Armstrong Heat Transfer Group
648 Moeller Street, Granby, Quebec J2G 8N1 - Canada
Ph: 450-478-2655 Fax: 450-375-3787

KSU-Heat Treat Workshop 2009

Armstrong Heat Transfer Group

Presented by James R. Smith – Product Mgr.

Power/Utilities/Process

with Engineering and Technical Support from:

Brian Kimbrough, Armstrong Intl. Inc.

- Director of Global Petrochemical Markets

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- Applications Specialist, Design Engineer

DETERMINING HEAT ENERGY REQUIREMENTS

STRUCTURAL & BIN/SILO HEAT TREAT GUIDELINES

THE ***ART*** AND THE **SCIENCE**

FOCUS ON USE OF INDIRECT STEAM-TO-AIR HEAT TREATMENT ALTERNATIVES FOR STRUCTURES AND EQUIPMENT

Armstrong – Heat Transfer Group

Equipment Design/Selection Criteria

- Fixed and/or Portable Steam/Air Fan Coil Heavy Duty Industrial, Factory Pre-Assembled Systems
- ***Utilization of In-Plant Building Pressurization Utilizing the PHYSICS of HOT AIR EXPANSION and Continuous Internal Recirculation.***
- ***Results in a steady, controlled heat up, "cook" and cool down.***
- ***Typically Utilizing LP-MP-HP Steam Sources with Controlled Hot Air Output of 160dgF Max to Obtain 140dgF of Recirculated Air and 125dgF Min. Surfaces.***

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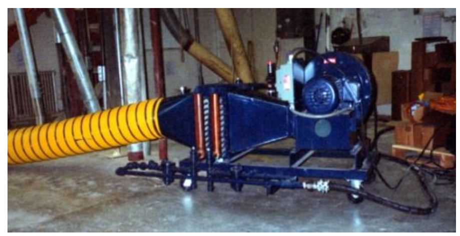
ARMSTRONG ***STEAM HEAT TREATMENT FOR INTEGRATED PEST MANAGEMENT (IPM)***

HOT BREATH HEATERS

Bring the Heat

HOT BIN HEATERS



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Armstrong Heat Transfer Group Steam Equipment
DESIGN CRITERIA

160F(71C) controlled discharge air temperature from the steam heaters.

- **Controls the building 'ramp up' rate to approximately 10F(6.0C) /hour for structural integrity.**
- **Prevents potential damage to electronics.**
- **160F(71C) discharge temperatures will maintain ambient room temperatures of 140F(60C) and 125F(51C) surface temperatures.**
- **Local temperature control at each heater.**
- **100% recirculation of the environmentally controlled building air.**
- **Energy requirement less than 25% of design during 'cook' cycle.**

STRUCTURES / BUILDINGS

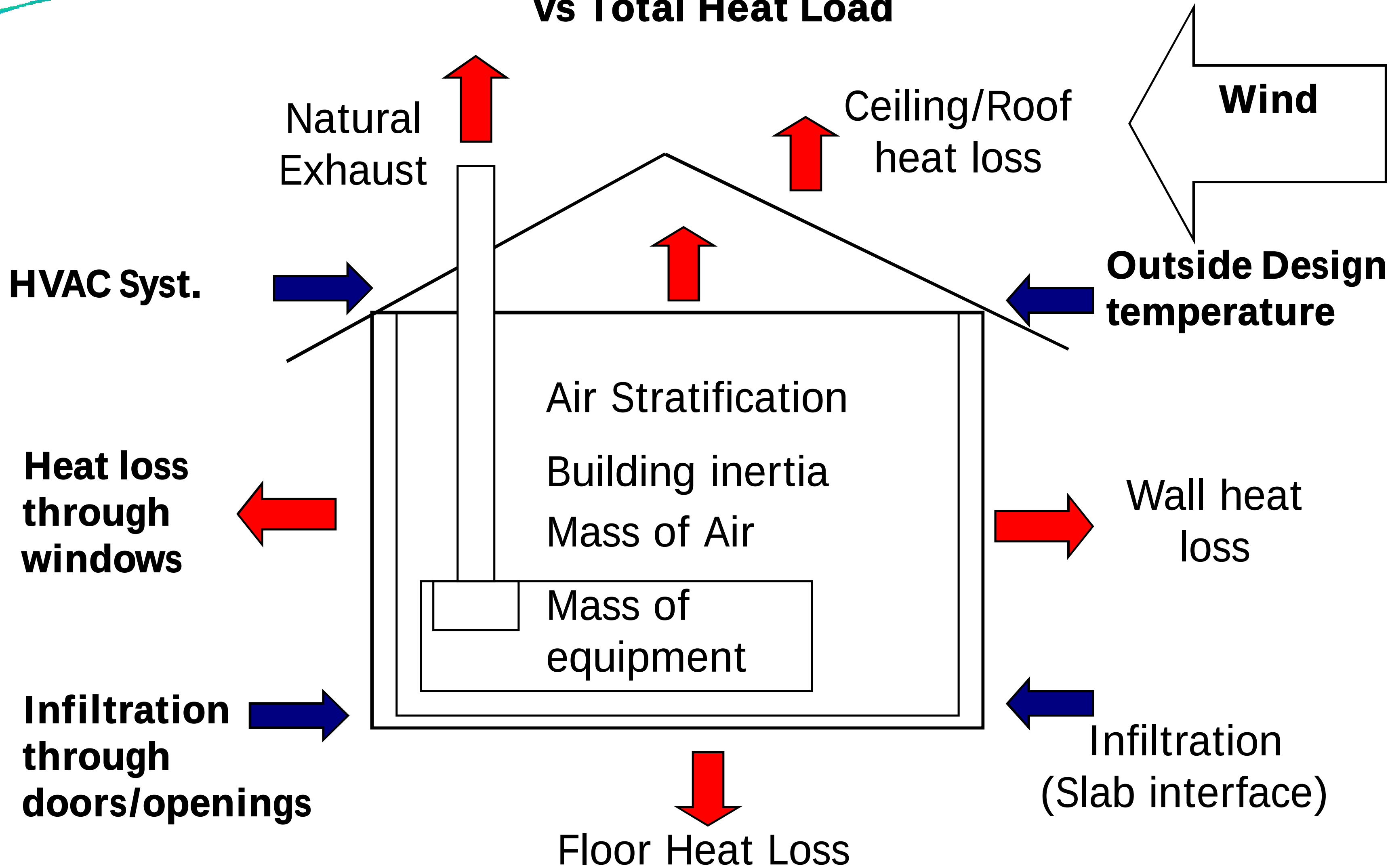
DATA CONSIDERATION

"ART " – When Minimal data is Available

for ESTIMATING PURPOSES ONLY with some ASSUMPTIONS utilized for calculations.

- ***"GENERAL" range of ASSUMED values, from field experience falls into a range of 7-10 BTUH/cu ft of volume. This is HIGHLY VARIABLE! (modern mills –very TIGHT often utilize 7-8 btuh/cu ft of heated space) –***
- ***NOTE : Errors in use of Assumed values can be +/- 50%!***
- ***Remember "Assumptions = ART!" = Errors!***

Air Infiltration, Heat Loss, and Thermal Inertia vs Total Heat Load



Design Considerations

- **Total Heat Load = combination of building losses, infiltration, and equipment density.**
- **The 'ramp up' time is usually 4-6 hours. The target is to elevate the building temperature 10F (6.0C) per hour.**
- **Target 'cook' temperature is typically125F (52C) to 140F and usually held for 12-14 hours for thorough heat penetration into the walls and equipment.**
- **'Cool down' time is usually 4-6 hours.**
- **Control of 'cook' temperature by auto-modulation of Steam Control valve not by cycling fans. Maintains maximum air flow.**

STRUCTURES / BUILDINGS

DATA CONSIDERATION

the ***SCIENCE***

BASIC FORMULA = Q = U x A x LMTD

Q = Load in BTU/hr

U = Heat Transfer Coefficient for
Surfaces/Materials , etc. (btuh/sqft/dgF)

A = Square footage of Areas/Surfaces Heated

LMTD = Temp Differences of surfaces (dg F)
(T1 Inside/T2 Outside)
(+ for STEAM ONLY!)

Q/LATENT HEAT of VAPORIZATION = Pounds/Hr Steam

STRUCTURES / BUILDINGS DATA CONSIDERATION

HEAT TRANSFER DATA INPUT – by Component
(support ref. via ASHRAE Fundamentals & Industry Experience)

AREAS OF CONSIDERATION:

- ROOF (if exposed to Outside)
- WALLS
- INTERMEDIATE FLOORS (heated above/below) (replaces Roof)
- BASEMENT OR BOTTOM FLOORS
- INTERIOR METAL EQUIPMENT
- INFILTRATION and SPACE (air) HEATING
- INTERNAL RECIRCULATION (AIR CHANGES THROUGH HEATERS)

STRUCTURES / BUILDINGS DATA CONSIDERATION

- **Q Walls – thermal loss through exterior wall**
- **Q Windows – thermal loss to outside**
- **Q Ground Floor – thermal loss through slab**
- **Q Interior Floors – thermal gain into structure**
- **Q Equipment Density – thermal gain into equipment (steel)**
- **Q Infiltration – air infiltration into structure**
- **Q Total – summation of all criteria**

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STRUCTURES / BUILDINGS
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ROOF - with Exposure to Outside

- Q (btuh)= U x A x (T1-T2)
- U = **Variable** (6" slab with 2-1/2" Insulation Typical)
- A = Sq. Ft. Area of Roof
- T1 = Inside Temperature (Max)
- T2 = Outside Temperature Design (Min) (**usually 50F**)

STRUCTURES / BUILDINGS
DATA CONSIDERATION

WALLS (4)– *EACH WALL CONSIDERED AS UNIQUE!*

- Q (btuh)= {U (walls) x [A(walls) – A(windows)] x (T3-T2) } + {U(windows) x A(windows) x (T3-T2)}
- U (walls) = **Variable** (4” brick/8” block/ceramic tile face-typical)
- U (windows) = **Variable** (single pane glass - typical)
- A (walls) = Sq. Ft. Area of Solid Walls
- A (windows) = Sq. Ft. Area of Windows
- T3 = Inside Surface Temperature (**final design temp dgF**)
- T2 = Outside Temperature Design (Min) (**usually 50F**)
  - Adjacent to Unheated Room – T2 = Adjacent Room Ambient
  - Adjacent to Heat Treated Room = T2 = (Shared Wall Heat Calc/2)

STRUCTURES / BUILDINGS
DATA CONSIDERATION

Intermediate Floors – Heated Above and Below

- Q = U x A x (T3-T4)
- U = **Variable/2** (divided by 2 because ½ floor heated above and below)
- A = Square foot Area of Floor
- T3 = Inside Surface Area Temp. (**Min final dg F**)
- T4 = Initial Floor Surface Temp. (**Room Setpoint dgF**)

STRUCTURES / BUILDINGS
DATA CONSIDERATION

Bottom Floor or Basement on Earth Slab

- Q = U x A x (T3-T5)
- U = **Variable**
- A = Square foot Area of Floor
- T3 = Inside Surface Area (**Minimum Final Design F**)
- T5 = Earth Avg. Temp. (typically **50F**)

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STRUCTURES / BUILDINGS
DATA CONSIDERATION

Interior Metal Equipment

(Highly Variable Component)

- Q = {U x A x M[lbs(metal)/sq ft] x (T3-T4)}/ **(ht up hrs)**
- U = **Variable**
- A = Square foot Area of ***Floor***
- M = **Variable** (lbs/sq ft) (Equipment Density)
- T3 = Inside Surface Area (**Final Design Condition dgF**)
- T4 = Initial Metal Surface Temp (**plant setpoint dgF**)

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STRUCTURES / BUILDINGS
DATA CONSIDERATION

Infiltration & Space (air) Heating

- Q = V x (sp.Ht. Air) x (1) x (T1-T2)
- V = Volume of Heated Space (cu ft)
- Specific Heat of Air = **0.018 (standard conditions)**
- Air Changes / Hour = **1** (use 2 for Older structures)
- T1 = Maximum Air Temp (**final design condition dgF**)
- T2 = Outside Air(typically **50F**) (Variable)

STRUCTURES / BUILDINGS
DATA CONSIDERATION

STEAM - PORTABLE OR FIXED HEATER

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Equipment Selection Criteria

RULES OF THUMB

1. Utilize 70dgF Ent. Air to Heater for Base Design
2. Calculate Minimum of 5 – Maximum of 10 Air Changes of Calculated Volume through Total No. of Heaters / Hour.
   - (***10 Air Changes as Basis when factors unknown***)

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SILOS/BINS /EQUIPMENT DATA CONSIDERATION

General *"RULES OF THUMB"*

SILOS/BINS may be either INSIDE or OUTSIDE
Steel or Concrete Construction Materials
CONCRETE Construction may often be found within structures

MASS HEAT UP LOAD OVER SEVERAL INITIAL HOURS –
WARM UP STAGE - IS HIGHEST ENERGY CONSUMPTION PERIOD

INTERNAL VOLUME of SILO/BIN is Primary Basis Factor

- Typical Bins Range from 8-10,000 cu.ft./bin on average
- Typical Bins/Silos may be 20 ft dia. X 80 ft high or larger

SILOS/BINS /EQUIPMENT DATA CONSIDERATION

General *"RULES OF THUMB"*

BINS/SILOS Heat Load based on CONSTRUCTION MATERIALS (*Inside* of Structures – Out of the elements)

- **Concrete** – Inside Building or Built Into Structure
  - Use **20** btuh/cu ft of Internal Volume as Basis
- **Steel Bins/Silos**– Inside Locations
  - Use **50** btuh/cu ft of Internal Volume as Basis
  - Steel Inside Radiation Losses = Steel Load x **2.0**

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SILOS/BINS /EQUIPMENT DATA CONSIDERATION

General *"RULES OF THUMB"*

BINS/SILOS Heat Load based on Construction Materials (*Outside* of Structures – In the elements)

- **External Condition Assumptions:**
  - **Variable by Location (typical 50dgF)** Ambient Temp.
  - **Variable MPH** Wind Load (confirm local conditions)
  - **No Rain, Dry conditions.**
- **Concrete** – Outside of Building
  - Use **40** btuh/cu ft of Internal Volume as Basis
- **Steel** – Outside of Building (may be 10ft dia. x 40ft H)
  - Use **100** btuh/cu ft of Internal Volume as Basis
  - Steel Outside Radiation Losses = Steel Load x **3.5**

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