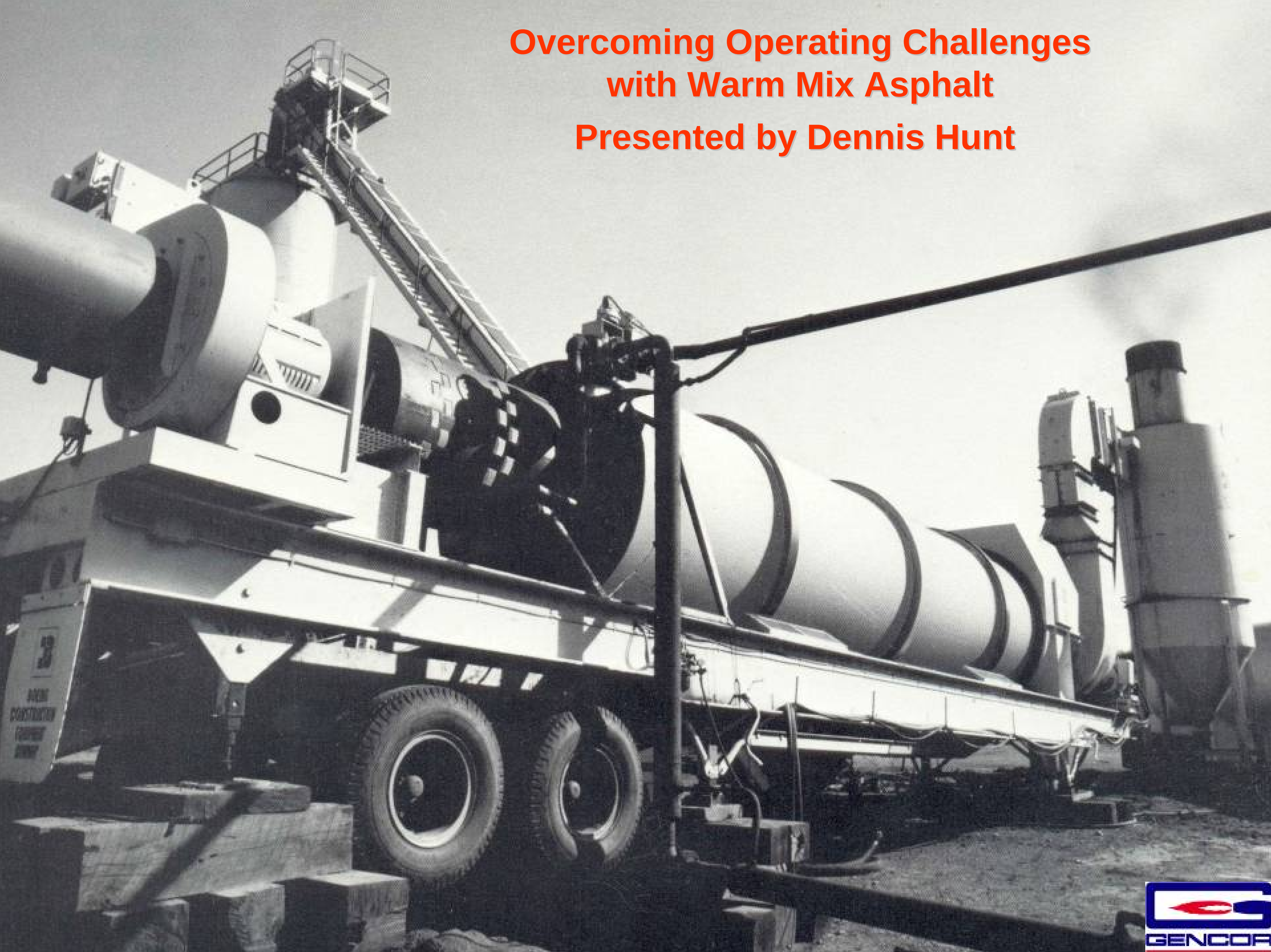
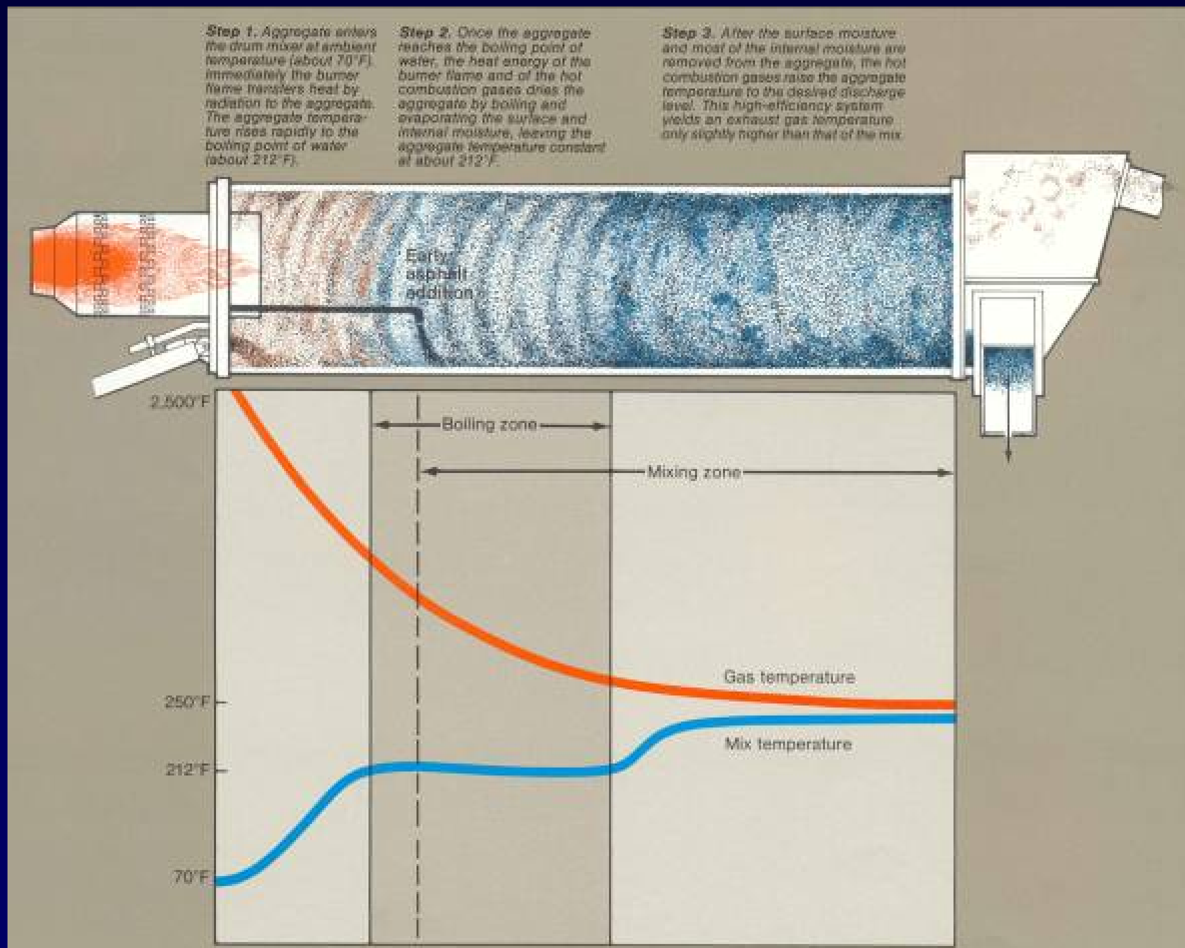
Overcoming Operating Challenges with Warm Mix Asphalt

Presented by Dennis Hunt



Warm Mix



Step 1. Aggregate enters the drum mixer at ambient temperature (about 70°F). Immediately the burner flame transfers heat by radiation to the aggregate. The aggregate temperature rises rapidly to the boiling point of water (about 212°F).
Step 2. Once the aggregate reaches the boiling point of water, the heat energy of the burner flame and of the hot combustion gases dries the aggregate by boiling and evaporating the surface and internal moisture, leaving the aggregate temperature constant at about 212°F.
Step 3. After the surface moisture and most of the internal moisture are removed from the aggregate, the hot combustion gases raise the aggregate temperature to the desired discharge level. This high-efficiency system yields an exhaust gas temperature only slightly higher than that of the mix.
Early asphalt addition
2,500°F
250°F
212°F
70°F
Boiling zone
Mixing zone
Gas temperature
Mix temperature

Warm Mix

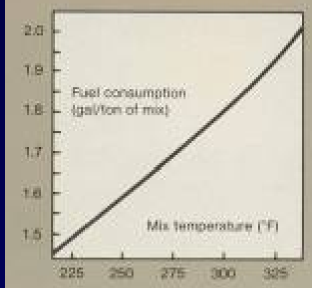
Early Asphalt Addition

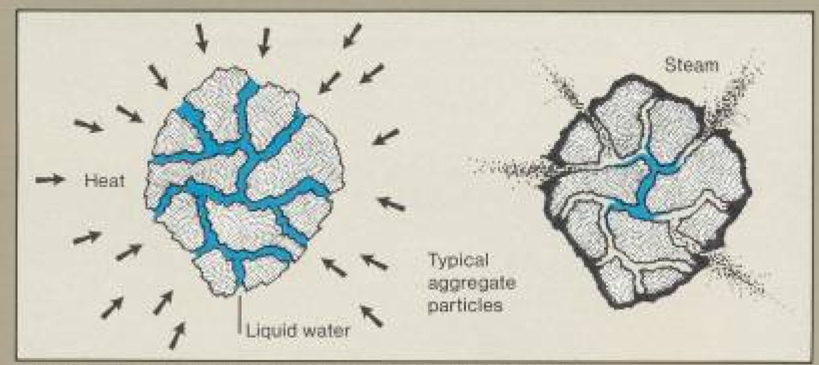
Early asphalt addition is the *key element* in the patented Boeing process. By early asphalt addition we mean that the liquid asphalt is injected in the all-important boiling zone (step 2 in the aggregate heating and drying process).

What's so important about the boiling zone? When the liquid asphalt enters the boiling zone, it interacts with the evolving steam. This interaction foams the asphalt. As the internal moisture leaves the aggregate pores, the foamed asphalt is drawn onto the surface and into the pores. This yields the superior coating for which Boeing plants are famous.

Lower Fuel Consumption Means Big Savings.

Lower mix temperatures mean reduced fuel consumption. It takes over 20% more fuel to produce a mix at 325°F than it does at 250°F. Boeing's patented process of early asphalt injection produces high-quality mixes at lower mix temperatures.





The evolving steam in the boiling zone causes the asphalt to foam and coat.

Warm Mix - Overview

- Producing warm mix will present some operational challenges to a properly tuned plant
- Operating at lower temperatures will exacerbate deficiencies in a plant system that is not properly tuned

Combustion

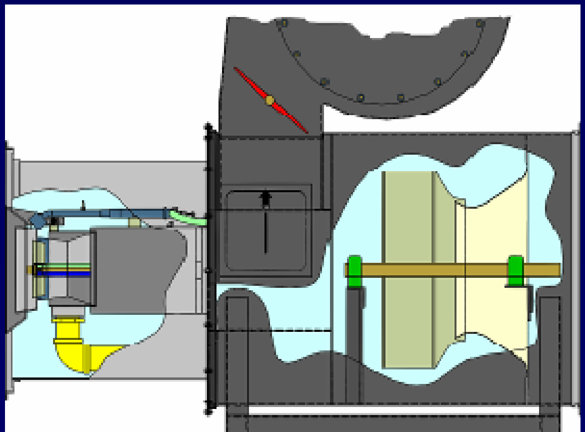
Combustion

Combustion efficiency can be explained in terms of the three T's

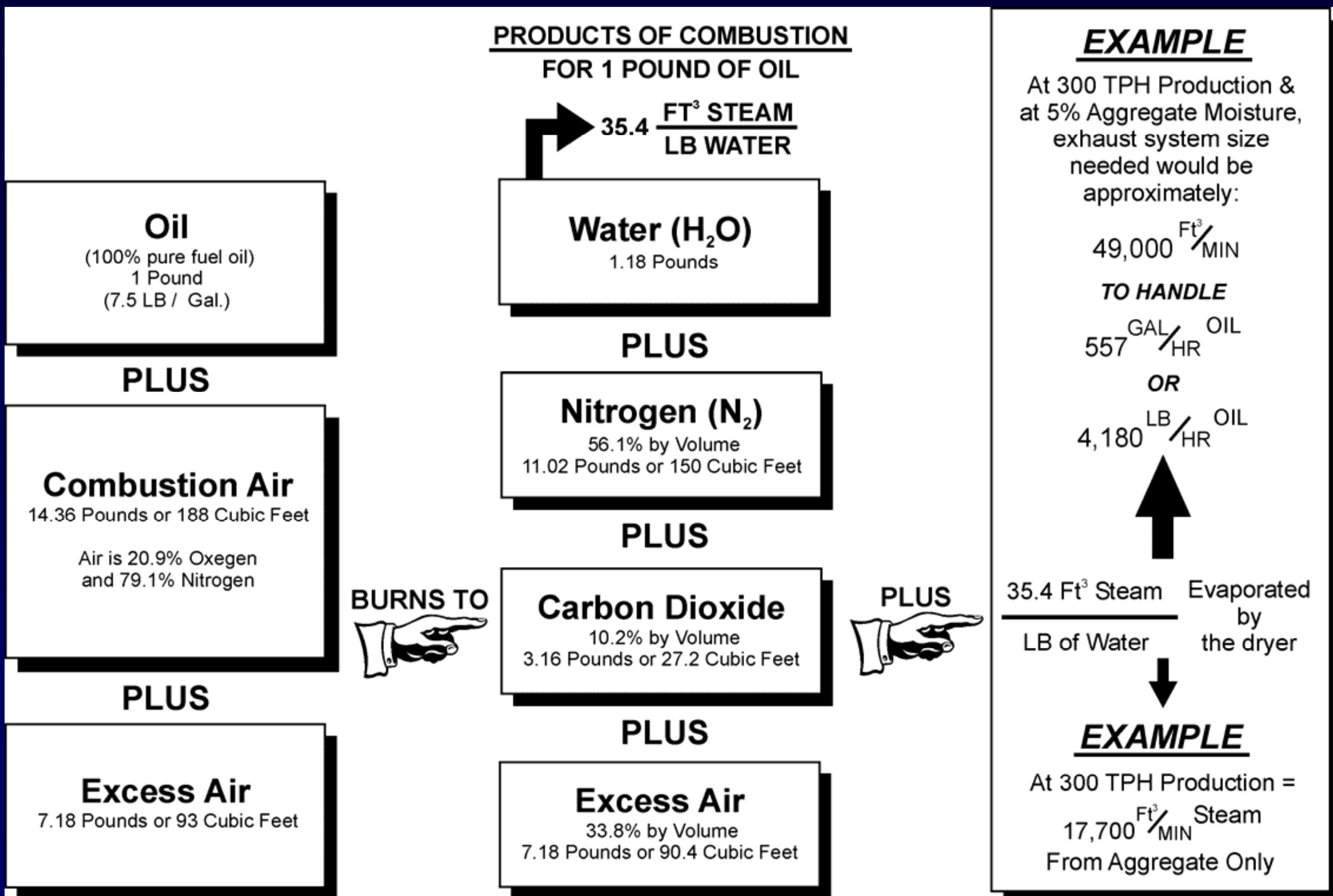
- **<u>Time</u>** - the amount of time the fuel has to combust or reside in the flame
- **<u>Turbulence</u>** - turbulation of the fuel, air and heat source provides for more complete combustion by keeping these components in contact with each other for a longer period of time
- **<u>Temperature</u>** - as the temperature difference (ΔT or Delta T) between the source of heat and the material being heated increases, so does the rate of heat transfer

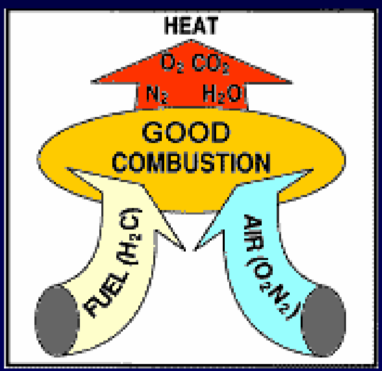
Combustion Air

- **Primary air** - provides a percentage of the combustion air, but more importantly, controls the amount of fuel that can be burned
- **Secondary air** - improves combustion efficiency by promoting the fuel to burn completely
- **Excess air -** is supplied to the combustion process to ensure each fuel molecule is completely surrounded by sufficient combustion air



Good Combustion





Keys to Proper Combustion

- Properly tuned burner
- Properly sized burner
- Properly sized combustion zone
- Proper fuel viscosity

Heating Basics

- A **BTU** (British thermal unit) is the amount of heat required to raise 1 pound of water 1 degree Fahrenheit
- **Specific Heat** is the measure of the heat energy required to raise the temperature of a specific quantity of a substance by a certain amount
  - Water = 1
  - Steam = .5
  - Aggregate = .22

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Heating Basics

- **<u>Sensible heat</u>** is heat energy that is transported by a body that has a temperature higher than its surroundings via conduction, convection, or both
- **<u>Latent heat</u>** describes the amount of energy in the form of heat that is required for a material to undergo a change of phase (also known as "change of state")
  - Evaporation takes 970 BTU's per pound

Produce Hot Mix Asphalt

- Virgin aggregate mix
  - Aggregate moisture 3%
- Mix temperature
  - 325^{o} F
- Fuel
  - Recycled fuel oil
    - Cost per gallon $1.50
    - BTU's per gallon 140,000

BTU's To Make 1 Ton of Hot Mix

Dry aggregate

Btu's to heat water
2000 (lbs) X 1% (moisture) X 1 (SH) X 212°F (boiling point) - 60°F (ambient temperature) = 3,040 Btu's Sensible heat

Btu's for evaporation
2000 (lbs) X 1% (moisture) X 1 (SH) X 970 (Latent Heat) = 19,400 Btu's Latent heat

Btu's to remove water vapor
2000 (lbs) X 1% (moisture) X .5 (SH) X 325°F (Mix temp) - 212°F (boiling point) = 1,130 Btu's Sensible heat

Total 23,570 per % Moisture

23,570 Btu's X 3 (% moisture removed) Total 70,710 Btu's per ton

Heat aggregate

2000 (lbs) X .22 (SH) X 325°F (mix temp) - 60°F (ambient temperature) = 116,600 Btu's Sensible heat

Total Btu's

70, 710 Btu's dry aggregate + 116,600 Btu's heat aggregate = 186,710 Btu's per ton at 100% efficiency

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BTU’s To Make 1 Ton of Hot Mix

Btu’s at 87.5 % efficiency

186,710 Btu’s X 1.14 = 212,849 Btu’s

Fuel usage

212,849 Btu’s per ton / 140,000 Btu’s per gallon recycled fuel oil = 1.52 gallons per ton

Fuel cost per ton

1.52 gallons per ton X $1.50 per gallon = $2.28 per ton

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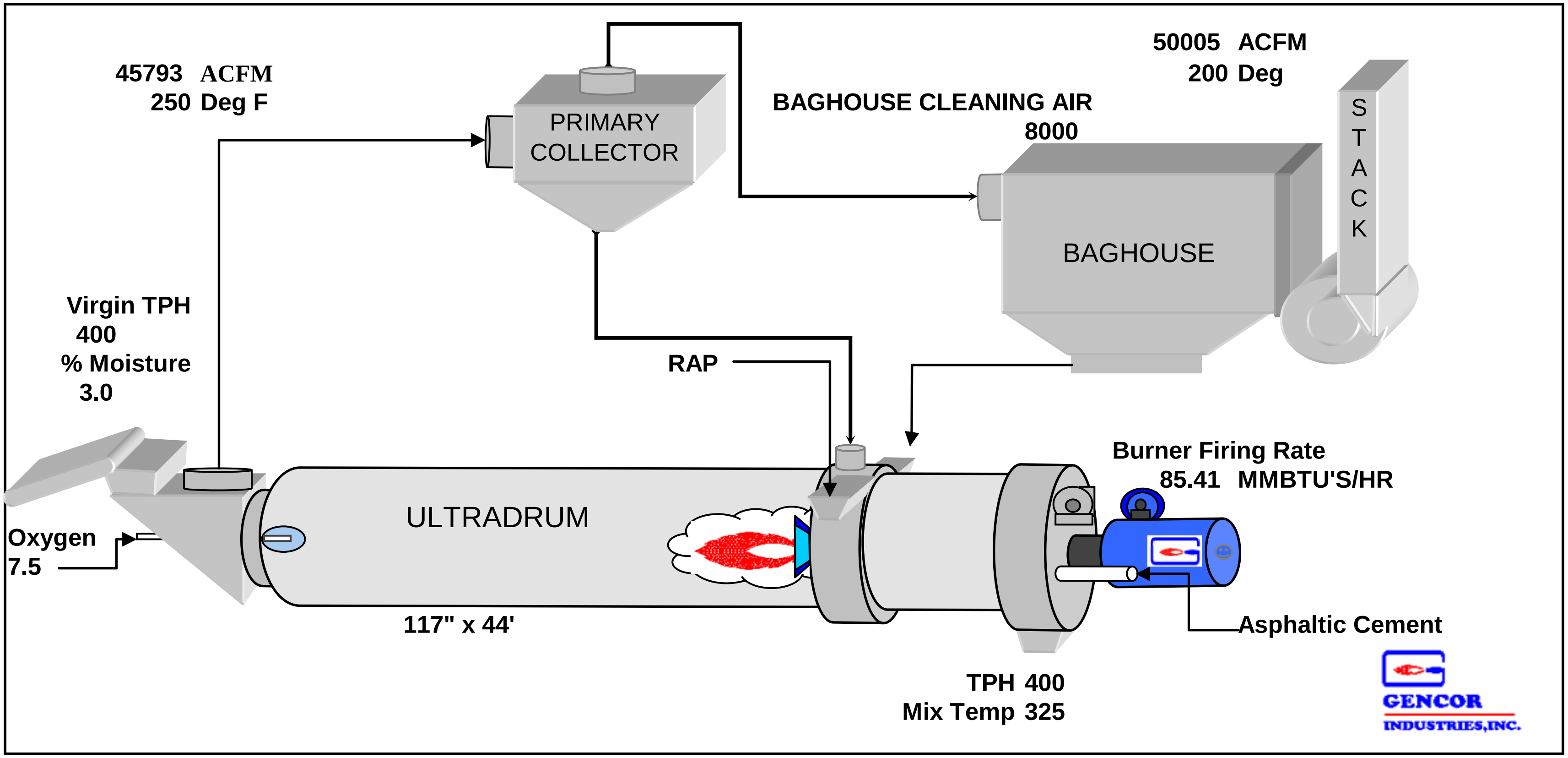
Hot Mix



212,849 Btu's

Produce Warm Mix Asphalt

- Virgin aggregate mix
  - Aggregate moisture 3%
- Mix temperature
  - 250^{o} F
- Fuel
  - Recycled fuel oil
    - Cost per gallon $1.50
    - BTU's per gallon 140,000

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BTU's To Make 1 Ton of Warm Mix

Dry aggregate

Btu's to heat water
2000 (lbs) X 1% (moisture) X 1 (SH) X 212°F (boiling point) - 60°F (ambient temperature) = 3,040 Btu's Sensible heat

Btu's for evaporation
2000 (lbs) X 1% (moisture) X 1 (SH) X 970 (Latent Heat) = 19,400 Btu's Latent heat

Btu's to remove water vapor
2000 (lbs) X 1% (moisture) X .5 (SH) X 250°F (Mix temp) - 212°F (boiling point) = 380 Btu's Sensible heat

Total 22,820 per % moisture

22,820 Btu X 3 (% moisture removed) Total 68,460 Btu per ton

Heat aggregate

2000 (lbs) X .22 (SH) X 250°F (mix temp) - 60°F (ambient temperature) = 83,600 Btu's Sensible heat

Total Btu's

68,480 Btu's dry aggregate + 83,600 Btu's heat aggregate = 152,080 Btu's per ton at 100% efficiency

BTU's To Make 1 Ton of Warm Mix

Btu's at 87.5 % efficiency

152,080 Btu's X 1.14 = 173,371 Btu's

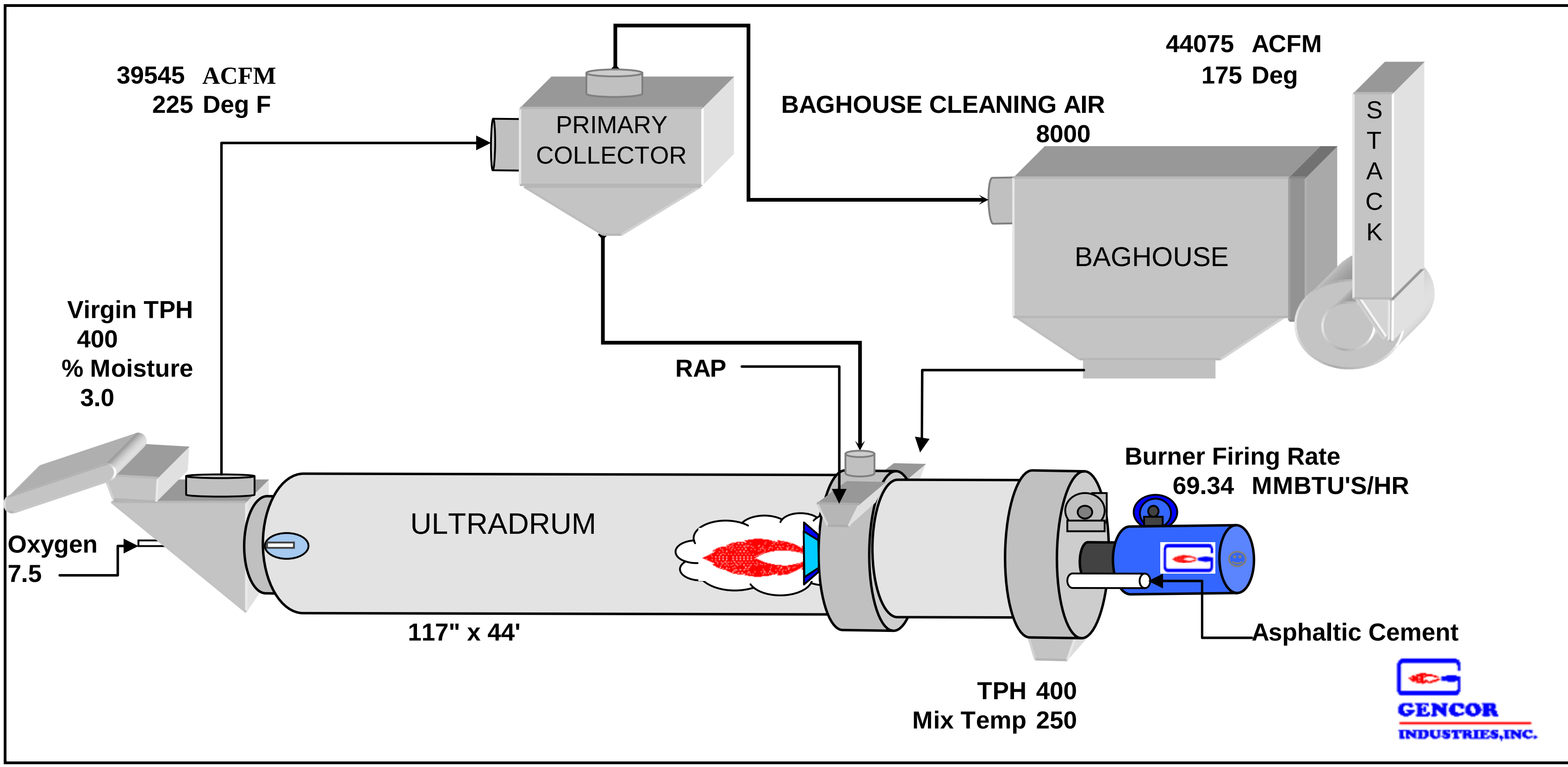
Fuel usage

173,371 Btu's per ton / 140,000 Btu's per gallon recycled fuel oil = 1.24 gallons per ton

Fuel cost per ton

1.24 gallons per ton X $1.50 per gallon = $1.86 per ton

Warm Mix



173,371 Btu's

Comparison

- 1 ton hot mix
  - 212,849 Btu's per ton
  - 1.52 gallons per ton
  - $2.28 per ton fuel cost
- 1 ton warm mix
  - 173,371 Btu's per ton
  - 1.24 gallons per ton
  - $ 1.86 per ton fuel cost

18.5% drop in heating demand
$.42 per ton drop fuel cost

Comparison

Hot Mix

Dry aggregate

- Btu's to heat water 3,040
- Btu's for evaporation 19,400
- Btu's to remove water vapor 1,380
- Total 23,570 per % moisture
  - 70,710 Btu per ton

- Heat aggregate
  - 116,600

- Total BTU's
  - 186,710 100% efficiency

Warm Mix

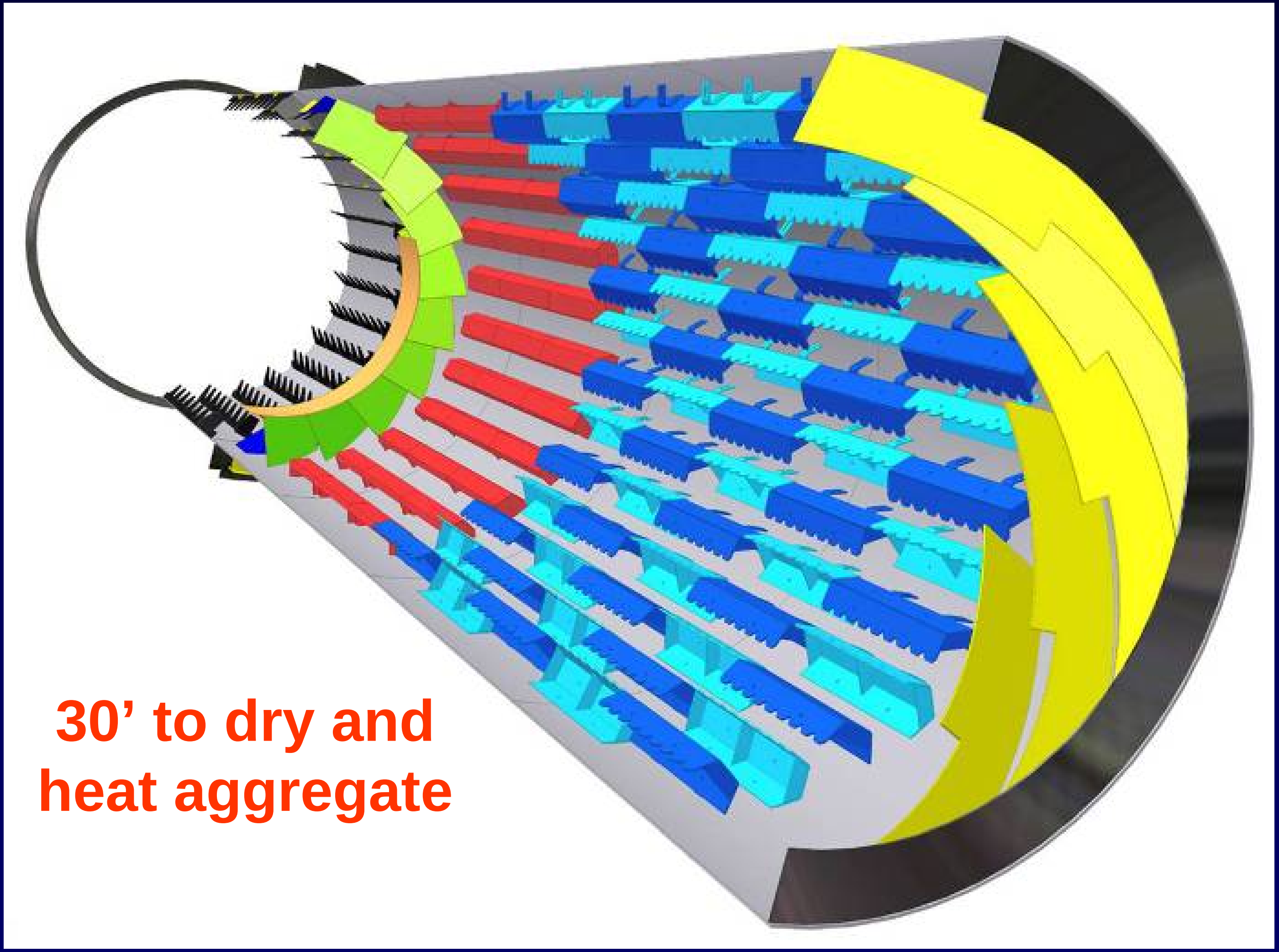
Dry aggregate

- Btu's to heat water 3,040
- Btu's for evaporation 19,400
- Btu's to remove water vapor 380
- Total 22,820 per % moisture
  - 68,460 Btu per ton

- Heat aggregate
  - 83,600

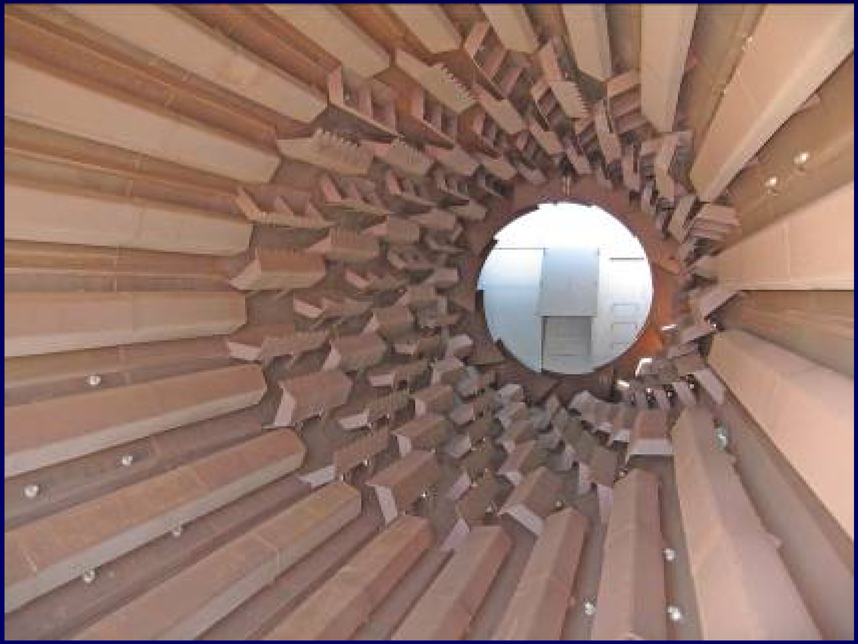
- Total BTU's
  - 152,080 100% efficiency

Dry and Heat Aggregate



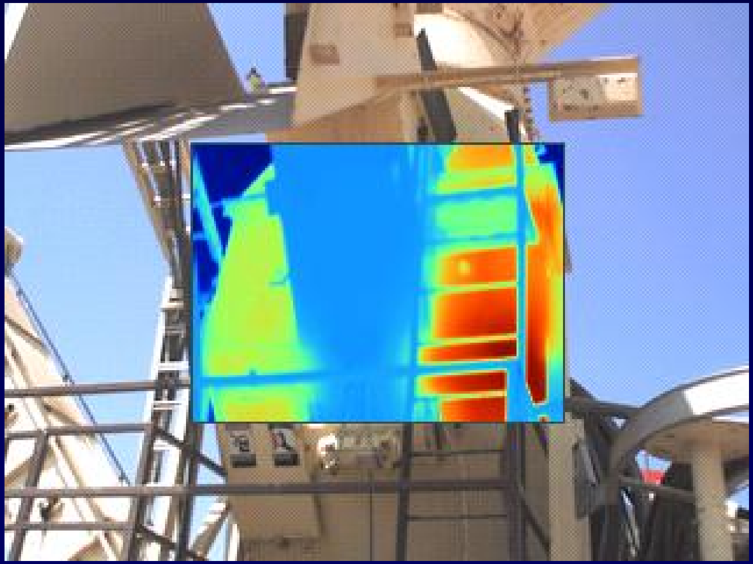
Drying Aggregate/Warm mix

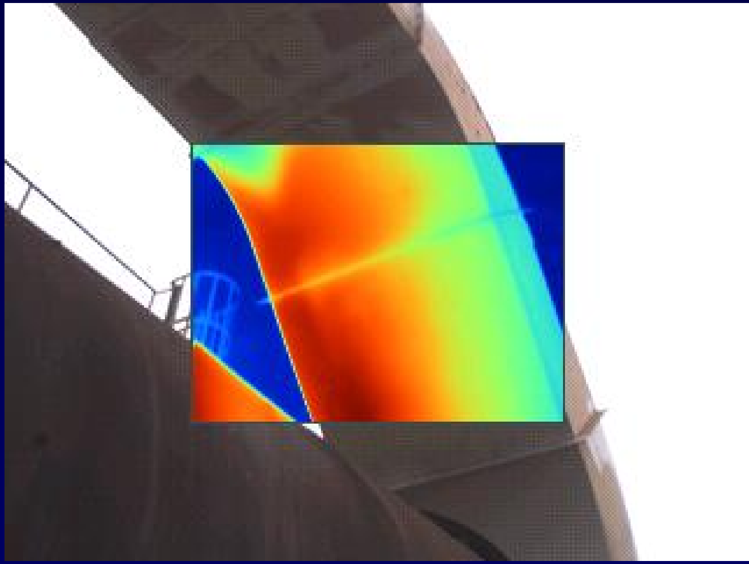
- To obtain the same level of drying, additional time is required for moisture to leave the aggregates
  - Flighting adjustment
  - Drum slope adjusted
  - Move heat to feed end of drum (counterflow drum)



Drum Flighting

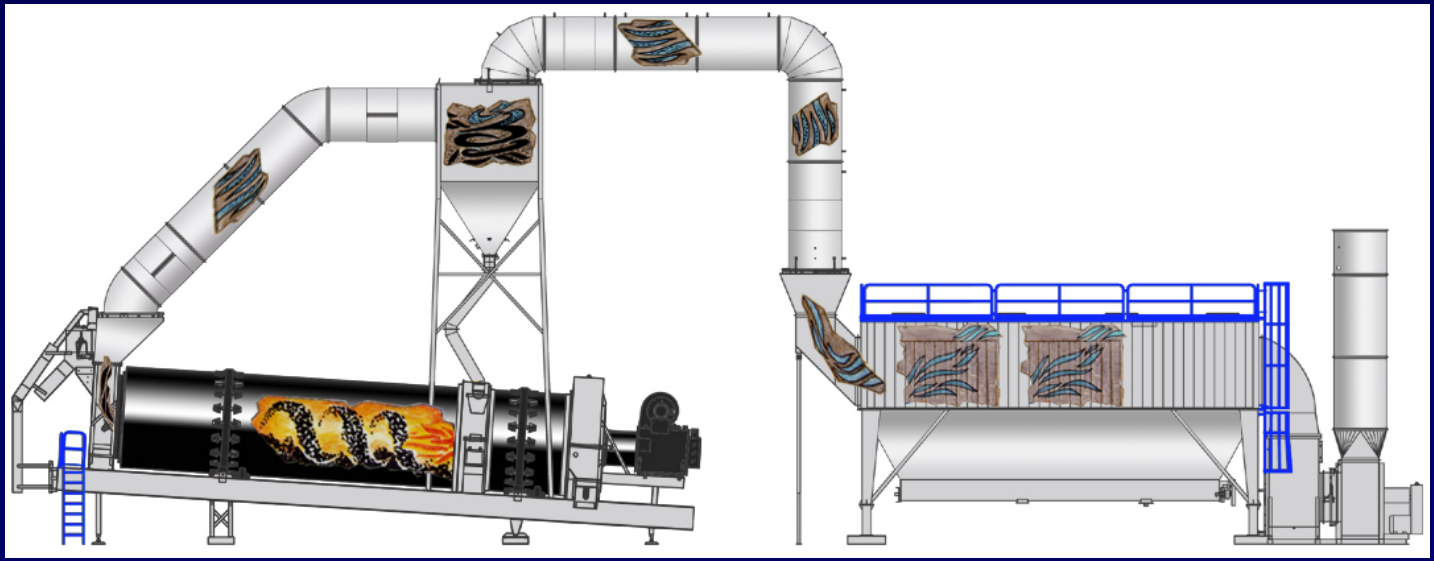
Veil in drum





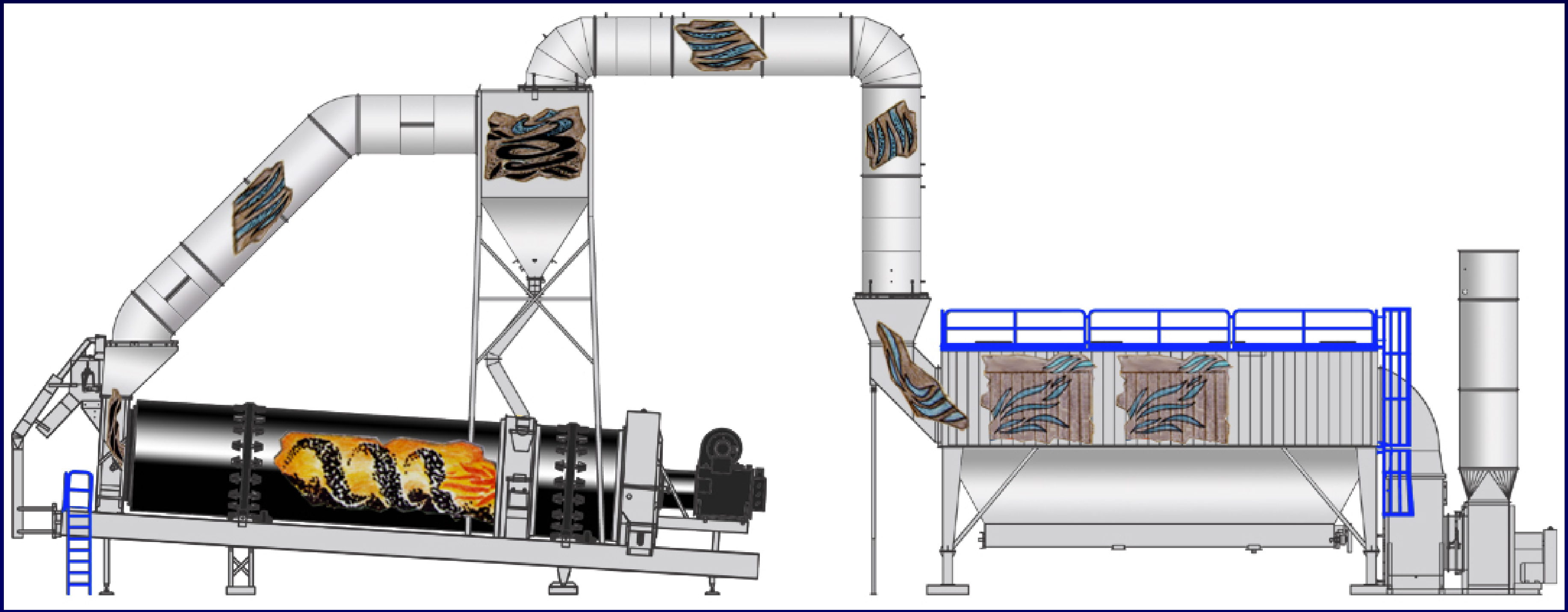
Exhaust System

- Function of the exhaust system
  - Remove combustion gases from dryer
  - Remove evaporated aggregate moisture (steam) from dryer
  - Remove / collect dust / fines from gases
  - Provide secondary air for burners
  - Pull hot gases through dryer so heat transfer can occur



Dew Point

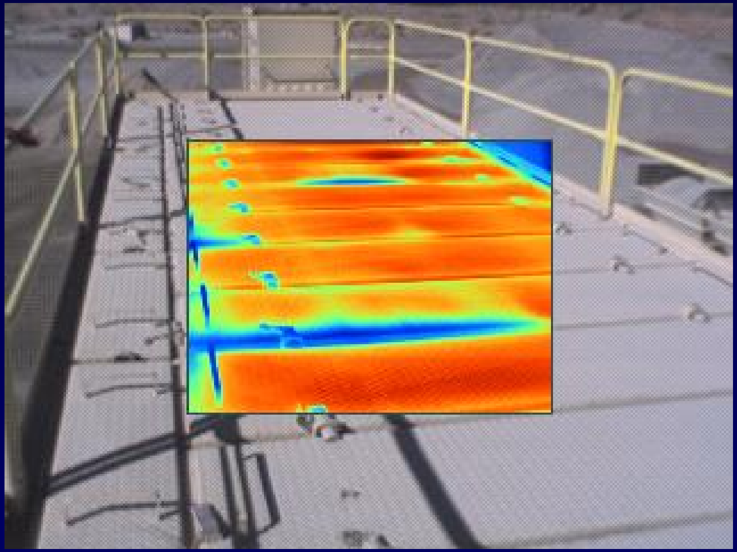
- Temperature across baghouse must remain above dew point (170°F)

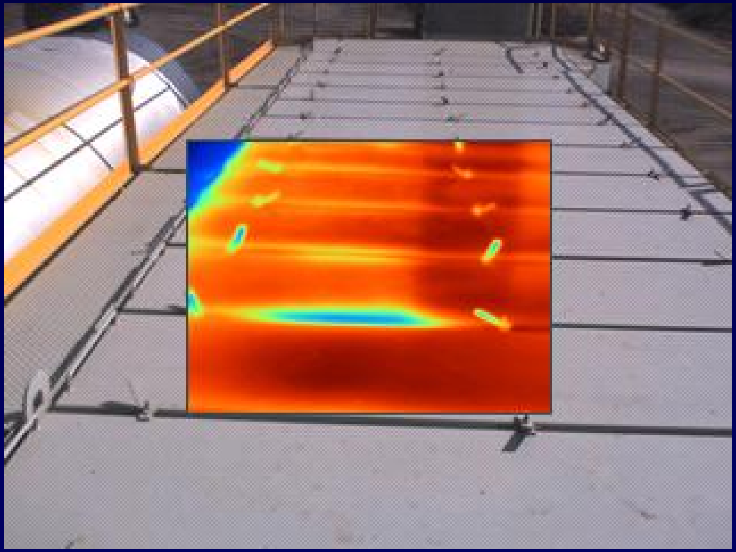


Moisture in Baghouse

Leakage Air

Leakage Air





Retained Moisture

Warm Mix Production

- Properly tuned burner
- Drying adjustments
- Flighting adjustments
- Keep baghouse above dew point
- Retained moisture

Questions?