需要增加4倍

Why is airspeed much lower than calculated?

为什么风速比计算的要低?



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Pad Pressure 水帘的压力



Pad pressure depends on the rate air flows through it...

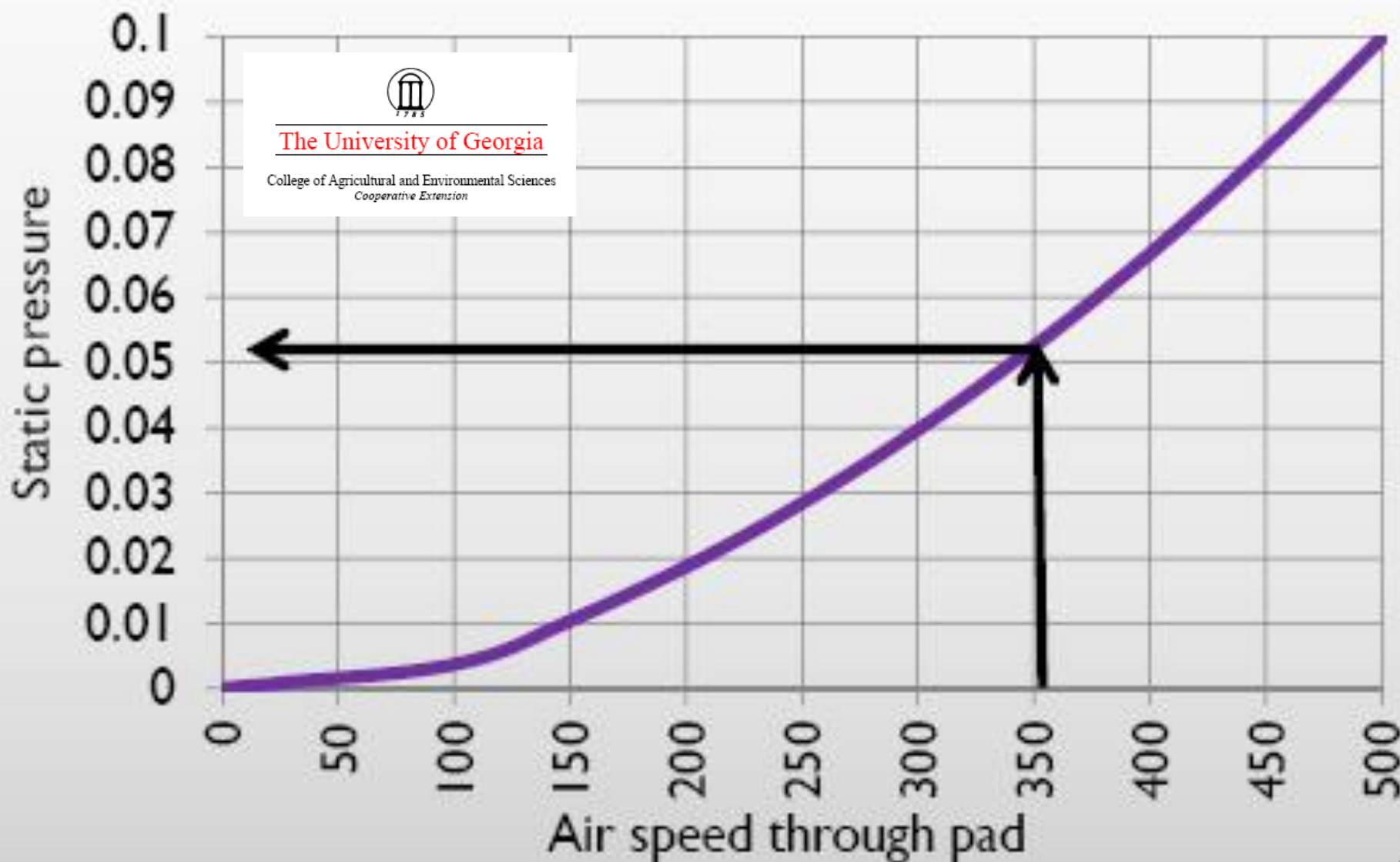
水帘的压力取决于通过水帘空气的流动率



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Cooling Pad Typical Airspeed & Pressure

水帘的典型的风速和压力



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Transition Pressure – Squeeze

过渡压力 – 挤压

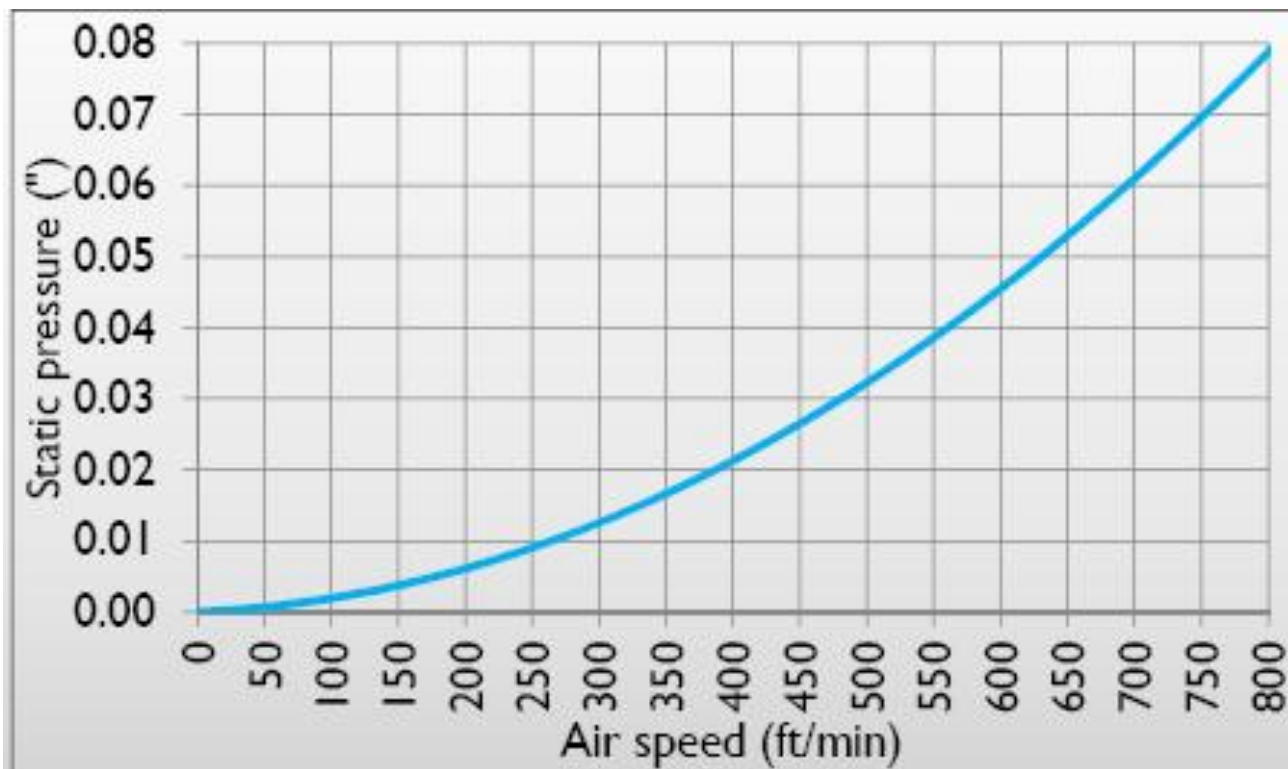


- Pad area is much larger than the cross-sectional area of the house.
- 鸡舍的水帘的面积要大于横切面面积
 - to obtain more air speed we add fans... 我们增加风机时获取更多的风速
 - We add more pad as we add fans.... 增加风机时增加水帘
 - But the cross-sectional area (pipe size) remains the same 但是横切面面积保持不变
- **Example: You are taking air from over 90m² of pad and cramming it into a 42m² pipe!**
- 举例：我们从90平方米的水帘进风，要42平方米的孔管



Big Dutchman.

Transition Pressure 过渡压力



Air speed (ft/min)	Pressure gain
100	0.00"
200	0.01"
300	0.013"
400	0.02"
500	0.03"
600	0.045"
700	0.06"
800	0.08"



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Total Pressure 500ft – 152m House

152米长的鸡舍全部压力



Airspeed 风速	400fpm - 2m/s 400fpm – 2米/秒	700fpm - 3.6m/s 700fpm – 3.6米/秒
Pad pressure 水帘压力	0.05" - 12.5pa	0.05" - 12.5pa
Transition pressure 过渡压力	0.02" - 5.0pa	0.06" - 15.0pa
Pipe pressure (past pad area) 管孔压力（通过 水帘的地方）	0.015" - 3.8pa	0.05" – 12.5pa
Total 整体	0.085" - 21.3pa	0.17" - 40.0pa



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Tunnel air speed & Total static pressure

隧道风速和整体负压



400ft/min = 0.09" - 0.11"

500ft/min = 0.10" - 0.12"

600ft/min = 0.13" - 0.15"

700ft/min = 0.16" - 0.18"

800ft/min = 0.18" - 0.20"

2.0m/s = 22 – 27pa

2.5m/s = 25 – 30pa

3.0m/s = 32 – 37pa

3.5m/s = 40 – 45pa

4.0m/s = 45 – 50pa



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Criteria For Selecting Fans

选择风机的标准



1. Ratings at pressure: m^3/hr 压力
率: 立方米/时
2. Energy factor cfm/watt or $\text{m}^3/\text{hr}/\text{Watt}$ 能量
>21cfm/watt
因素 > 21cfm/瓦
3. Air flow ratio: an indicator of how well the fan holds up under high static pressures **> 0.75**
空气流动率: 在高负压 > 0.75 下风机的承受力)
4. Shutter always behind fan 百叶
窗始终在风机后面
5. Only Cone Fans 圆
锥形风机
6. Purchase fan based on efficiency – not price
购买风机时考虑效率 – 不要考虑钱



**** Based on BESS LABS FAN MANUAL**

纵向通风 Tunnel ventilation

举个例子：

对于一栋120m*14m*2.5m(12度倾角)的肉鸡平养舍，风机处的工作负压大概维持在50Pa左右

来看2组风机，形状大小相似，功率相同：

Brand	voltage	Model	Size in "	Cone	Motor	Air Flow (cfm) ("w.c. SP)				VER (cfm/W) ("w.c. SP)			
						0.05	0.10	0.15	0.20	0.05	0.10	0.15	0.20
Multifan	3 phase 400V, 50 Hz	4D140-3PP-55	54	Y	1.1	29900	28200	26000	22700	23.5	21	18.6	15.7
Qingdao Big Herdsman	3 phase 380V, 50 Hz	55" cone, 1.1 kW	55	Y	1.1	28800	26400	23200	17700	20.1	18.1	15.7	12.1

某国产设备55寸带拢风筒 BD 54寸带拢风筒 风机

BD: 风量 22700cfm (38590m³/h) @ 50Pa / 能效15.7

BH: 风量 17700cfm (30090m³/h) @ 50Pa / 能效12.1

纵向通风 Tunnel ventilation

举个例子：

对于一栋120m*14m*2.5m(12度倾角)的肉鸡平养舍，风机处的工作负压大概维持在50Pa左右

BD： 风量 22700cfm (38590m³/h) @ 50Pa / 能效15.7

BH： 风量 17700cfm (30090m³/h) @ 50Pa / 能效12.1

若是将房舍的最大平均风速设计到3m/s的话， 各品牌需要多少台风机呢？

$$BD = (\tan 12^\circ * 7 + 2.5 + 2.5) / 2 * 14 * 3600 * 3 / 38590 = 12 \text{ 台}$$

$$BH = (\tan 12^\circ * 7 + 2.5 + 2.5) / 2 * 14 * 3600 * 3 / 30090 = 16 \text{ 台}$$

我们来估算一个差价：

BD 单台3000元来举例， 总价 36000元 →

BH 单台2000元来举例， 总价 32000元

BD贵了4000元在初次设备投资上

但是！



Big Dutchman.



纵向通风 Tunnel ventilation

举个例子：对于一栋120m*14m*2.5m(12度倾角)的肉鸡平养舍，风机处的工作负压大概维持在50Pa左右

BD：风量 22700cfm (38590m³/h) @ 50Pa / 能效15.7 - 12台

BH：风量 17700cfm (30090m³/h) @ 50Pa / 能效12.1 - 16台

风扇运行起来后的能耗

$$BD = 22700 * 12 / 15.7 / 1000 = 17.4 \text{ KW}$$

$$BH = 17700 * 16 / 12.1 / 1000 = 23.4 \text{ KW}$$

每运行1小时，即产生6度电的差距（养殖用电约为0.5元/度）

假设

3个月平均每天12小时全开	= 90 * 12 = 1080小时
3个月平均每天6小时全开	= 90 * 6 = 540 小时
3个月平均每天3小时全开	= 90 * 3 = 270 小时
3个月不开	= 0 小时
	= 1890 小时

纵向通风 Tunnel ventilation

举个例子： 对于一栋120m*14m*2.5m(12度倾角)的肉鸡平养舍，风机处的工作负压大概维持在50Pa左右

每运行1小时，即产生6度电的差距 （养殖用电约为0.5元/度）

则 $1890 * 6 * 0.5 = 5670$ 元 - 1年

差价的4000元大约1年即可实现回报。

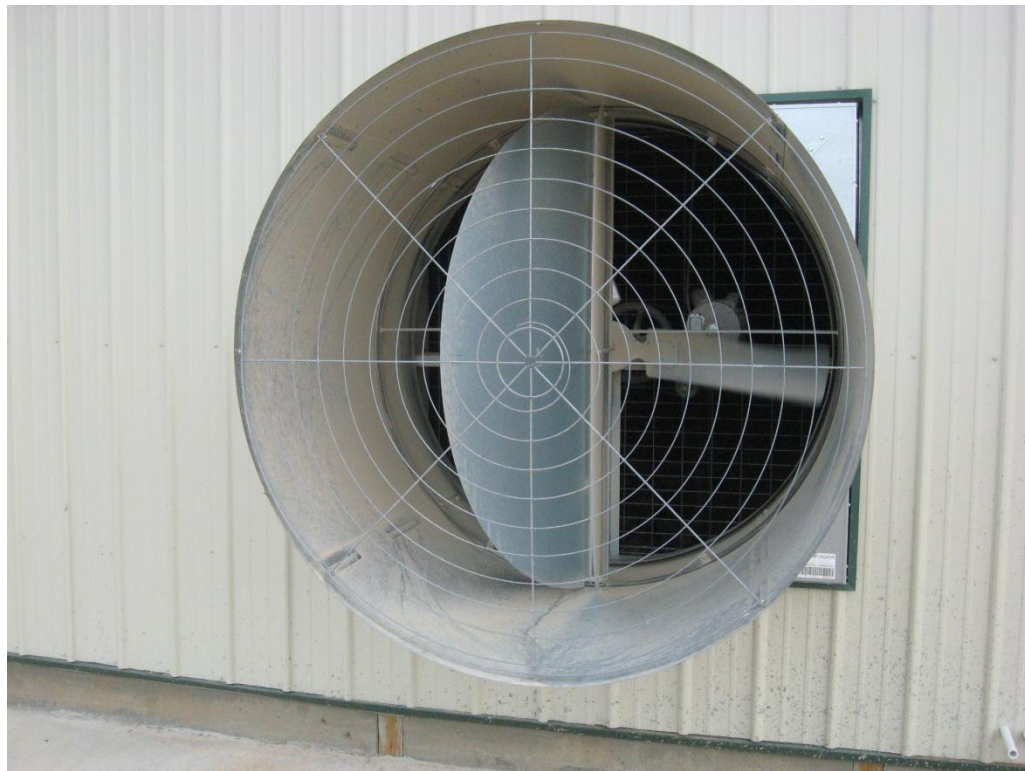
**而此后的每一年
都将为您节省5000+RMB**



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Cones Increase Fan Efficiency

圆锥体增加风机的效率



Cones increase fan
capacity by 25%
圆锥体增加25%的效能

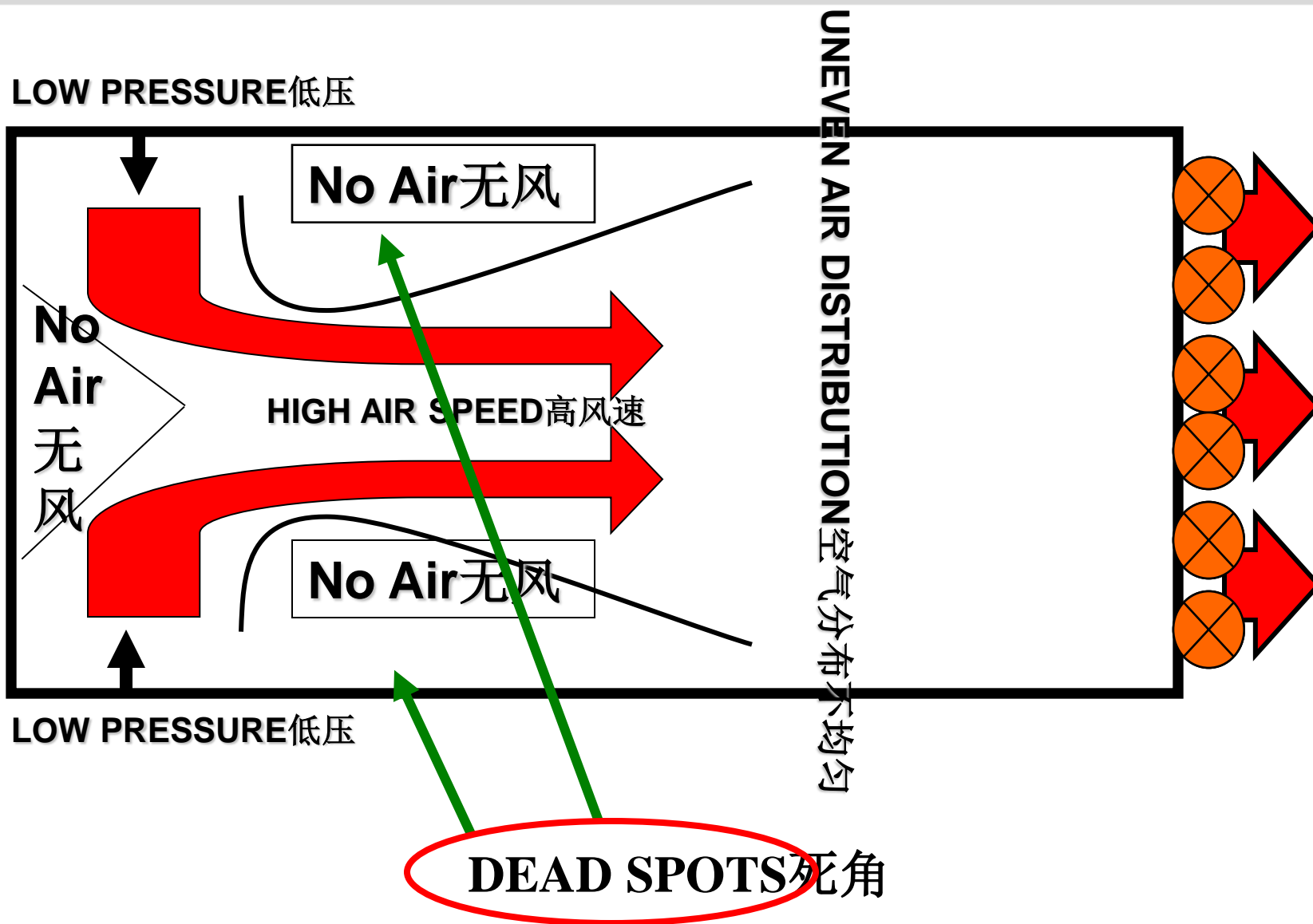


Shutter on the outside of
the fan reduces fan
volume by 20%!
百叶窗装在风机外侧减少
20%的声响

Low Inlet Air Speed < 2.5m/s or 500fpm
低的进风小窗的风速<2.5米/秒或是500fpm



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Dead Spots 死



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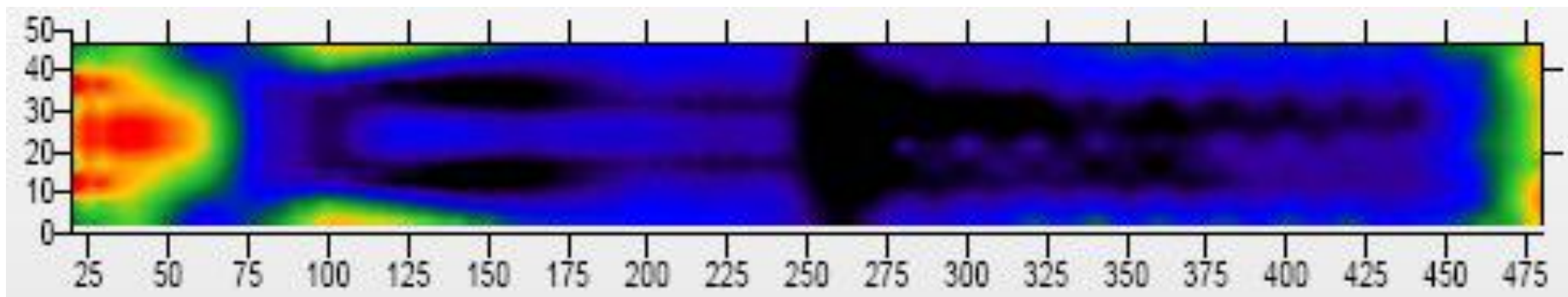
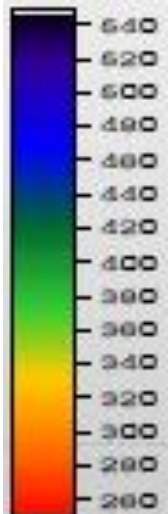


Air speed 18" above floor

← fans

98'	76'	54'	32'	10'	
752	542	383	298	131	6'
681	578	439	374	284	14'
563	460	344	276	218	24'

Centerline



Side Wall Airspeeds

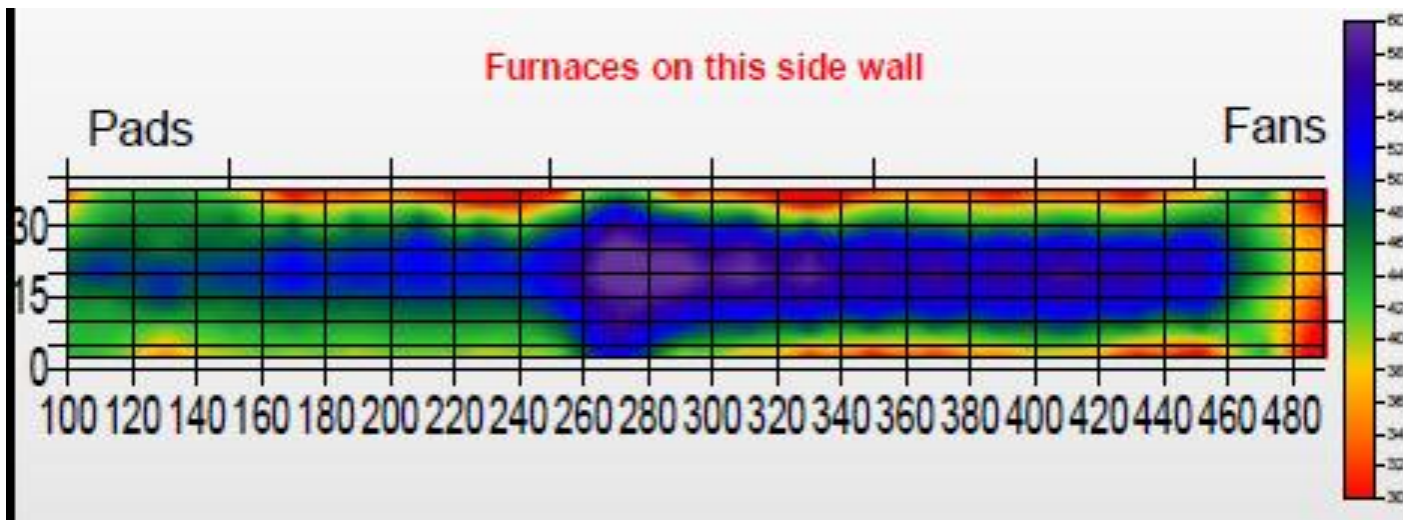
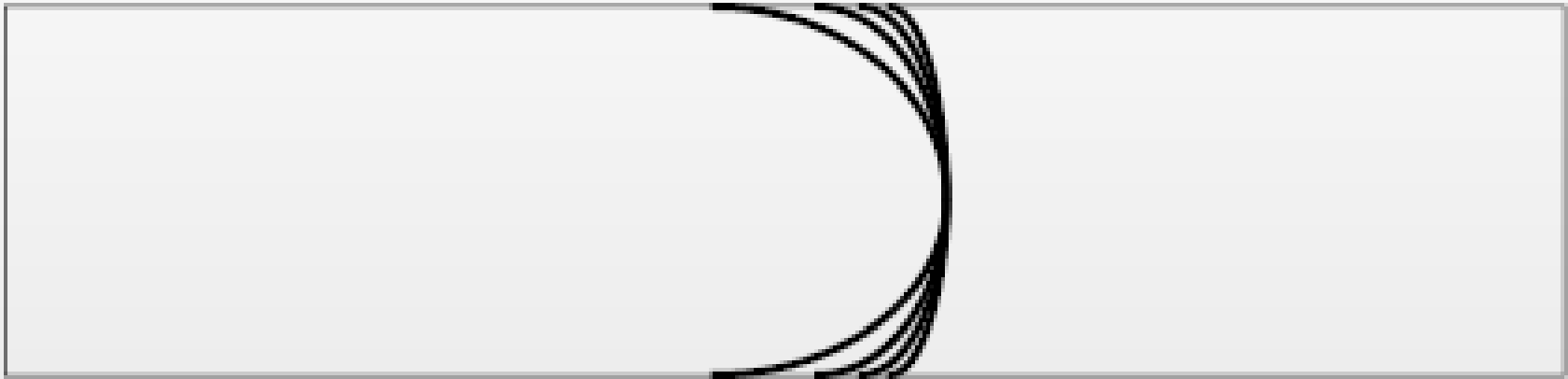
侧墙风速



BIG Dutchman



► Rough walls decrease uniformity

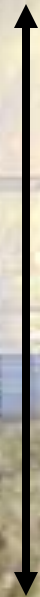


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BAFFLES 挡风板

EVERY 25ft or 8m 每8米一个



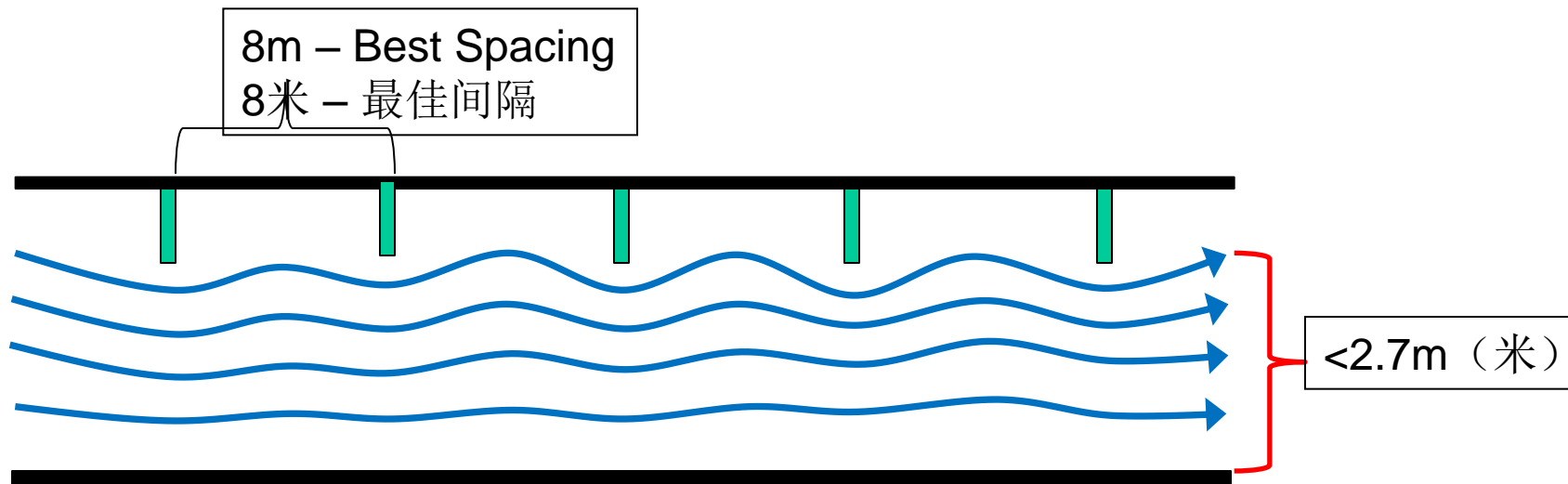
Max 9ft or 2.75 from floor

最高9英尺或是2.75的米高度

Best Deflector Spacing 最佳的导流板间隔



- ❖ Closer spacing = more uniform airspeed.
- ❖ 间隔越近=更均匀的风速
- ❖ Best option = 8m (25ft) centers & 2.7m (9ft) above floor.
- ❖ 最佳位置=8米间隔，2.7米高度
- ❖ More smaller deflectors is best
- ❖ 导流板越小越好





Big Dutchman

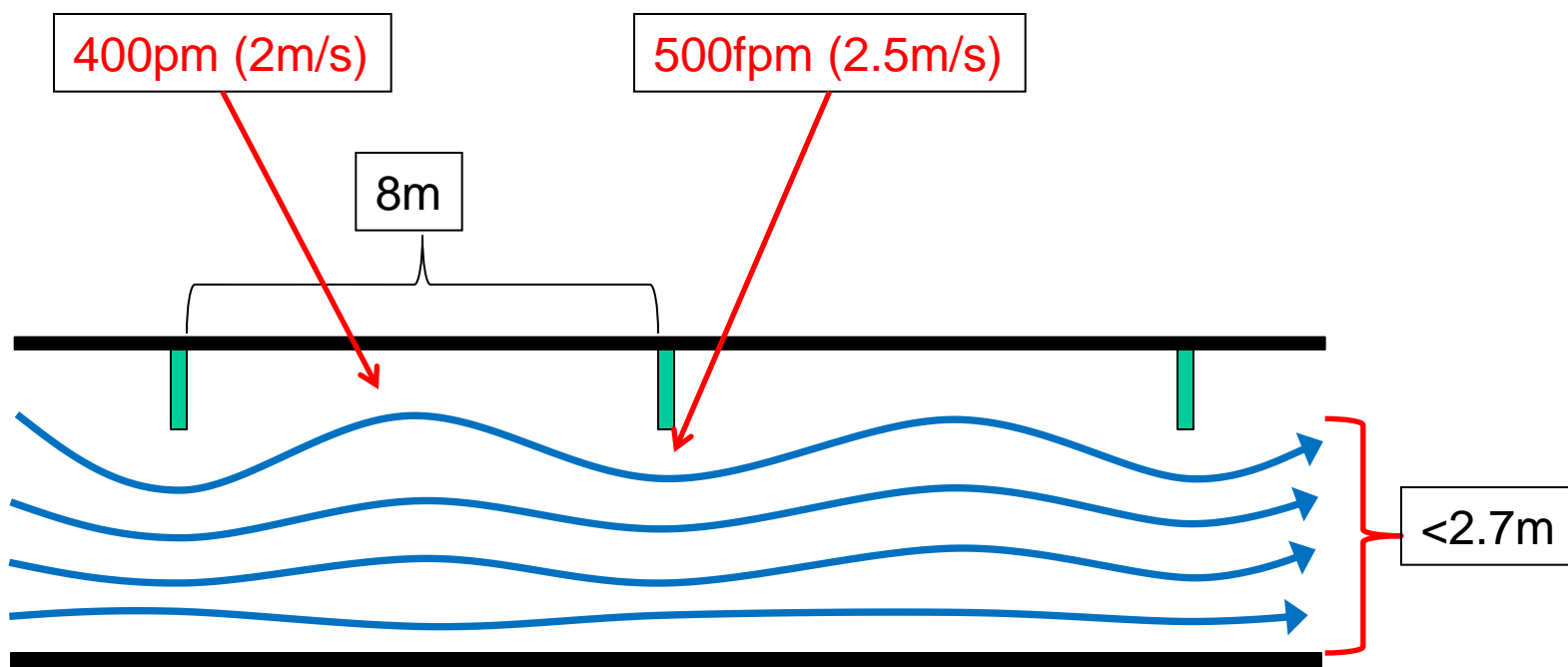
Air Deflectors Heights & Airspeed

挡风板的高度和空气流动速度



9ft (2.7m) Deflectors – Baffles 2.7米高的挡风板

- ❖ Airspeed under deflector: 500fpm or 2.5m/s
- ❖ 挡风板下空气流动速度：2.5米/秒
- ❖ Airspeed between: 400fpm or 2m/s
- ❖ 挡风板之间2米/秒





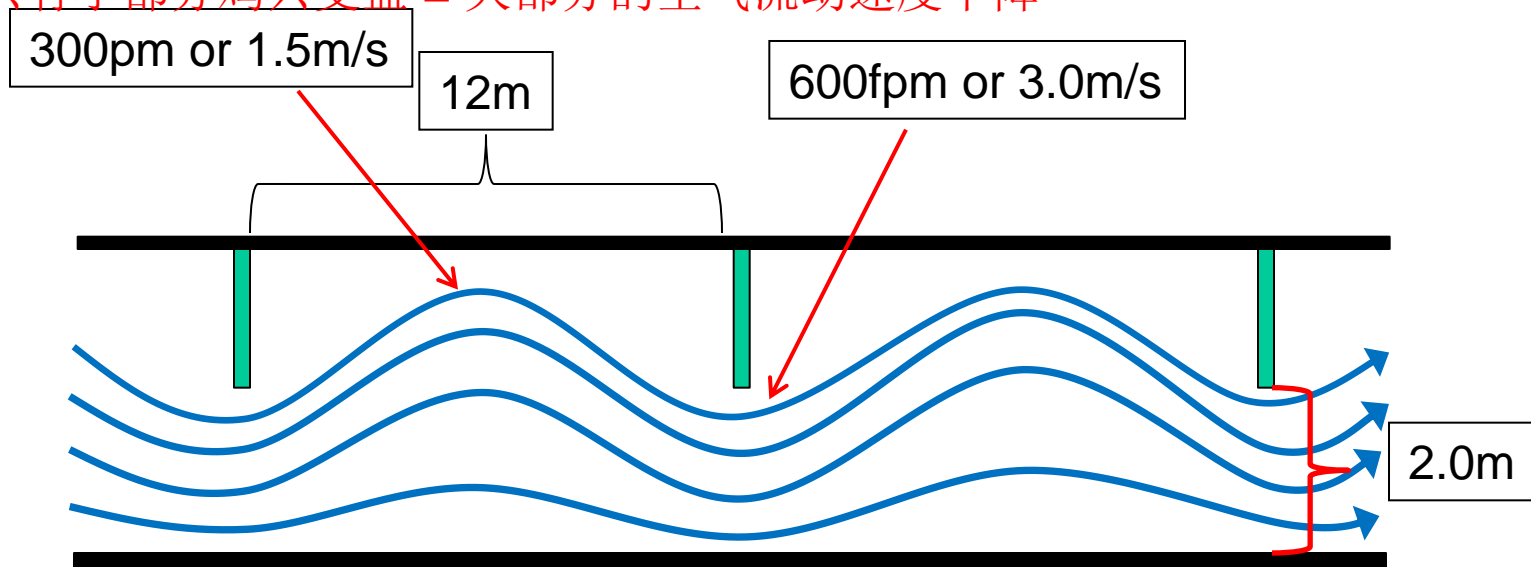
Big Dutchman

Air Deflectors Heights & Airspeed 挡风板的高度和空气流动速度



6ft (2.0m) Deflectors – Baffles 2米高的挡风版

- ❖ Airspeed under deflector: 600fpm or 3.0m/s
- ❖ 挡风板下面的空气流动速度：3米/秒
- ❖ Airspeed between: 300fpm or 1.5m/s
- ❖ 挡风板中间：1.5米/秒
- ❖ Lowering Deflector = Airspeed only increases directly below deflector!
- ❖ 挡风板越低 = 只有挡风板正下方的风速增加
- ❖ Only small number of birds benefit – significant number have reduced airspeed!
- ❖ 只有小部分鸡只受益 = 大部分的空气流动速度下降





Big Dutchman.

Restrictive Deflector 限制性的导流板





Big Dutchman.

Minimum Ventilation
最小通风



6. Managing Evaporative Cooling

6. 水帘制冷系统的管理

How can we improve heat removal? 我们怎样将更多的热量移出屋外



Big Dutchman



Answer: 答案:

- ❖ Lower the air temperature?
- ❖ 降低空气的温度?



How can we improve heat removal?

我们怎样将更多的热量移出屋外



Big Dutchman



Answer: 答案:

- ❖ Use of evaporative cooling system?
- ❖ 使用制冷系统?
- ❖ If the temperature difference between the birds and the air is minimal, the sensible heat removal from the birds will be minimal.
- ❖ 如果空气的温度和鸡只的温度差很小，鸡只体表的热量移到屋外也会很少
- ❖ Increase the temperature difference though the use of evaporative cooling...bird heat removal will be increased.
- ❖ 虽然使用了制冷系统...温差增加，鸡只移到外面的热量将会增加

Pads produce cooling through evaporation of water into the air which increases the RH of the air!

水帘将用水制冷后的空气带进鸡舍，将增加空气的相对湿度！



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Evaporative Cooling 制冷系统



Primary function: Keep house below 29°C or 85°F

主要功能：让鸡舍保持在29度以下

80%+ Cooling produced by air movement....Airspeed first...then pads

80%以上的水帘在空气的流动下工作...首先是风速，然后是水帘



Maximum Cooling Produced through evaporation is a function of RH

蒸发时产生最大的制冷是湿度的作用



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%RH	100	0	0	0	0	0	0	0	0	0
	90	1	1	1	1	2	2	2	2	2
	80	2	3	3	3	3	3	3	4	4
	70	4	4	4	5	5	5	5	6	6
	60	5	5	6	6	7	7	7	8	8
	50	7	7	8	8	9	9	10	10	10
	40	8	9	9	10	11	11	12	13	13
	30	10	10	11	12	13	14	15	15	16
	20	11	12	13	14	15	16	17	18	20
	10	13	14	16	17	18	19	21	22	23
		21.1	23.9	26.7	29.4	32.2	35.0	37.8	40.6	43.3
			Temperature °C							



Maximum Temp Reduction @ 32°C & 20% RH

32度, 20%湿度时的最大降温



Maximum Cooling Produced By Evaporation

蒸发产生最大的制冷

%RH	100	21.1	23.9	26.7	29.4	32.2	35.0	37.8	40.6	43.3
	90	19.9	22.6	25.3	28.0	30.7	33.4	36.2	38.8	41.6
	80	18.7	21.3	23.9	26.5	29.2	31.8	34.4	37.1	39.7
	70	17.4	19.9	22.4	24.9	27.4	30.0	32.5	35.1	37.6
	60	16.1	18.4	20.8	23.2	25.6	28.1	30.5	32.9	35.4
	50	14.6	16.9	19.1	21.4	23.7	26.0	28.3	30.6	32.9
	40	13.1	15.2	17.3	19.4	21.6	23.7	25.9	28.1	30.3
	30	11.6	13.5	15.4	17.4	19.3	21.3	23.3	25.3	27.3
	20	9.7	11.6	13.4	15.1	16.8	18.6	20.3	22.1	23.8
	10	7.9	9.5	11.2	12.7	14.2	15.6	17.1	18.5	19.9
		21.1	23.9	26.7	29.4	32.2	35.0	37.8	40.6	43.3

32.2°C – 16.8°C =

Temperature °C



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Evaporative Cooling

水帘制冷



To achieve maximum cooling we would have to evaporate the maximum amount of water = 100% Humidity

要产生最大的制冷作用，我们需要使用大量的水=100%湿度

Evaporative cooling systems are designed to achieve 70 – 75% efficiency at saturating the air!

蒸发制冷水帘系统的设计，将饱和空气的效率达到70-75%





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Cooling Produced By 6" or 15cm Pad @ 75% efficiency

75%效率，15cm水帘产生的制冷

Expected Cooling Produced by 15cm/ 6" Pad System
由15cm水帘产生的制冷

%RH 湿度	Temperature °C 温度									
	18	21	24	27	29	32	35	38	41	43
100	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8	40.6	43.3
95	17.9	20.7	23.4	26.2	28.9	31.7	34.4	37.2	39.9	42.7
90	17.5	20.2	22.9	25.7	28.4	31.1	"Dead Zone" 盲区			
85	17.1	19.8	22.4	25.2	27.8	30.6				
80	16.7	19.3	21.9	24.6	27.3	29.9	32.6	35.3	37.9	40.6
75	16.2	18.8	21.4	24.1	26.7	29.3	31.9	34.6	37.2	39.8
70	15.7	18.3	20.9	23.5	26.1	28.7	31.3	33.9	36.4	39.1
65	15.3	17.8	20.4	22.9	25.4	28.0	30.6	33.1	35.7	38.3
60	14.8	17.3	19.8	22.3	24.8	27.3	29.8	32.3	34.9	37.4
55	14.3	16.8	19.3	21.8	24.3	26.8	29.3	31.8	34.3	36.8
50	13.8	16.2	18.7	21.1	23.4	25.9	28.3	30.7	33.2	35.6
45	13.3	15.7	18.1	20.5	22.9	25.3	27.7	29.8	32.2	34.6
40	12.8	15.1	17.4	19.8	22.2	24.6	26.6	28.9	31.3	33.6
35	12.3	14.5	16.8	19.1	21.4	23.7	25.7	28.0	30.2	32.5
30	11.7	13.9	16.1	18.3	20.4	22.6	24.8	26.9	29.2	31.3
25	11.2	13.3	15.4	17.5	19.6	21.7	23.8	25.9	28.0	30.1
20	10.6	12.7	14.7	16.7	18.7	20.7	22.8	24.8	26.8	28.8
15	10.0	12.0	13.9	15.9	17.8	19.7	21.7	23.6	25.5	27.4
10	9.4	11.3	13.2	15.1	16.9	18.7	20.5	22.3	24.1	25.9

Ideal Conditions 理想情况

Dangerous Conditions
危险情况



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Cooling Produced By 6" or 15cm Pad @ 75% efficiency

75%效率, 15cm水帘产生的制冷

Expected Cooling Produced by 15cm/ 6" Pad System

由15cm水帘产生的制冷

%R
H湿
度

	18	21	24	27	29	32	35	38	41	43
100	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8	40.6	43.3
95	17.9	20.7	23.4	26.2	28.9	31.7	34.4	37.2	39.9	42.7
90	17.5	20.2	22.9	25.7	28.4	31.1	33.8	36.6	39.3	42.0
85	17.1	19.8	22.4	25.2	27.8	30.6	33.2	35.9	38.6	41.3
80	16.7	19.3	21.9	24.6	27.3	29.9	32.6	35.3	37.9	40.6
75	16.2	18.8	21.4	24.1	26.7	29.3	31.9	34.6	37.2	39.8
70	15.7	18.3	20.9	23.5	26.1	28.7	31.3	33.9	36.4	39.1
65	15.3	17.8	20.4	22.9	25.4	28.0	30.6	33.1	35.7	38.3
60	14.8	17.3	19.8	22.3	24.8	27.3	29.8	32.3	34.9	37.4
55	14.3	16.8	19.2	21.7	24.2	26.6	29.1	31.6	34.1	36.6
50	13.8	16.2	18.7	21.1	23.4	25.9	28.3	30.7	33.2	35.6
45	13.3	15.7	18.1	20.4	22.7	25.1	27.5	29.8	32.2	34.6
40	12.8	15.1	17.4	19.7	22.0	24.3	26.6	28.9	31.3	33.6
35	12.3	14.5	16.8	19.1	21.4	23.7	25.9	28.0	30.2	32.5
30	11.7	13.9	16.1	18.3	20.5	22.6	24.8	26.9	29.2	31.3
25	11.2	13.3	15.4	17.5	19.6	21.7	23.8	25.9	28.0	30.1
20	10.6	12.7	14.7	16.7	18.7	20.7	22.8	24.8	26.8	28.8
15	10.0	12.0	13.9	15.9	17.8	19.7	21.7	23.6	25.5	27.4
10	9.4	11.3	13.2	15.1	16.9	18.7	20.5	22.3	24.1	25.9
	18	21	24	27	29	32	35	38	41	43

29°C Line
29度线

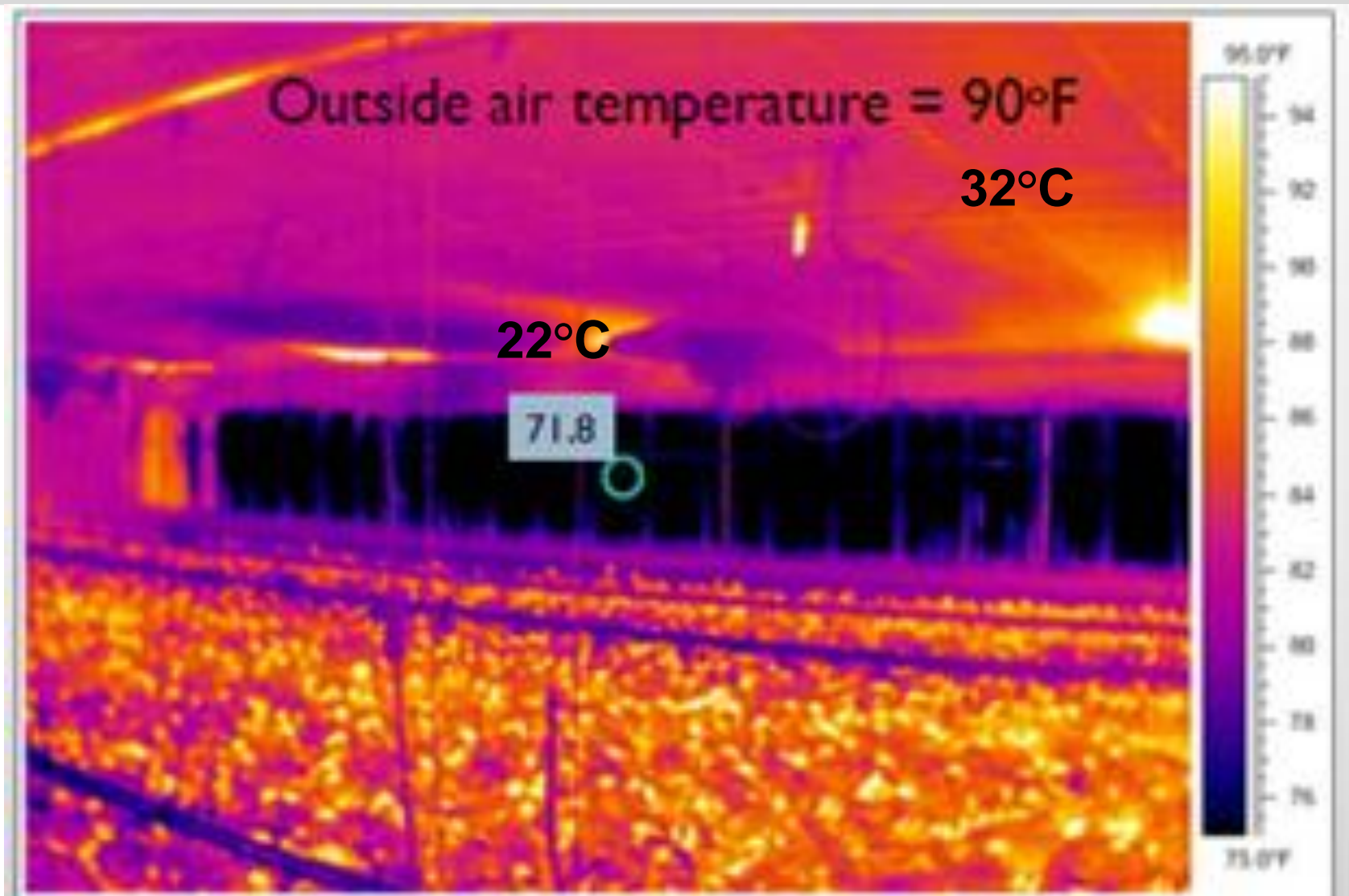
Temperature °C 温度



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Evaporative Pad Efficiency

水帘效率（外界温度32度）





Big Dutchman

Evaporative Pad Efficiency 水帘效率



Are the pads producing the expected cooling?

水帘能产生预期的制冷效果吗？

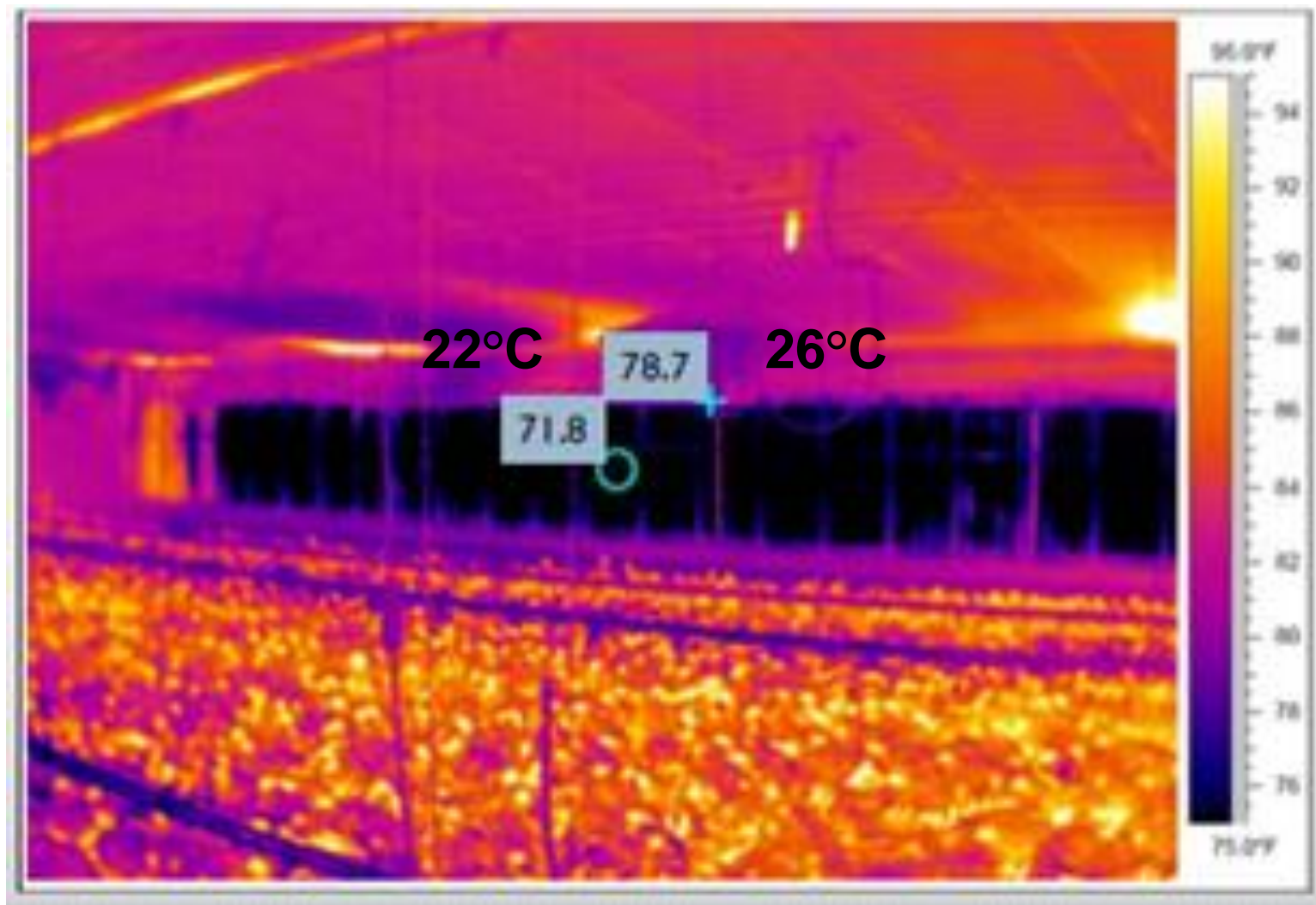
- ❖ $\text{Pad Cooling} = (\text{Outside} - \text{Pad}) \times 0.75$
- ❖ 水帘 = (外界-水帘) *0.75
 - ❖ Pad cooling efficiency = 75%
 - ❖ 水帘的效率 = 75%
 - ❖ Pad = wet bulb temperature
 - ❖ 水帘= 湿球温度
 - ❖ Incoming = Outside (Shade) – Pad Cooling (dog house)
 - ❖ 进入鸡舍=外界（阴凉处）-水帘（水帘间）
- ❖ $\text{Pad Cooling} = (90^{\circ}\text{F} - 71.8^{\circ}\text{F}) \times 0.75$
- ❖ 水帘制冷 = (90华氏-71.8华氏) *0.75
- ❖ $= (18.2^{\circ}\text{F}) \times 0.75$
- ❖ $= 13.7^{\circ}\text{F}$
- ❖ Incoming Expected = Outside – Pad Cooling
- ❖ 预期进来的温度=外界 - 水帘制冷温度
- ❖ $= 90^{\circ}\text{F} - 13.7^{\circ}\text{F}$
- ❖ $= 76.3^{\circ}\text{F}$



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Why is Temperature Drop Less than Expected?

为什么实际的下降温度比预期的要小?

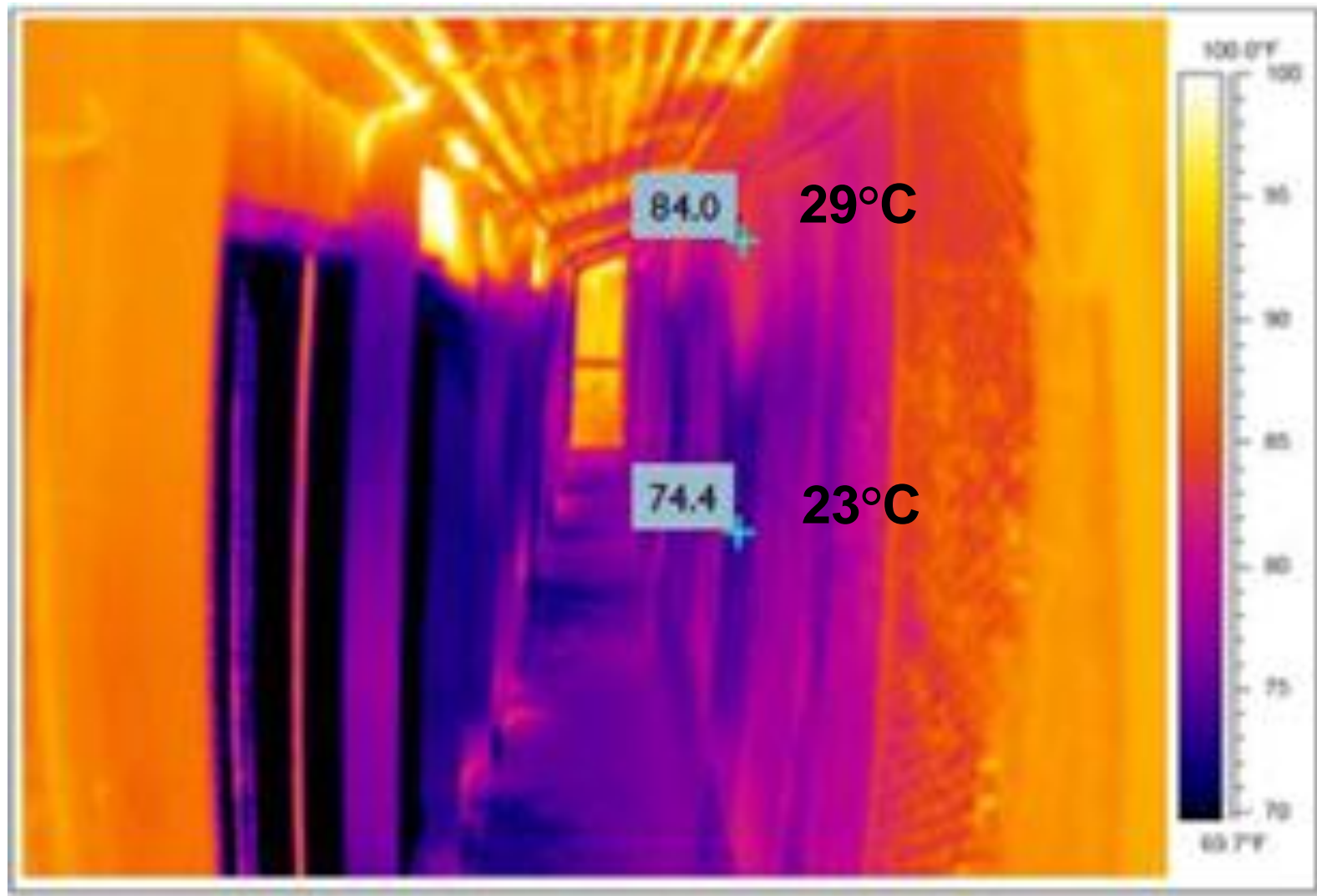


Is Pad Room Well Sealed & Insulated?



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水帘间的密闭和保温情况好吗？

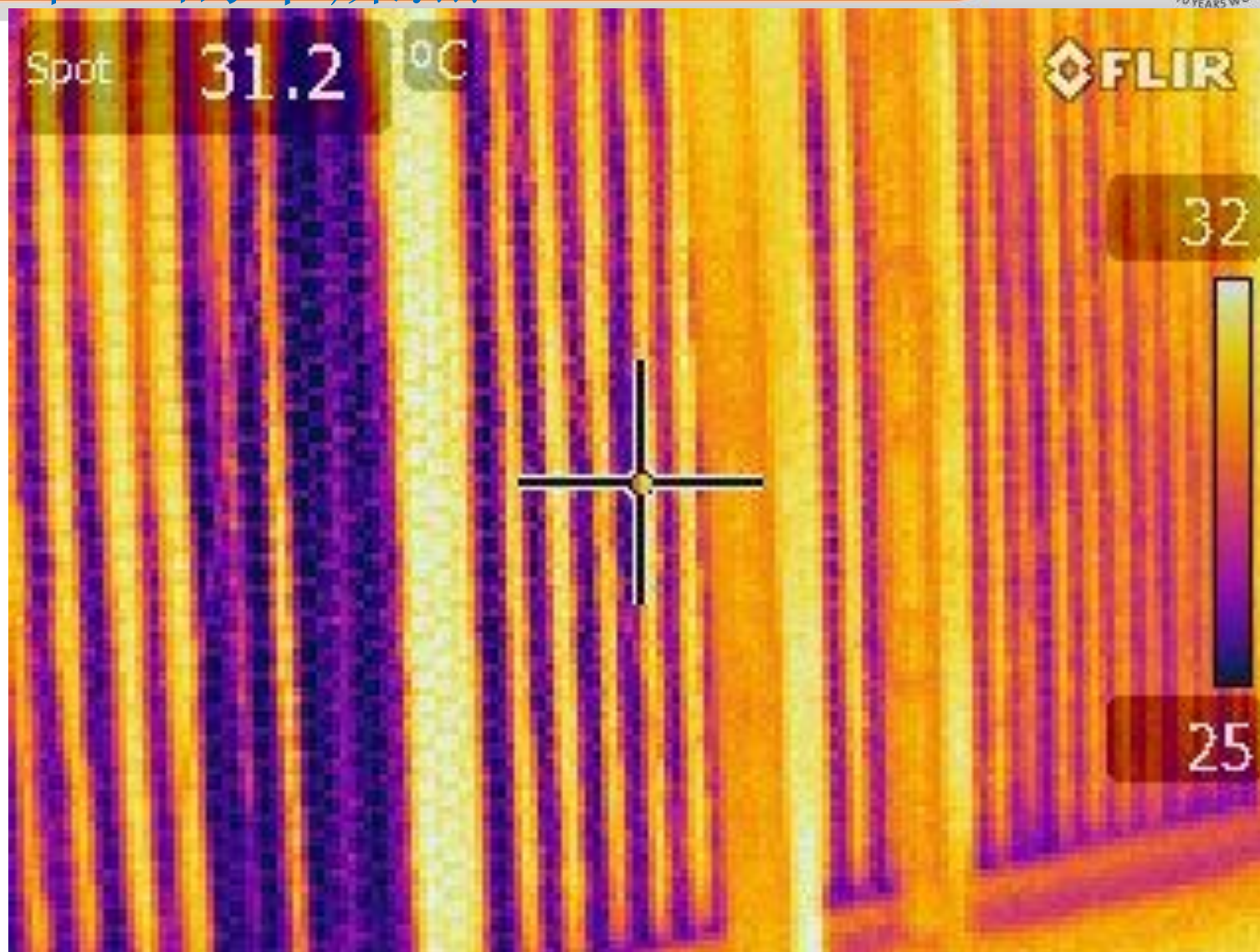


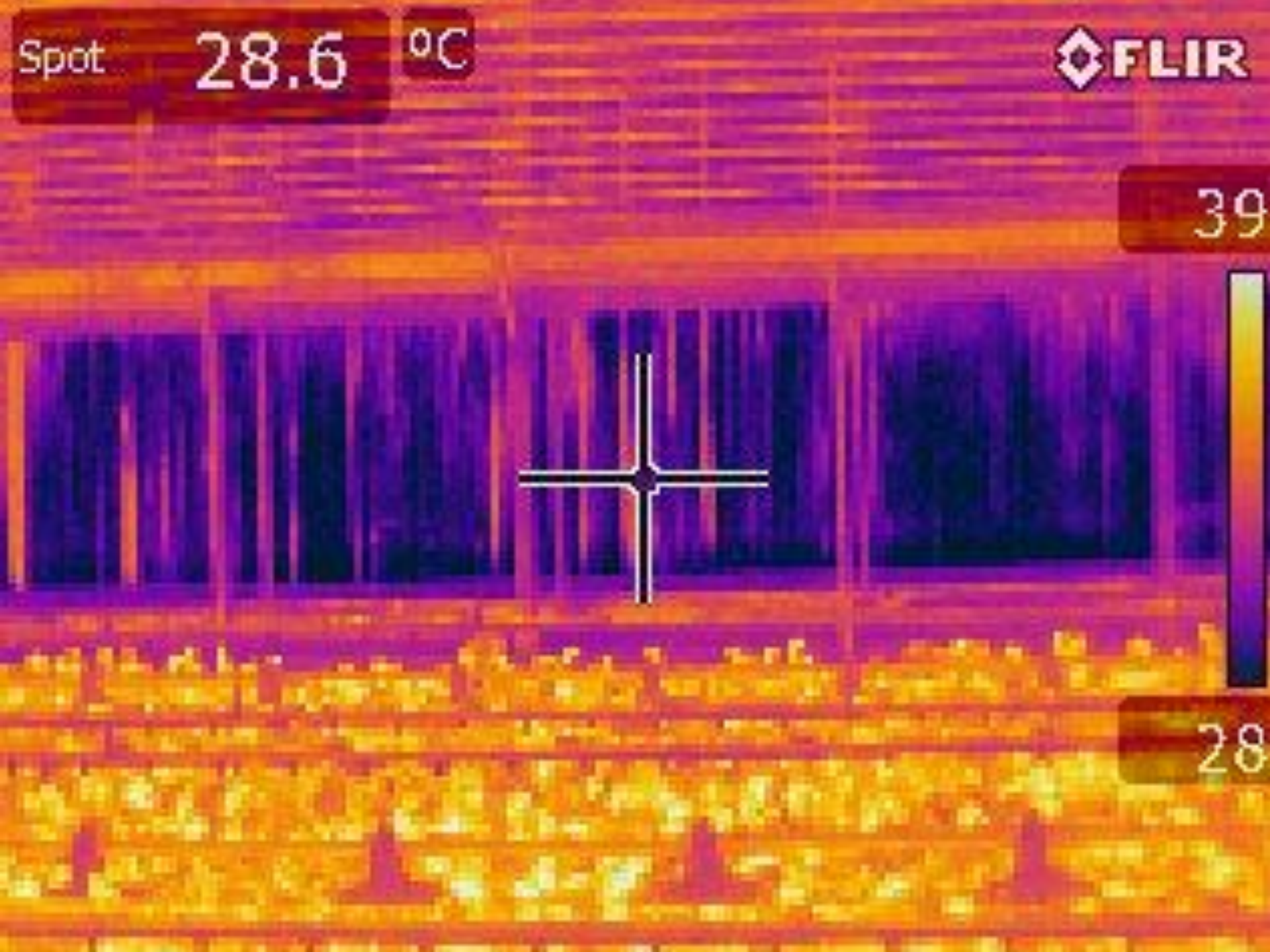
Dry Spots on Cooling Pads

水帘上的干燥点



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Cooling Pad Operating Rules!

水帘的运行原理！



- ❖ All fans should be on before operating cooling pads!
- ❖ 所有的风机必须在水帘使用前开启
- ❖ Pads should not be used at temperatures below 28 –29°C
- ❖ 水帘在28-29度以下不要使用
- ❖ House humidity not to exceed 85 – 90%!!!
- ❖ 鸡舍的湿度不能超出85-90%!!
- ❖ Do not use fogging in conjunction with pads if RH is above 75%
- ❖ 如果湿度超过75%，水帘不要使用水汽
- ❖ Pads to be used from 9am – 10pm – nighttime operation will increase heat stress
- ❖ 水帘使用时间是从小早上9点到晚上10点，夜间的运行将会增加热应激。



Evaluating Tunnel Ventilation Performance

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评估隧道通风的性能



1. Check fan maintenance
检查风机的维修保养
2. Check static pressure sensor accuracy
检查负压测量仪的准确性
3. Tightness check
密闭性检查
4. Operating static pressures?
负压的运用?
5. Check evaporative cooling pad system
检查水帘系统



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Tools of the Trade 测量仪器





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Fan Maintenance 风机的维修保养





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Fan Maintenance

风机的维修保养



- ❖ Ensure correct pulley size!
- ❖ 保证滑轮尺寸正确!
- ❖ The lower the belt rides in the pulley, the slower the RPM – lower the air volume moved.
- ❖ 滑轮上皮带转动的速度越低，每分钟的转速越低---空气流动量越低
- ❖ If $RPM < 5\%$ of manufacturers specifications – check



钟转速小于

Which effectively changes the size of the motor pulley



The lower in the pulley the belt rides, the slower the fan spins, the lower the amount of air moved



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Minimum Ventilation
最小通风



7. Evaporative Cooling Maintenance

7. 水帘的维修保养

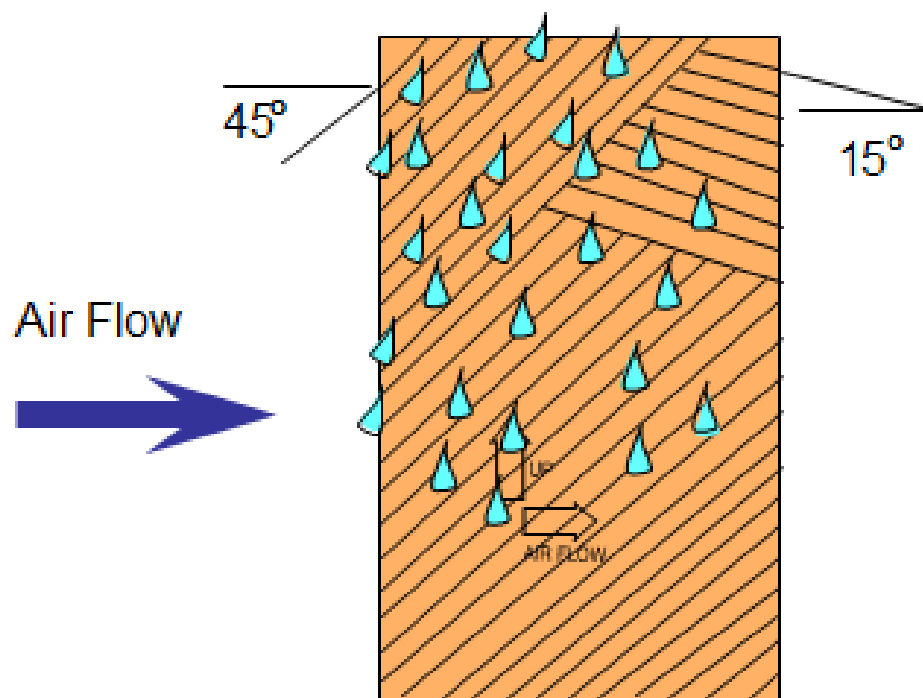


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纵向通风 Tunnel ventilation

湿帘优势



这样的角度让更多的水接触进气流。

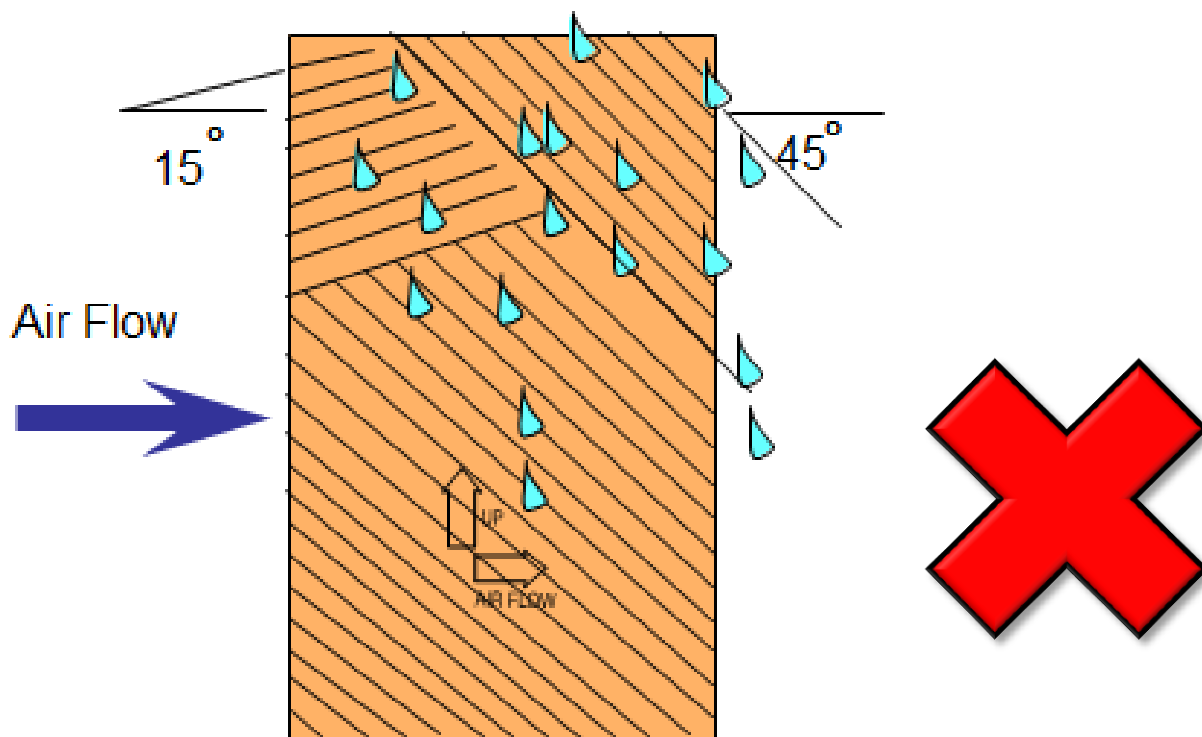


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纵向通风 Tunnel ventilation

湿帘优势



安装角度不能错。否则水会被大量吹入鸡舍。



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When to Replace Pads? 何时替换水帘





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Water Distribution 布水





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纵向通风 Tunnel ventilation

湿帘





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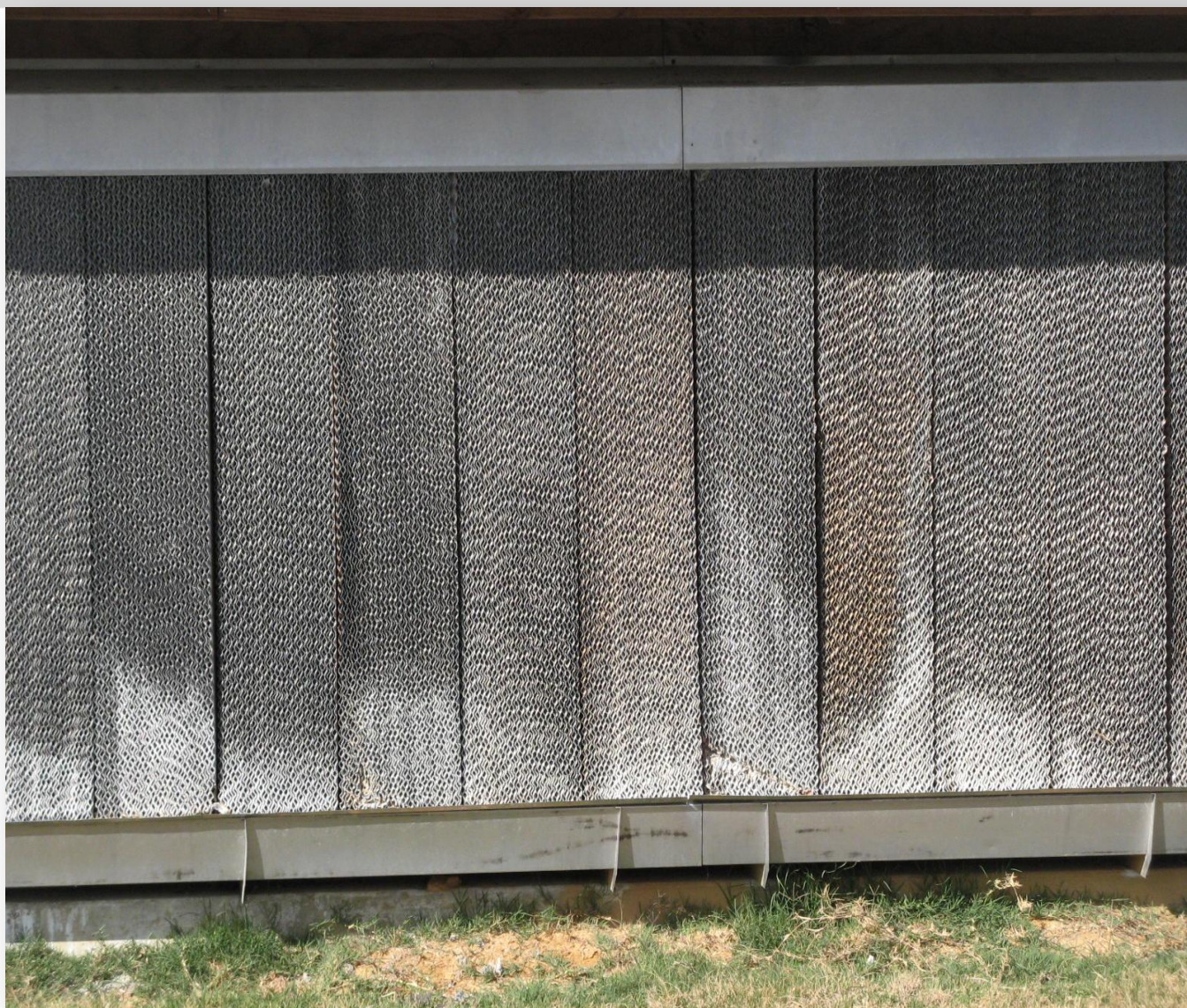
Mineral Build-up 矿物质堆积





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Mineral Build-up 矿物质堆积

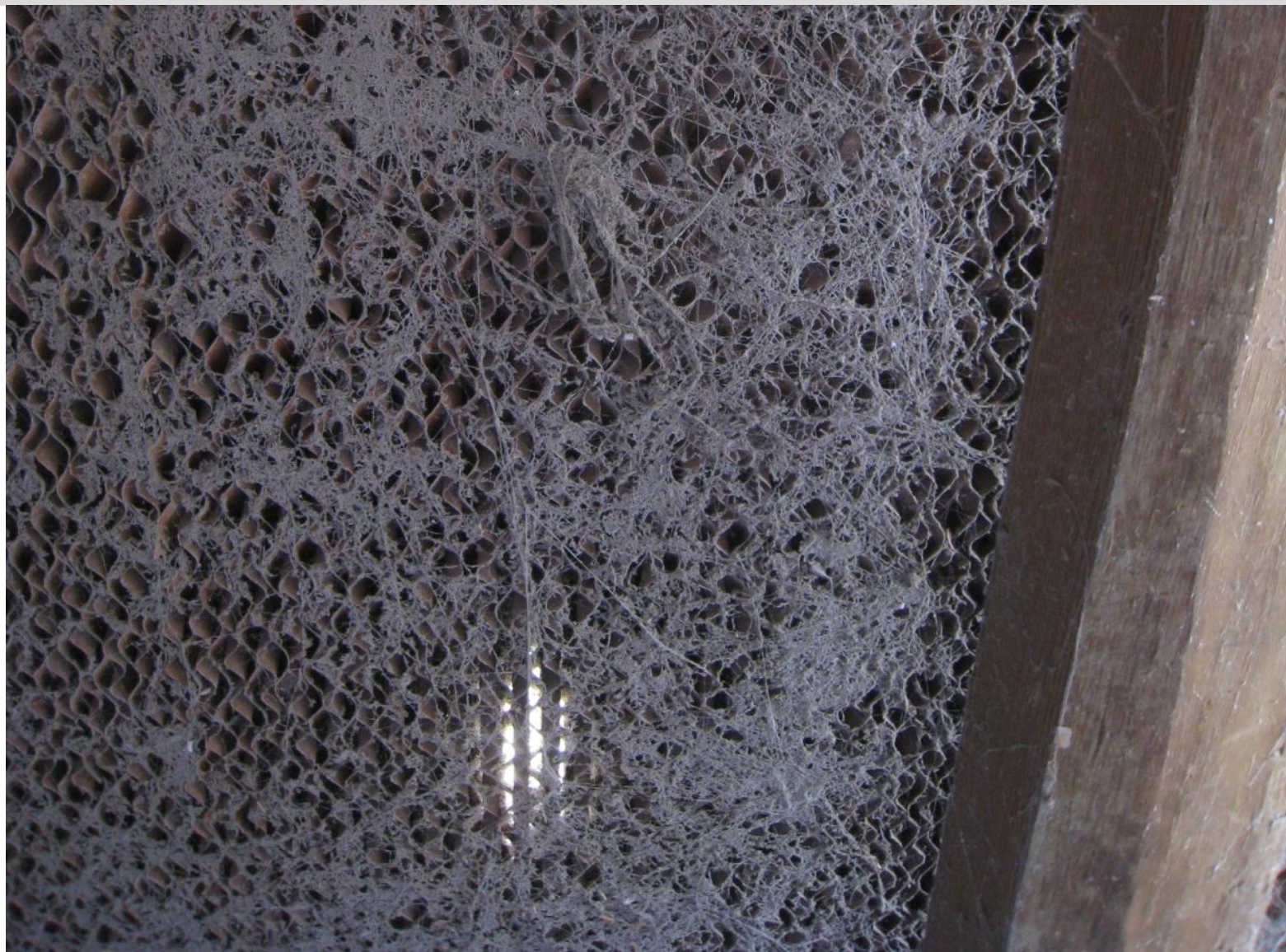




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Pad Cleaning – Soft Brush

水帘的清洗-软刷子



Clean Water = Increased Pad Life

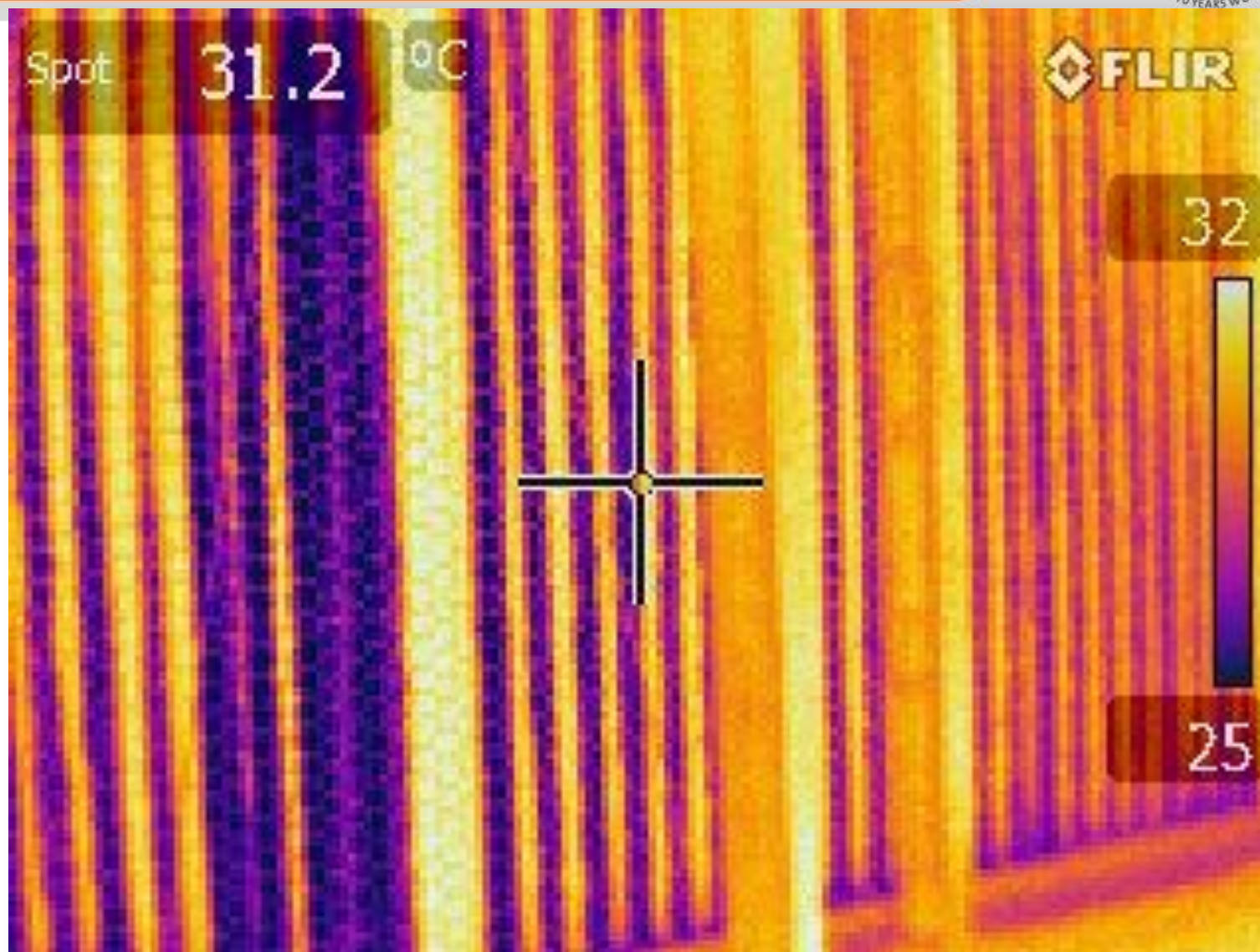
干净的水 = 使用寿命的延长



Dry Spots on Cooling Pads

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水帘上的干早点



Minimum Pad Maintenance Schedule!

最低要求的水帘保养计划表



MINIMUM MAINTENANCE SCHEDULE

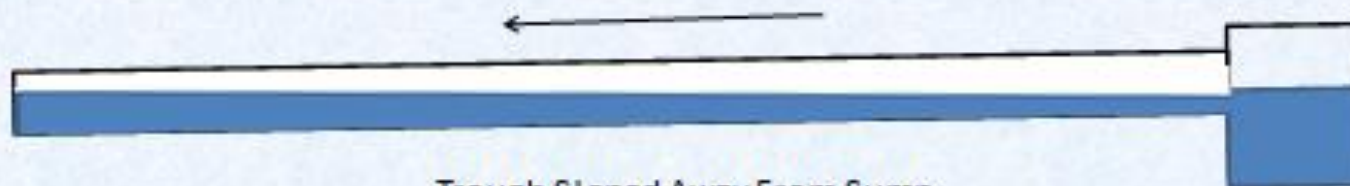
Maintenance Operation	SCHEDULE:		
	Weekly	Monthly	Yearly
Clean the foot valve or the pump filter screen		X	
Flush in-line strainer	X		
Check for dry streaks on pad material	X		
Clean debris from face of pad material	X		
Clean cooling control and sensor		X	
Clean cooling panel distribution pipe holes		X	
Clean cooling panel collection trough			X
Drain and clean sump tank		X	
Clean/check float valve		X	

Sump Installation Is Critical

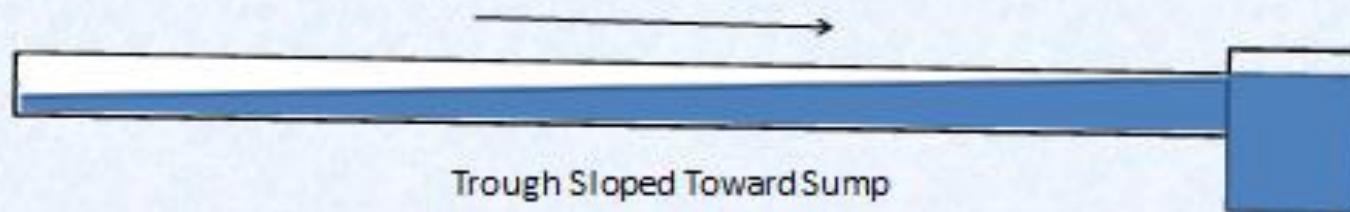
水吊箱的安装很重要



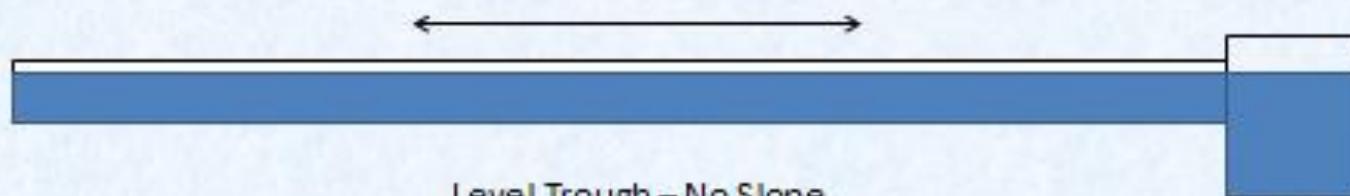
Big Dutchman



Trough Sloped Away From Sump



Trough Sloped Toward Sump



Level Trough – No Slope

Sump Installation Is Critical

水帘箱的安装很重要



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1. Routine Cleaning & Flushing

常规的清洁和冲洗



- Remove & clean filters
- 把过滤片拆开清洗
- Dirty filters restrict flow – up to 100%
- 脏的过滤片限制流动 – 至100%





4 Refill System & Add Cleaner 替换系统或是加清洁剂



Refill Trough & Sump with
enough water to cycle
cleaning products

定期用充足的水或清洁产
品来替换或是冲洗



Use Only Approved Cleaning Products

只使用被批准的清洁产品



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Approved Chemicals for Cooling Pads

Cooling Systems



CAUTION Consult Chemical Manufacturer for current information regarding labeling and dosages.

Algae Control

Chemical Name: Physan 20
Company Name: Marli Products, Inc.
320 West 6th Street
Tustin, CA 92780
Phone: (714) 544-7711, 1-800-546-7711
Fax: (714) 544-4830
www.physan.com
email: physan@earthlink.net

Chemical Family: Quaternary Ammonia
Active Ingredient Level: 20%
Manufacturer's Recommended Dosage: 1 tsp. per 15 gal. of water.

Chemical Name: Evap 100 Algicide
Company Name: Neogen Corporation
944 Nandino Boulevard
Lexington, KY 40511
Phone: 800-621-8829
Fax: 800-255-1168
www.neogen.com Email: bioprotection@neogen.com

Chemical Family: Quaternary Ammonia and Tributyltin Oxide
Active Ingredient Level: 19%
Manufacturer's Recommended Dosage: 4 oz. per 100 gal. water in system for initial dose followed by 2 oz. per 100 gal. water weekly thereafter.

Chemical Name: Triathlon
Company Name: OHR, Inc.
P.O. Box 230
Mainland, PA 19451
Phone: 1-800-659-6745
www.olympichort.com

Chemical Family: Quaternary Ammonia
Active Ingredient Level: 20%
Manufacturer's Recommended Dosage: 1 oz. per 30 gal. of cooling water. Treat ever other week.

Chemical Name: Green-Shield
Company Name: Whitmire Research Laboratories
3568 Tree Court Ltd. Blvd.
St. Louis, MO 63122
Phone: 1-800-777-8570
Fax: 636-225-3739
www.wrmg.com

Chemical Family: Quaternary Ammonia
Active Ingredient Level: 20%
Manufacturer's Recommended Dosage: 1 oz. per 6 gal. of water for cleaning surfaces.

Munters Corporation
4215 Legion Dr. Mason, MI 48854-1036 USA
(517) 676-7070 Fax (517) 676-7078
www.munters.us/aerotech

FORM: GM1128
Rev. 3, July 2009
Page 1 of 2

Physan 20

Evap XL

Triathalon

Green-Shield

5 “HydroFoamer” – An Alternative Option

水疗发泡剂 – 另一种选择



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pH Monitoring – Soft Pads

PH检测—水帘变柔



- ❖ High pH - about 10.7 in system
- ❖ 高pH值 – 系统内大概10.7
- ❖ No Bleed off or draining program – Leads to Soft Pads
- ❖ 没有将水排出去 – 导致水帘柔软
- ❖ pH Needs to be: 6 – 8
- ❖ pH值范围I : 6-8

Options:方法:

1. Bleed off 12.5 litre/h/m of pad
水帘每米每小时的排水量是12.5升
2. or *Dump the tank once a week*
或者每周更换一次蓄水池
3. **Reduce ON / OFF Cycles**
减少开/关的周期



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Big Dutchman®

THANK YOU





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Thank you for making
Big-Dutchman a part
of your business!