
TURNING GREEN
ASTEC
INDUSTRIES, INC.

Boggs Paving, Inc.

Rock Hill, South Carolina

Warm Mix Demo

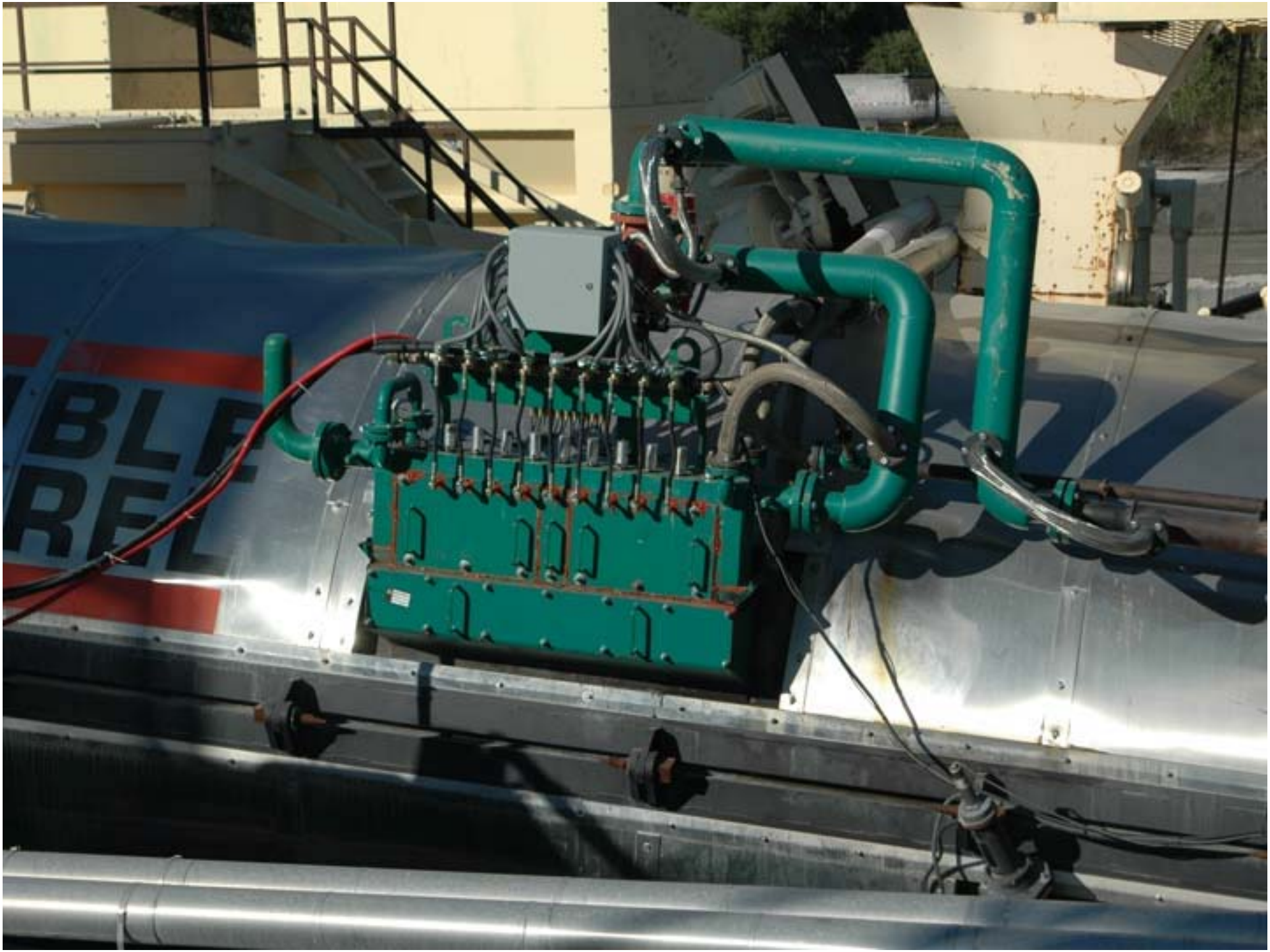
October 10, 2007

- 15,000 tons
- 50% RAP @ 270°F (132 C) / PG 64-22
- Contractor has 50,000 more tons under contract


This Street
Paved With
Environmentally
Friendly
Warm Mix Asphalt
York County
South Carolina
ASTEC
Boggs
PAVING, INC.
GREEN


A SIX PACK
Boggs
NO
TRUCK DRIVERS
IN
CONTROL TOWER
Boggs
ALL TRUCKS
MUST BE ON
CB CHANNEL
13


ASTEC




CN2
SPORTS

Background

- Warm Mix: mix temperatures 50-100F cooler than conventional mix methods
- Achieved by lowering the viscosity of the AC binder
- Various methods: additives, additives with water, foaming with water only, etc.
- Foaming first introduced in the 1950’s
- Current trends towards fuel efficiency and emissions reductions make Warm Mix more attractive

Background

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- Achieved by lowering the viscosity of the AC binder
- Various methods: additives, additives with water, foaming with water only, etc.
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Advantages of Warm Mix

- Economic Advantages:
  - 14% reduction in fuel consumption (50F)
  - Ideal for high percentages of RAP
- Ecological Advantages
  - Reduced fuel consumption = reduced greenhouse gas emissions
  - No visible smoke or odor
  - “Green” asphalt plants = better neighbors

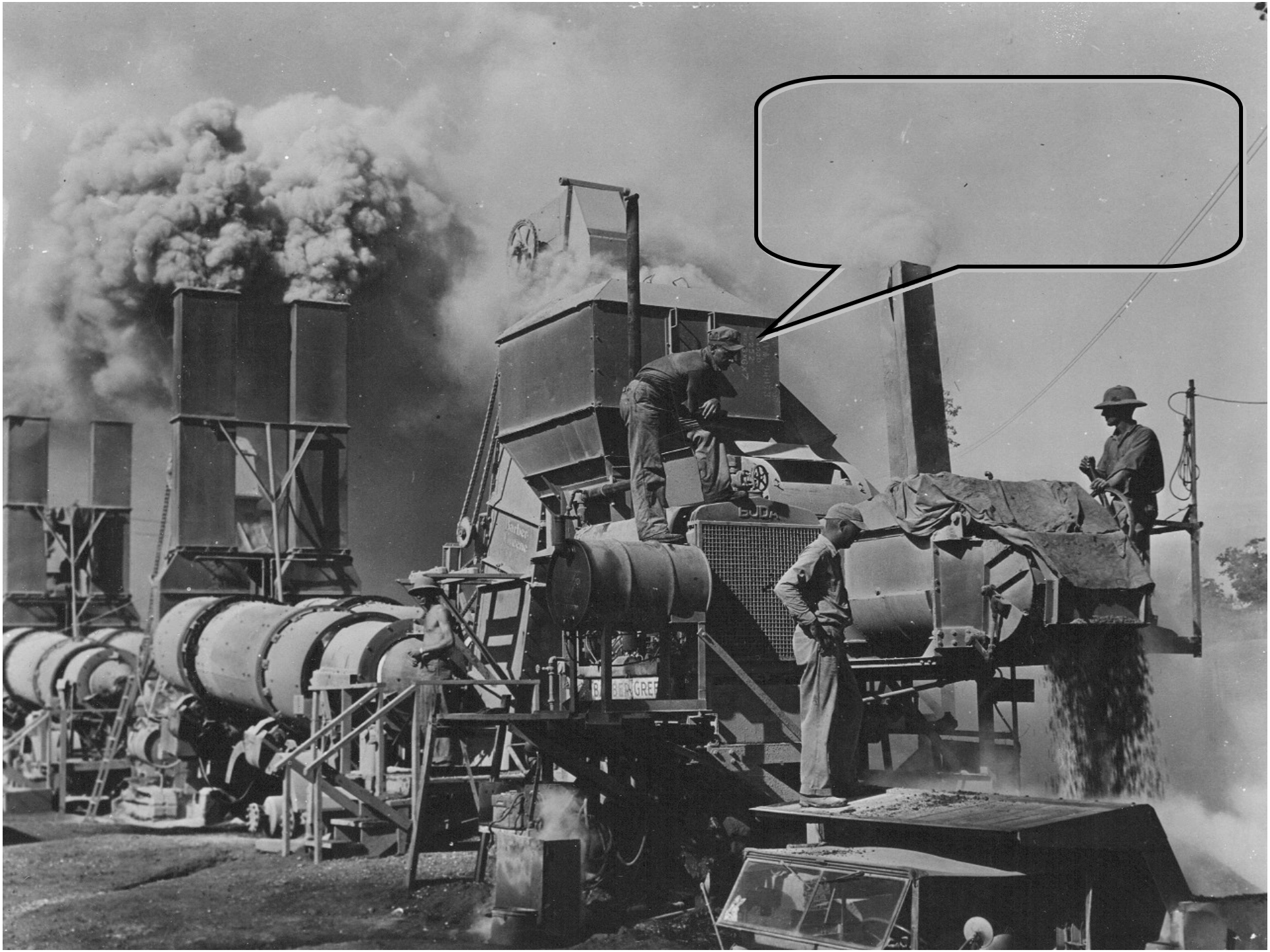
Additional Warm Mix Advantages

- Less oxidation of AC
- Lower plant cost ($300k - $500k)
- Lower plant maintenance cost
- Plant safety
- Paving crew safety

No Smoke – No Smell…Why?

- **Light oils are either put in asphalt or left in asphalt during refining**
- **These light oils boil above 285°F**
- **By mixing at below 285°F, the boiling point is never reached…eliminating smoke (vapor) and corresponding smell**


PHOTO OF BOTHELL ROAD
TAKEN MAY. 8. 1912
BY C.S SEATTLE, WASH.




ROADTEC
ROADTEC
ROADTEC
NO SMOKE AT THE PAVER!

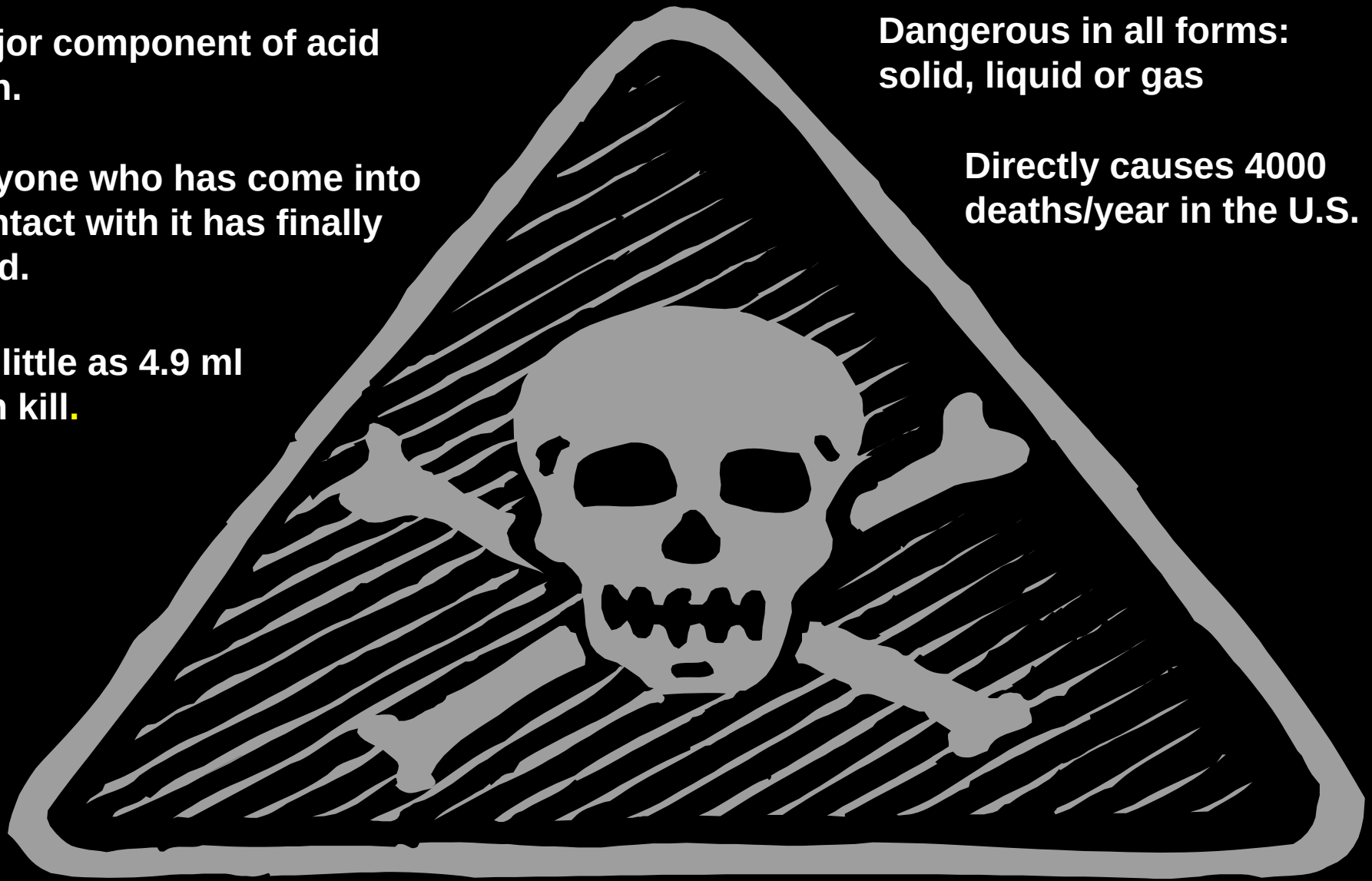

CONVENTIONAL
HOT MIX
WARM MIX

DANGER: Di-hydrogen Monoxide

Major component of acid rain.

Anyone who has come into contact with it has finally died.

As little as 4.9 ml can kill.

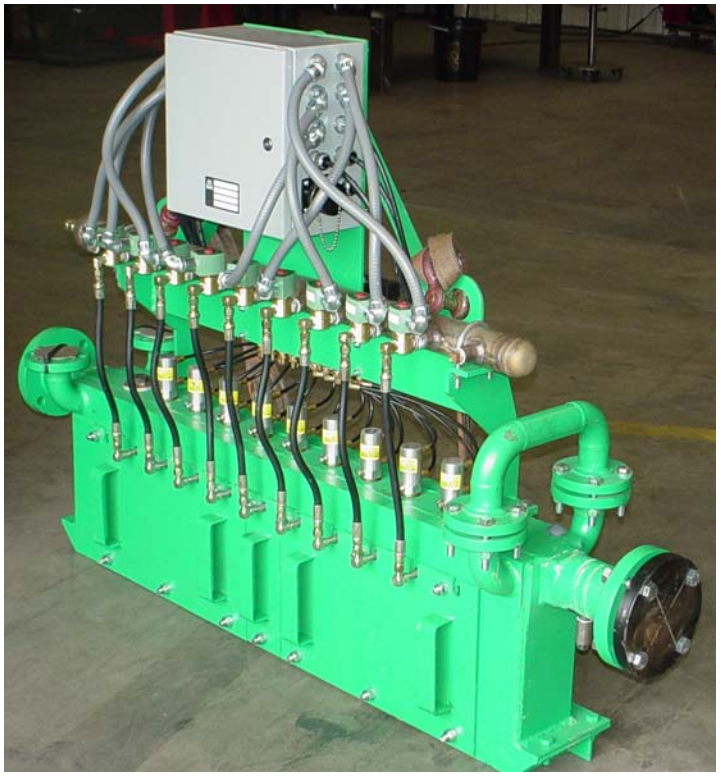


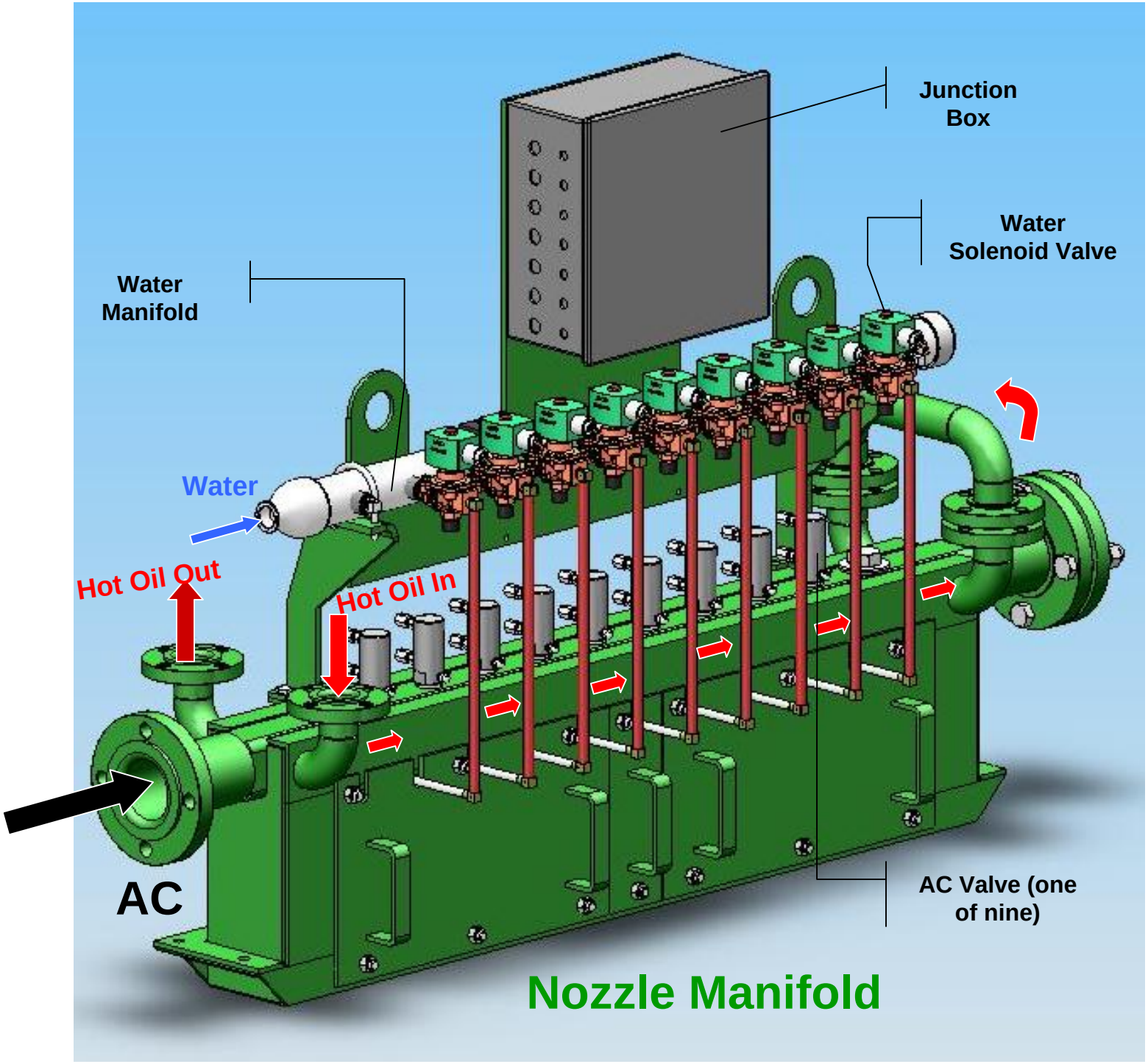
Dangerous in all forms: solid, liquid or gas

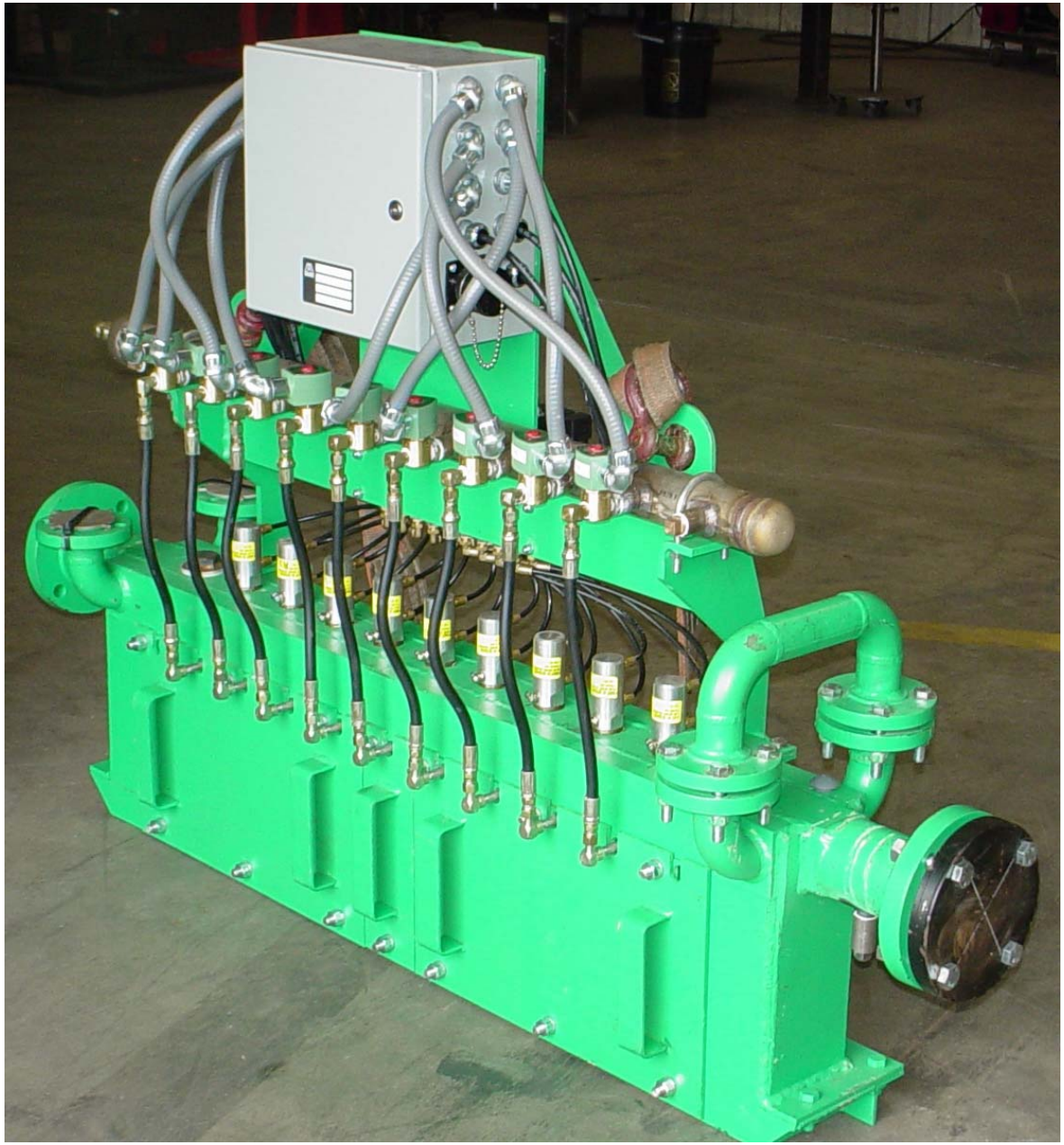
Directly causes 4000 deaths/year in the U.S.

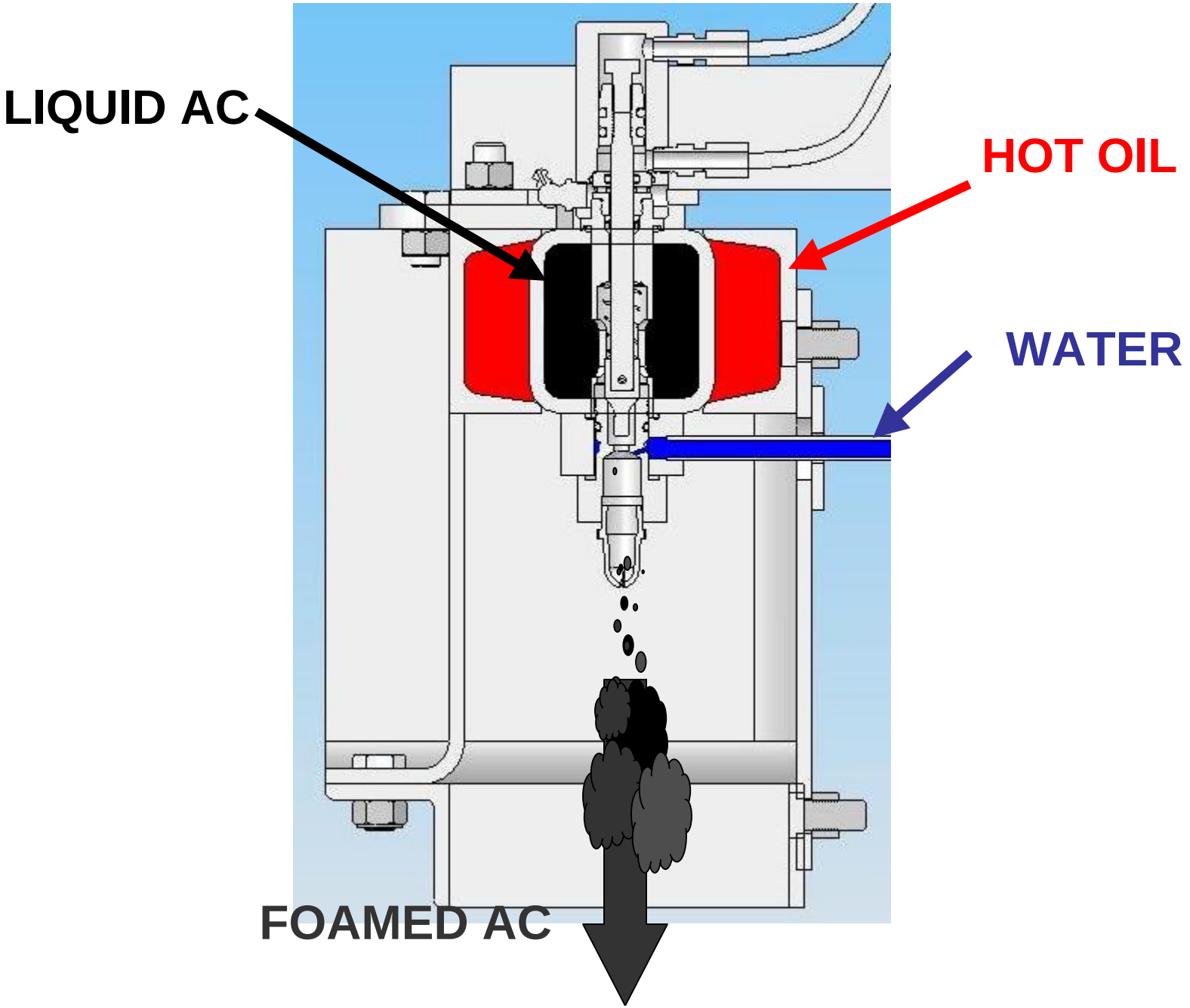
Astec Multi-nozzle Device

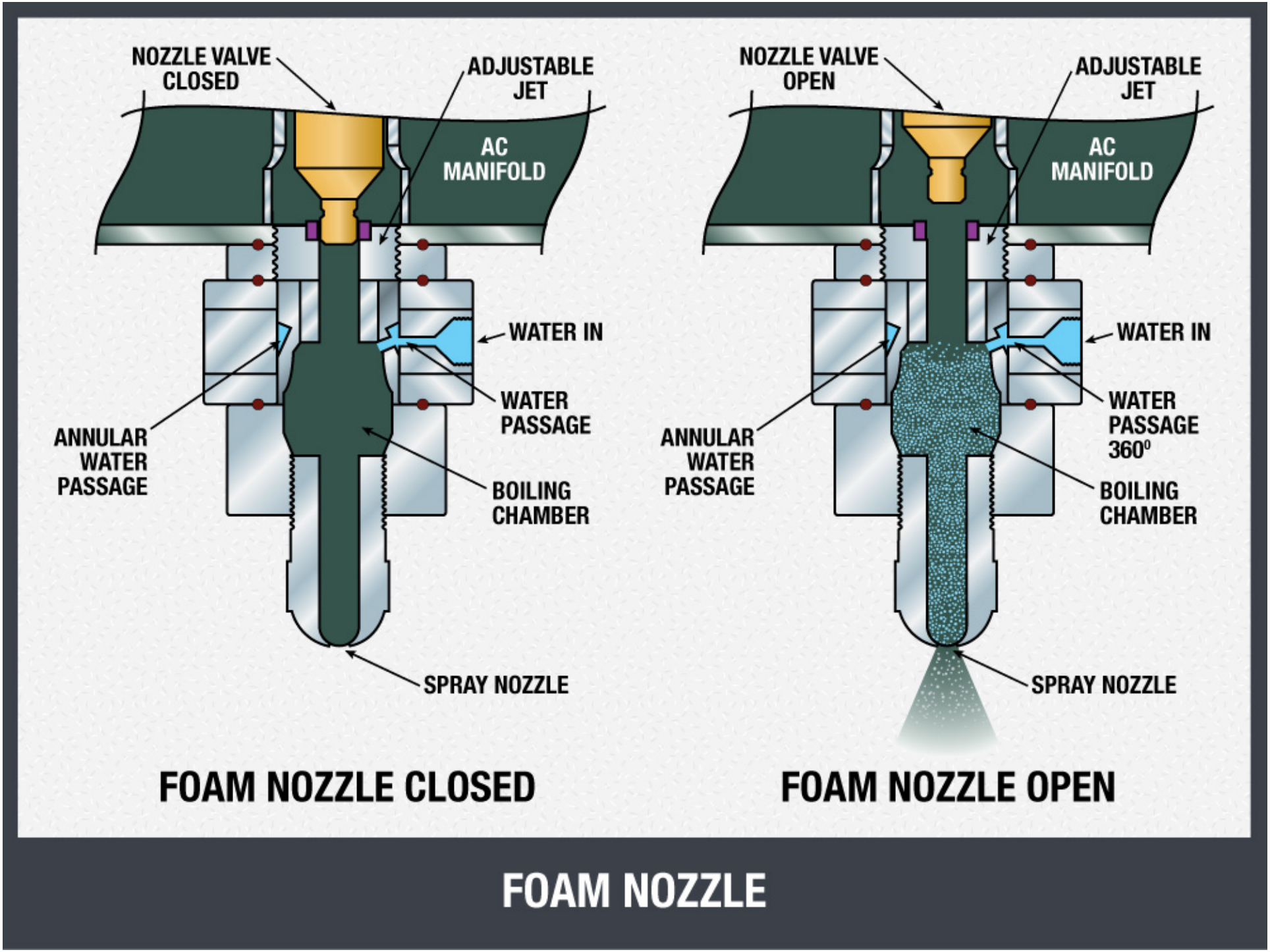
- Mixes water and AC to create microscopic steam bubbles to foam the AC
- Water flow rate = 2% of AC flow rate (NOT 2% of mix!)
- 2.5 TPH AC per nozzle, 8 nozzles = 400 TPH mix
- PLC controlled
- Mix transported, placed and compacted using “normal” procedures



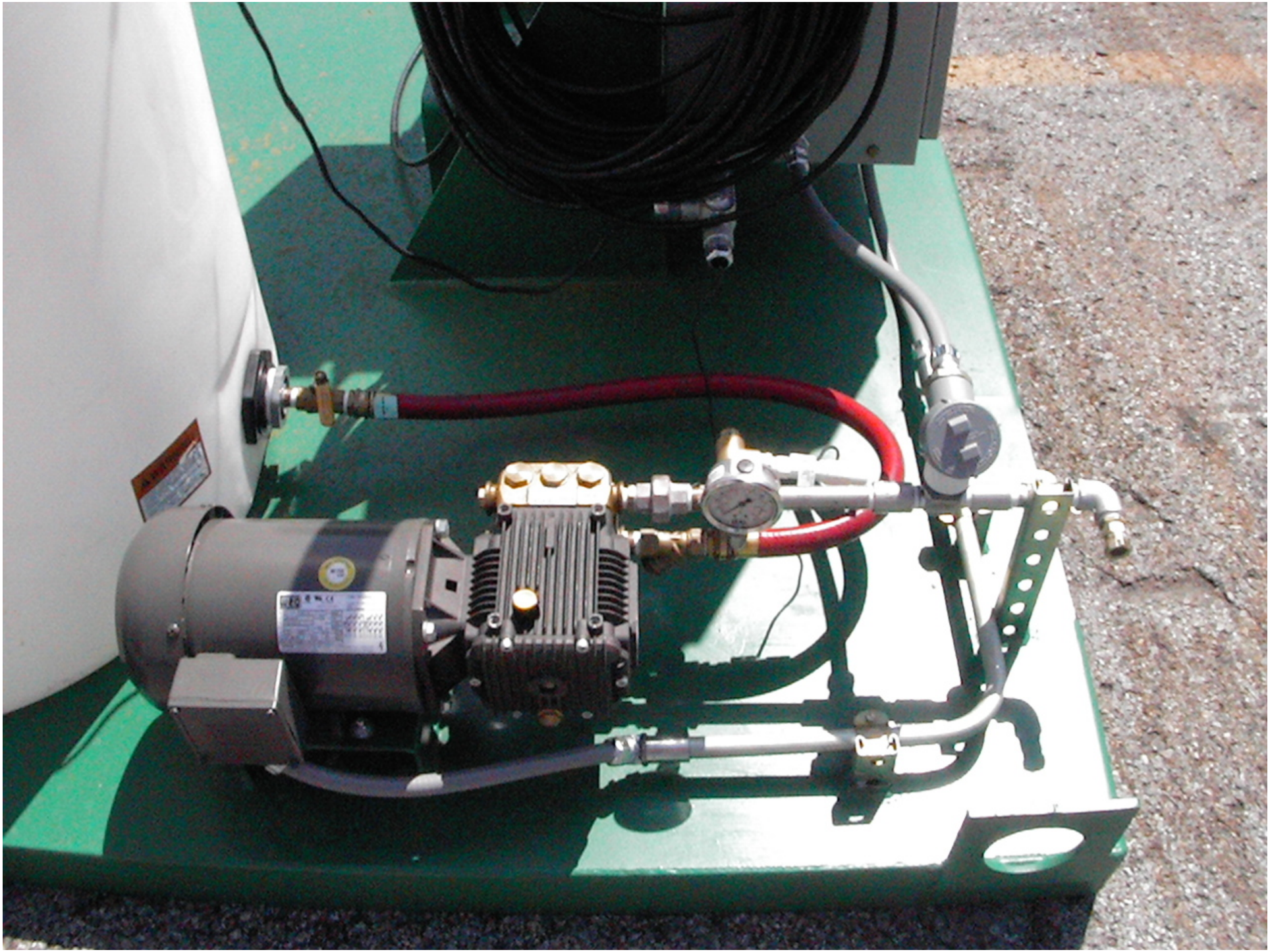

Junction Box
Water Solenoid Valve
Water Manifold
Water
Hot Oil Out
Hot Oil In
AC
AC Valve (one of nine)
Nozzle Manifold



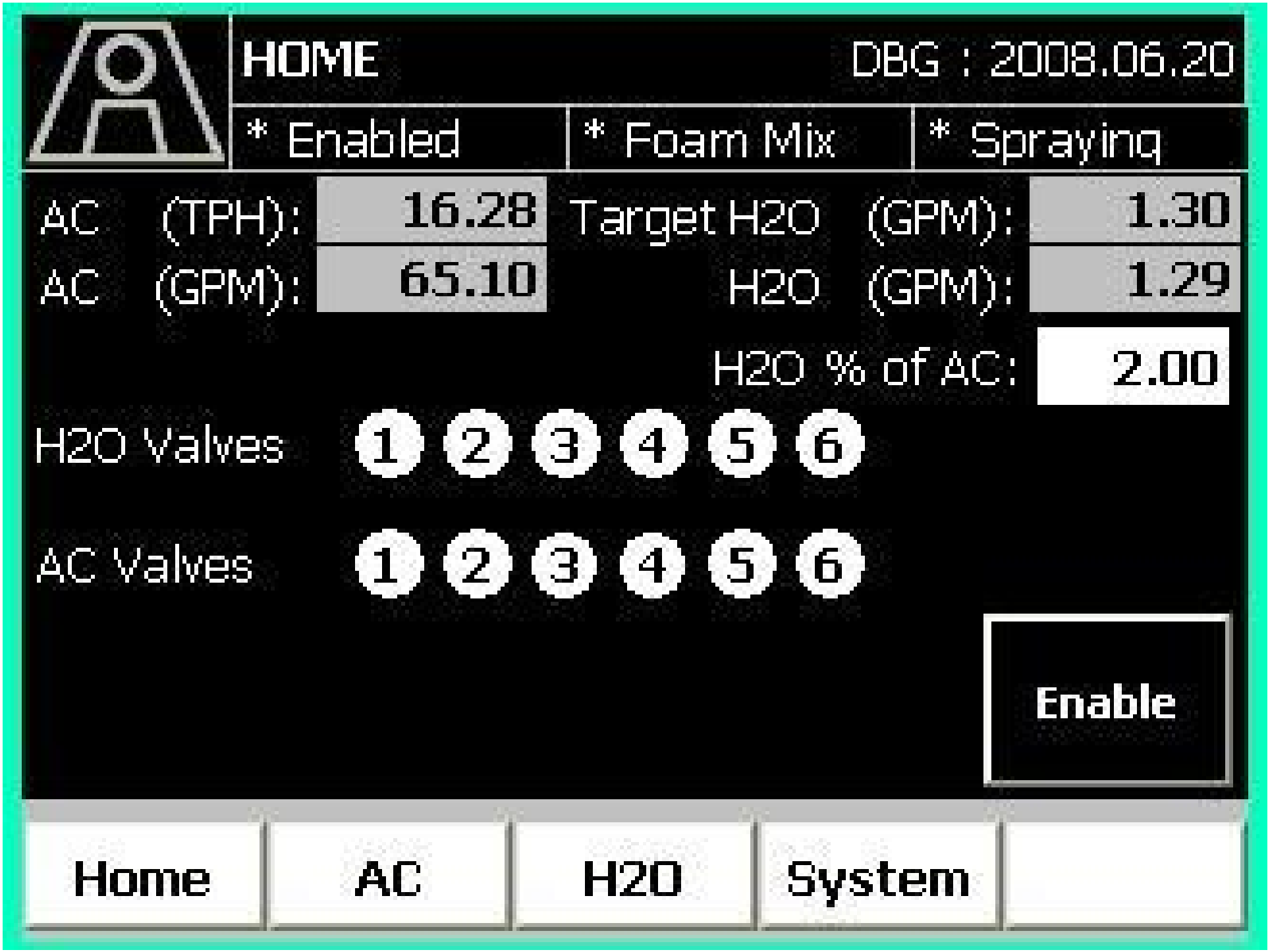

LIQUID AC
HOT OIL
WATER
FOAMED AC

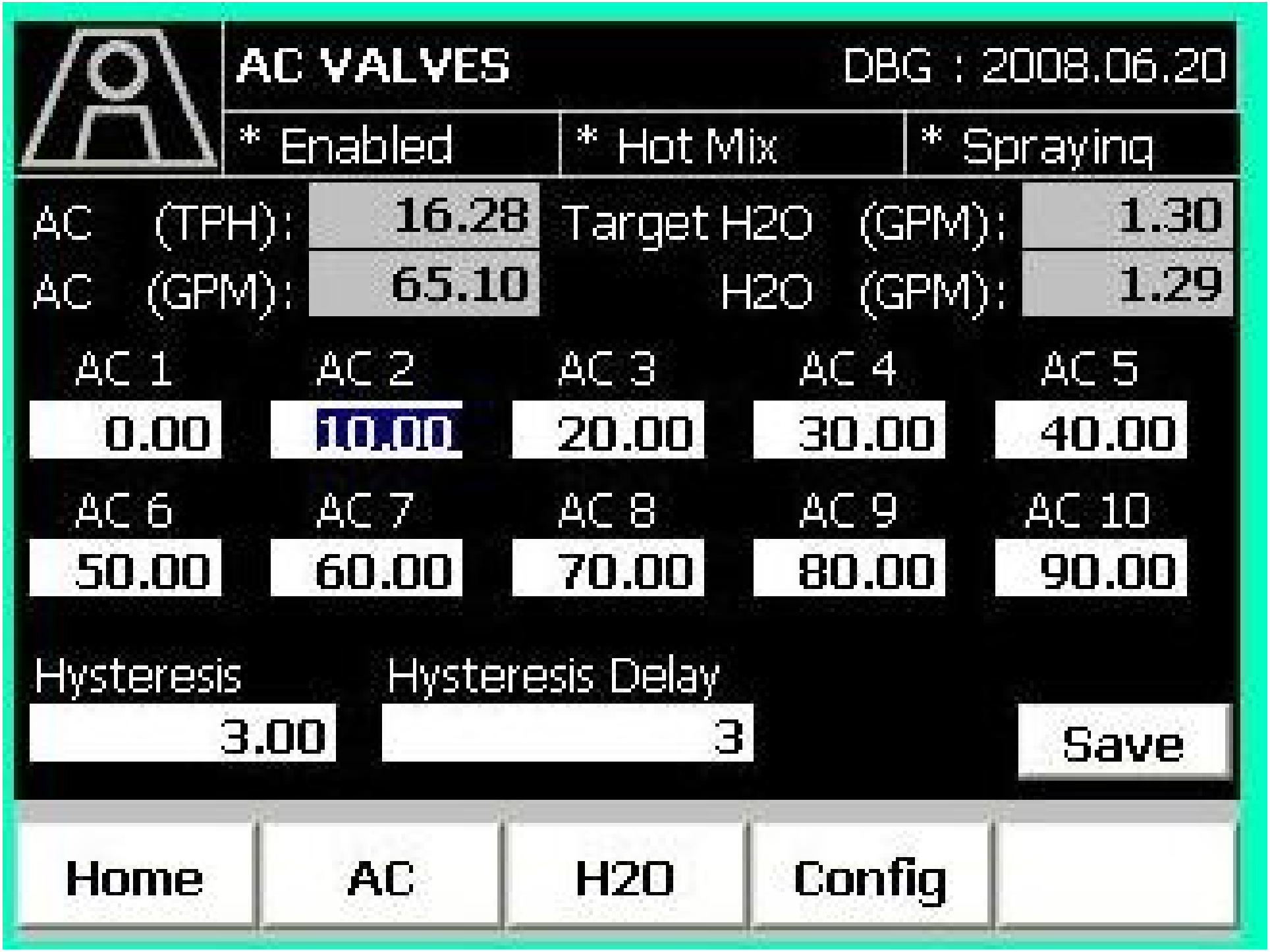

NOZZLE VALVE CLOSED
ADJUSTABLE JET
AC MANIFOLD
WATER IN
WATER PASSAGE
ANNULAR WATER PASSAGE
BOILING CHAMBER
SPRAY NOZZLE
FOAM NOZZLE CLOSED
NOZZLE VALVE OPEN
ADJUSTABLE JET
AC MANIFOLD
WATER IN
WATER PASSAGE 360⁰
ANNULAR WATER PASSAGE
BOILING CHAMBER
SPRAY NOZZLE
FOAM NOZZLE OPEN
FOAM NOZZLE

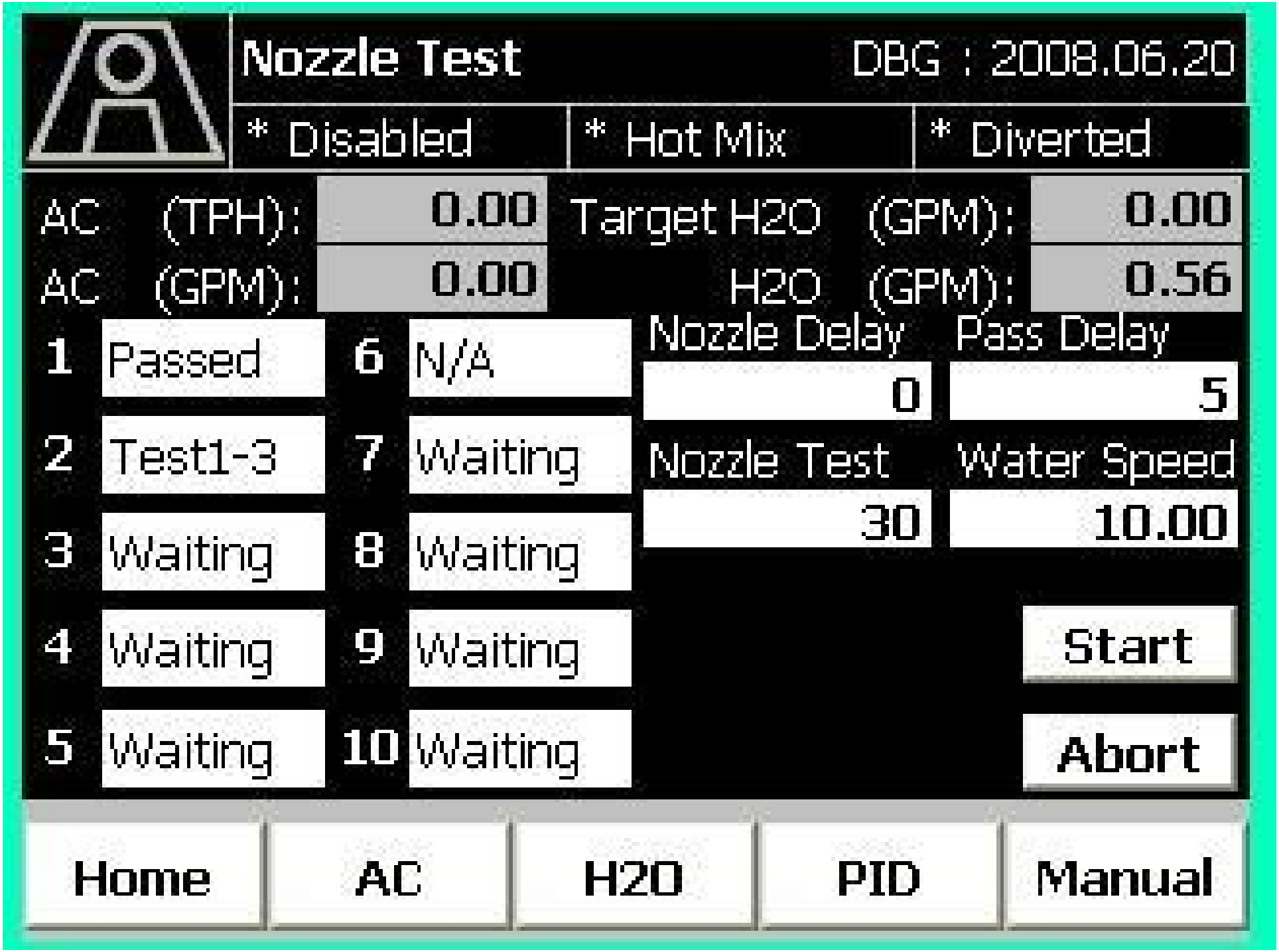
WATER AND CONTROL SKID

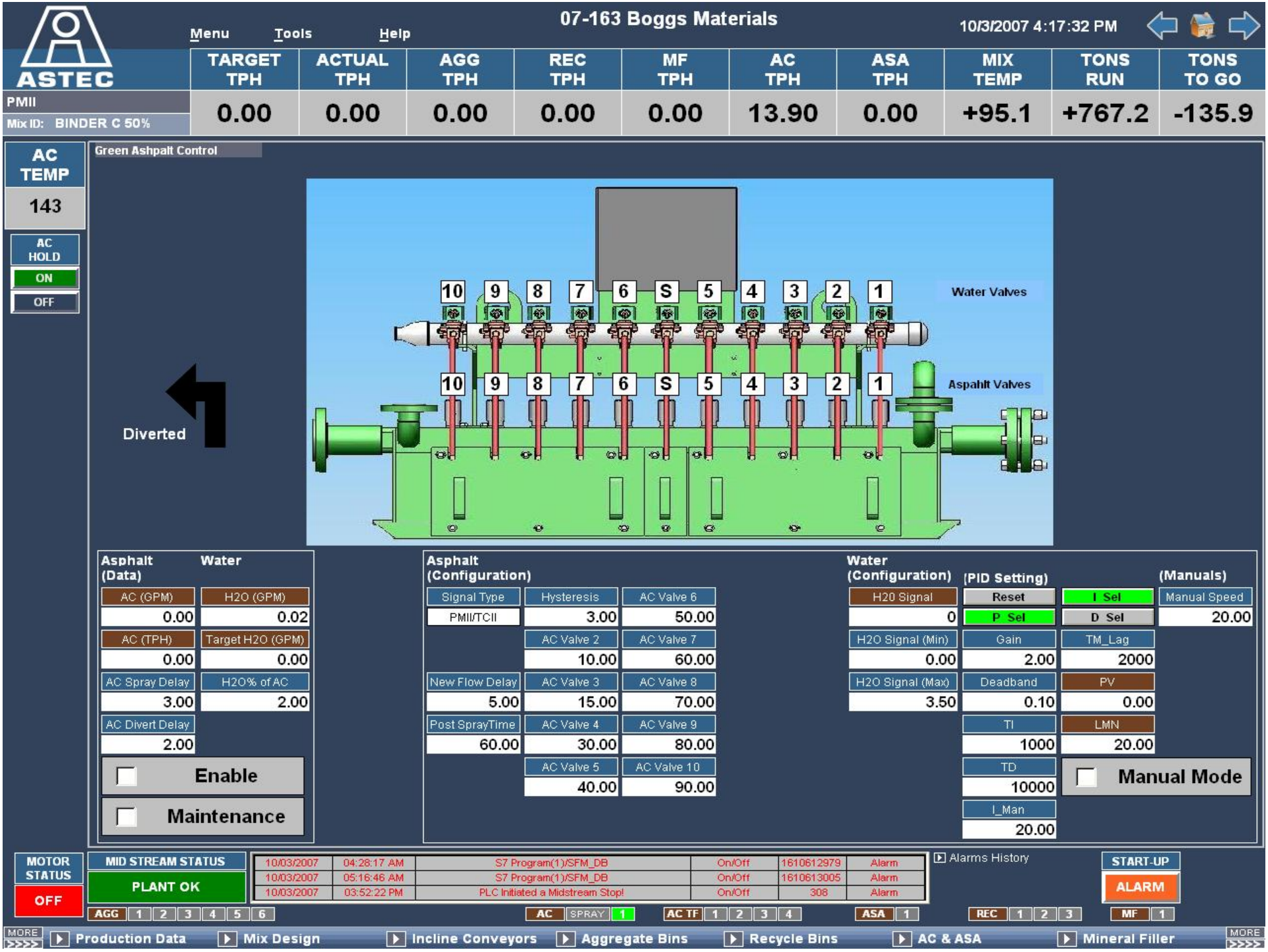


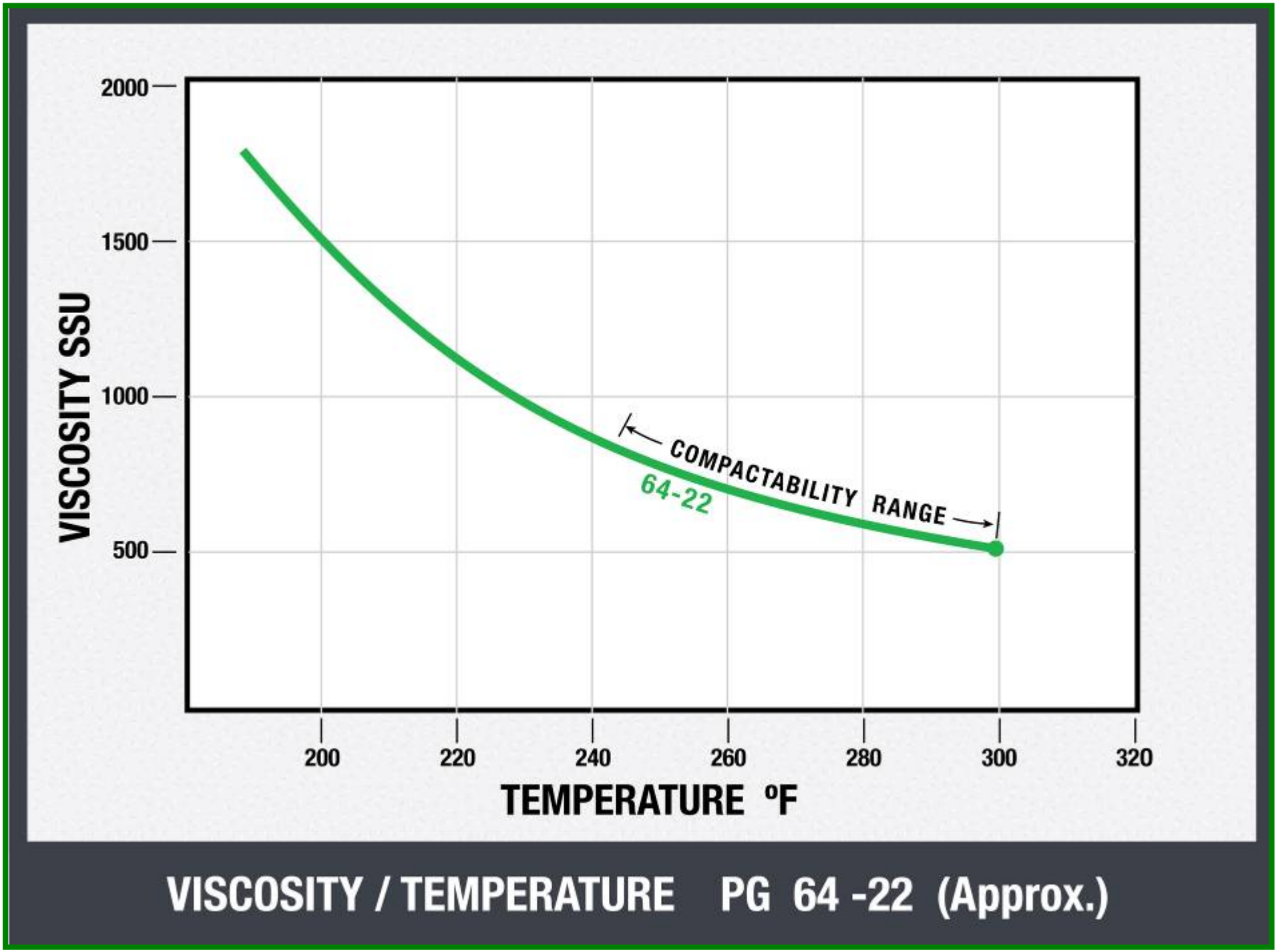
TOUCH PANEL IN CONTROL HOUSE


HOME
DBG : 2008.06.20
* Enabled
* Foam Mix
* Spraying
AC (TPH): 16.28
AC (GPM): 65.10
Target H2O (GPM): 1.30
H2O (GPM): 1.29
H2O % of AC: 2.00
H2O Valves 1 2 3 4 5 6
AC Valves 1 2 3 4 5 6
Enable
Home
AC
H2O
System

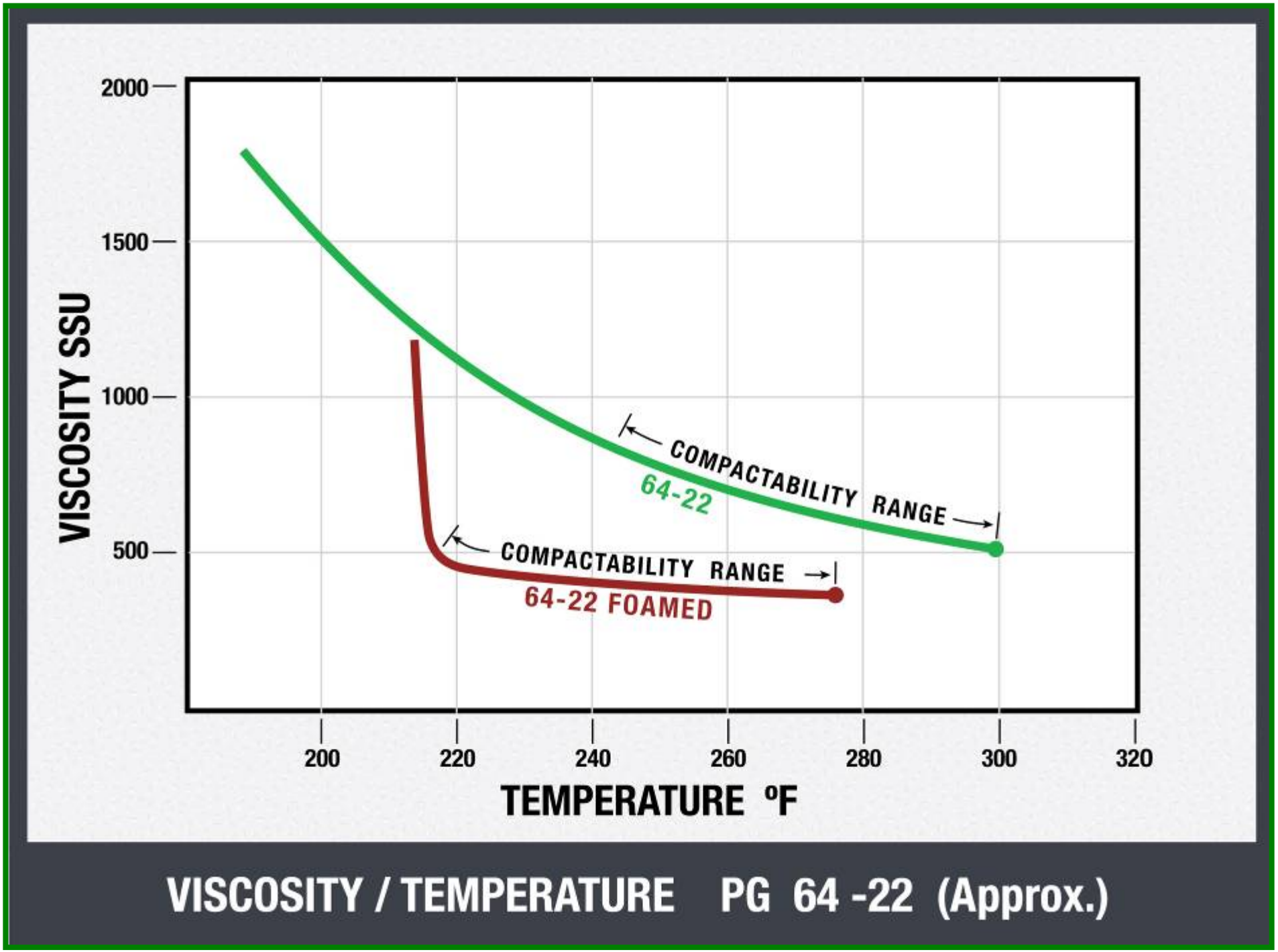

AC VALVES
DBG : 2008.06.20
* Enabled
* Hot Mix
* Spraying
AC (TPH): 16.28
Target H2O (GPM): 1.30
AC (GPM): 65.10
H2O (GPM): 1.29
AC 1
0.00
AC 2
10.00
AC 3
20.00
AC 4
30.00
AC 5
40.00
AC 6
50.00
AC 7
60.00
AC 8
70.00
AC 9
80.00
AC 10
90.00
Hysteresis
3.00
Hysteresis Delay
3
Save
Home
AC
H2O
Config


Nozzle Test
DBG : 2008.06.20
* Disabled
* Hot Mix
* Diverted
AC (TPH): 0.00
AC (GPM): 0.00
Target H2O (GPM): 0.00
H2O (GPM): 0.56
1 Passed
2 Test1-3
3 Waiting
4 Waiting
5 Waiting
6 N/A
7 Waiting
8 Waiting
9 Waiting
10 Waiting
Nozzle Delay
0
Pass Delay
5
Nozzle Test
30
Water Speed
10.00
Start
Abort
Home
AC
H2O
PID
Manual


ASTEC
Menu
Tools
Help
07-163 Boggs Materials
10/3/2007 4:17:32 PM
TARGET TPH
ACTUAL TPH
AGG TPH
REC TPH
MF TPH
AC TPH
ASA TPH
MIX TEMP
TONS RUN
TONS TO GO
PMII
Mix ID: BINDER C 50%
0.00
0.00
0.00
0.00
0.00
13.90
0.00
+95.1
+767.2
-135.9
AC TEMP
143
AC HOLD
ON
OFF
Green Ashpalt Control
Diverted
10 9 8 7 6 S 5 4 3 2 1
Water Valves
Aspahlt Valves
Asphalt (Data)
Water
AC (GPM)
0.00
H2O (GPM)
0.02
AC (TPH)
0.00
Target H2O (GPM)
0.00
AC Spray Delay
3.00
H2O% of AC
2.00
AC Divert Delay
2.00
Enable
Maintenance
Asphalt (Configuration)
Signal Type
PMII/TCII
Hysteresis
3.00
AC Valve 6
50.00
AC Valve 2
10.00
AC Valve 7
60.00
New Flow Delay
5.00
AC Valve 3
15.00
AC Valve 8
70.00
Post SprayTime
60.00
AC Valve 4
30.00
AC Valve 9
80.00
AC Valve 5
40.00
AC Valve 10
90.00
Water (Configuration)
H20 Signal
0
H2O Signal (Min)
0.00
H2O Signal (Max)
3.50
(PID Setting)
Reset
P Sel
I Sel
D Sel
Gain
2.00
TM_Lag
2000
Deadband
0.10
PV
0.00
TI
1000
LMN
20.00
TD
10000
I_Man
20.00
(Manuals)
Manual Speed
20.00
Manual Mode
MOTOR STATUS
OFF
MID STREAM STATUS
PLANT OK
10/03/2007 04:28:17 AM S7 Program(1)/SFM_DB On/Off 1610612979 Alarm
10/03/2007 05:16:46 AM S7 Program(1)/SFM_DB On/Off 1610613005 Alarm
10/03/2007 03:52:22 PM PLC Initiated a Midstream Stop! On/Off 308 Alarm
Alarms History
START-UP
ALARM
AGG 1 2 3 4 5 6
AC SPRAY 1
AC TF 1 2 3 4
ASA 1
REC 1 2 3
MF 1
MORE
Production Data
Mix Design
Incline Conveyors
Aggregate Bins
Recycle Bins
AC & ASA
Mineral Filler
MORE



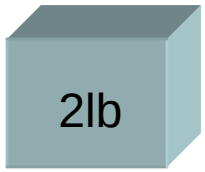
VISCOSITY / TEMPERATURE PG 64 -22 (Approx.)



VISCOSITY / TEMPERATURE PG 64 -22 (Approx.)

Astec Foamed Asphalt

How much water <u>injected</u> per virgin ton of mix ?



3 ¾” x 3 ¾” x 3 ¾”

How much water stays in the mix?

- AC Content: 5%
- Voids: 25% (pre-compaction), 5% (post-compaction)
- Density: 110 lbm/ft³ (pre-compaction);140 lbm/ft³ (post-compaction)

$$\textbf{Volume of uncompacted mix (ft}^3\textbf{/ton)} = \frac{\textbf{2000 lbm/ton}}{\textbf{110 lbm/ft}^3} = \textbf{18.2 ft}^3\textbf{/ton}$$

Of this 18.2ft³, 25% (4.54ft³) consists of air voids.

$$\textbf{Volume of AC (ft}^3\textbf{/ton)} = \frac{\textbf{5\% X 2000 lbm/ton}}{\textbf{65 lbm/ft}^3} = \textbf{1.54 ft}^3\textbf{/ton}$$

How much water stays in the mix is limited by the volume of air voids.

Available volume for foamed AC (ft^3/ton) = 4.54 ft^3/ton + 1.54 ft^3/ton = 6.08 ft^3/ton

0.016 ft^3/lbm (ambient temperature liquid water) to 30.53 ft^3/lbm (superheated steam at 300˚F)

BEFORE COMPACTION

$$\text{Mass of water (lbm/ton)} = \frac{4.54\ ft^3/ton}{30.53\ ft^3/lbm} = 0.149\ lbm/ton$$

$$\text{Mass \% of remaining injected water} = \frac{0.149\ lbm/ton \times 100\%}{2000\ lbm/ton} = 0.0075\%$$

How much water stays in the mix is limited by the volume of air voids.

AFTER COMPACTION

$$\text{Volume of compacted mix } (ft^3/ton) = \frac{2000\ lbm/ton}{140\ lbm/ft^3} = 14.3\ ft^3/ton$$

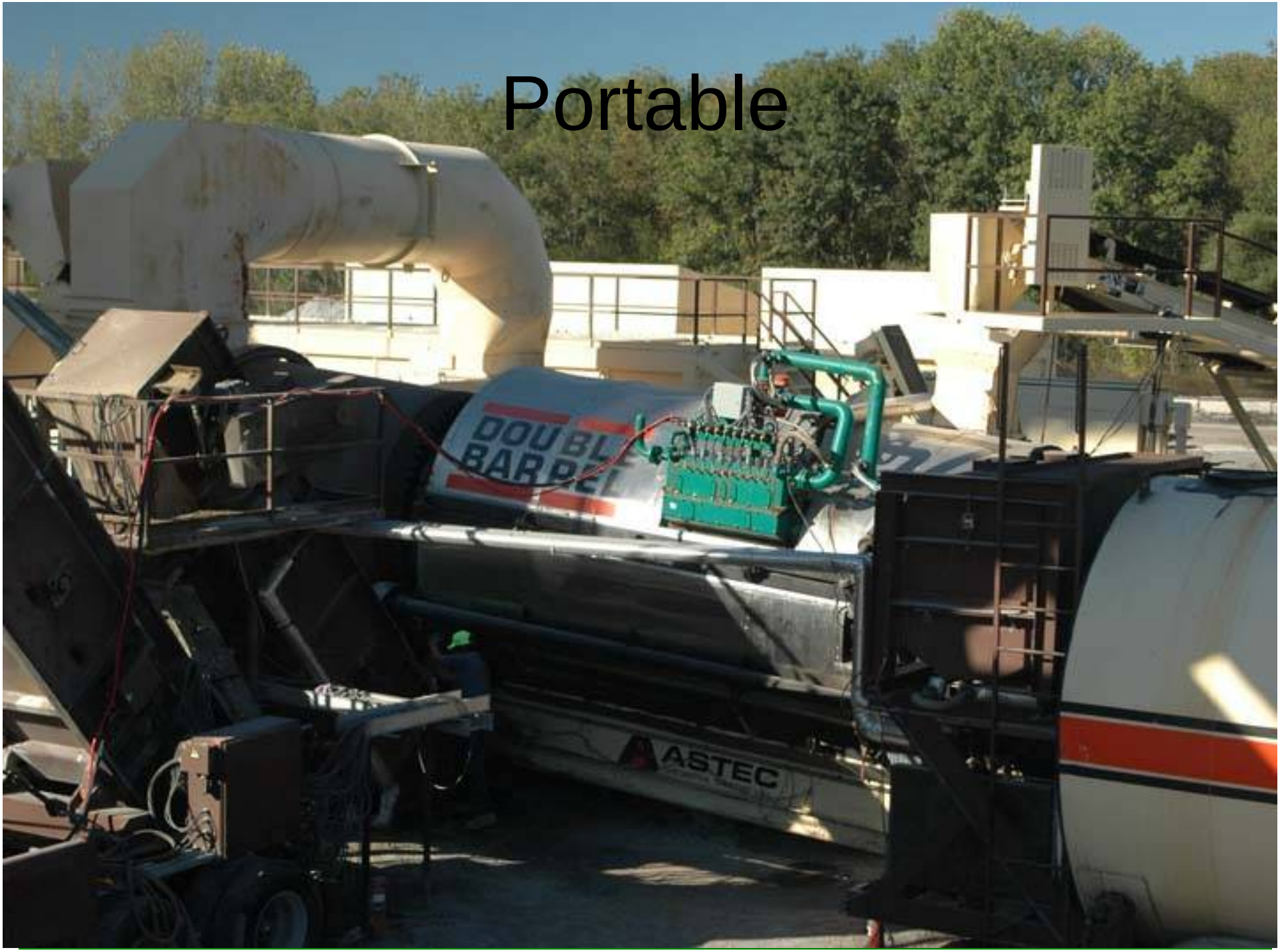
$$\text{Remaining void volume } (ft^3/ton) = 0.05 \times 14.3\ ft^3/ton = 0.715\ ft^3/ton$$

$$\text{Mass of remaining water (lbm/ton)} = \frac{0.715\ ft^3/ton}{30.53\ ft^3/lbm} = 0.0234\ lbm/ton$$

$$\text{Mass \% of remaining injected water} = \frac{0.0234\ lbm/ton \times 100\%}{2000\ lbm/ton} = 0.0012\%$$

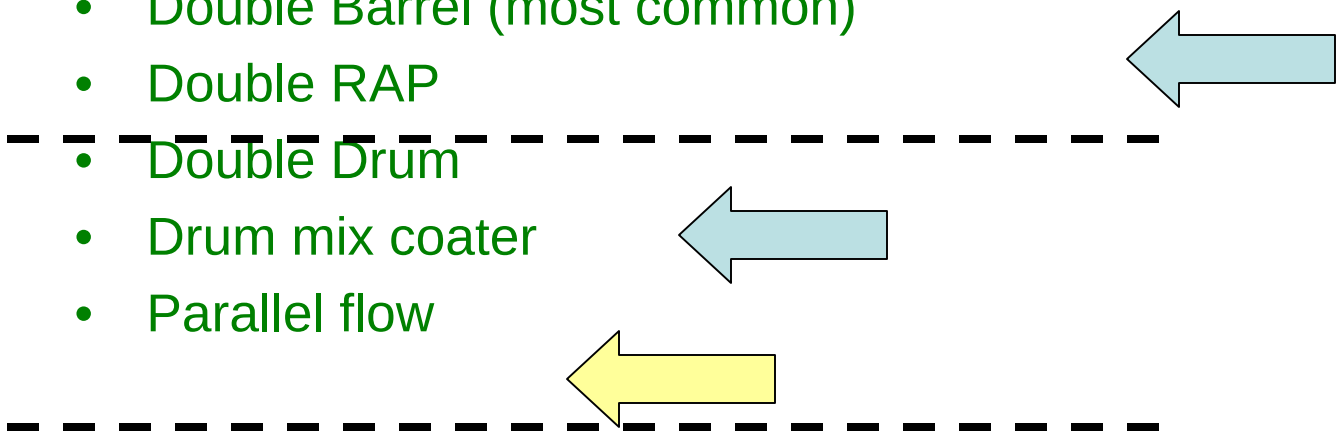
Typical Installation

Portable



Installations

- Double Barrel (most common)
- Double RAP
- Double Drum
- Drum mix coater
- Parallel flow



Mechanical Installation Requirements

- **Piping recon a MUST for a "no surprises" retrofit installation.**
  - **Sometimes may be by customer reps**
  - **Sometimes requires a visit by Astec**
- **Plant must be down 2 days for mechanical installation – typically Saturday-Sunday.**
- **Typical installation takes 2 fitter/welders about 2 x 10 hour days (+ or –)**
  - **Starts Friday afternoon after shutdown.**
  - **Plant ready to run HMA Monday morning.**
- "New" installation takes much less time as most of the piping is new
  - No time-consuming pipe and AC box modifications.

Electrical Installation Requirements

- **Time required depends upon plant configuration and cabling requirements.**
- **Generally, electrical installation takes between 16 and 20 man-hours including check-out.**
- **Most electrical and mechanical installation can occur concurrently.**
  - After mechanical installation is complete, electrical installation may be finished.
  - Allow a day for system checkout (most system functions may be checked out while running HMA).

System Costs

¼ ¢/ton additive cost:

5 ¢ per truck load

$1 for every 400 tons

Based on 0.0785 $/ft³ water including sewage fee

What we have done to date

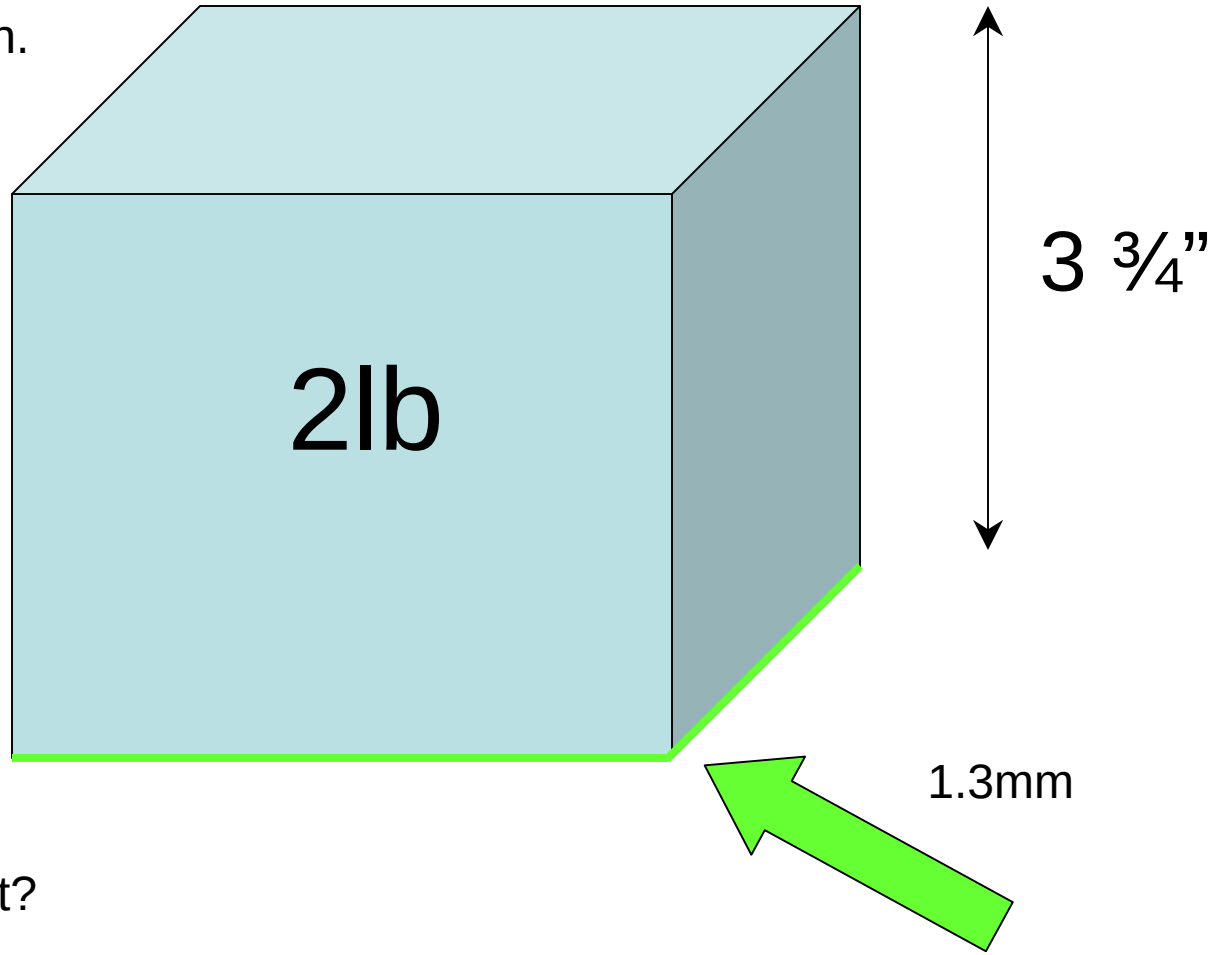
- **Sold over 180 units to create hot foam mechanically**
- **Stored in silo for 4 days**
- **Produced 76-22 (Polymers) and placed at 270^{o}F**
- **Produced rubber mix at 270^{o}F**

What we have done to date

- **Numerous Demonstration Projects**
  - **North Carolina**
  - **South Carolina**
  - **Tennessee x 4**
  - **Alabama**
  - **Texas**
  - **Arkansas**
  - **California**
  - **Kentucky**
  - **British Columbia**
  - **Ohio x 2**
  - **Illinois**
  - **Maryland**
  - **Louisiana**
  - **Florida x 2**
  - **Massachusetts**

Mix Design Modifications

- No fines addition.
- No AC reformulation.



- Anti-stripping agent?

Production / Construction Techniques and Issues

If some of the water remains in the mix, won't I show a high AC content?

NO

- A small amount of water remains in the mix after compaction
- Theoretically, this could show up as AC content.
- Maximum of 0.0012% of the water remains.
- Beyond the measurement accuracy of AC content (typically reported to the nearest 0.1%).

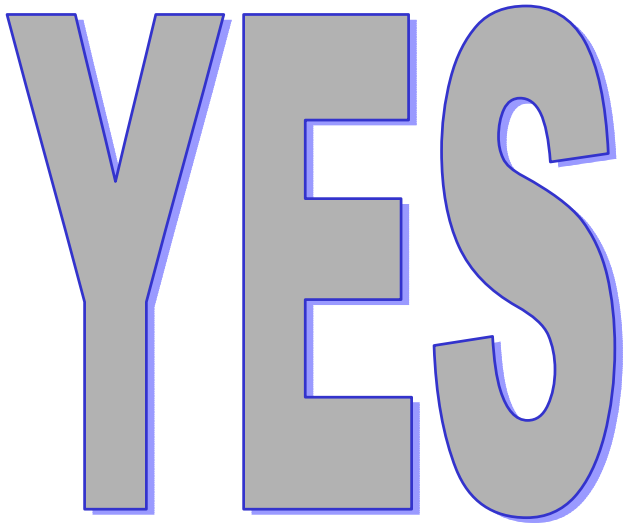
Won’t the baghouse temperature be too low when I lower mix temperature?

- Depends on a number of factors.
- Decreases BH temps about 35°F to 40°F (CF dryer) all other factors constant.
- **Things go better with RAP**

Can coating be affected?

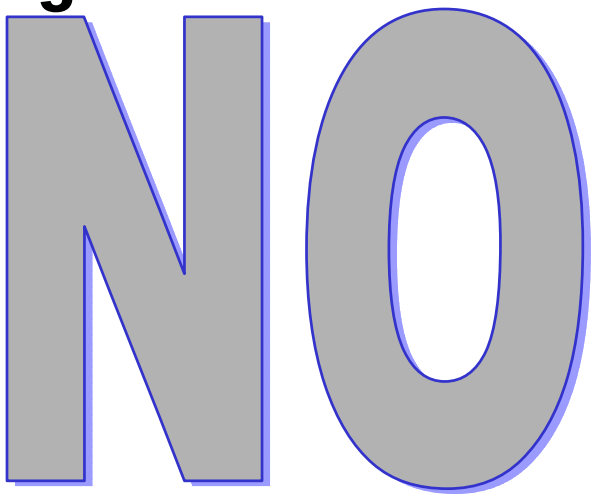
- Depends on a number of factors
- Coating is affected by many factors: aggregate, mix temperature, AC type, and/or fines content
- Generally, coating decreases with mix temperature
- **Coating begins to deteriorate below 250°F**
- Good coating has been observed below 200°F
- Green System has significantly improved coating if coating initially appeared less complete

Do I have to do anything special to my binder?



- Keep standard binder at 300°F or higher
- AC Foaming nozzles have 3/8” openings
- AC temperatures above 300°F ensure low enough viscosity for a reasonable (<40psig) backpressure.

Won't I experience a drop in mix temperature since I am adding water?



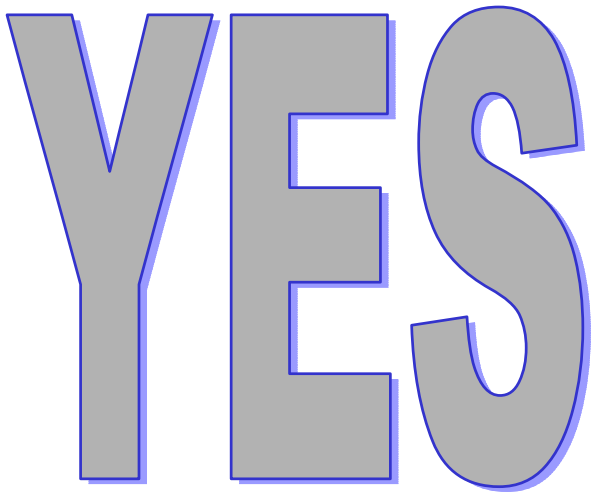
- Significant temperatures drops during ordinary hauls in moderate weather is caused by internal moisture
- Internal moisture signs: steam and water at the silo tops, water running out of the truck beds, and a drop in mix temperature (27°F per ½%).
- Water remaining in the mix post compaction is 0.0012% (0.07°F drop)

What mix temperatures should I run?

240F - 250F (virgin)

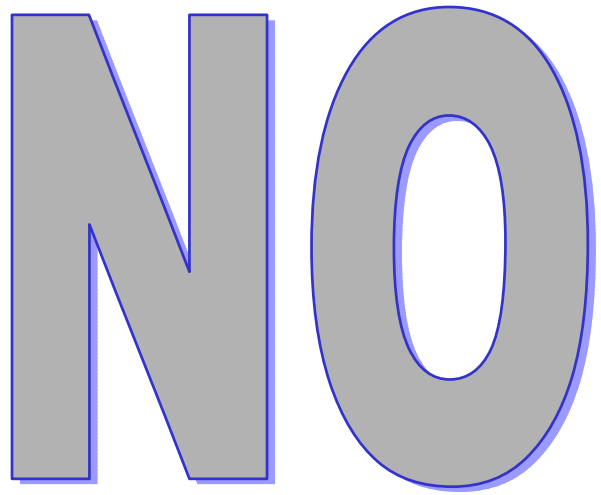
270F - 280F (RAP)

Can I run WMA produced using the Astec Green System at higher temperatures?



- There is no danger in running the mix at higher temperatures
- Mix simply remains workable for a longer period

Will running WMA with RAP affect the heating and mixing of the RAP?



- RAP still obtains its heat from superheated virgin aggregate.
- There is just less superheat required.

Running RAP is like…

Cold Water

+

Hot Water

=

Warm Water

RAP

(Ambient Temperature)

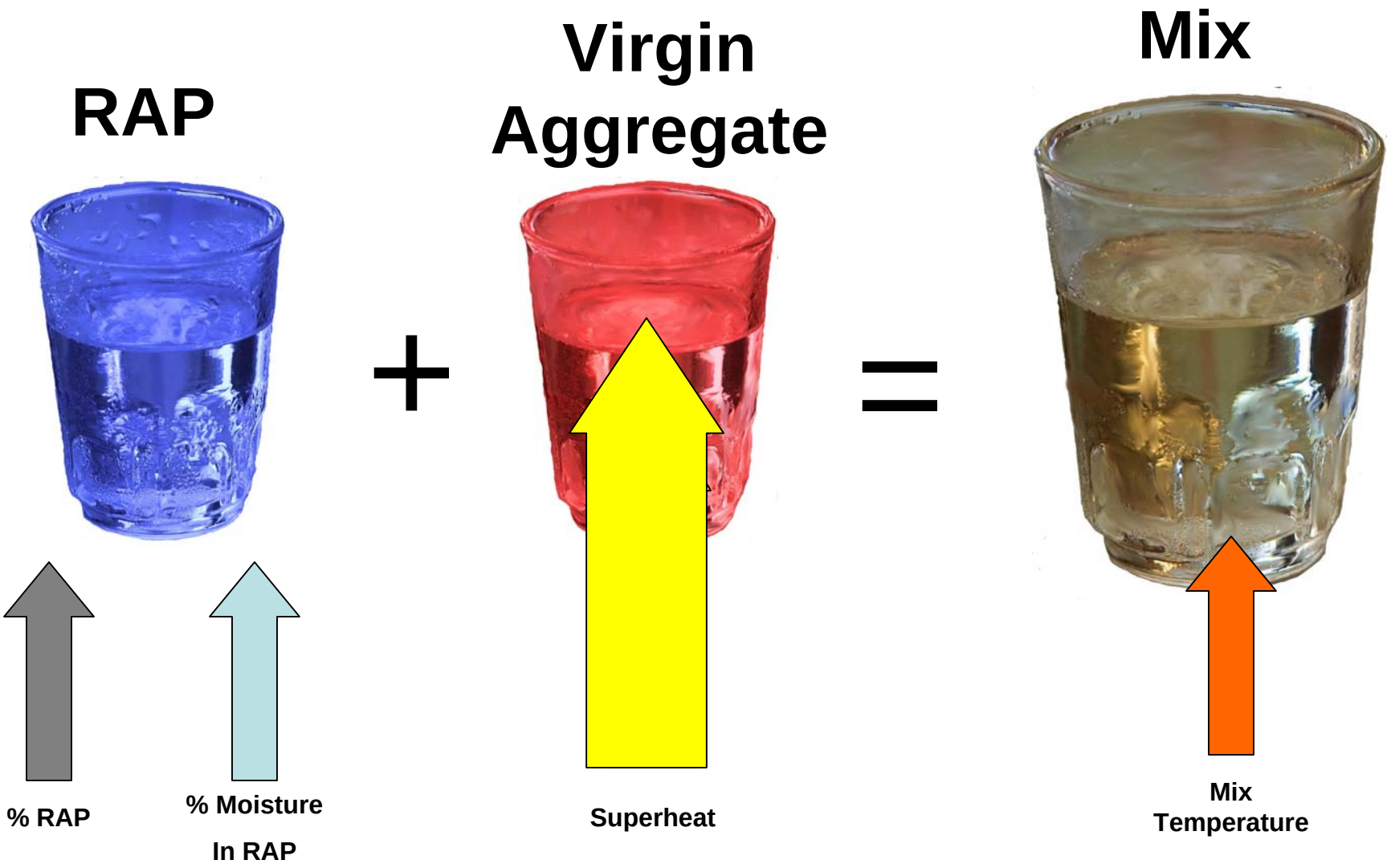
Virgin Aggregate

(Superheated Temperature)

Mix

(Mix Temperature)

What affects the level of superheat?

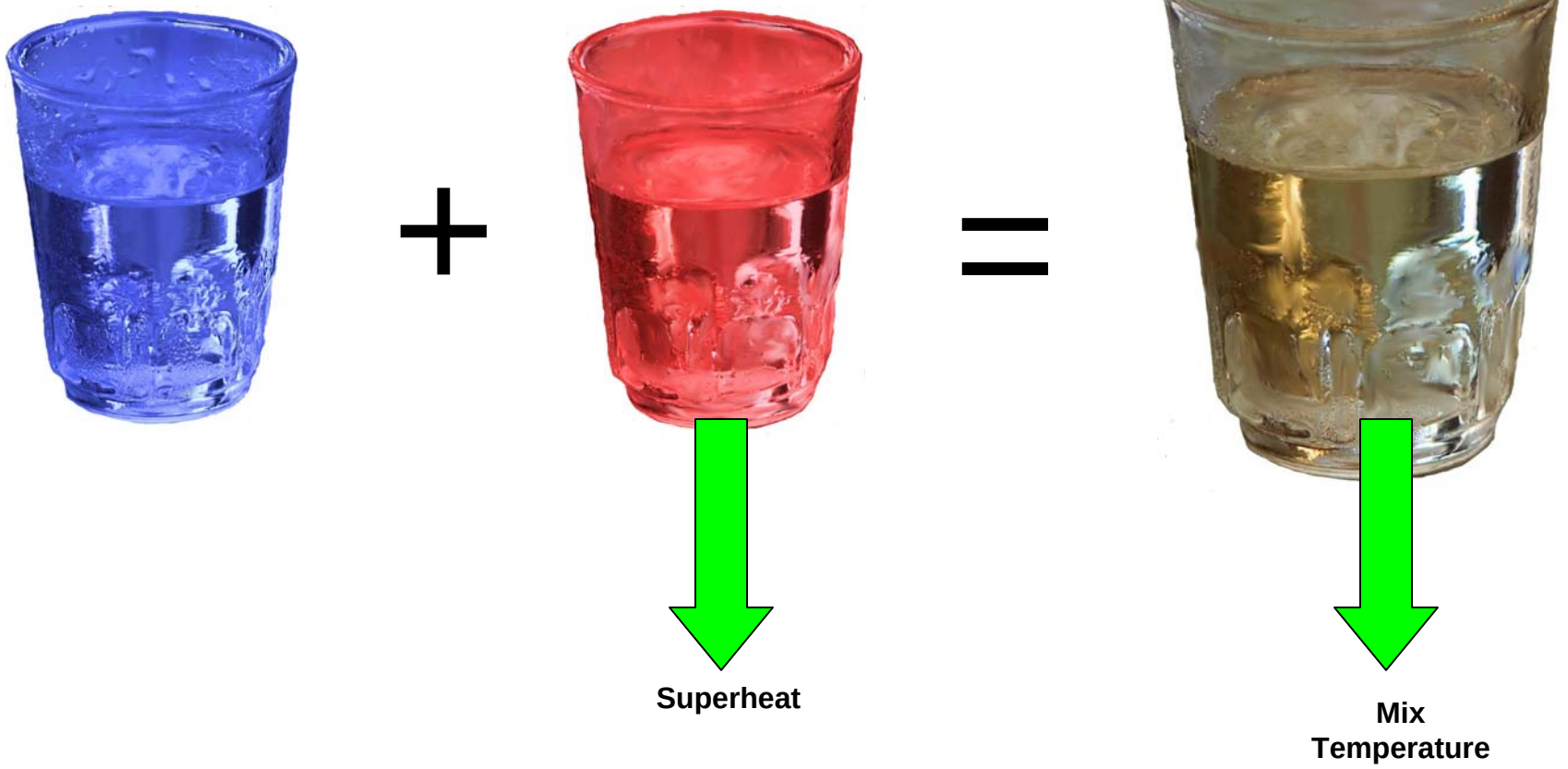


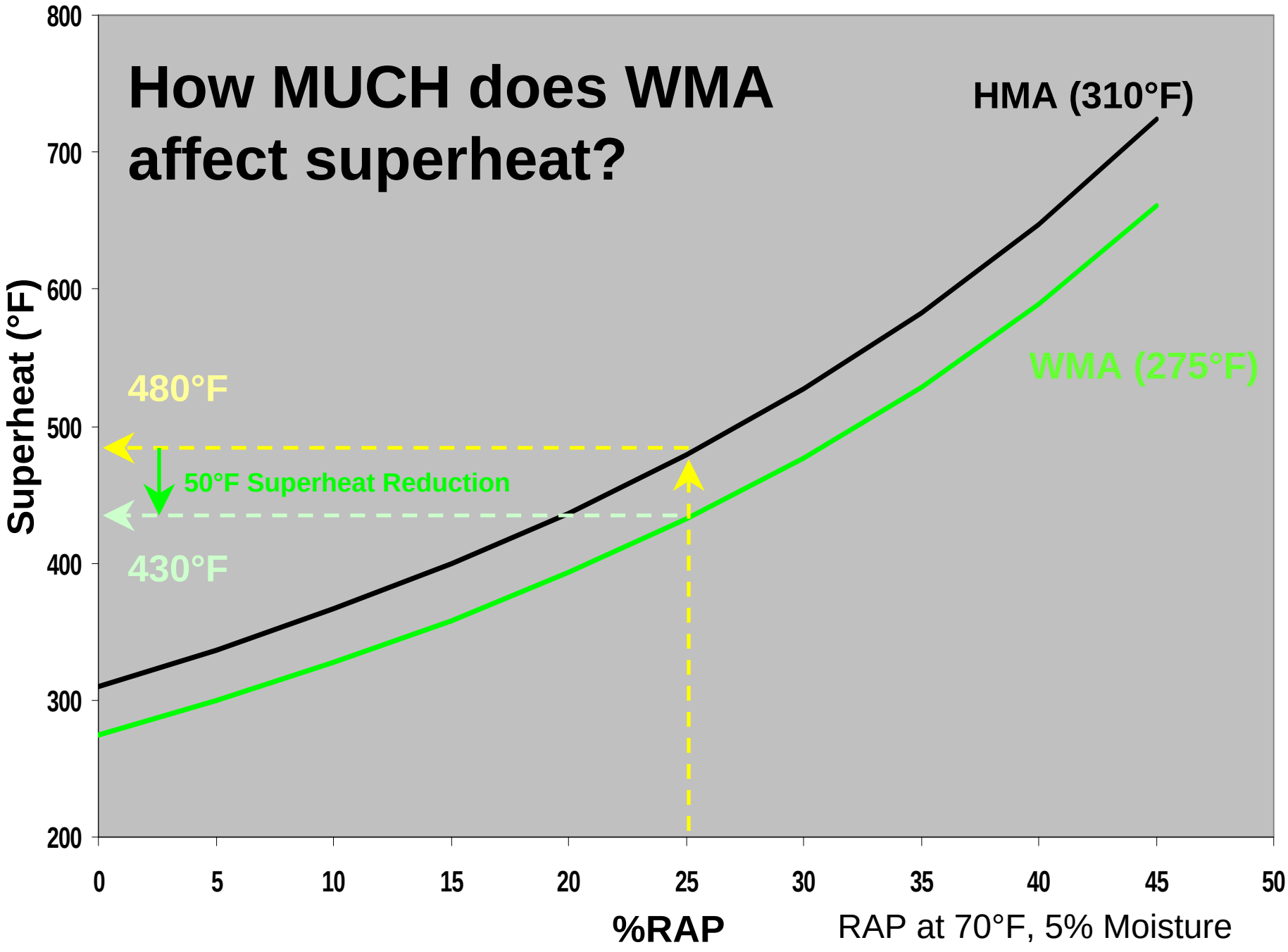
How does WMA affect superheat?

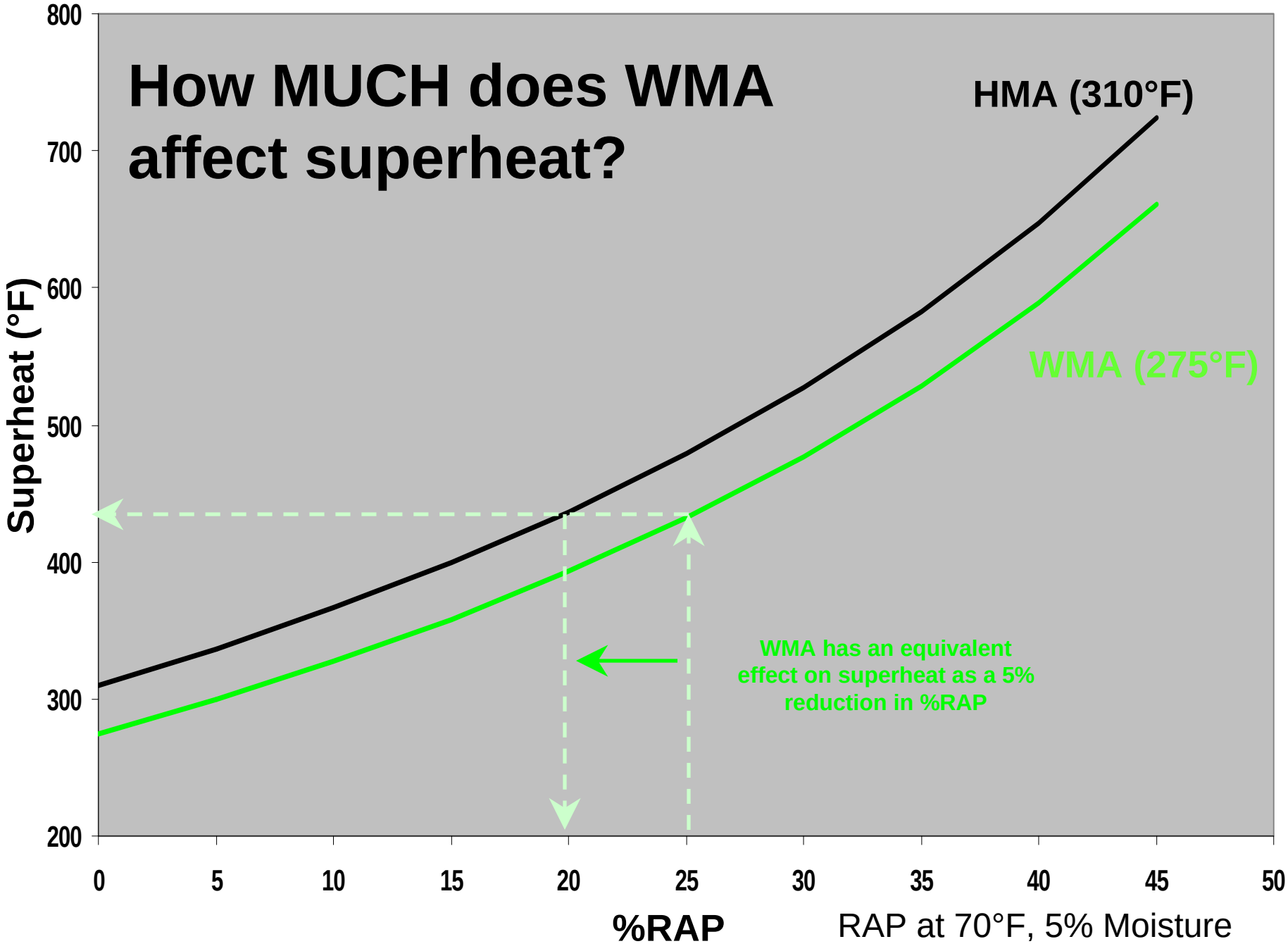
RAP

Virgin Aggregate

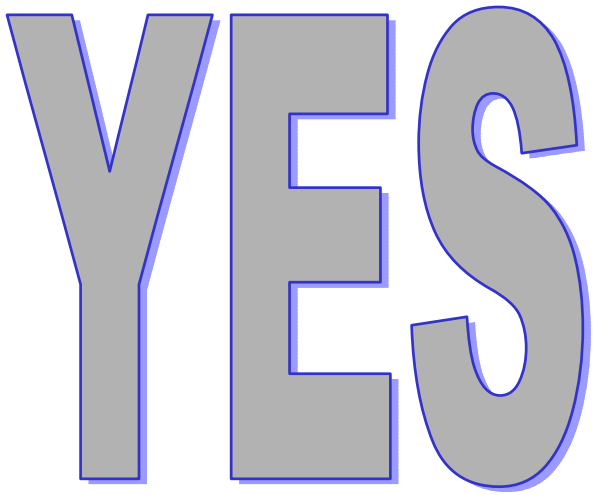
Mix




How MUCH does WMA affect superheat?
HMA (310°F)
WMA (275°F)
480°F
50°F Superheat Reduction
430°F
Superheat (°F)
800
700
600
500
400
300
200
0
5
10
15
20
25
30
35
40
45
50
%RAP
RAP at 70°F, 5% Moisture

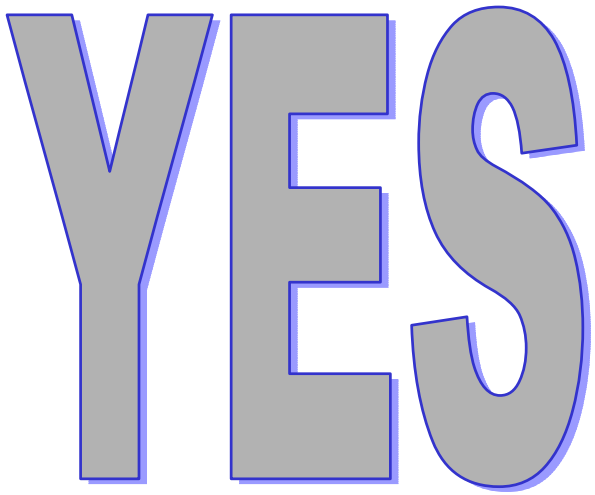

How MUCH does WMA affect superheat?
HMA (310°F)
WMA (275°F)
WMA has an equivalent effect on superheat as a 5% reduction in %RAP
Superheat (°F)
800
700
600
500
400
300
200
0
5
10
15
20
25
30
35
40
45
50
%RAP
RAP at 70°F, 5% Moisture

Can WMA produced using the Astec Green System be stored?



- As long as the corresponding HMA may be stored
- First test was 24 hours then 48 hours
- Have stored as long as 4 days

Will rolling patterns change?



- Generally, crews have been able to begin rolling immediately.
- At some locations, less rolling was required
- Experiment. Each situation is unique.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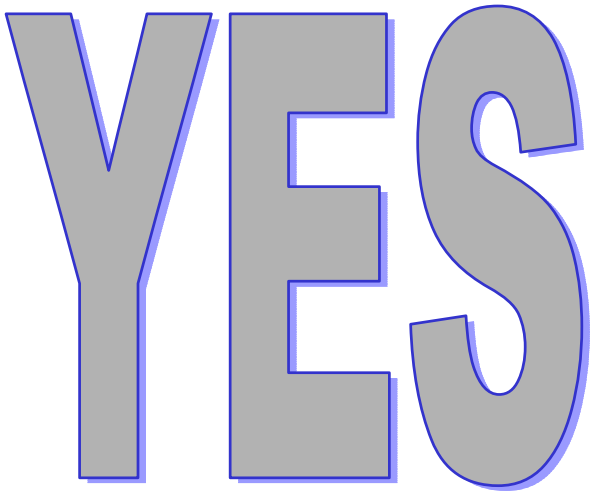
Is handwork different than that of HMA?

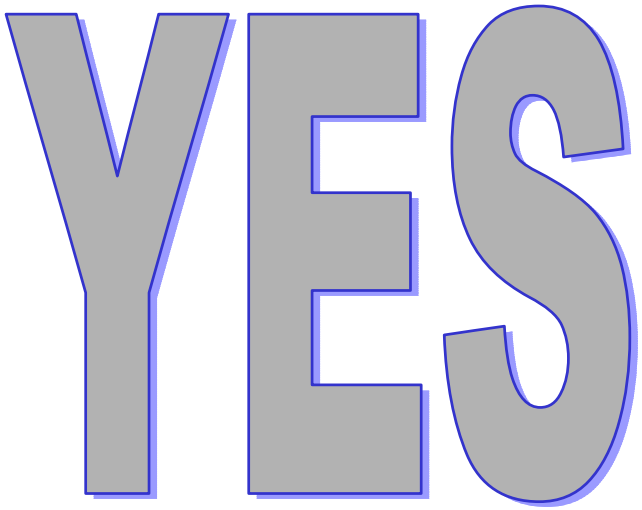


- Can be different depending upon the situation
- Cold day tight quarter handwork became difficult on one job
- Straight pulls were no issue.

Does WMA produced with the Astec Green System look different?

- Can look the same as ordinary HMA minus smoke as smell
- Can look rich (especially virgin mixes) due to film thickness

Won’t my water freeze when it gets cold?



- “Cold weather package” available through Astec Parts.
- Not meant for “winterizing”.
- What about anti-freeze?

It's Green!

- **Use 14% less fuel due to 50°F lower temperature and lower exhaust temp.**
- **14% less $C0_2$ emissions**
- **Reduced volatiles**
- **Better, longer-lasting pavement**

No Smoke – No Smell…Why?

- **Light oils are either put in asphalt or left in asphalt during refining**
- **These light oils boil at above 285ºF**
- **By mixing at below 285ºF, the boiling point is never reached…eliminating smoke (vapor) and corresponding smell**


CONVENTIONAL
HOT MIX
WARM MIX

Reduced Emissions

Volatile Organic Compounds (VOC)*

Mix Temperature (˚F)	Load-out Emissions (lb/yr)	Silo-filling Emissions (lb/yr)	% Reduction
325	2346	7312	
275	**669**	**2084**	**71.5**
260	**459**	**1430**	**80.4**

❖ Based upon a plant producing mix at 400TPH with a total yearly production of 600,000 tons

Demonstration

- **On June 21, 2007, the City of Chattanooga agreed to mill high traffic road and use 50% RAP @ 270ºF with 64-22**
- **The RAP was fractionated**
- **The 64-22 AC was foamed**
- **Southeastern Materials produced and laid the mix**

Lojac Inc.

Nashville, Tennessee

Warm Mix Demo

September 26, 2007

- **30% RAP @ 260°F / PG 64-22**
- **700 tons binder**
- **700 tons surface mix**
- **100 tons surface / PG 76-22 @ 270°F**


2007 9 26


STOP
STOP
ROADTEC
2007 9 26

Lojac Inc.

Nashville, Tennessee

Warm Mix Demo

October 3, 2007

- **Tennessee D.O.T. Warm Mix Test**

Tennessee DOT Warm Mix Test

Technology Demonstration Test Results:

Nashville Area, September 2007, Limestone

- Advera WMA
- 1150 Tons Placed
- % AC 5.16 & 5.28
- % Air Voids 4.7
- Stability 1475
- TSR 51.9%
- Density 92.7%

- Sasobit
- 705 Tons Placed
- % AC 5.14
- % Air Voids 3.5
- Stability 1825
- TSR 65.5%
- Density 91.0%

- Evotherm
- 750 Tons Placed
- % AC 5.22 & 5.36
- % Air Voids 5.1
- Stability 1455
- TSR 72.7%
- Density 91.0%

- Astec Green System
- 775 Tons Placed
- % AC 5.19 & 5.29
- % Air Voids 4.0
- Stability 2200
- TSR 84.3%
- Density 91.6%

QA Testing

Technology Demonstration Test Results:

Nashville Area, September 2007, Limestone

Advera WMA	Sasobit	Evotherm	Astec Green System
1150 Tons Placed	705 Tons Placed	750 Tons Placed	775 Tons Placed
% AC 5.16 & 5.28	% AC 5.14	% AC 5.22 & 5.36	% AC 5.19 & 5.29
% Air Voids 4.7	% Air Voids 3.5	% Air Voids 5.1	% Air Voids 4.0
Stability 1475	Stability 1825	Stability 1455	Stability 2200
TSR 51.9%	TSR 65.5%	TSR 72.7%	TSR 84.3%
Density 92.7%	Density 91.0%	Density 91.0%	Density 91.6%

State may require TSR test prior to paving

Standard QA testing

Compaction at 10°F less than plant exit temp.

Reheated WMA retains WMA properties

Voluntary testing/documentation a good idea


This Street
Paved With
Environmentally
Friendly
Warm Mix Asphalt
York County
South Carolina
ASTEC
Boggs
PAVING, INC.
GREEN


A SIX PACK
Boggs
Boggs
NO
TRUCK DRIVERS
IN
CONTROL TOWER
Boggs
ALL TRUCKS
MUST BE ON
CB CHANNEL
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Questions ?