Evolution of Asphalt Plants, Recycle, and Warm Mix Asphalt

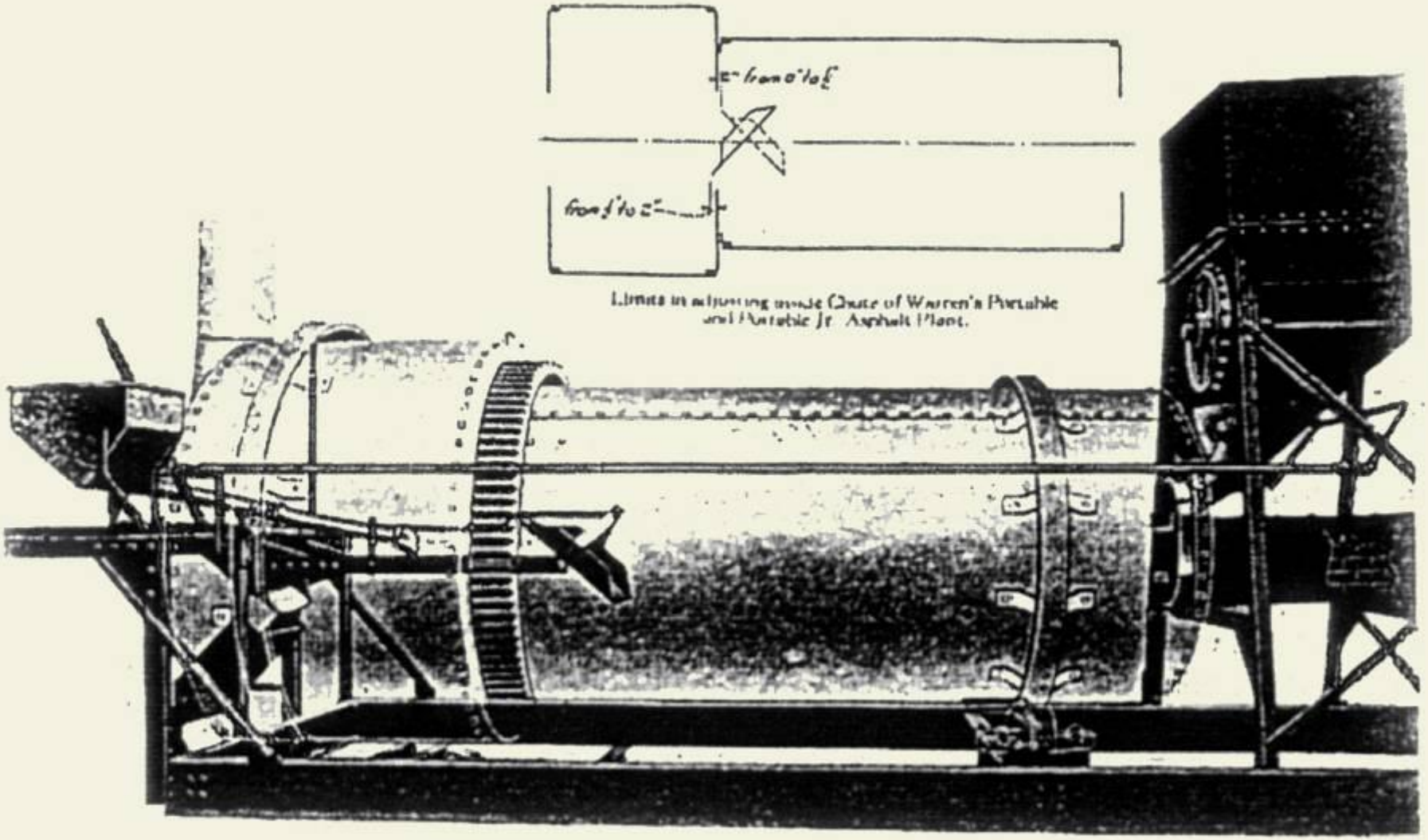
1598

Sir Walter Raleigh discovers Trinidad Asphalt Lake

1893

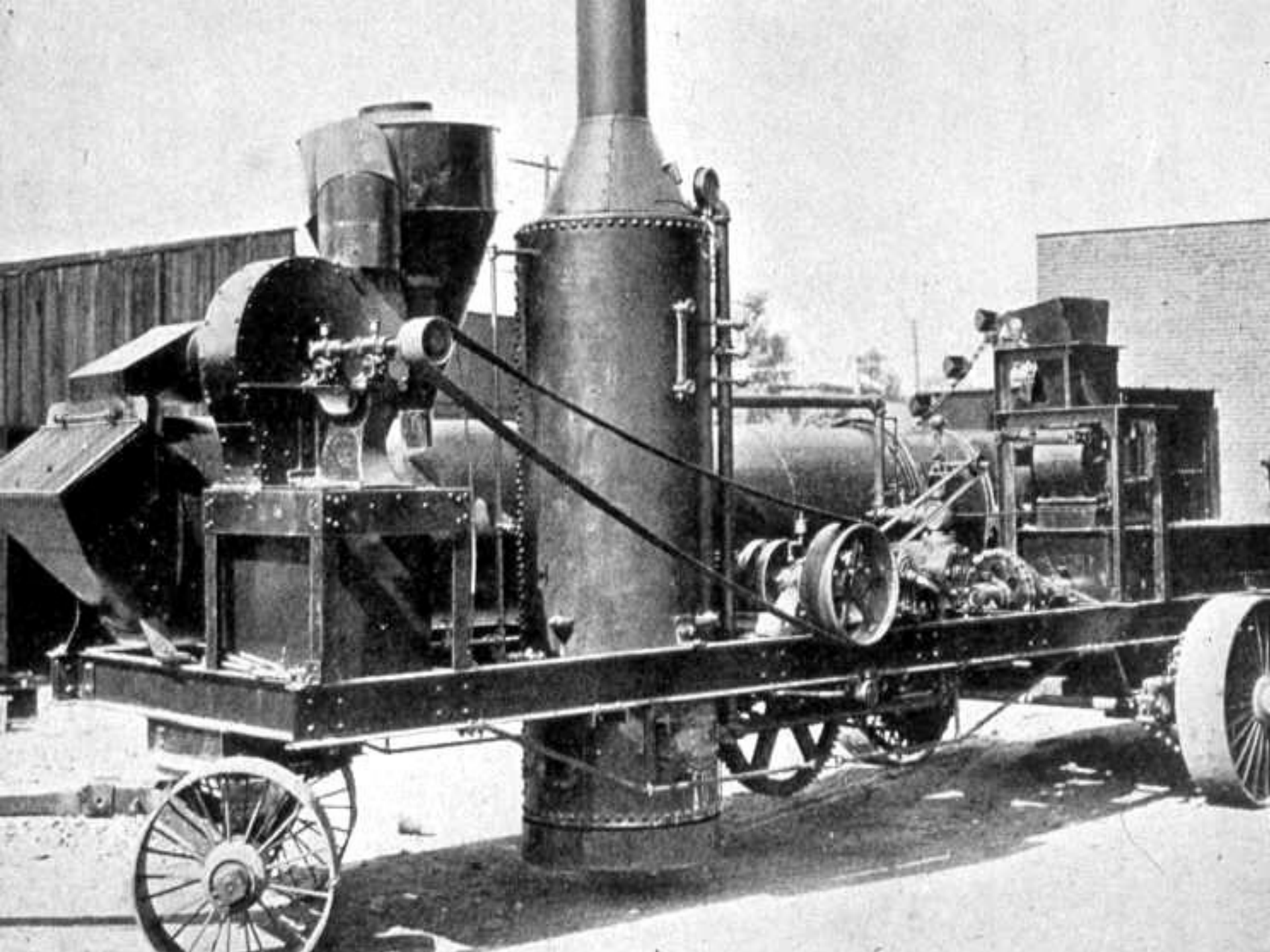
Barber Asphalt & Paving Co.

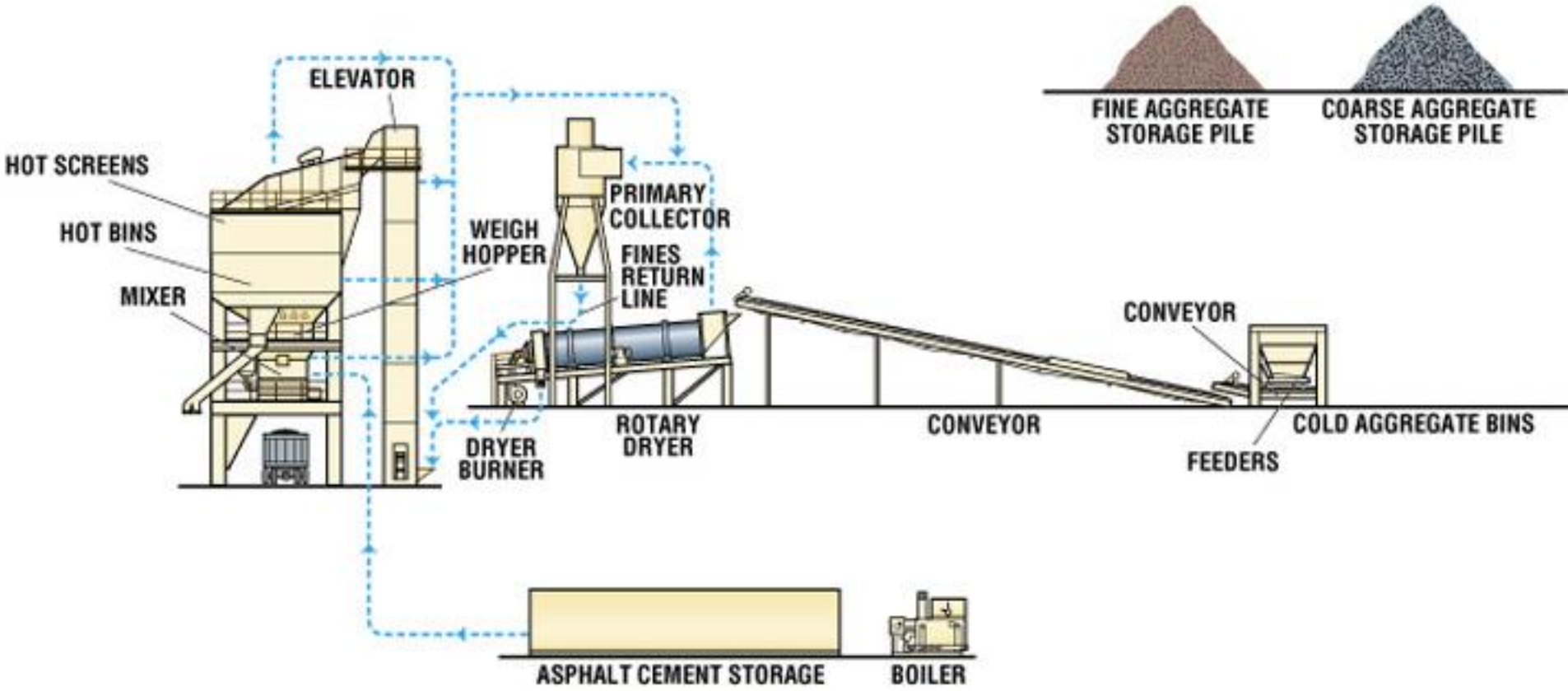
WARREN'S PORTABLE ASPHALT PLANT



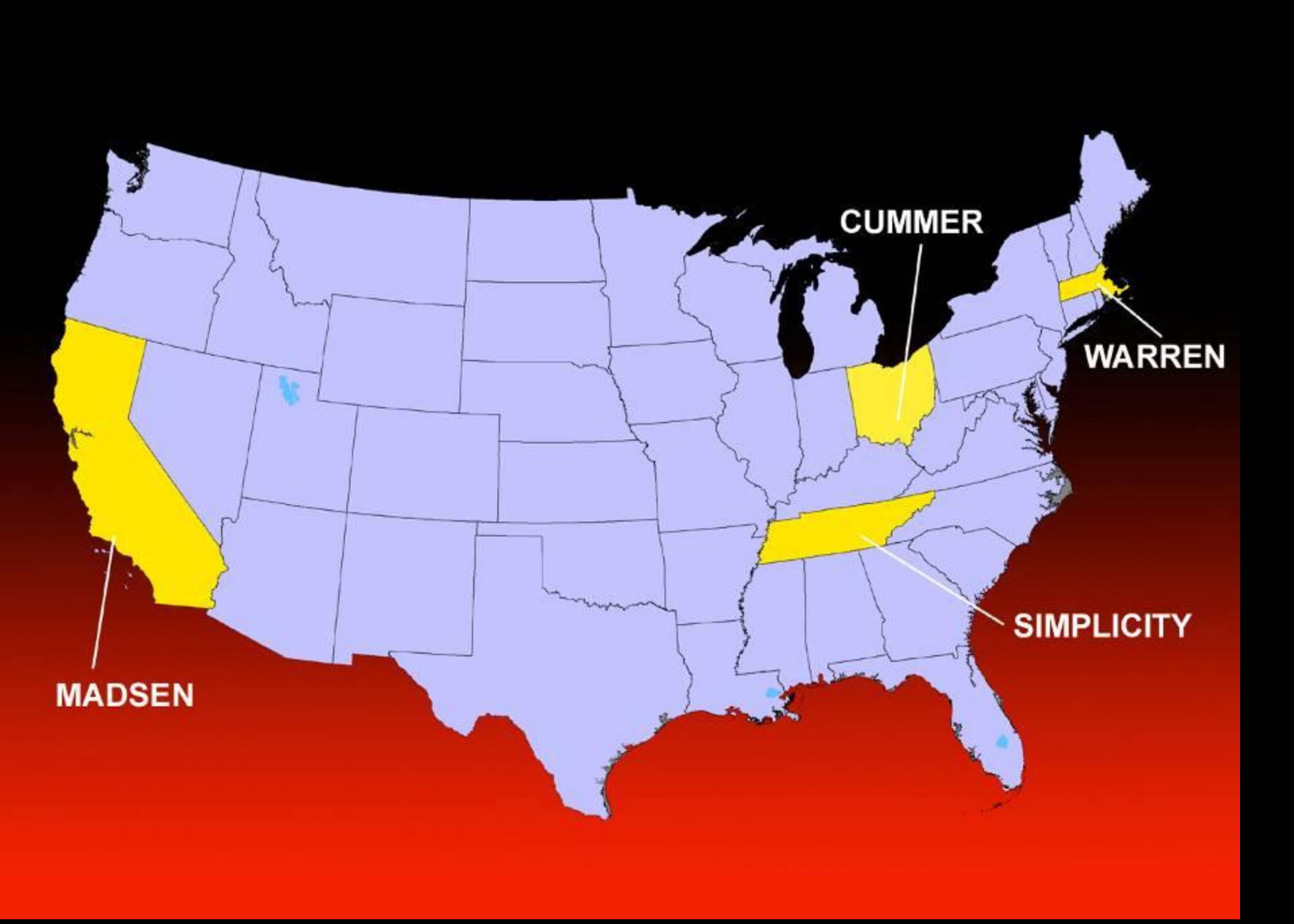
Lines in adjusting inside Chute of Warren's Portable and Portable Jr. Asphalt Plant.

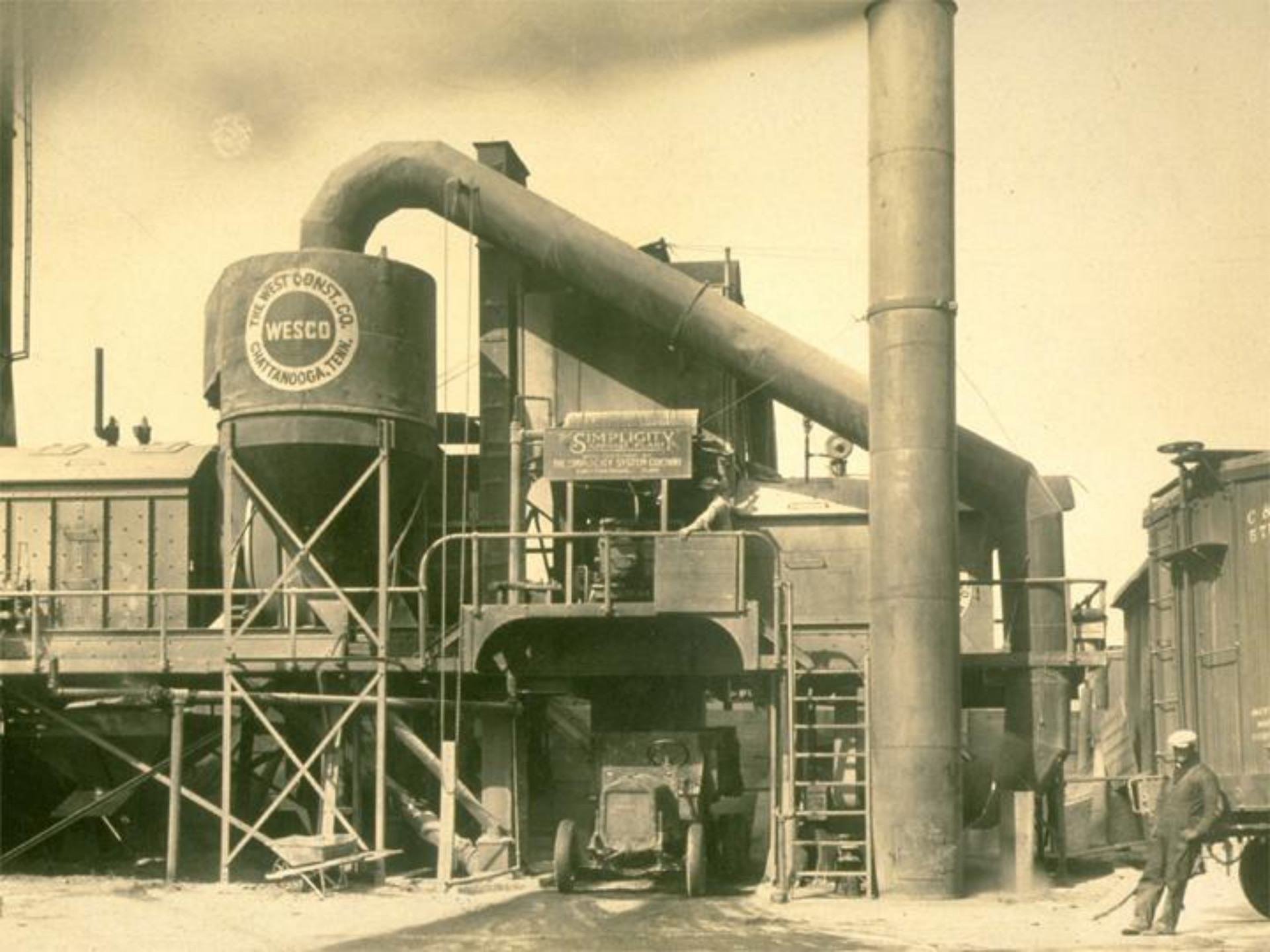

PHOTO OF BOTHELL ROAD
TAKEN MAY 8, 1912
W B & S SEATTLE, WASH.

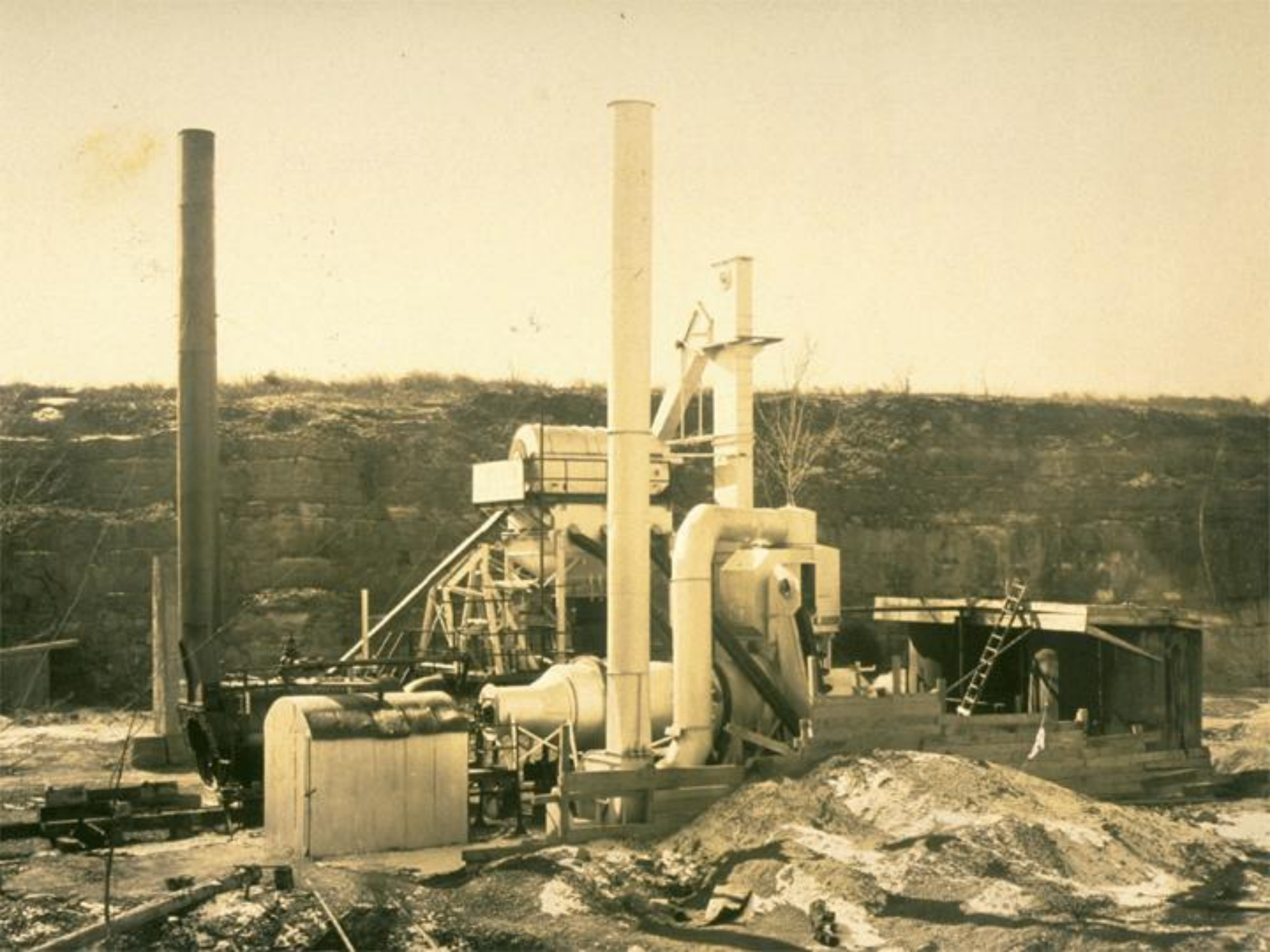


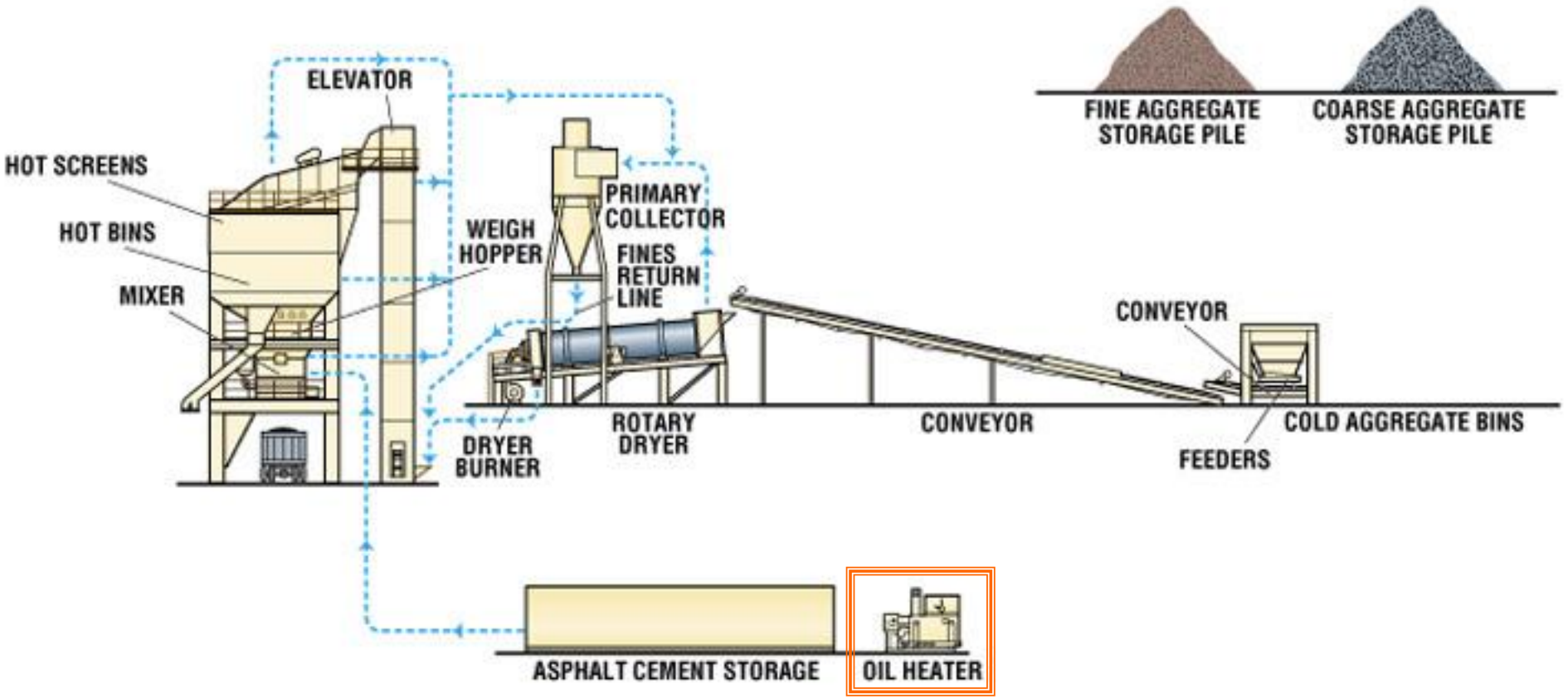


PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS

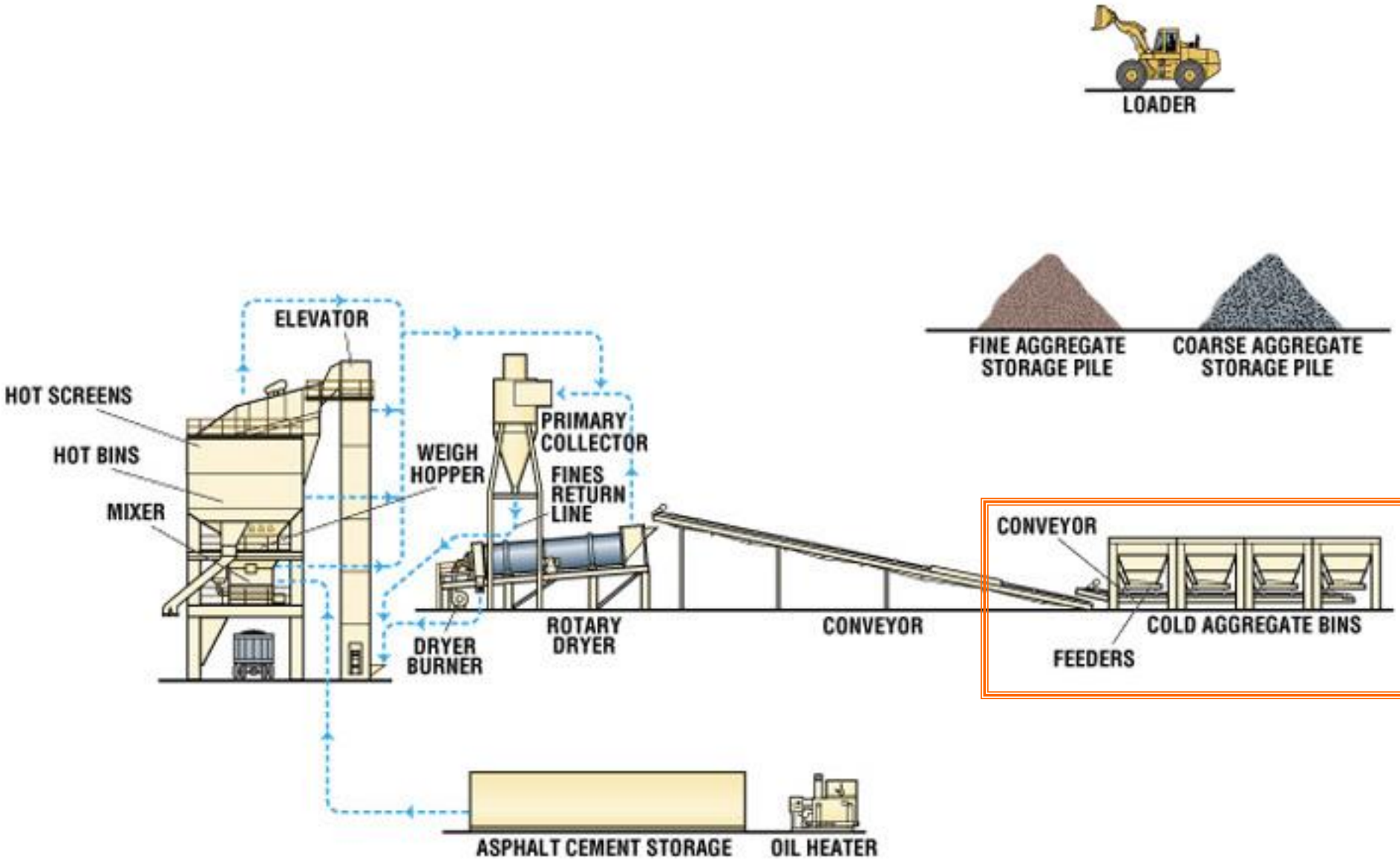

CUMMER
WARREN
SIMPLICITY
MADSEN


THE WEST CONST. CO.
WESCO
CHATTANOOGA, TENN.
SIMPLICITY





PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS



PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS

Grading Requirements for Coarse Aggregates

Size Number	Normal Size (Sieves with Square Openings)	Amounts Finer Than Each Laboratory Sieve (Square-Openings), Weight Percent												
		4 inch (100mm)	¾ inch (90mm)	3 inch (75mm)	2 ½ inch (63mm)	2 inch (50mm)	1 ½ inch (37.5mm)	1 inch (25mm)	¾ inch (19mm)	½ inch (12.5mm)	⅜ inch (9.5mm)	No. 4 (4.75mm)	No. 8 (2.36mm)	No. 16 (1.8mm)
1	3½ in. to 1½ in. (90 to 37.5mm)	100	90-100		25-60		0-15		0-5					
2	2½ in. to 1½ in. (63 to 37.5mm)			100	90-100	35-70	0-15		0-5					
3	2 in. to 1 in. (50 to 25mm)				100	90-100	35-70	0-15		0-5				
357	2 in. to No 4 (50 to 4.75mm)				100	95-100		35-70		10-30		0-5		
4	1½ in. to ¾ in. (37.5 to 19mm)					100	90-100	20-55	0-15		0-5			
467	1½ in. to No. 4 (37.5 to 4.75mm)					100	95-100		35-70		Oct-34	0-5		
5	1 in. to ½ in. (25 to 12.5mm)						100	90-100	20-55	0-10	0-5			
56	1 in. to ⅜ in. (25 to 9.5mm)						100	90-100	40-85	10-40	0-15	0-5		
57	1 in. to No. 4 (25 to 12.5mm)						100	95-100		25-60		0-10	0-5	
6	¾ in. to ⅜ in. (25 to 4.75mm)							100	90-100	20-55	0-15	0-5		
67	3¼ in. to No. 4 (19 to 4.75mm)							100	90-100		20-55	0-10	0-5	
7	½ in. to No. 4 (12.5 to 4.75mm)								100	90-100	40-70	0-15	0-5	
8	⅜ in. to No. 8 (9.5 to 2.36mm)									100	85-100	10-30	0-10	0-5

Yellow indicates range of passing on 57's

ASTM Gradation Surface Standards

Mesh Number and Size	Surface Area Sq. Ft/Lb
200	150.2
100	73.9
50	37.2
30	18.8
16	9.3
8	4.65
4	2.33
3/8″	1.16
1/2″	0.87
3/4″	0.58
1″	0.43
1-1/2″	0.29
3″	0.145

Extreme Ranges of Gradation For 57 Stone

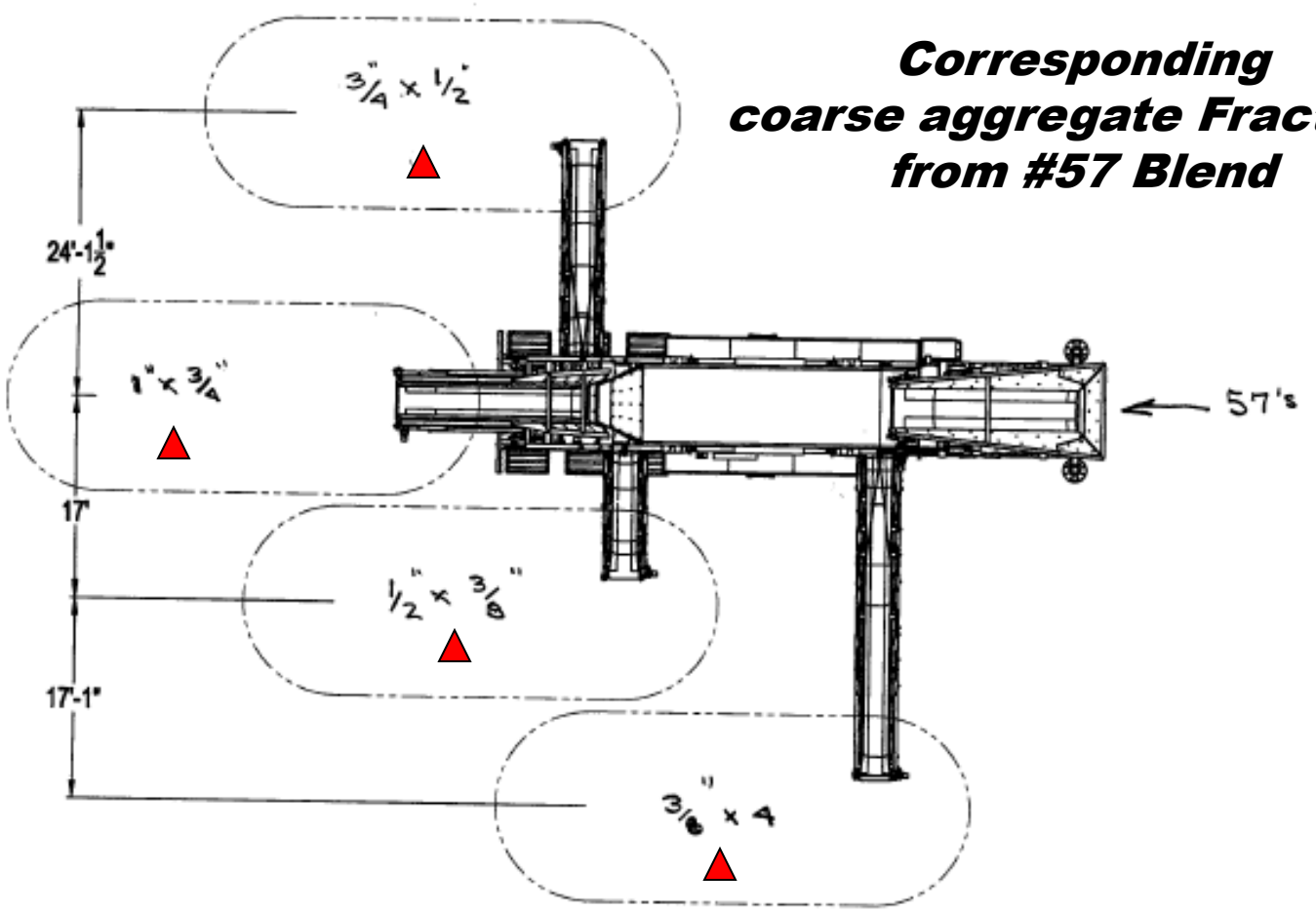
57 Stone	Coarse	Area	Fine	Area
1	5	2.15	0	0
3/4				
1/2	70	60.9	40	34.8
3/8				
4	25	58.2	50	116.5
8	8		5	23.2
16	16		5	46.5

121.3 ⟷ **221.0**

Surface area at coarse extremes — Surface area at fine extremes

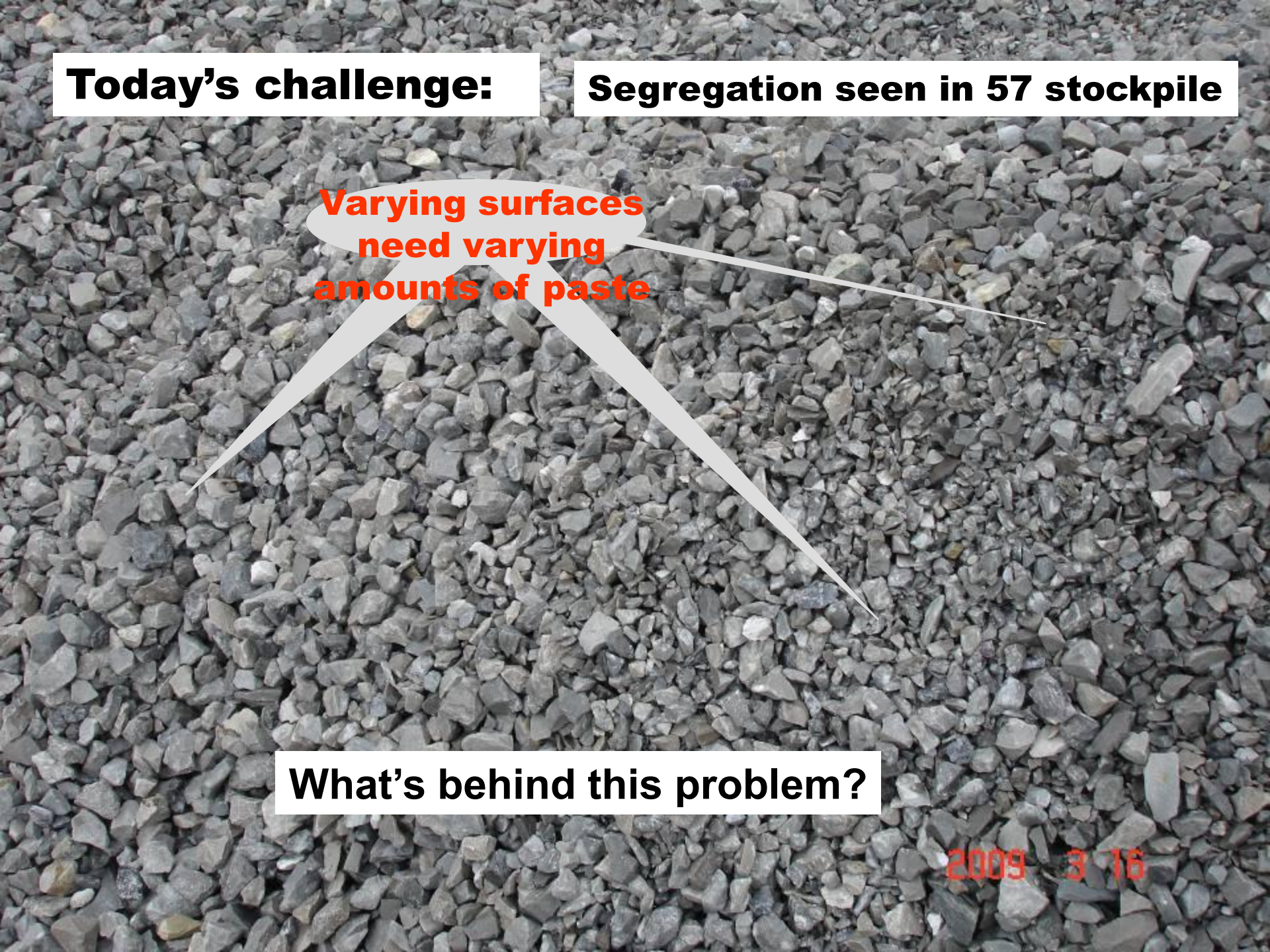
A RANGE OF 80% +

These windrows are the same sizes identified from the Max Density Chart *AND* the Haystack Profile



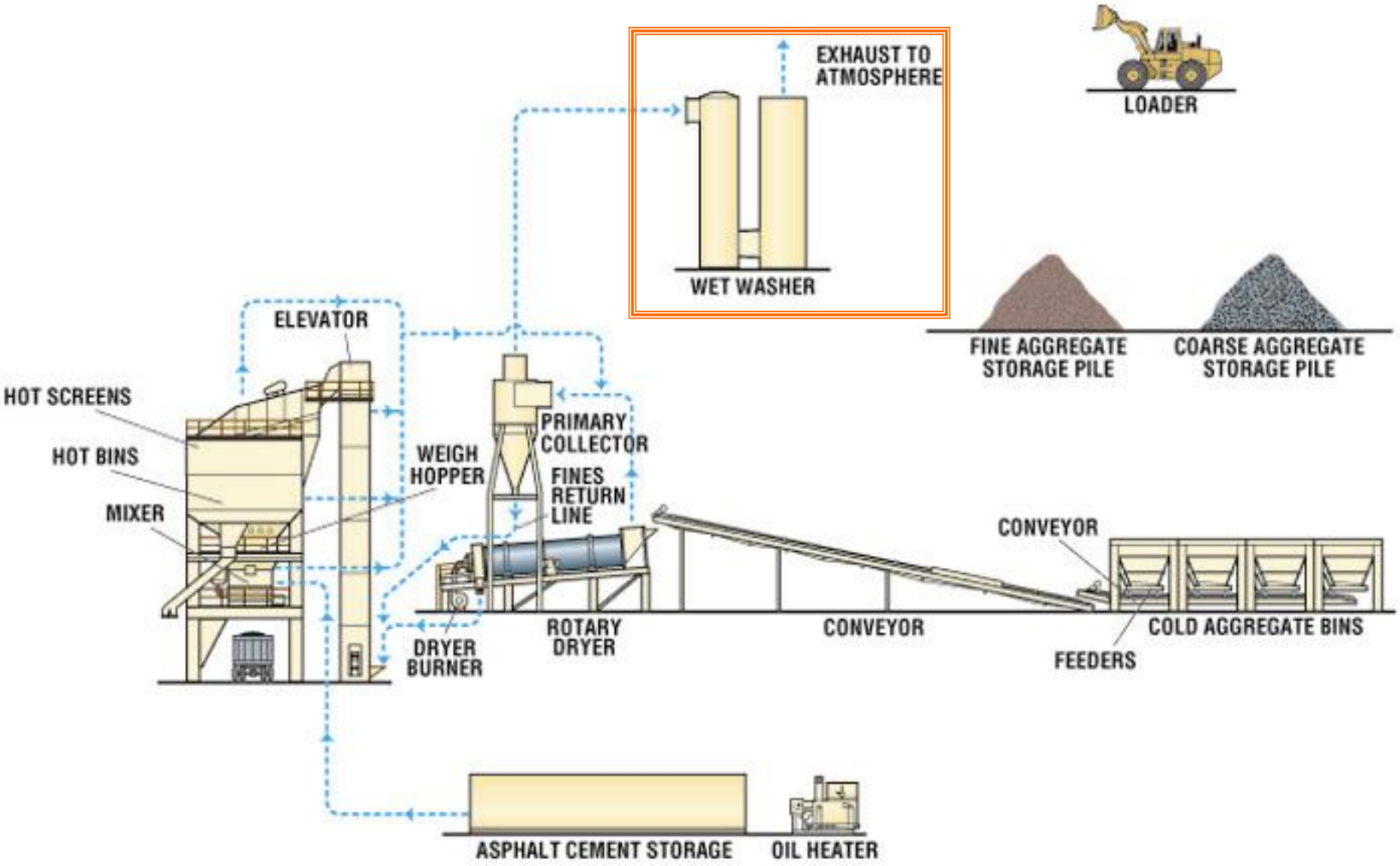
Corresponding coarse aggregate Fractions from #57 Blend

Screening with Kolberg-Pioneer FT6203,
3 screens in place, make 4 windrows from 57's

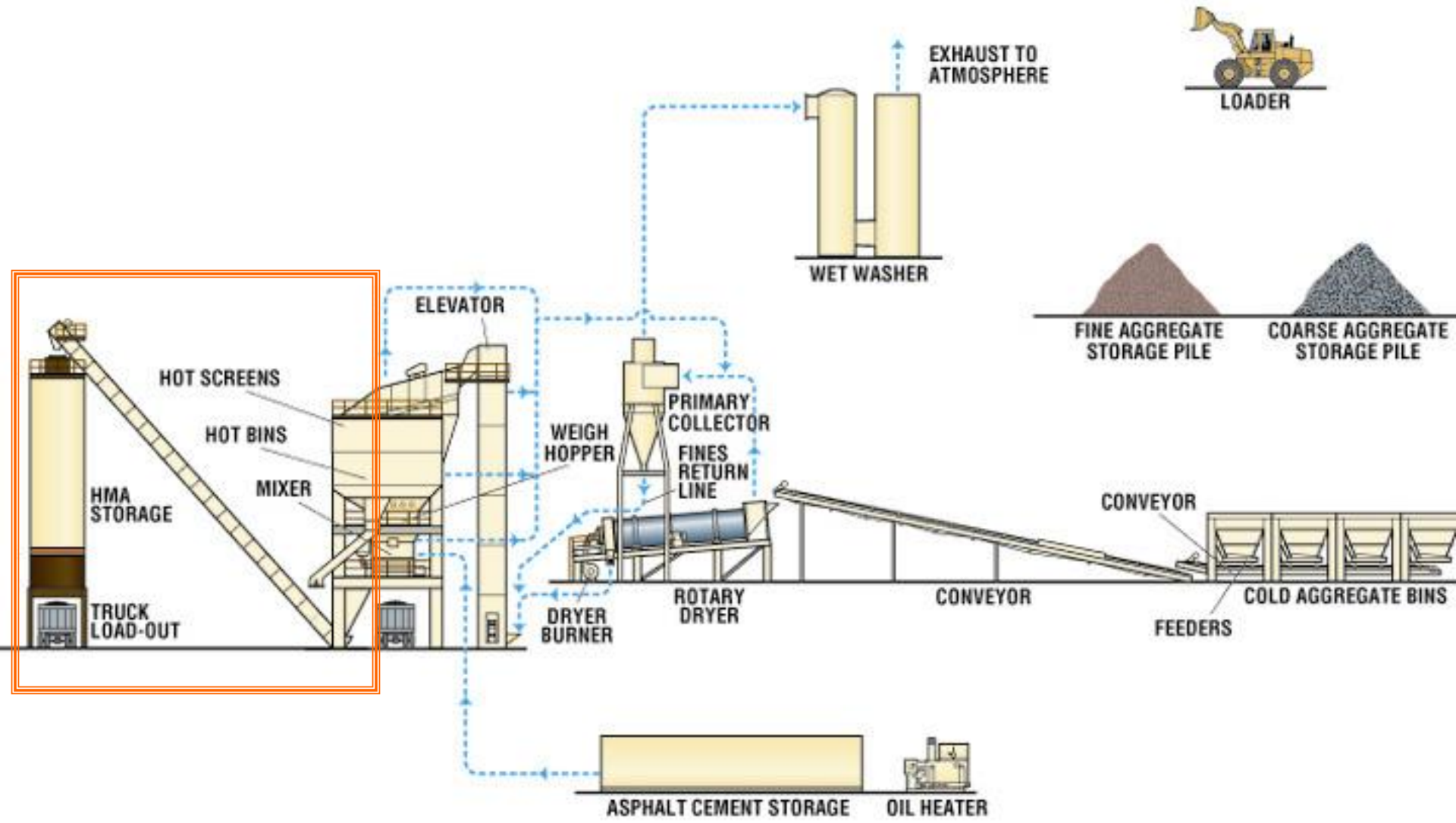

Today's challenge:
Segregation seen in 57 stockpile
Varying surfaces need varying amounts of paste
What's behind this problem?
2009 3 16


Screened three-quarter by half
2009 3 16

Screened 57's

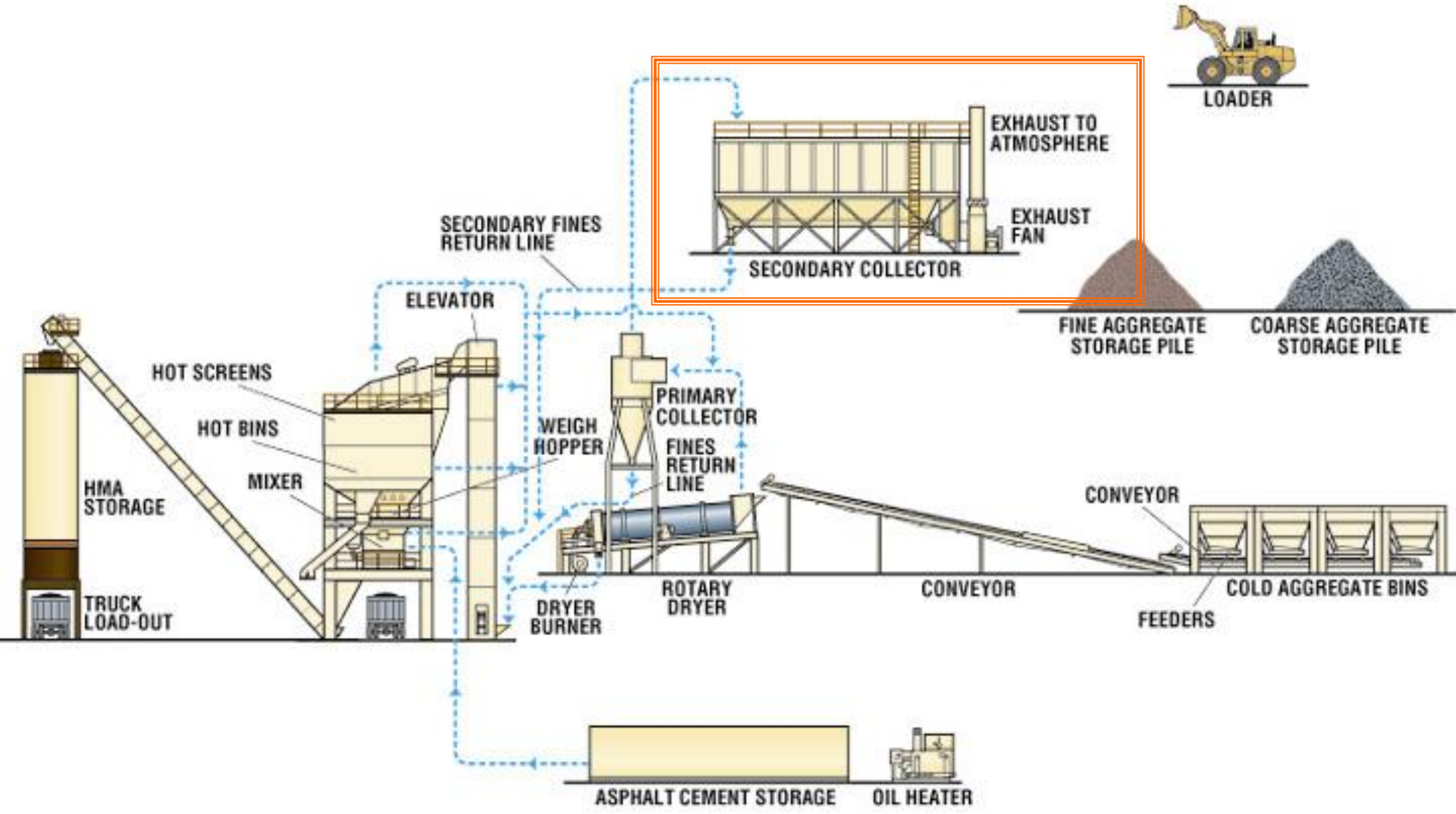


PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS

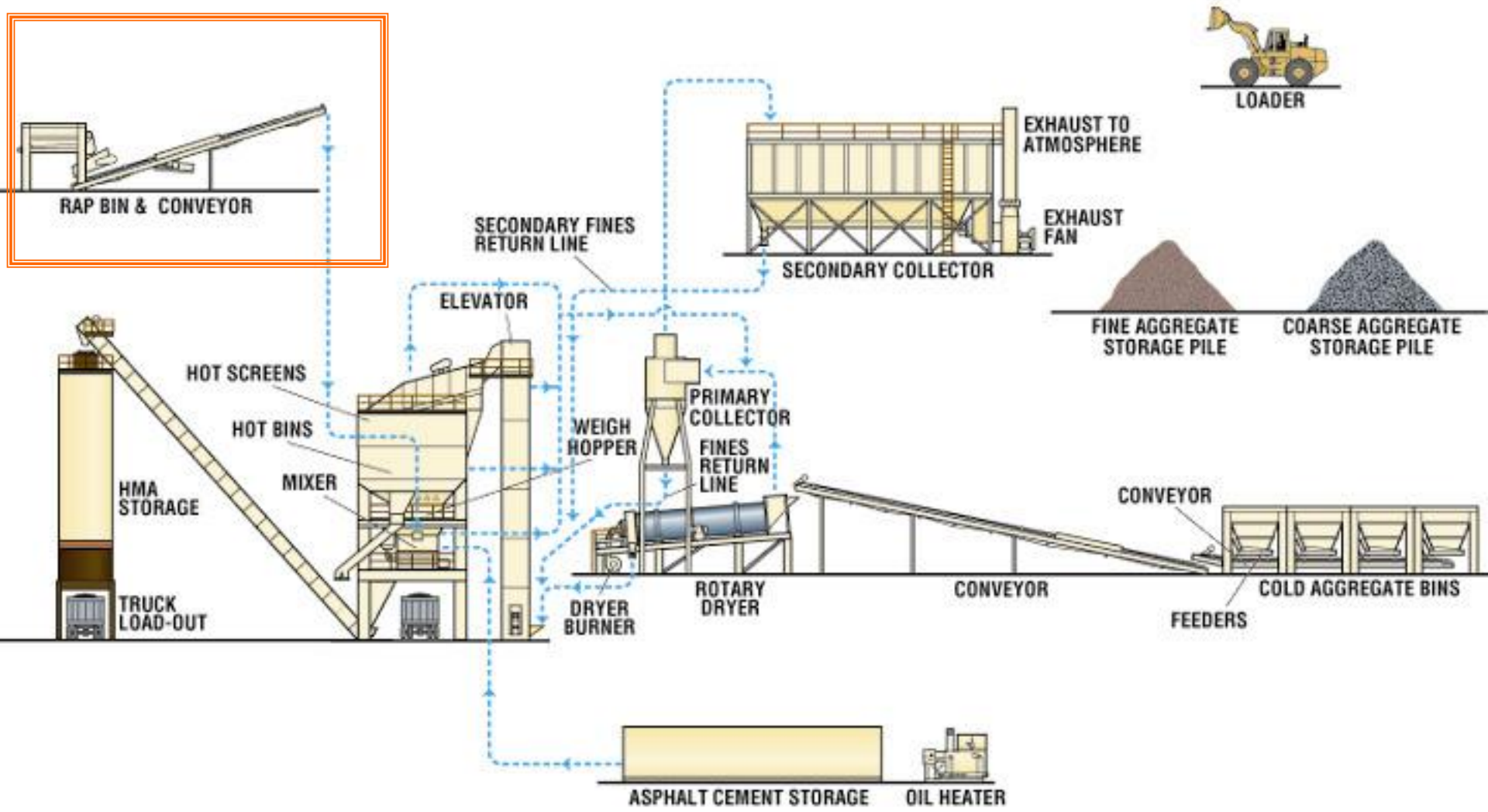


PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS

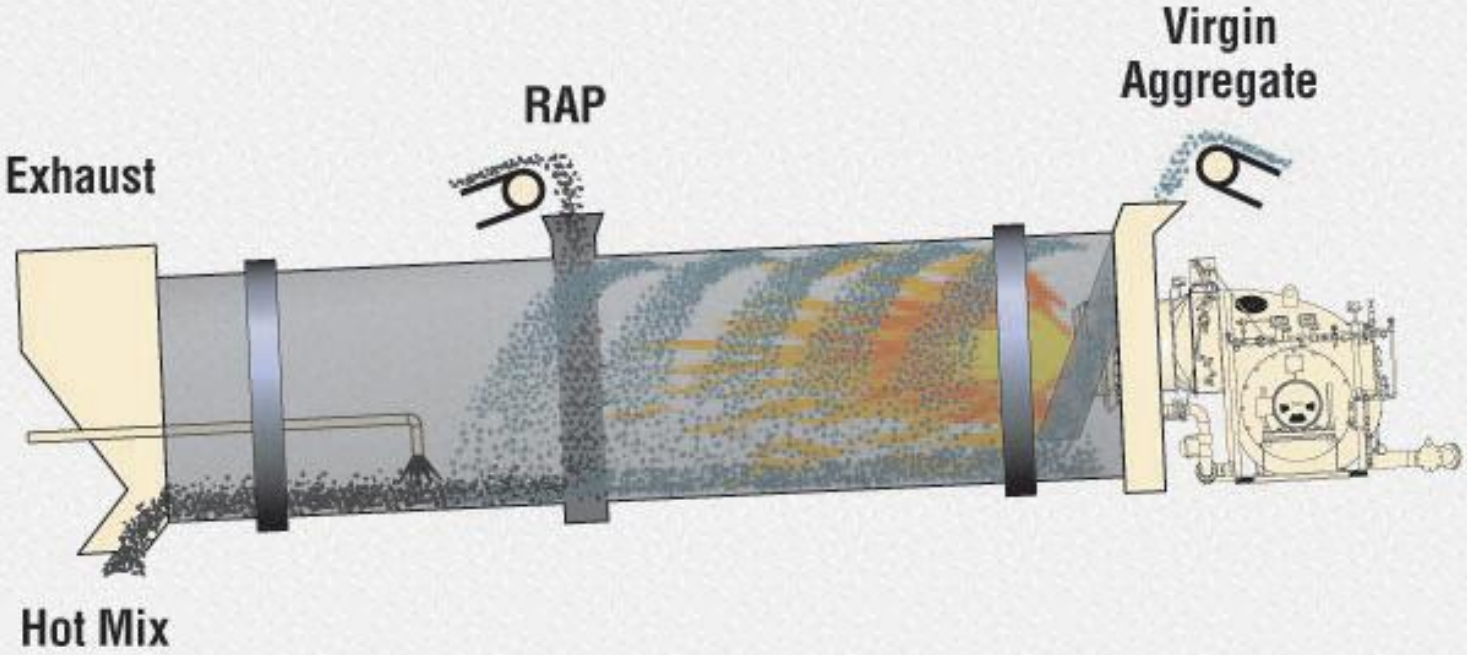

INDUSTRIAL
BOILER CO.



PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS



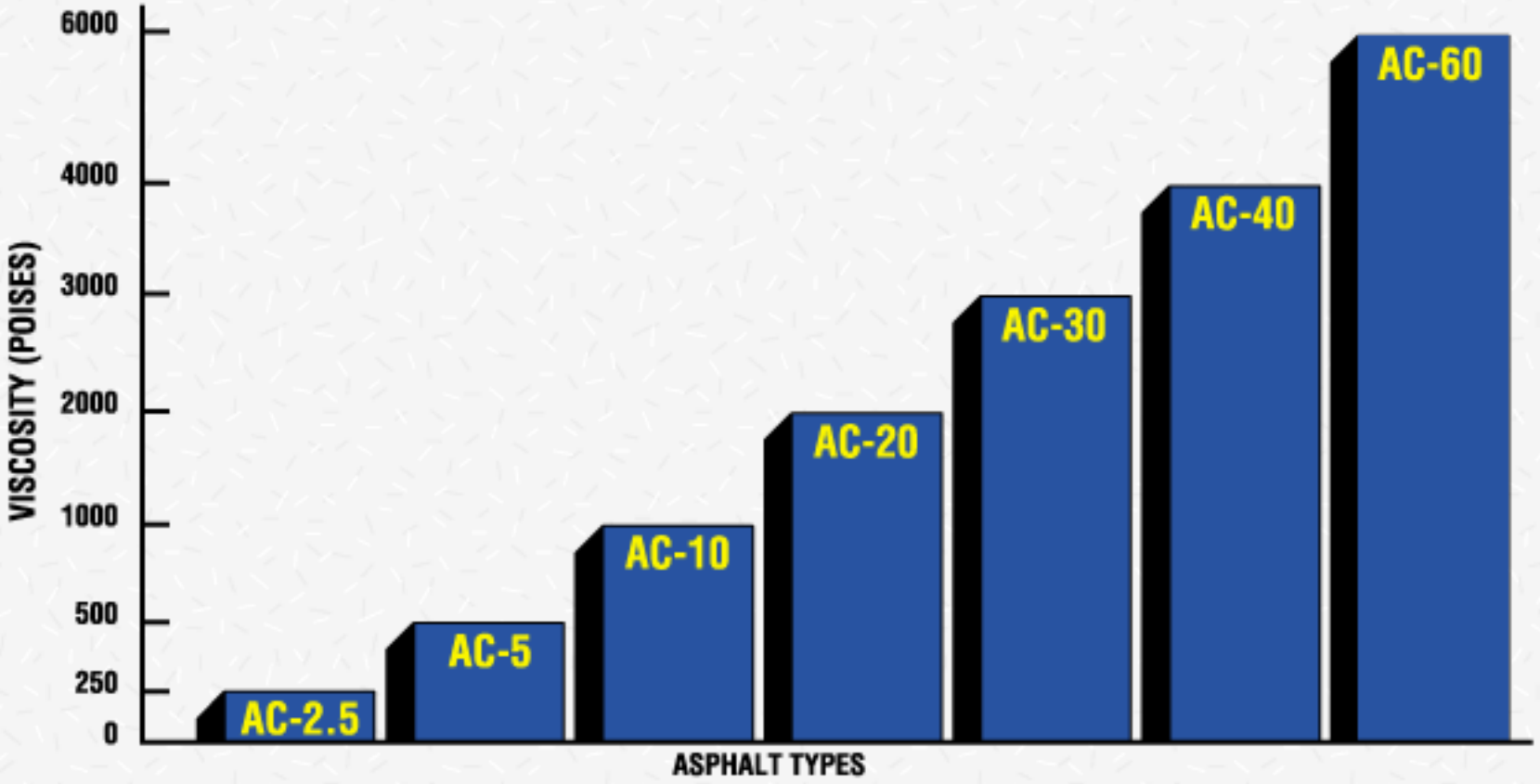
PROCESS FLOW DIAGRAM FOR BATCH MIX ASPHALT PAVING PLANTS



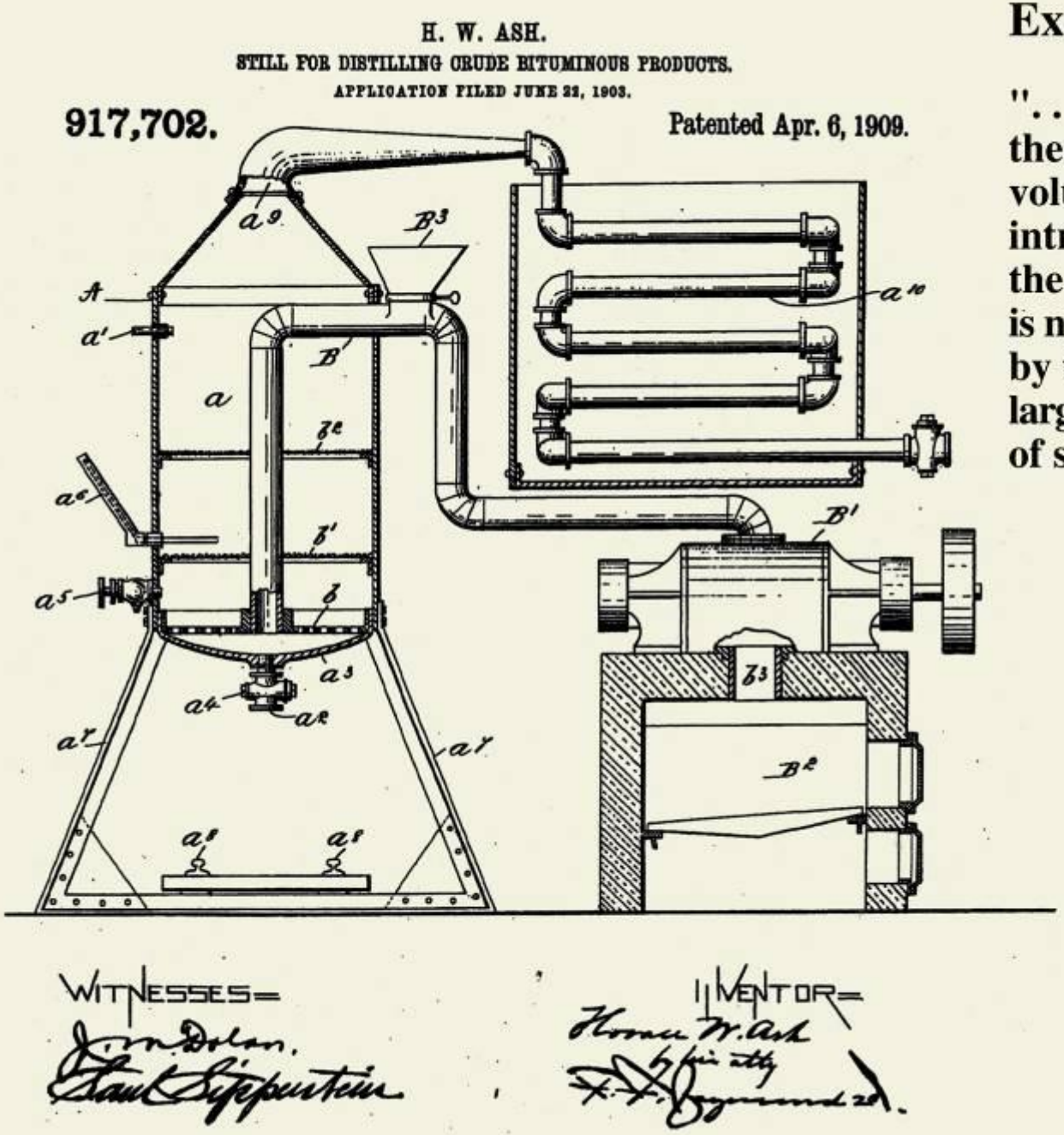
Parallel Flow Drum Mixer

LIQUID ASPHALT SPECIFICATIONS

1900-1970 Penetration (77˚F)
1975-1995 Viscosity (140˚F)
1995-Now Performance Grading PG
64˚C High Temperature (147˚F)
-22˚C Low Temperature

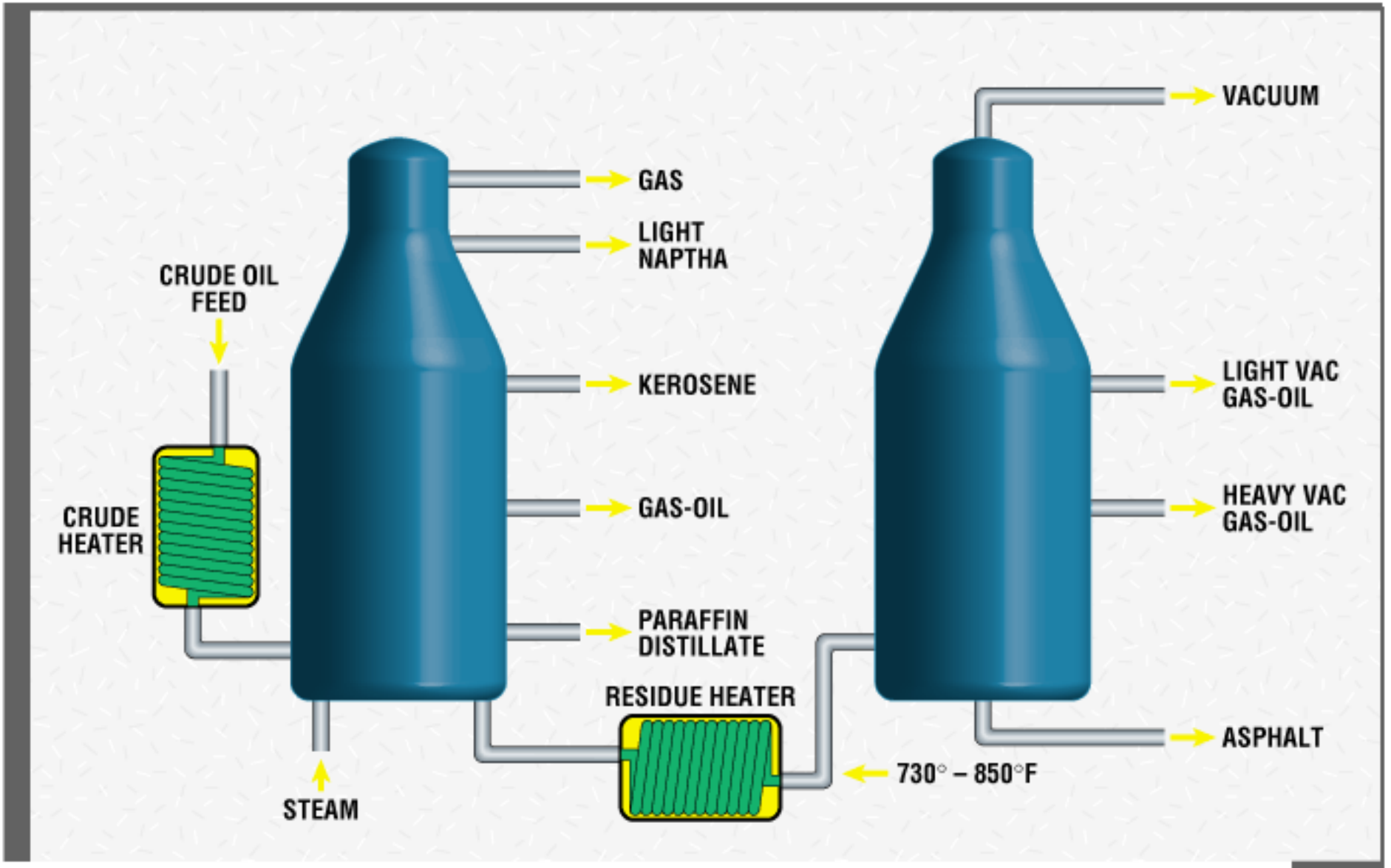


ASPHALTS FROM VARIOUS CRUDE OILS

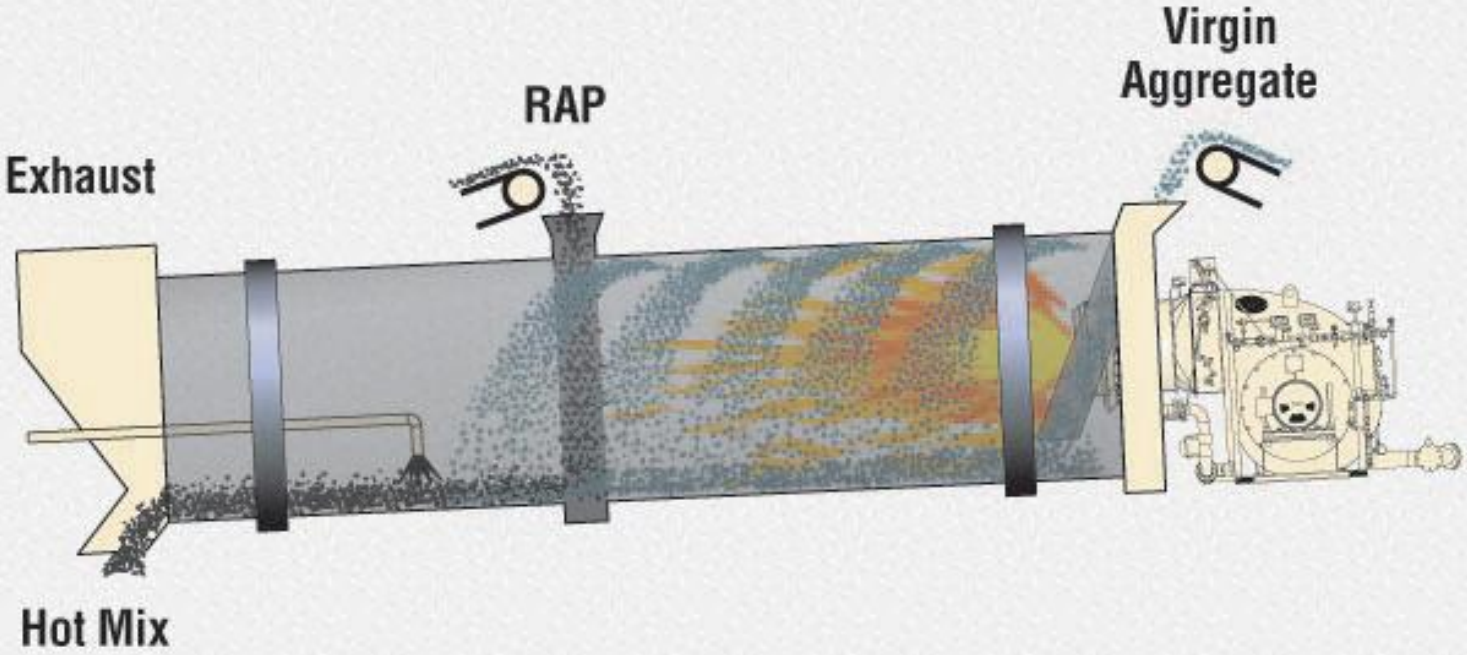


Excerpt from the Patent:

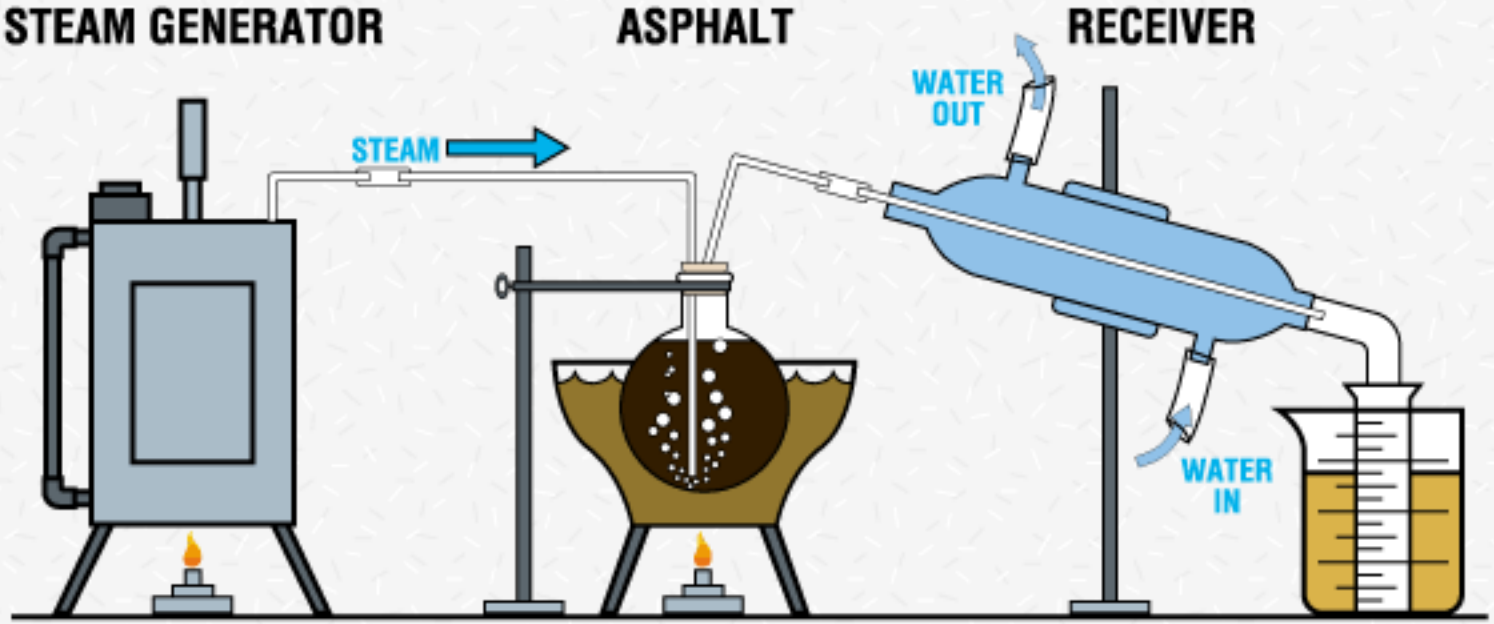
". . . the bituminous material therein may be subjected to a volume of heated air or steam introduced into the bottom of the still whereby the material is not only heated, but is aerated by the passage through it of large quantities of air in the form of small globules or bubbles."



REFINERY FLOW DIAGRAM



Parallel Flow Drum Mixer



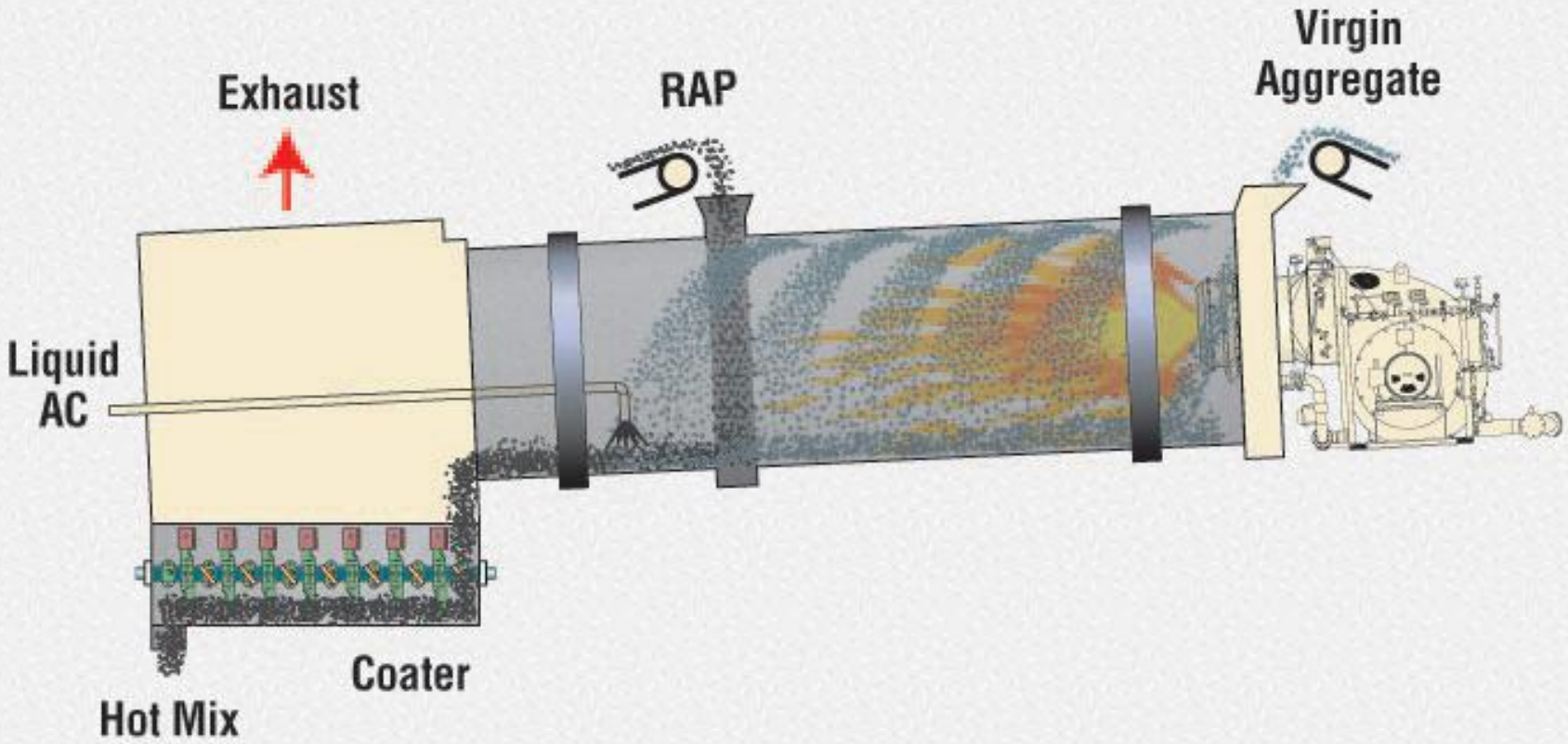
PROCEDURE

1 Warm Asphalt to 300°F
2 Start Steam Flow
3 Continue Heat to 450°F with Steam Flow
4 Collect and Measure Oil Carried Over

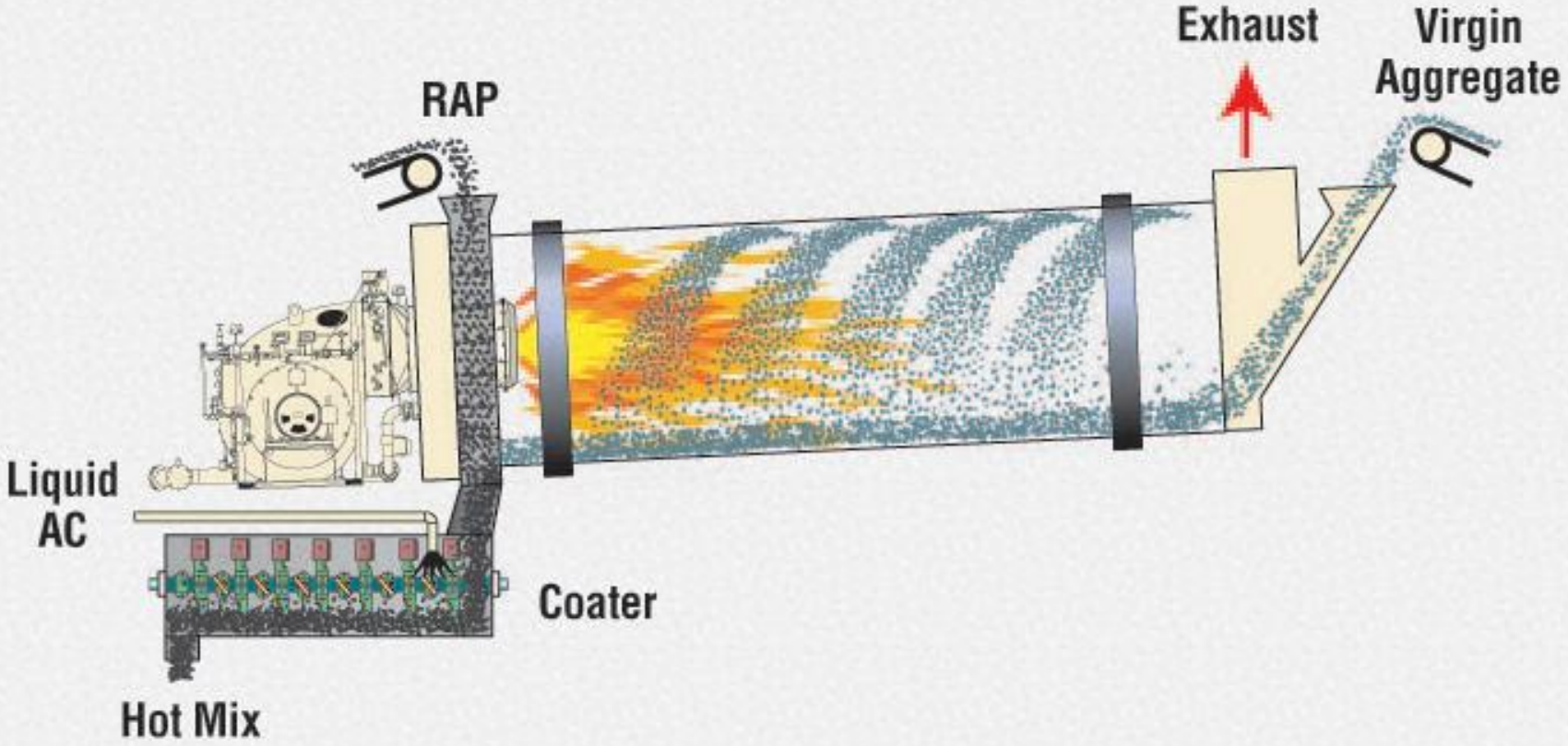
ASTM D255 STEAM DISTILLATION TEST

STEAM DISTILLATION TEST

No.	Grade	Original Liquid					Loss on Heating, 5 HR (325° F)				Steam Distillation (D-255 Modified)			
		Penetration (77 °F)	Viscosity Kinematic (140 °F) (P)	Ductility 77 °F (CM)	Flash Point C.O.C. °F	Smoke Point °F	ASTM D 1754%	Penetration (77 °F)	Ductility After CM	Viscosity Kinematic (140 °F) (P)	% Loss by Weight	Penetration	Viscosity Kinematic (140 °F) (P)	Maximum Temperature °F
1.	AC20	97	2190	110+	550	–	0.65	52	110	4650	2.63	63	3620	450
2.	AC30	69	3150	–	490	165	0.35	47	–	7140	2.13	54	4790	430
3.	AC20	66	1930	–	605	155	0.38	41	–	3600	1.79	47	3020	440
4.	AC20	84	2250	–	565	190	0.28	53	–	4870	2.27	67	3170	438
5.	AC20	57	2450	–	650	190	0.10	36	–	6585	0.65	50	3260	450
6.	HMA2.5	390	184	–	610	165	0.49	183	–	371	0.95	300	233	–
7.	AC5	182	508	–	500	300	0.79	85	–	1770	4.91	100	1220	480
8.	AC20	72	2325	–	595	245	0.03	47	–	5980	1.30	67	2640	435
9.	AC5	169	559	–	585	275	0.45	91	–	1450	1.90	134	773	437
10.	AC85/100	97	1320	–	640	270	0.58	46	–	5480	2.20	63	2370	437
11.	AC2.5	196	579	–	560	190	0.27	103	–	1350	2.10	164	787	445
12.	AC2.5	176	500	–	600	300	0.25	89	–	1420	1.28	152	612	445



Parallel Flow Drum Mixer With Coater

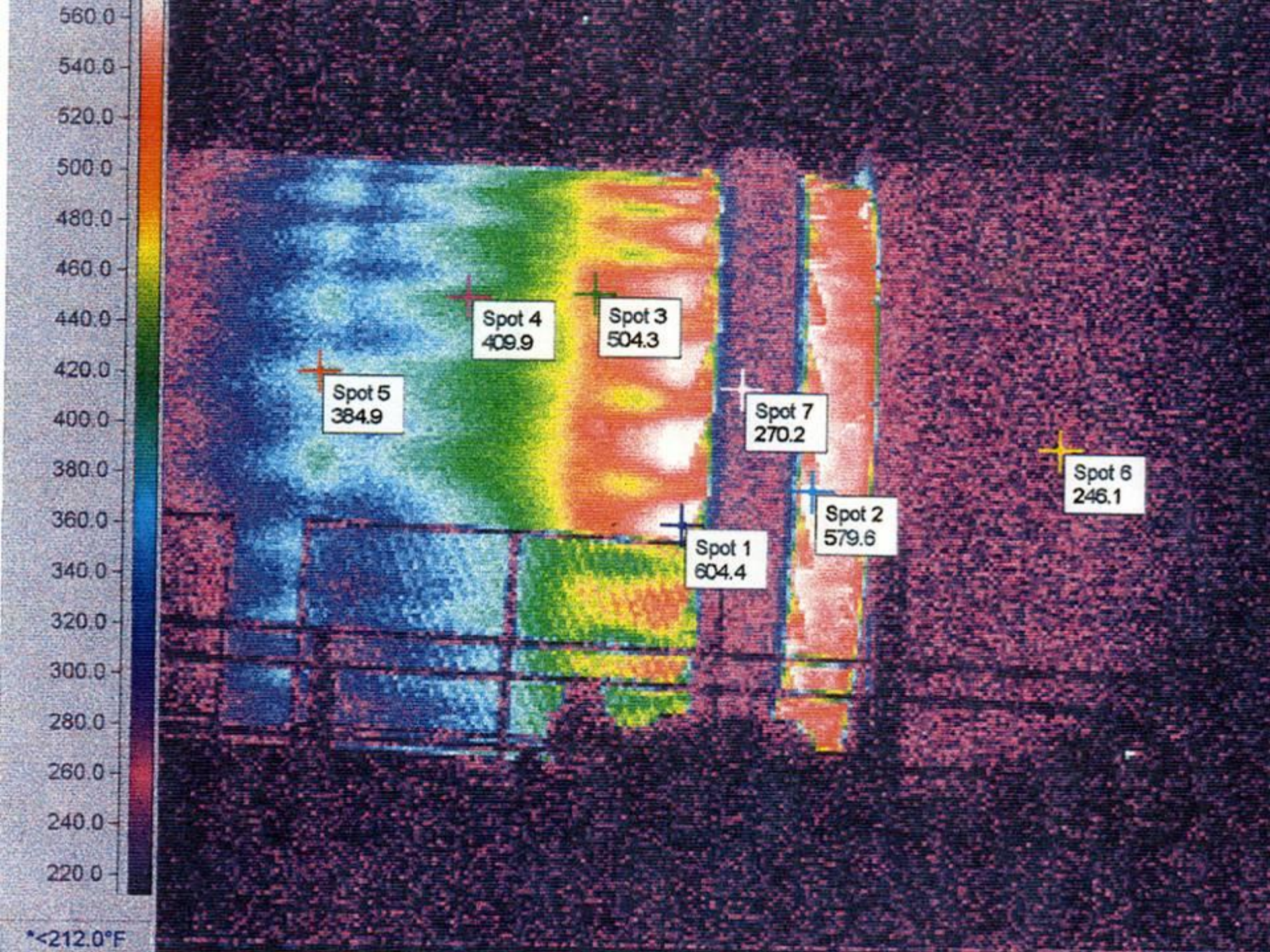


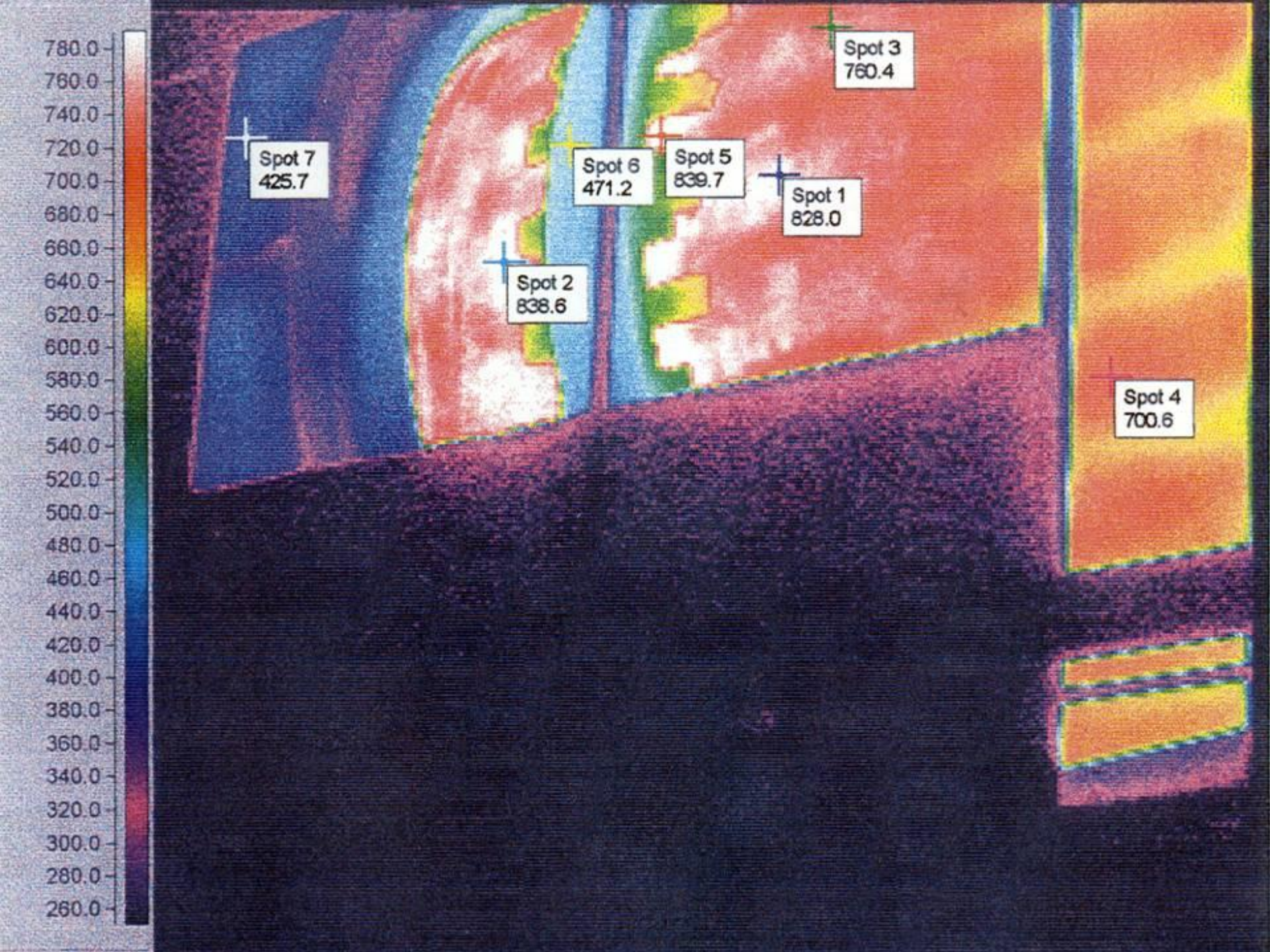
Counterflow Drying Drum With Coater

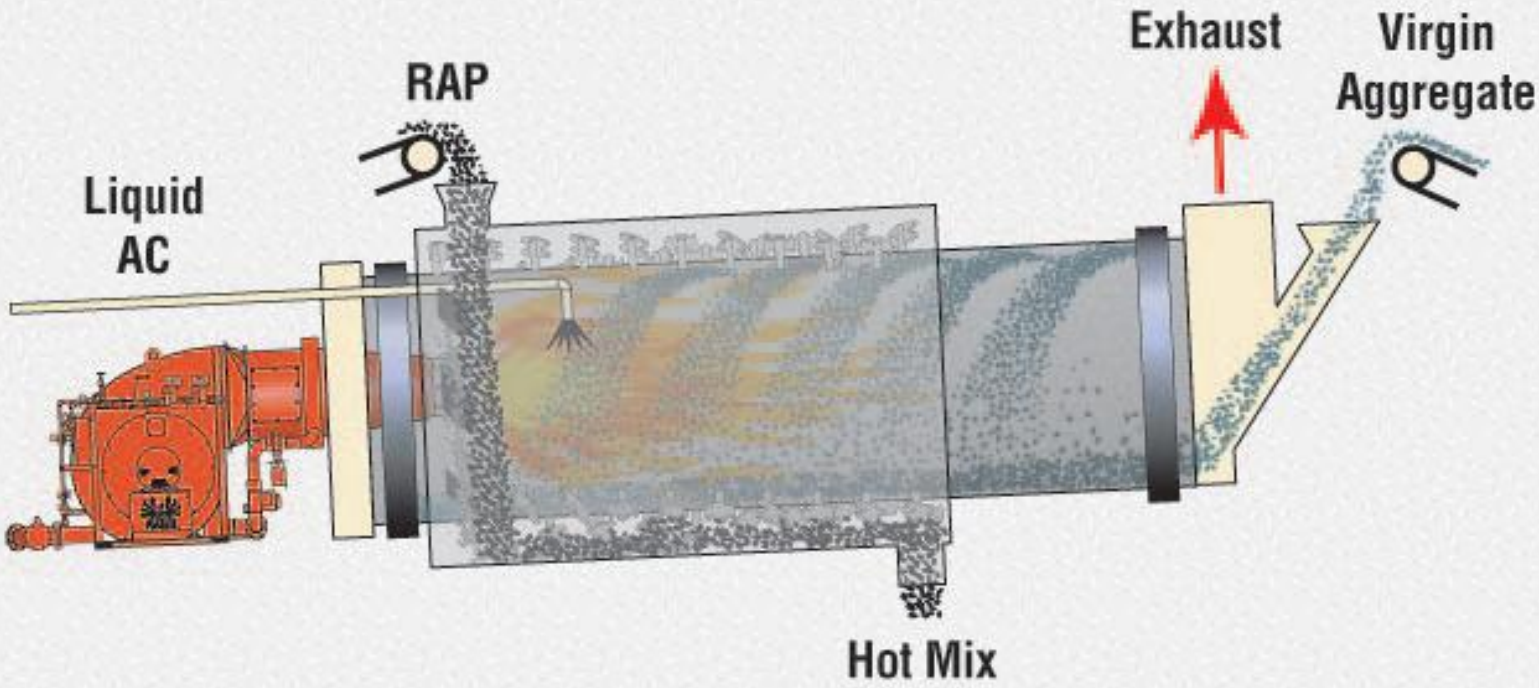
RAP Content (%)	RAP Moisture Content (%)	Superheat Required (°F) 240°F Mix	260°F Mix	280°F Mix	300°F Mix
10	0	269	291	313	335
	1	274	296	318	340
	2	279	301	323	345
	3	284	306	328	350
	4	289	311	333	355
	5	294	316	338	360
20	0	292	317	342	367
	1	303	328	353	378
	2	314	339	364	389
	3	325	350	375	400
	4	336	361	386	411
	5	347	372	397	422
30	0	324	352	330	408
	1	343	371	599	427
	2	362	390	418	446
	3	381	409	437	465
	4	400	428	456	484
	5	419	447	475	503
40	0	366	397	430	463
	1	424	426	459	492
	2	453	455	488	521
	3	482	484	517	550
	4	511	513	546	579
	5	540	542	575	608
50	0	420	460	500	540
	1	464	504	544	588
	2	508	548	588	628
	3	552	592	632	672
	4	596	636	676	716
	5	640	680	720	760

NOTE: Calculations assume 10°F loss from dryer to pugmill and 70°F outside air temperature.

Standard Counterflow Dryer (superheat required)

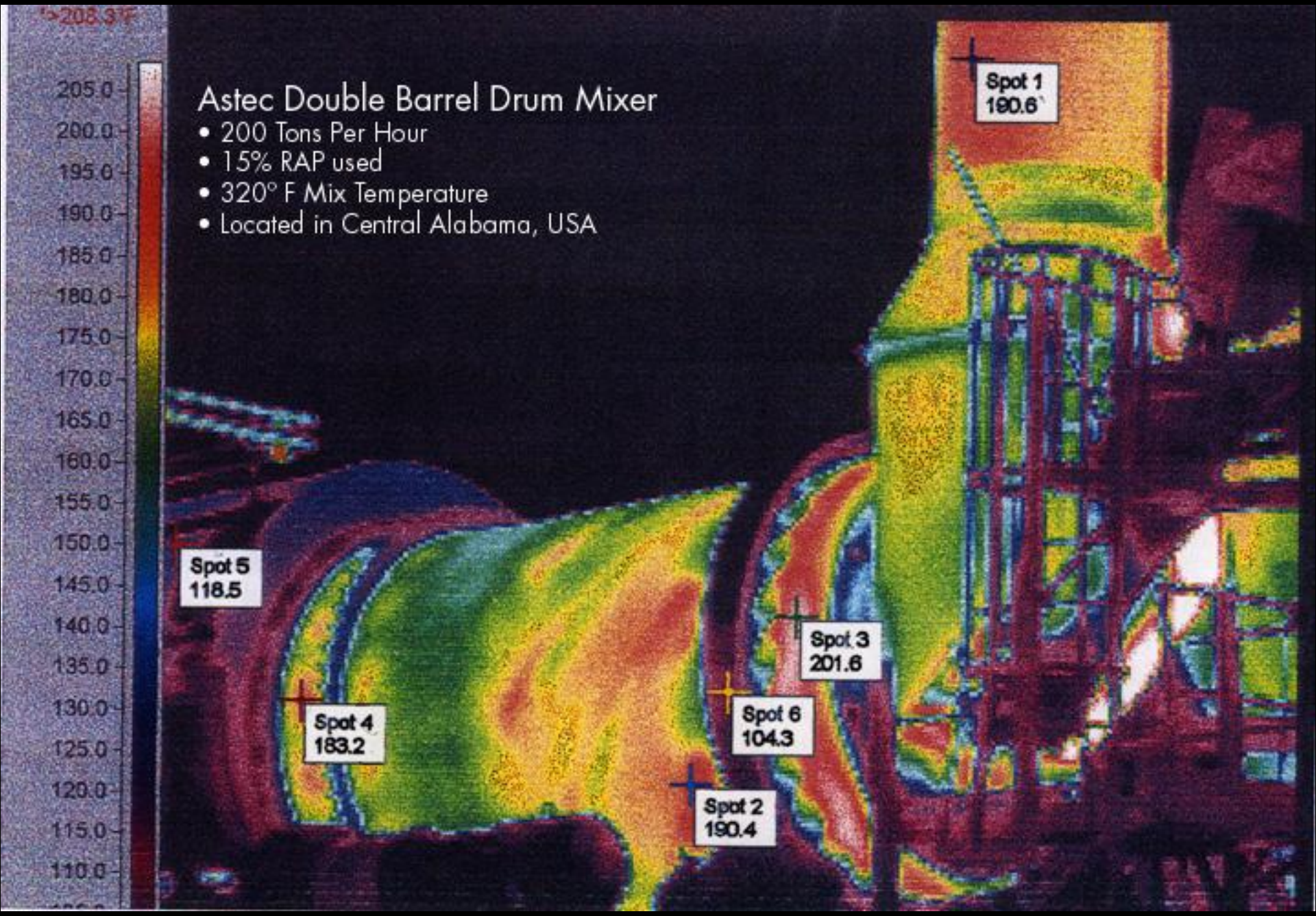

560.0
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
240.0
220.0
*<212.0°F
Spot 4
409.9
Spot 3
504.3
Spot 5
384.9
Spot 7
270.2
Spot 6
246.1
Spot 2
579.6
Spot 1
604.4


780.0
760.0
740.0
720.0
700.0
680.0
660.0
640.0
620.0
600.0
580.0
560.0
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
Spot 3
760.4
Spot 7
425.7
Spot 6
471.2
Spot 5
839.7
Spot 1
828.0
Spot 2
838.6
Spot 4
700.6

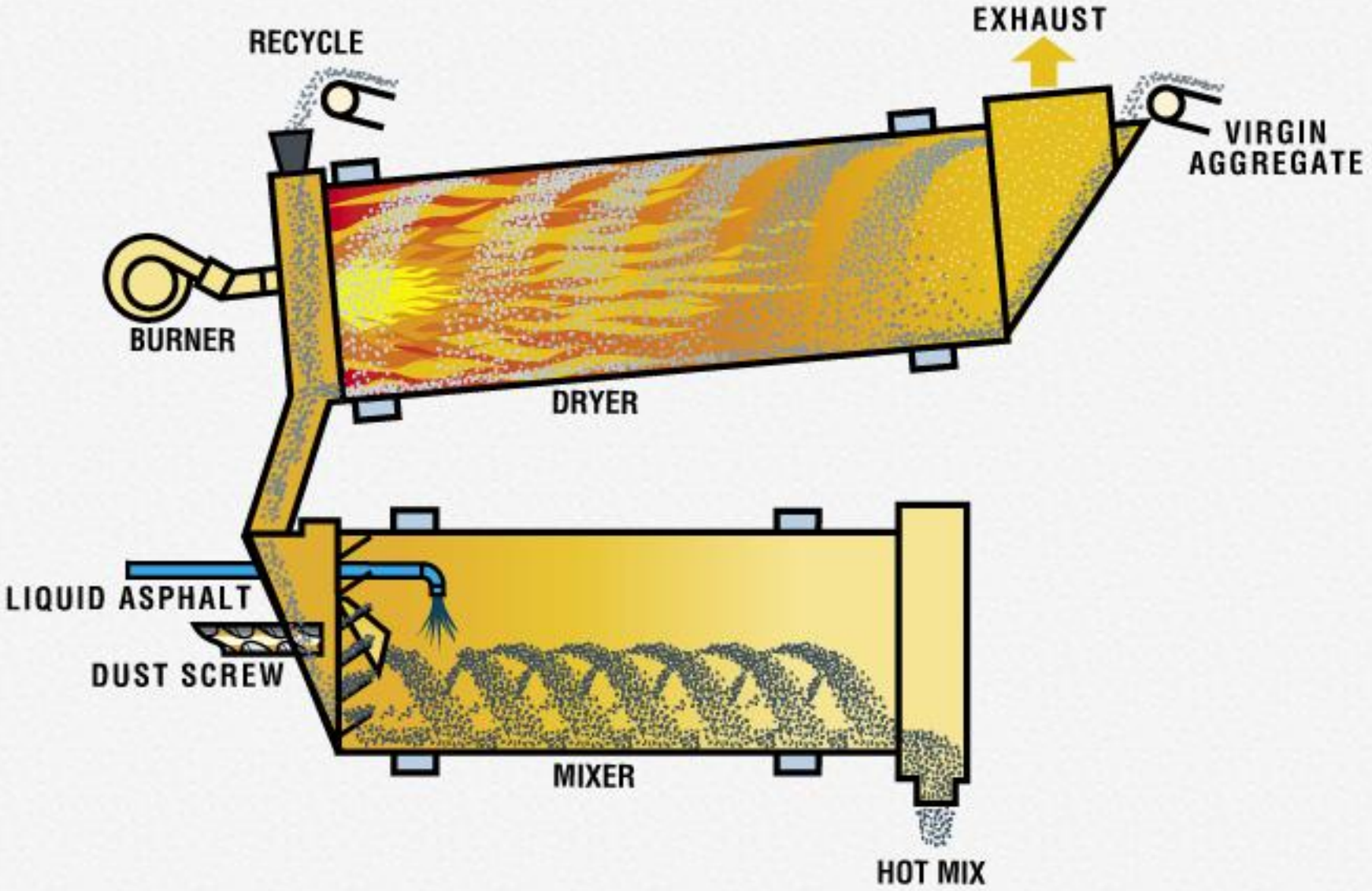


Double Barrel® Combination Dryer/Mixer

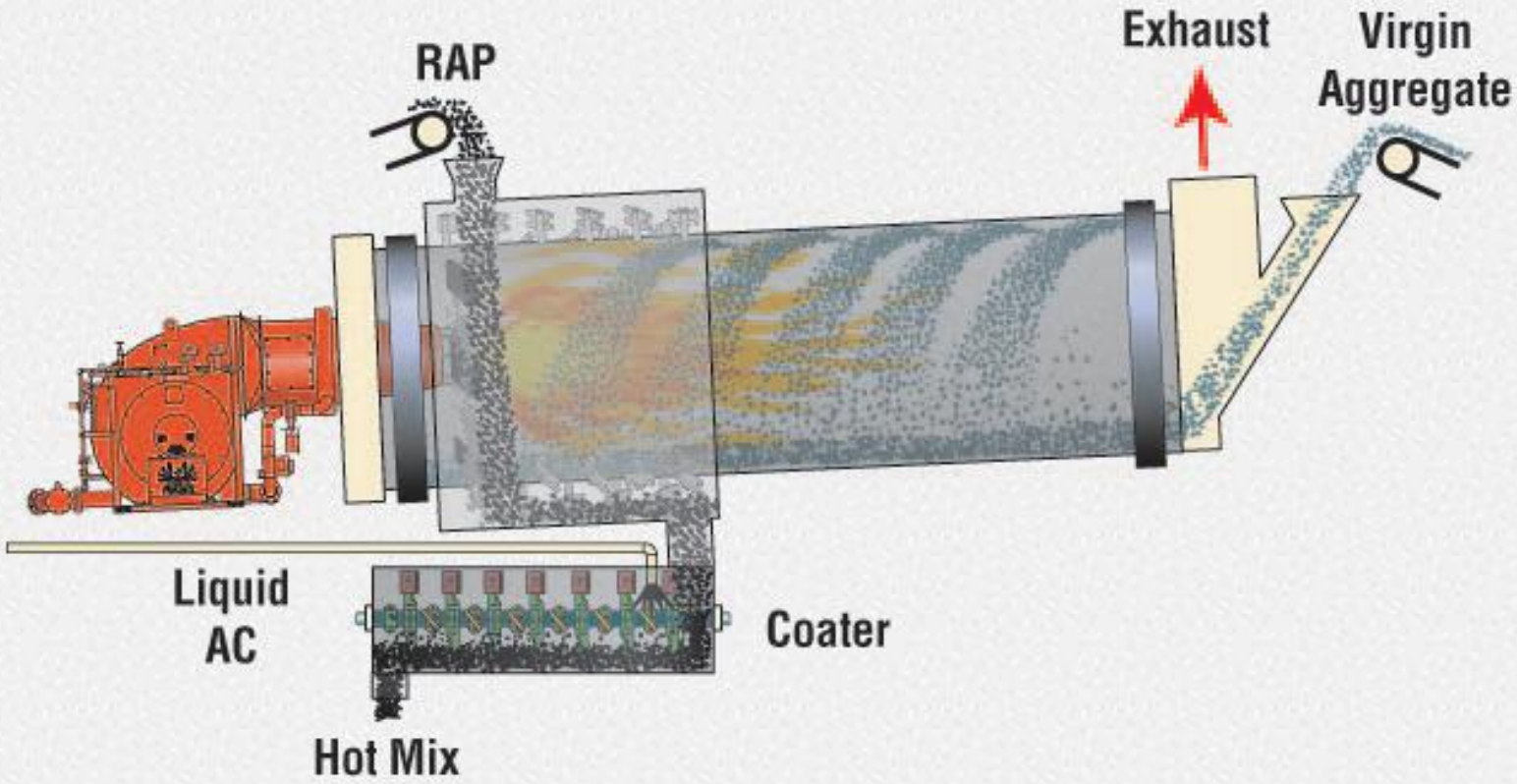

ASTEC
DOUBLE BARREL GREEN
ASTEC
NORTHWEST
1539-1900


Astec Double Barrel Drum Mixer
• 200 Tons Per Hour
• 15% RAP used
• 320° F Mix Temperature
• Located in Central Alabama, USA
Spot 1
190.6
Spot 2
190.4
Spot 3
201.6
Spot 4
183.2
Spot 5
118.5
Spot 6
104.3
205.0
200.0
195.0
190.0
185.0
180.0
175.0
170.0
165.0
160.0
155.0
150.0
145.0
140.0
135.0
130.0
125.0
120.0
115.0
110.0


*>248.0°F
240.0
230.0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
*<80.6°F
Spot 4
226.1
Spot 1
246.5
Spot 7
248.0
Spot 3
162.1
Spot 5
161.4
Spot 2
190.9
Spot 6
91.7
Astec Double Barrel Drum Mixer
• 145 Tons Per Hour
• 30% Rap used
• 300° F Mix Temperature
• Located In Central Florida, USA

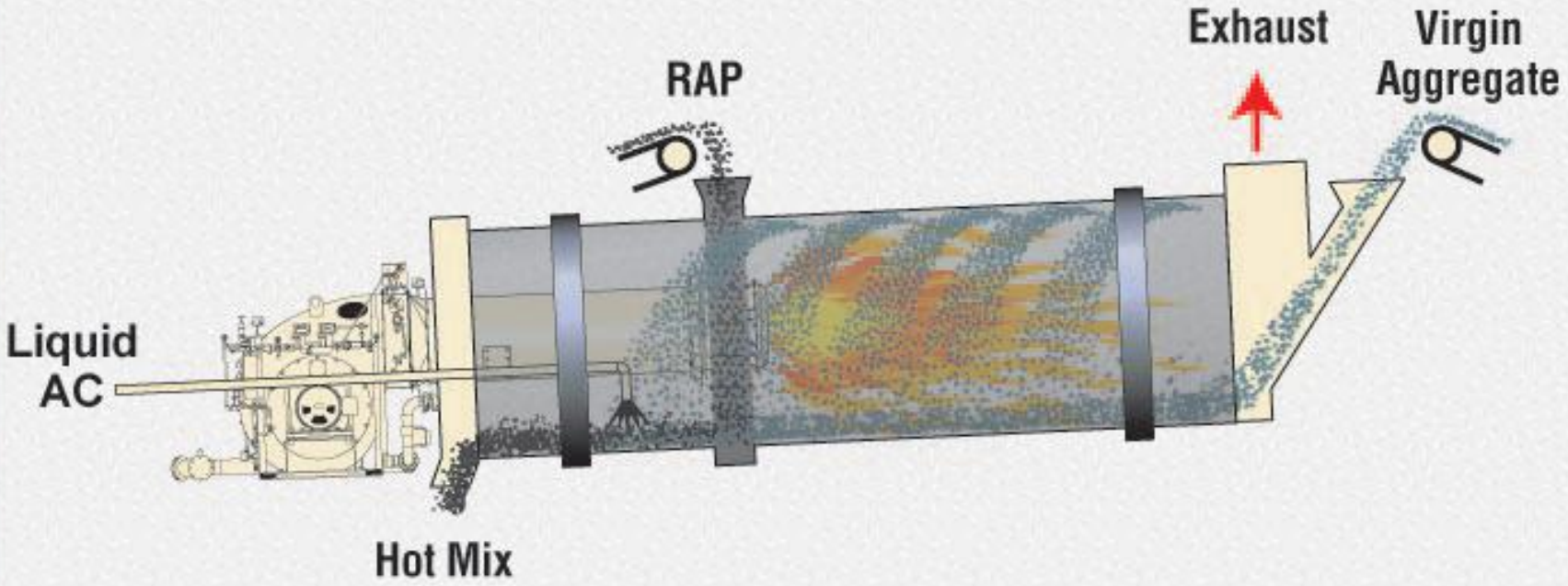


COUNTER FLOW DRYER AND ROTARY MIXER



Double RAP™ Dryer With Coater

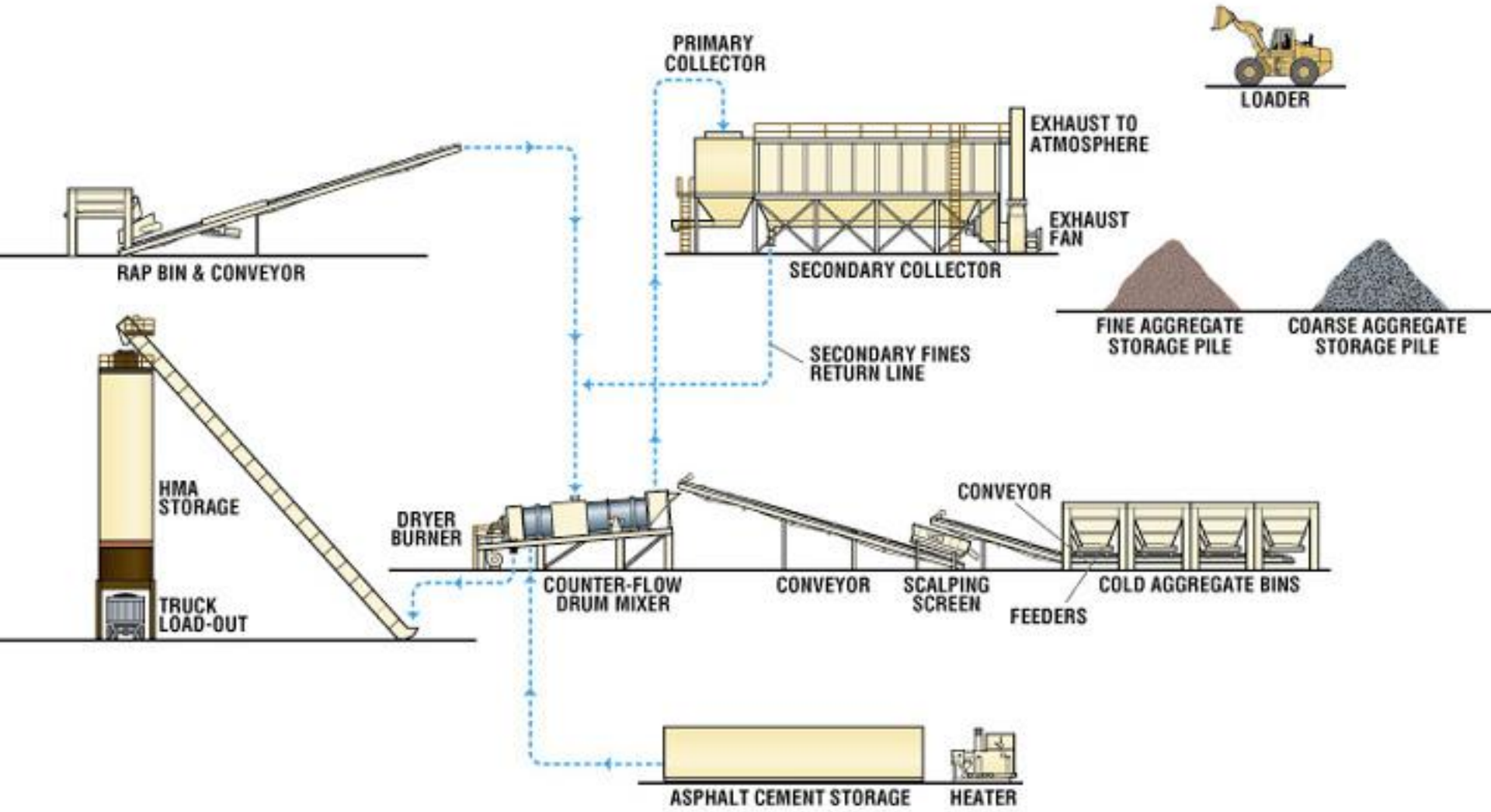

DOUBLE
RAP
GREEN
ASTEC



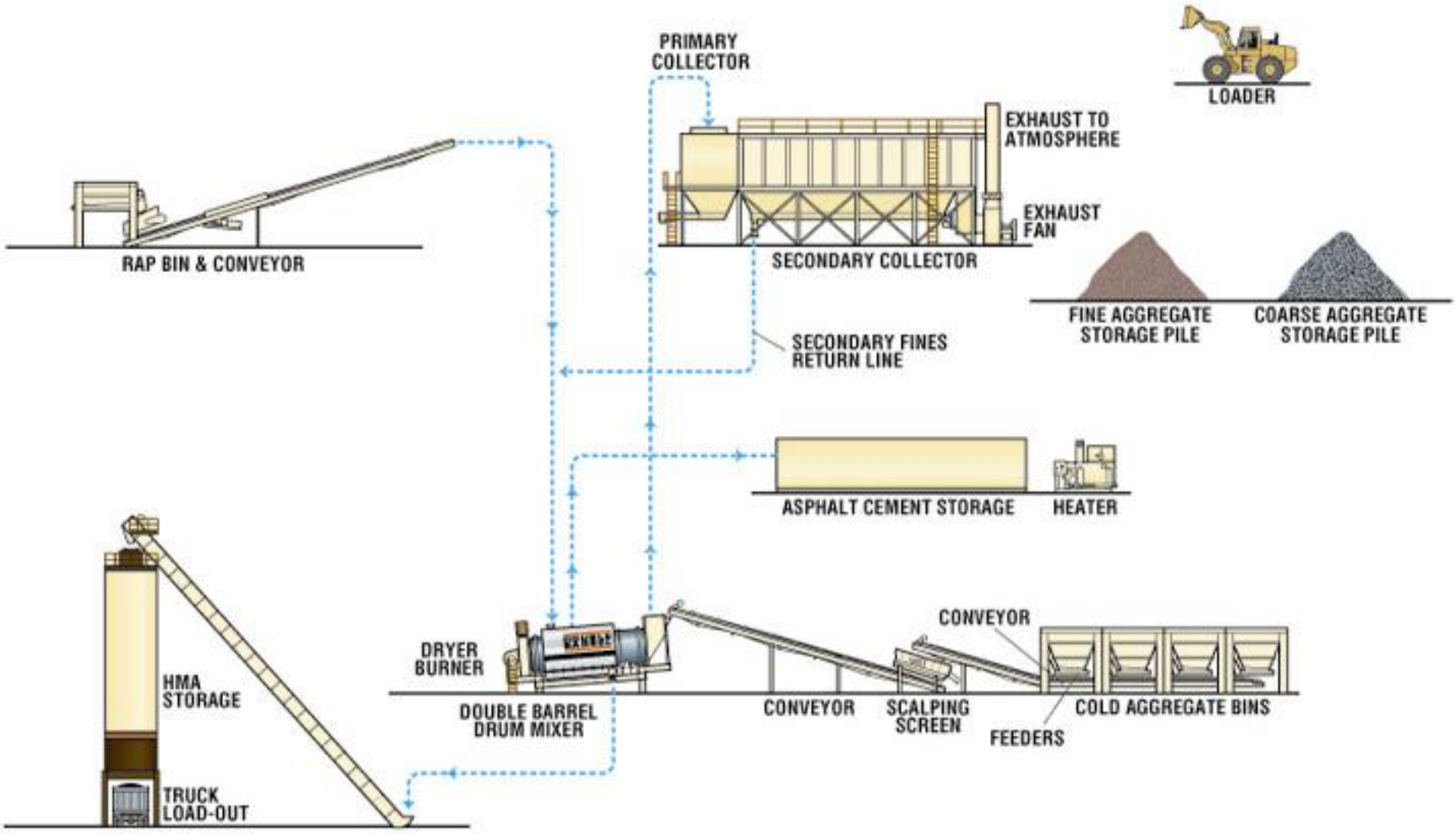
Counterflow Drum Mixer


*>462.4°F
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
240.0
220.0
200.0
180.0
160.0
*<79.9°F
Gencor Counterflow Drum Mixer
• 215 Tons Per Hour
• 20% RAP used
• 305° F Mix Temperature
• Located on the Southeast Coast of Florida, USA
Spot 6
244.8
Spot 5
245.1
Spot 3
300.6
Spot 1
460.1
Spot 8
286.3
Spot 7
204.7
Spot 4
275.5
Spot 2
265.4


*>255.6°F
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
240.0
220.0
200.0
180.0
*<0.4°F
Gencor Counterflow Drum Mixer
• 200 Tons Per Hour
• 40% RAP used
• 305° F Mix Temperature
• Located on the Southeast Coast of Florida, USA
Spot 8
250.4
Spot 6
285.2
Spot 7
375.0
Spot 5
361.2
Spot 4
424.8
Spot 3
540.0
Spot 2
243.5
Spot 1
272.3



PROCESS FLOW DIAGRAM FOR COUNTER-FLOW DRUM MIX ASPHALT PAVING PLANTS



PROCESS FLOW DIAGRAM FOR DOUBLE BARREL DRUM MIX ASPHALT PAVING PLANTS


Spray Sewer
Spray Sewer
Spray Sewer
SCALE HOUSE AND PLANTS


ASTEC
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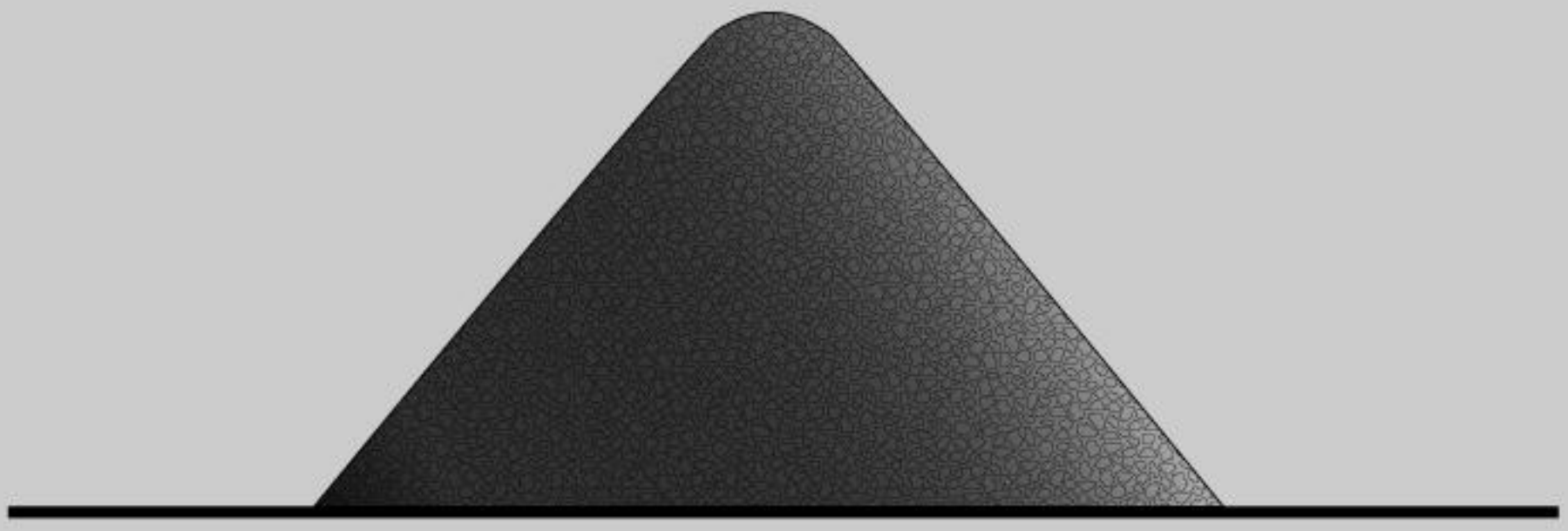
Evolution of Recycling

Use of Recycle Pavement in the United States

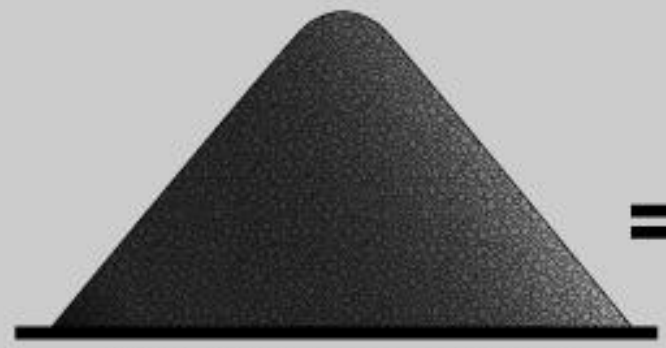
1910.....approximately 10%
1925.....0
1970.....0
1976.....3%
1980—85.....15% (some 50%)
2000.....15%
2010.....25-30% (some 50%)

Full-Lane Milling Machine

Reclaimed Asphalt Pavement
(RAP)



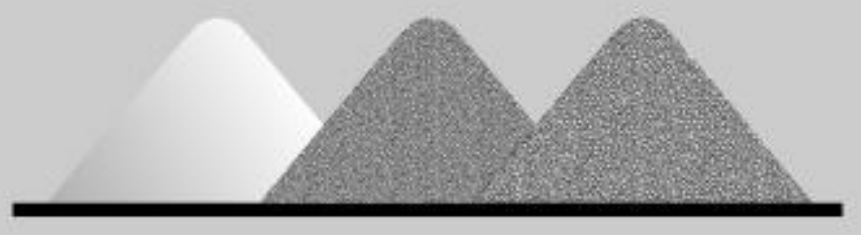
RAP Pile With 1/2” Minus to 3/4” Minus Aggregate



30,000 Tons of RAP

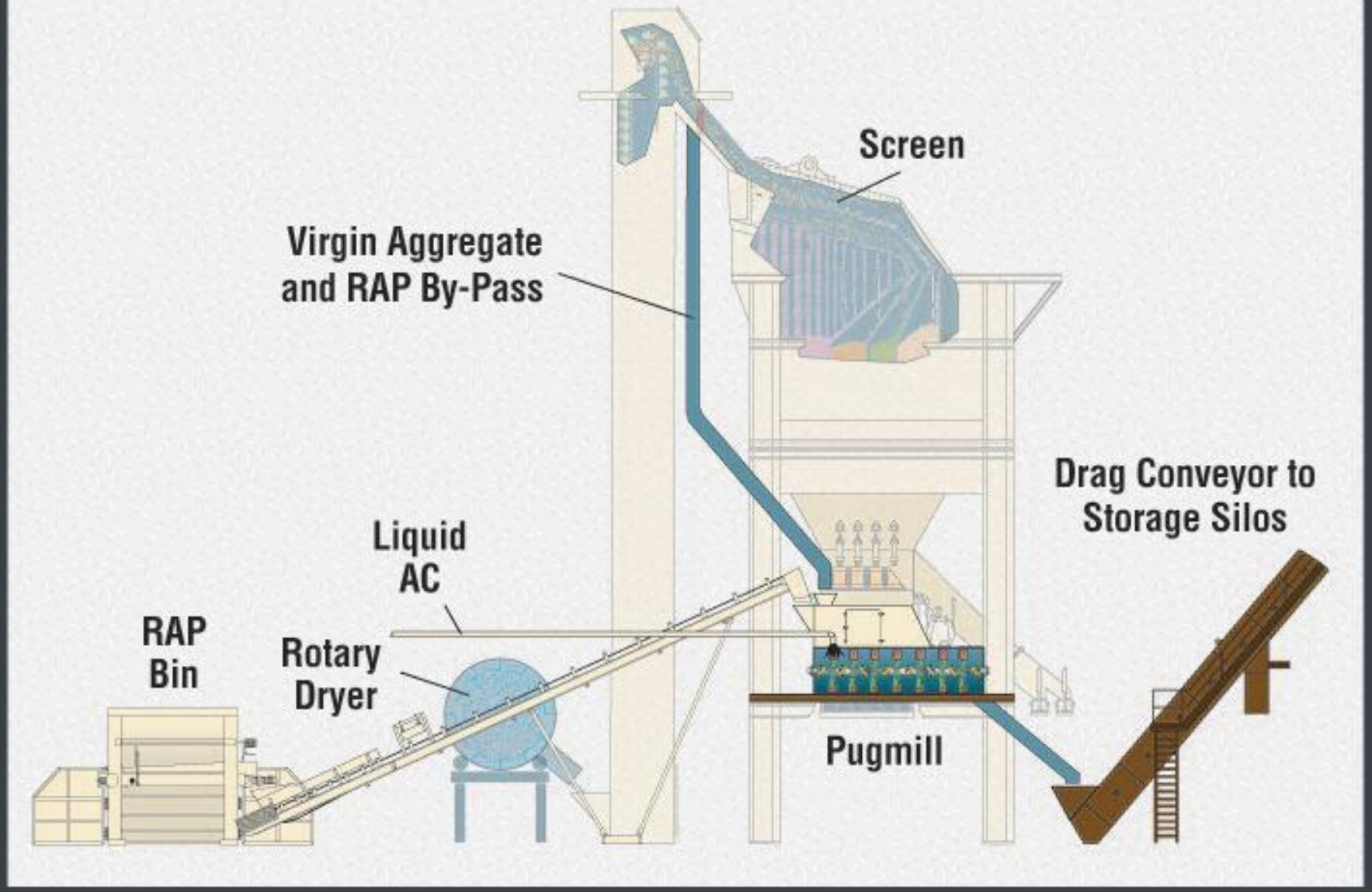
=

70 - 6,000 Gallon Transport Trailers
and 28,200 Tons of Clean Aggregate

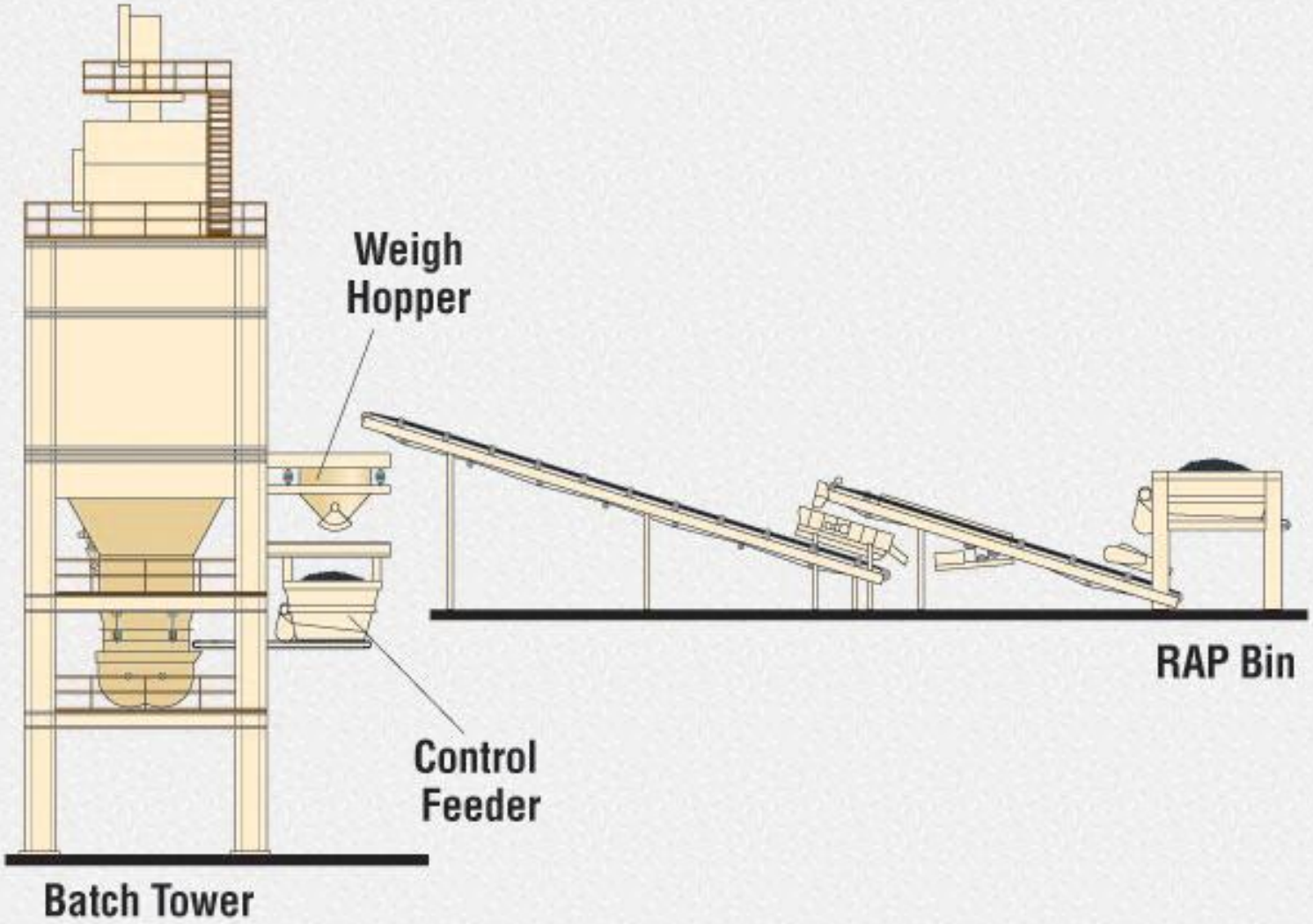


RAP is Worth the Virgin Material It Replaces

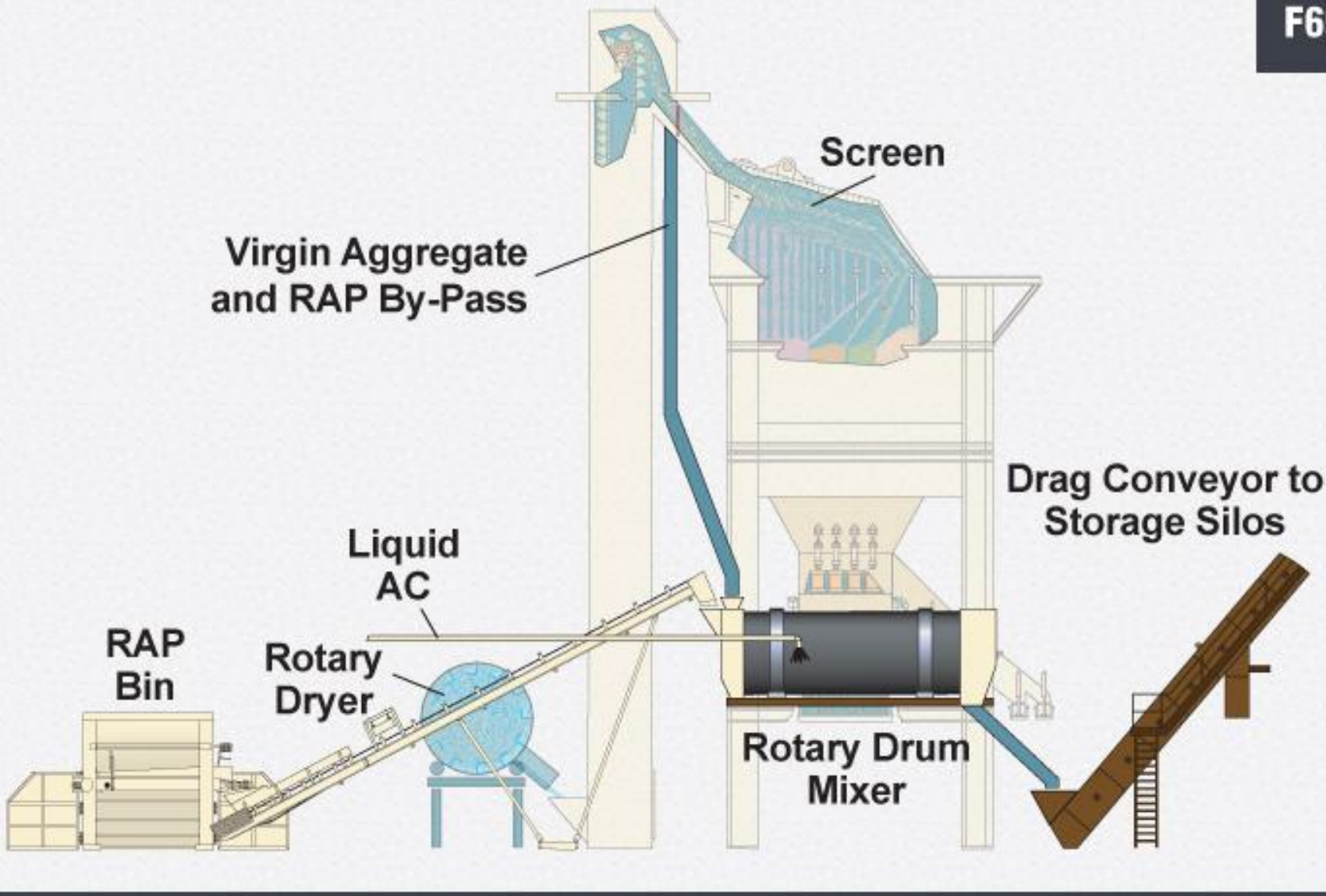
HMA Batch Facility



Batch Plant with Pugmill Mixer



RAP Delivery System for Batch Plants



Batch Plant with Drum Mixer

Virgin Aggregate and RAP By-Pass

Screen

Fifth Bin

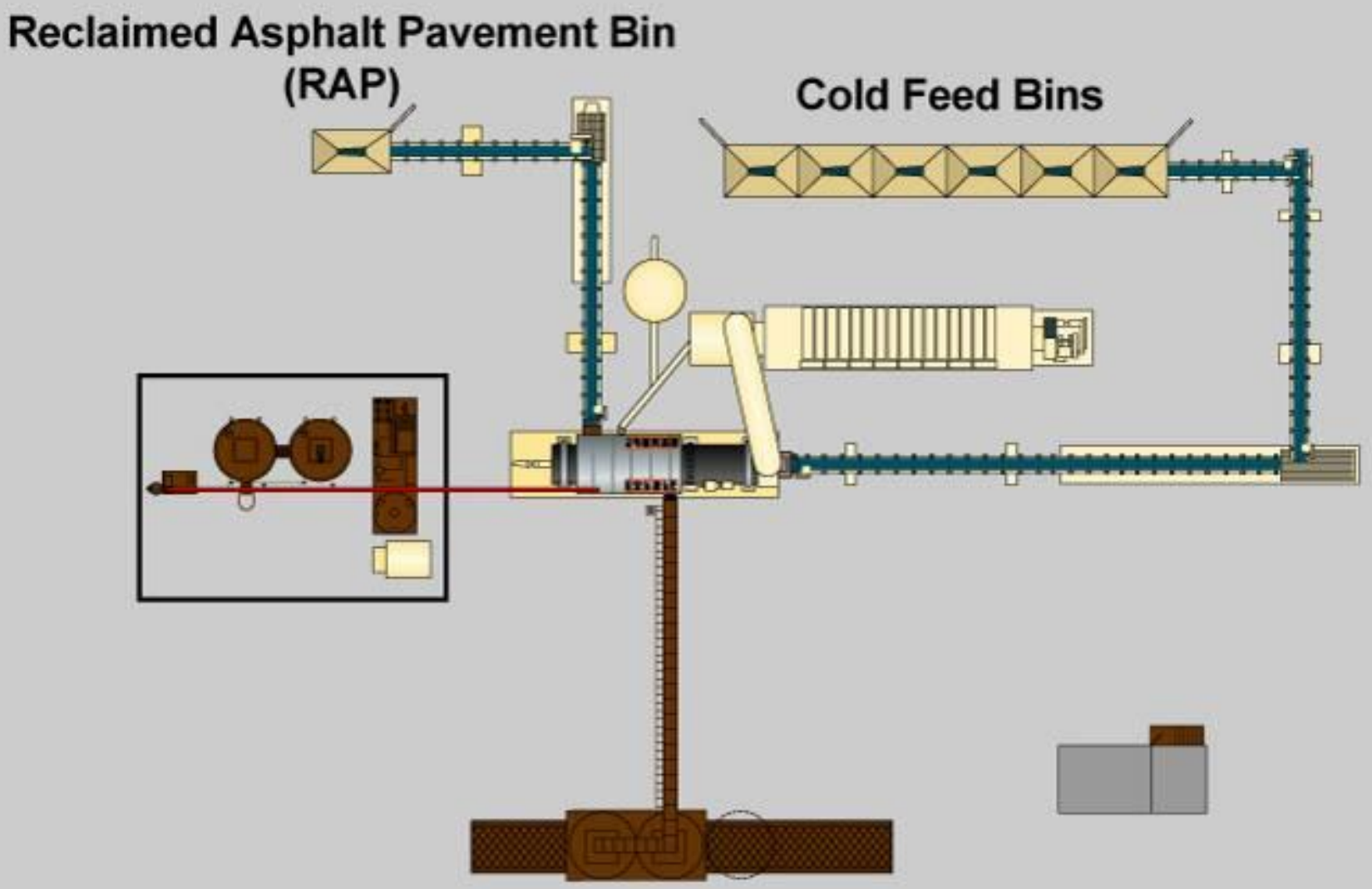
Double RAP Drum Dryer/Mixer

Virgin Aggregate to Screen Only

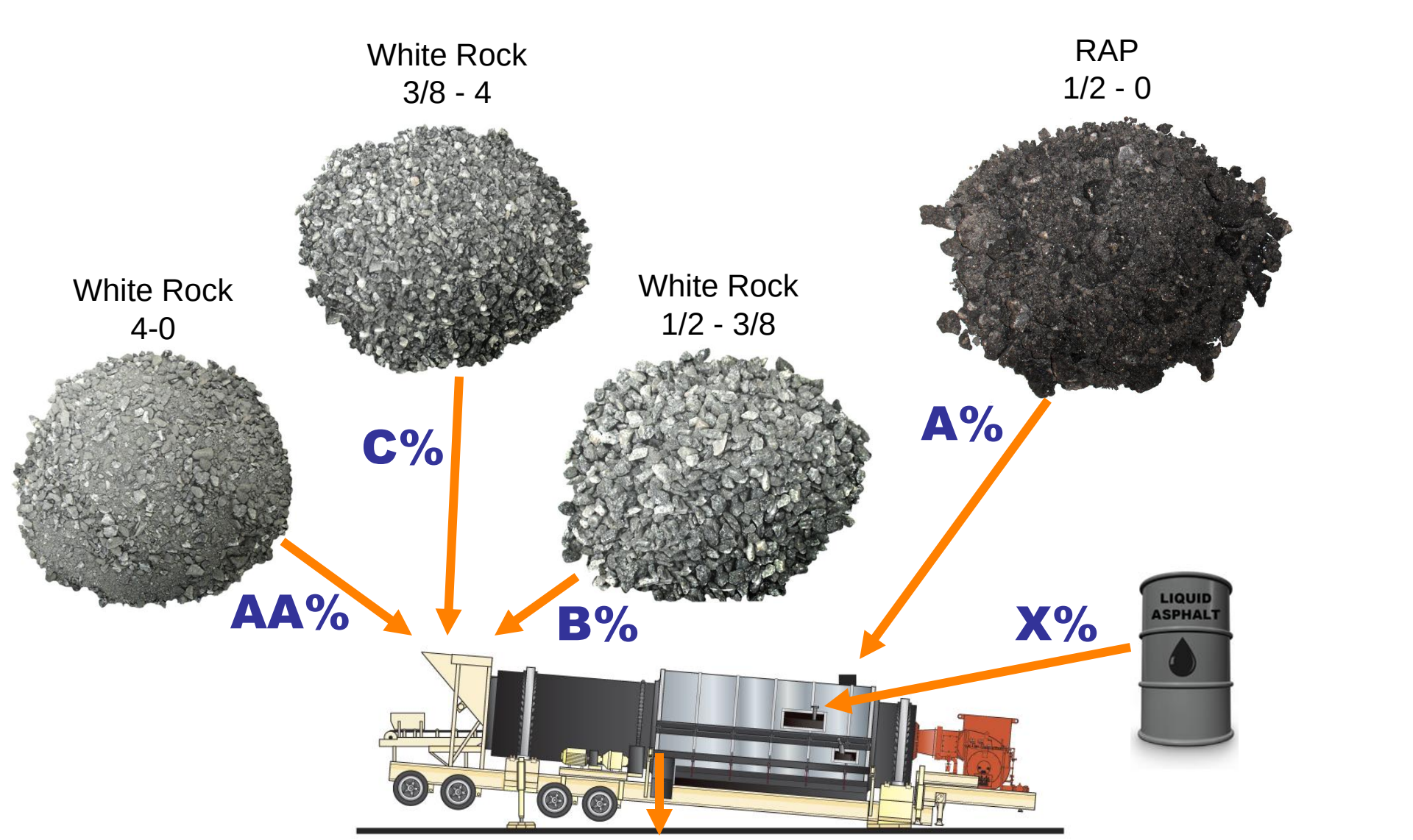
RAP

Virgin Aggregate and RAP to Fifth Bin

Batch Plant with Double RAP Dryer



1980-1990's HMA Facility with Single RAP Bin



SUPERPAVE MIX WITH 1/2 RAP

Barriers to increasing the use of more Recycle

- **Meeting voids & asphalt content with Superpave Mix Design**
- **Meeting skid requirements**
- **Hardness of asphalt with high RAP - need to use softer virgin asphalt cement…fatigue cracking**
- **Special mixes like SMA**
- **Limit RAP to 15% when polymers are used**

Meeting Superpave Mix Design requirements

Controlling Air Voids and Asphalt Content = Controlling Segregation

1/2 x 0 (12mm x 0)

6% AC

1/2 x 4 (12mm x 6mm)

4% AC

4 x 0 (6mm x 0)

7% AC

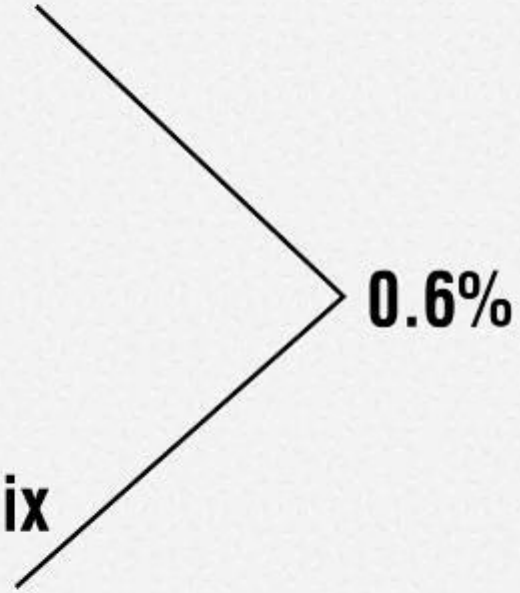
Surface Area

- 1 lb. of 3/8” (9mm) Aggregate = 1 sq. ft.
- 1 lb. of -200 mesh = 150 sq. ft.

Liquid Asphalt coats Surface Area

@ 20% RAP Coarse AC Contribution to Mix

= 0.20 x 4% = 0.8%



Fine AC Contribution to Mix

= 0.20 x 7% = 1.4%

@ 40% RAP Coarse AC Contribution to Mix

= 0.40 x 4% = 1.6%

Fine AC Contribution to Mix

= 0.40 x 7% = 2.8%

1.2%

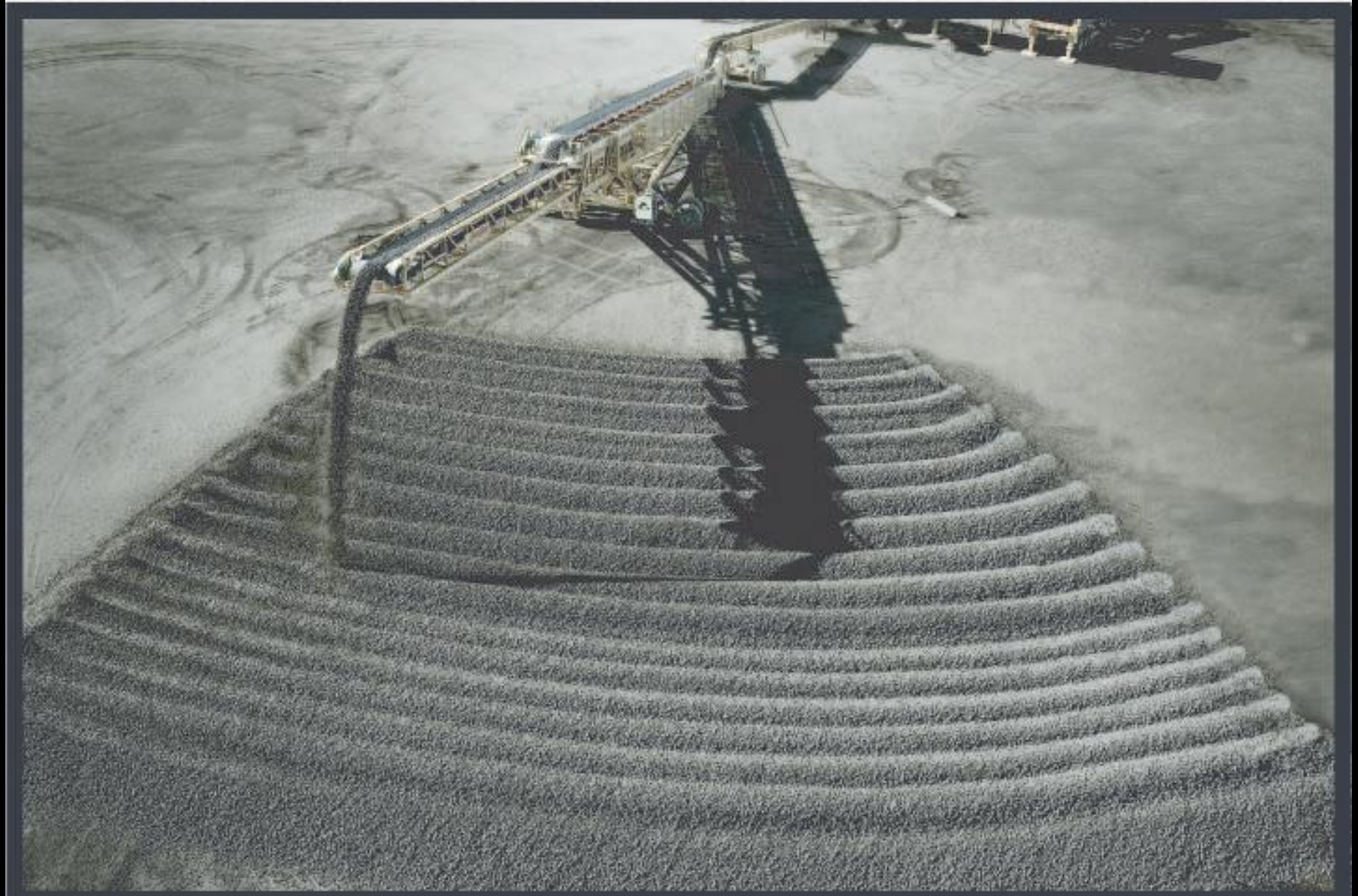
Rutting Often Occurs in Older Overlay Pavements


Blaw-Knox
UltiMat

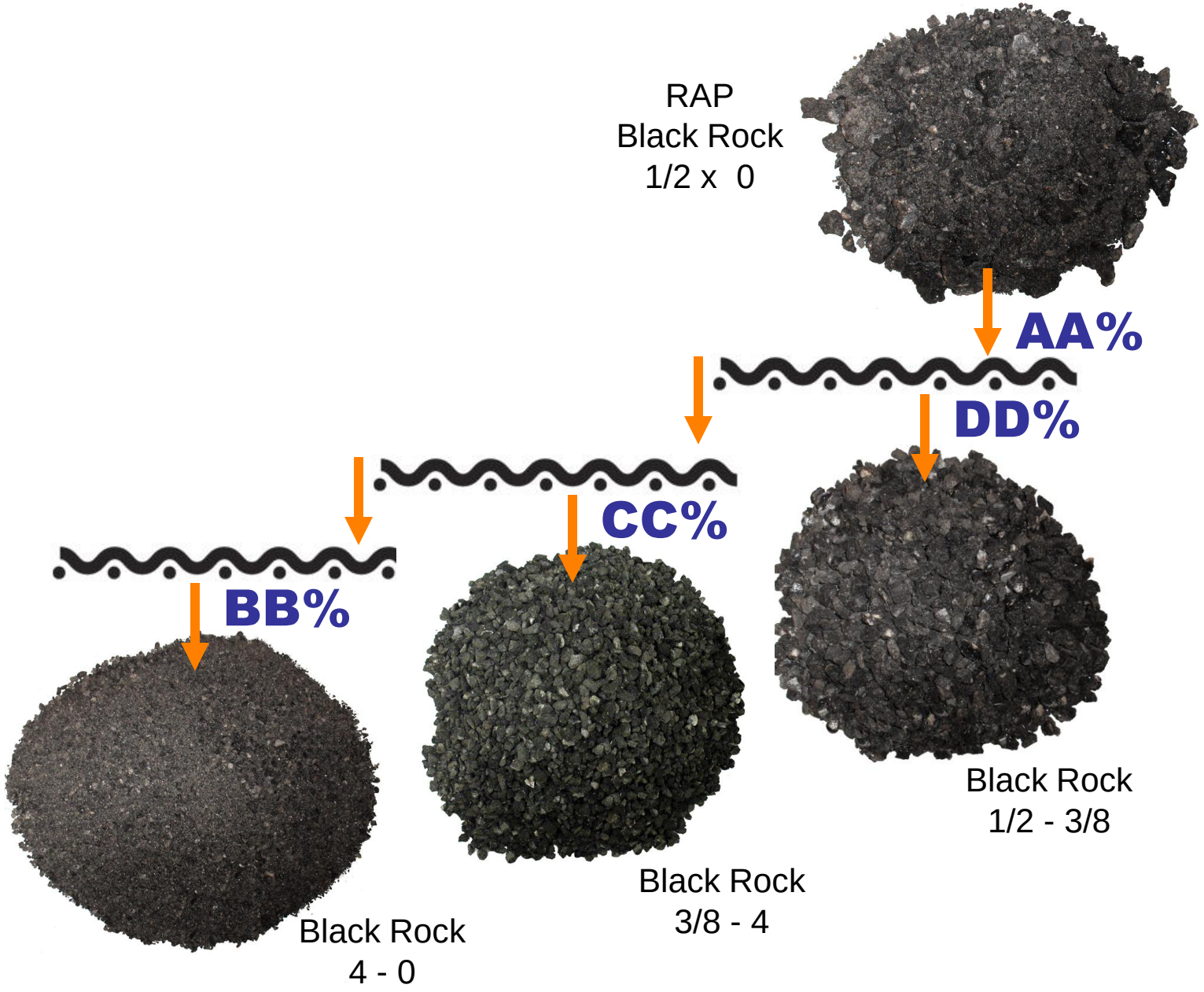
End of Load Segregation

Rock Quarry

Oil Well



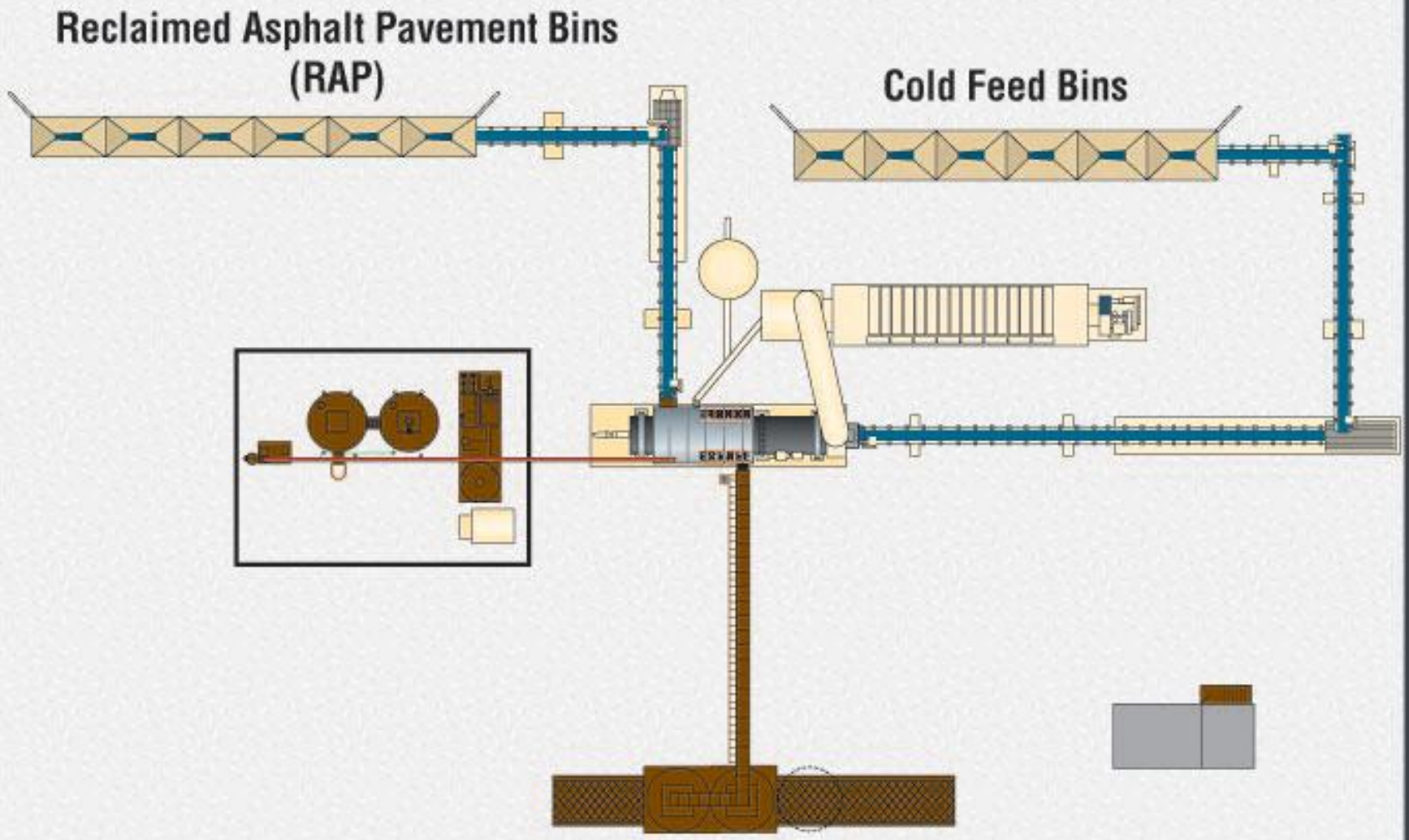
Telescoping Stacker



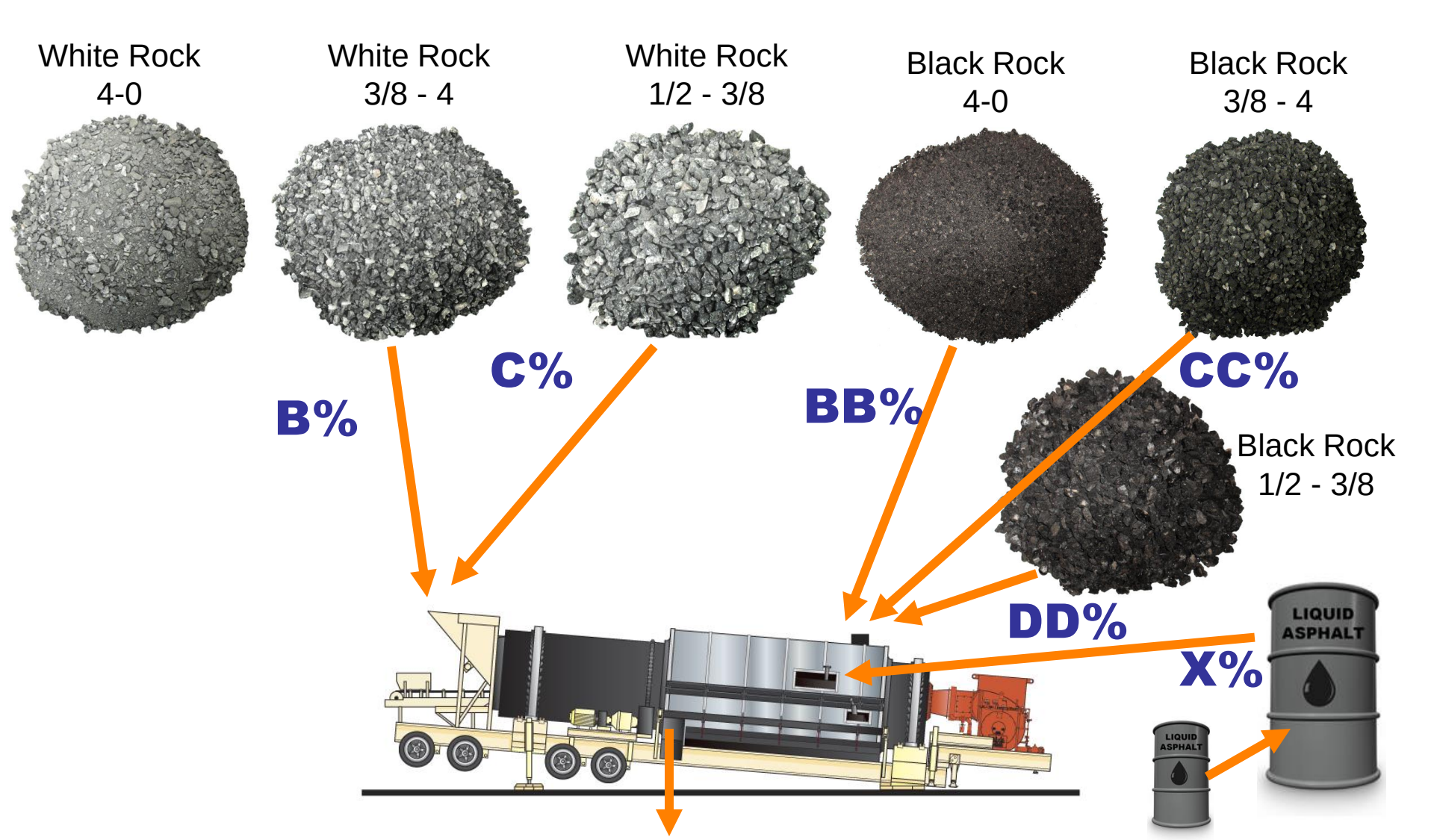
PROCESSED RAP SCREENED TO ORIGINAL INGREDIENTS

Track-Mounted Crusher with Screen


2007 6 7



Today's HMA Facility with Multiple RAP Bins



SUPERPAVE MIX WITH PROCESSED RAP - CHOICE #2

Use of RAP for High Traffic Surface Mixes

- **Is RAP made from skid resistance aggregate?**
  - **Yes! - No problem**
  - **No! - By fractionating RAP the minus ¼", it can be used in any mix since aggregates finer than ¼" do not effect skid numbers**

White Rock
4-0

White Rock
3/8 - 4

White Rock
1/2 - 3/8

Black Rock
4-0

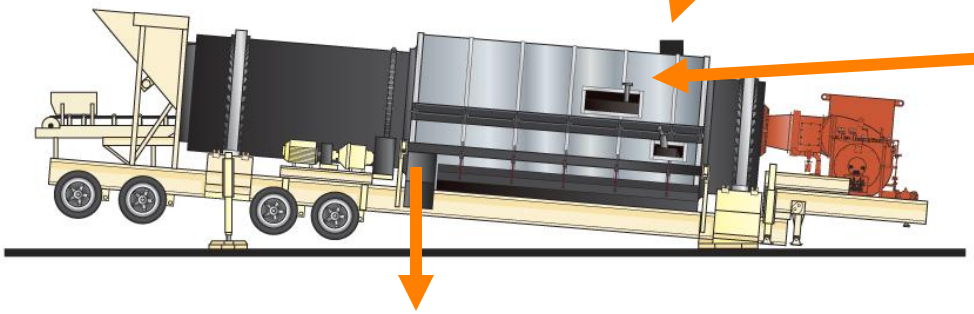
Black Rock
3/8 - 4

B%

C%

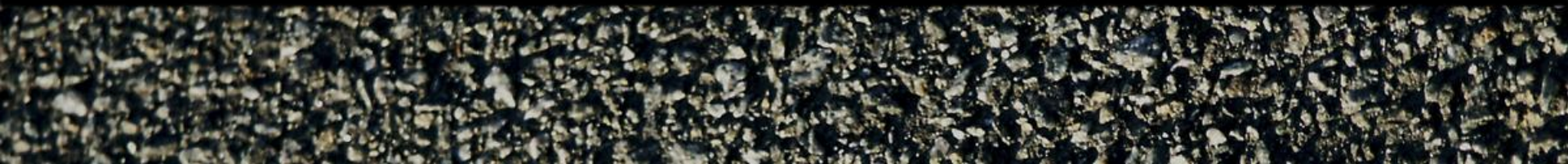
BB%

Black Rock
1/2 - 3/8



X%

SUPERPAVE MIX WITH PROCESSED RAP - CHOICE #1



Should we use softer binder with high RAP?

Should the RAP be limited to no more than 15% when using Polymers?

NCAT Test Track RAP Sections

1. **virgin control mix with PG 67-22**
2. **20% RAP with PG 67-22 virgin binder**
3. **20% RAP with PG 76-22 virgin binder**
4. **45% RAP with PG 52-28 virgin binder**
5. **45% RAP with PG 67-22 virgin binder**
6. **45% RAP with PG 76-22 virgin binder**
7. **45% RAP with PG 76-22 + Sasobit**

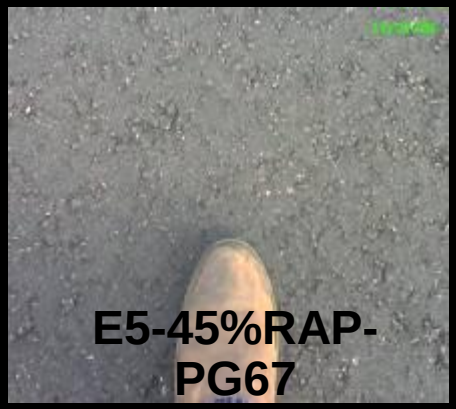
All sections were placed as a 2” mill and fill on existing sections

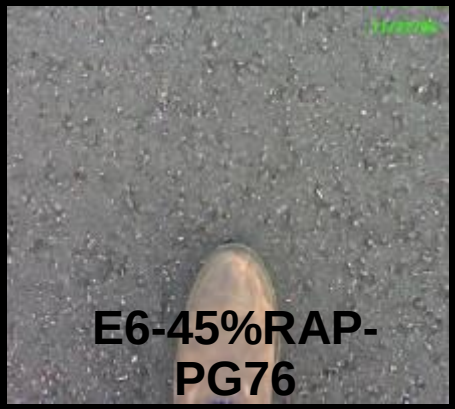

N5-0%RAP-PG67


W3-20%RAP-
PG76


W4-20%RAP-
PG67

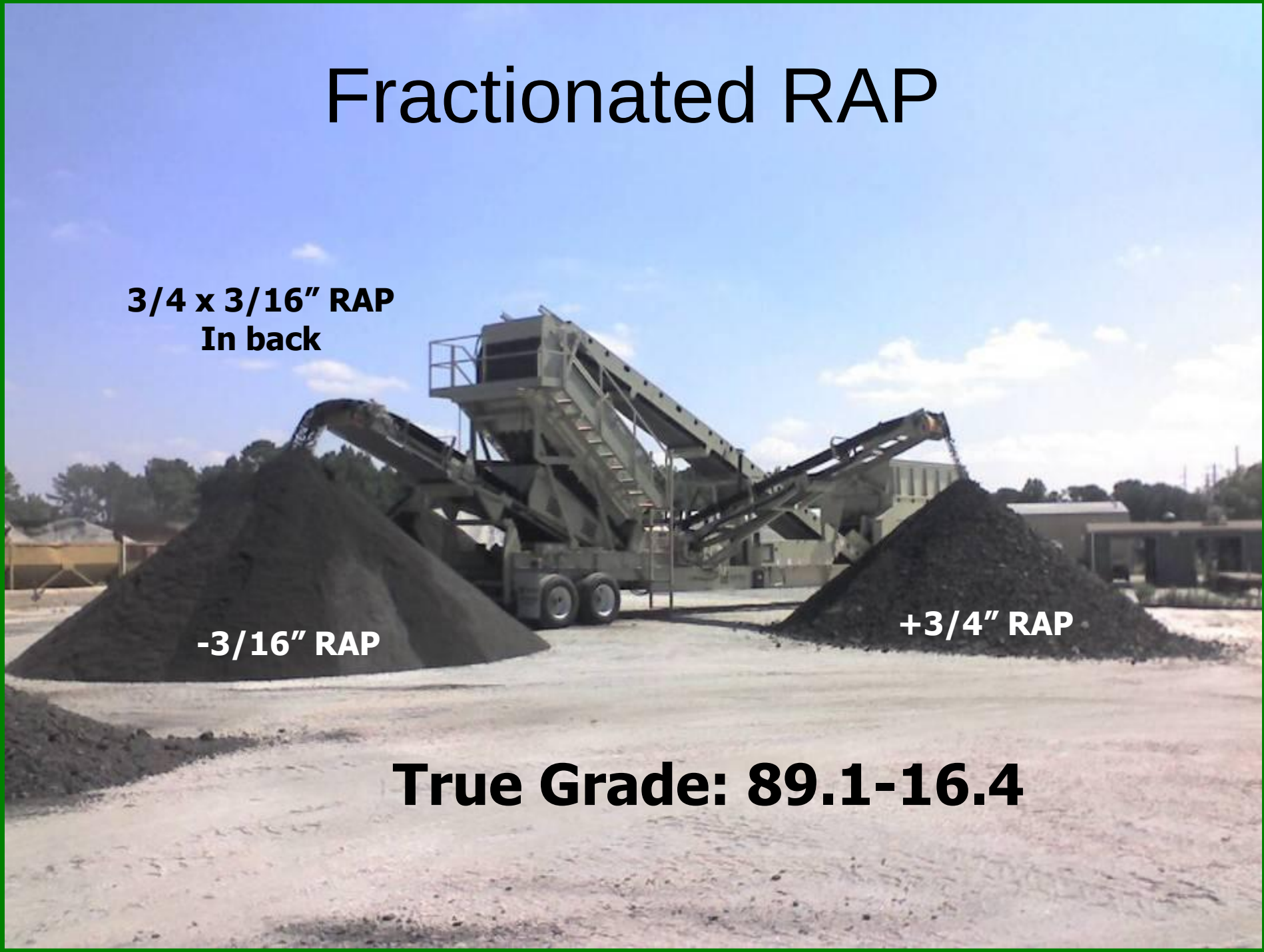

W5-45%RAP-RA500


E5-45%RAP-
PG67

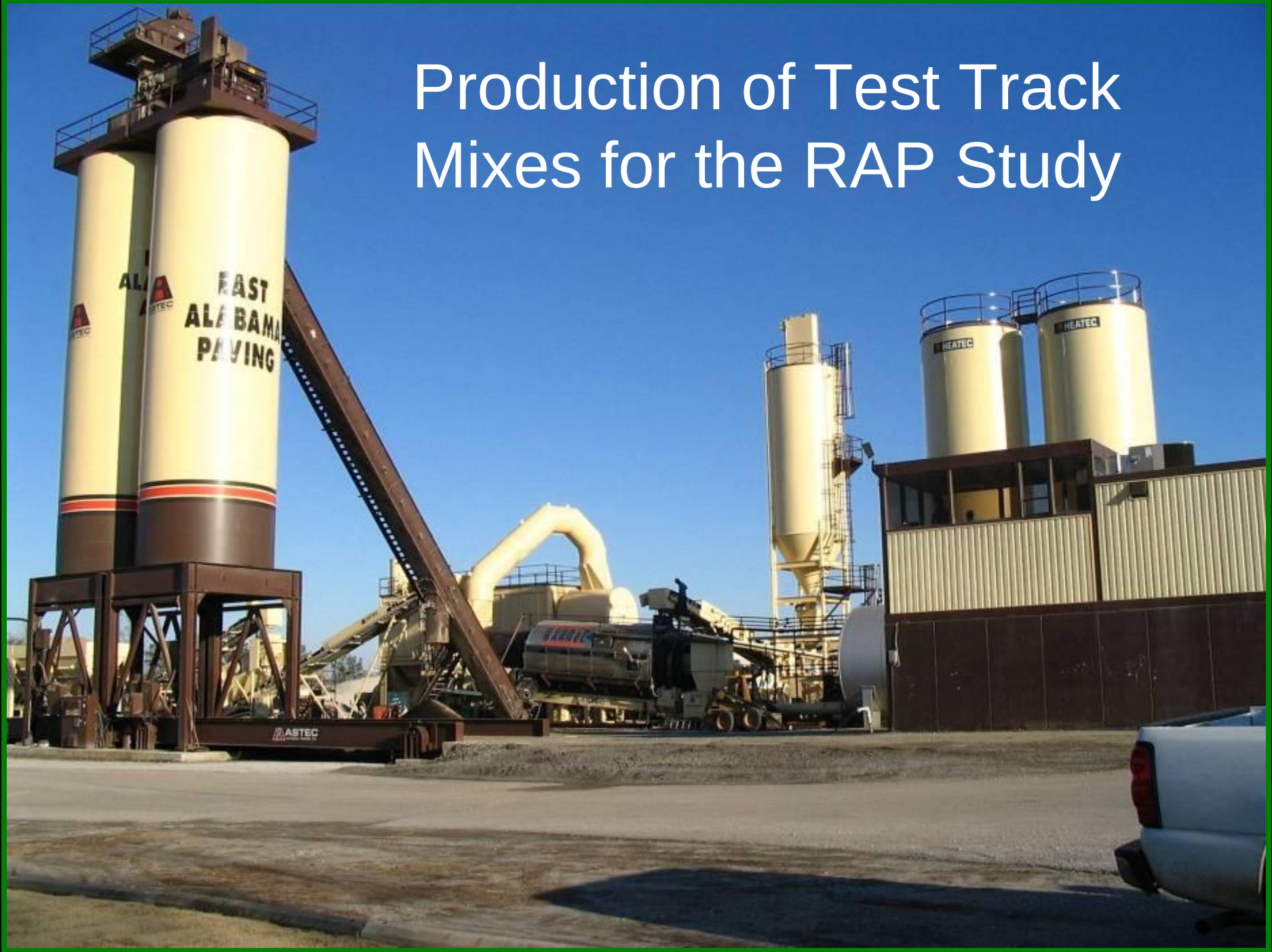

E6-45%RAP-
PG76


E7-45%RAP-
PG76s

Fractionated RAP



True Grade: 89.1-16.4



Production of Test Track Mixes for the RAP Study

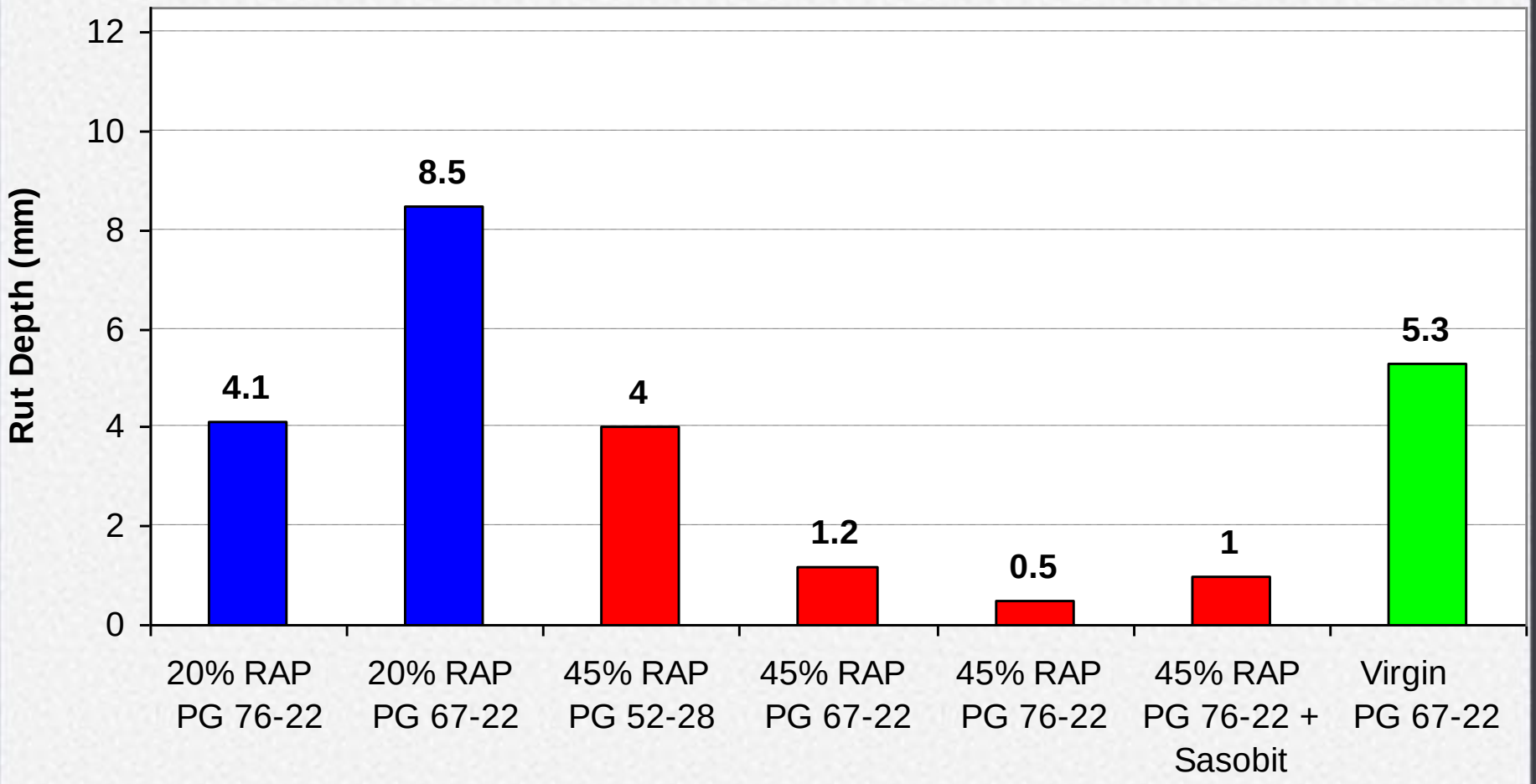
Recycled Mix Production

Predicted and Recovered Binder Grades

Section	%RAP[1]	%RAP Binder[2]	Virgin Binder		Virgin Binder + RAP	
			PG Grade	True Grade	Predicted Grade	Recovered Grade
W3	20%	18.2%	PG 76-22	78.1 -23.8	80.1 -22.4	78.1 -30.3
W4	20%	17.6%	PG 67-22	68.4-31.2	72.0 -28.6	74.2 -29.7
W5	45%	42.7%	PG 52-28	54.7-32.8	69.4 -25.8	74.1 -30.2
E5	45%	41.0%	PG 67-22	68.4-31.2	76.9 -25.1	80.9 -26.2
E6	45%	41.9%	PG 76-22	78.1-23.8	82.7 -20.7	85.5 -25.7
E7	45%	42.7%	PG 76-22 +1.5% Sasobit	83.2 -20.6	85.7 -18.8	86.3 -24.3
N5	0%	0%	PG 67-22	68.4-31.2	68.4 -31.2	71.1 -32.4

Test Section Construction

Rutting Performance @ 10 M ESALs



E7 45% RAP PG76-22+Sasobit

Cracking first noted in E7 in January 2008

Estimated Price Differences Compared to Virgin Mix with PG 67-22

Based on $10 Agg., $400 neat asphalt, $585 polymer asphalt, $9 RAP

- **20% RAP with PG 67-22…… -14.9%**
- **20% RAP with PG 76-22…… +11.3%**
- **45% RAP with PG 52-28…… -36.2%**
- **45% RAP with PG 67-22…… -41.4%**
- **45% RAP with PG 76-22…… -11.9%**
- **45% RAP with PG 76-22 + Sasobit… -1.0%**

Will high RAP in surface mix effect the Life of the Pavement?

Yes…It will

- **Reduce rutting and**
- **Give at least as long life in fatigue**

Substitute 50% RAP for 4% polymers can achieve practically the same results

Changing the grade of liquid when RAP increases…WHY?

- **To obtain density in mix**
- **"Is this beneficial or necessary?"**
  Perception has been that it is necessary to extend pavement life

With Warm Mix (hot foam), we can achieve density without changing grades at 50% RAP

Foam Liquid Asphalt
How much water?

1 ton mix – 2,000 lb.

20 cu ft. (25% void or 5 cu. ft.)

5.3% liquid – 106 lb.

Volume of liquid – 1.63 cu. ft.

1 lb. H_2O when converted to steam = 30 cu. ft.

Expansion - $\frac{30}{1.63} = 18$

However only room for 5 cu. ft.

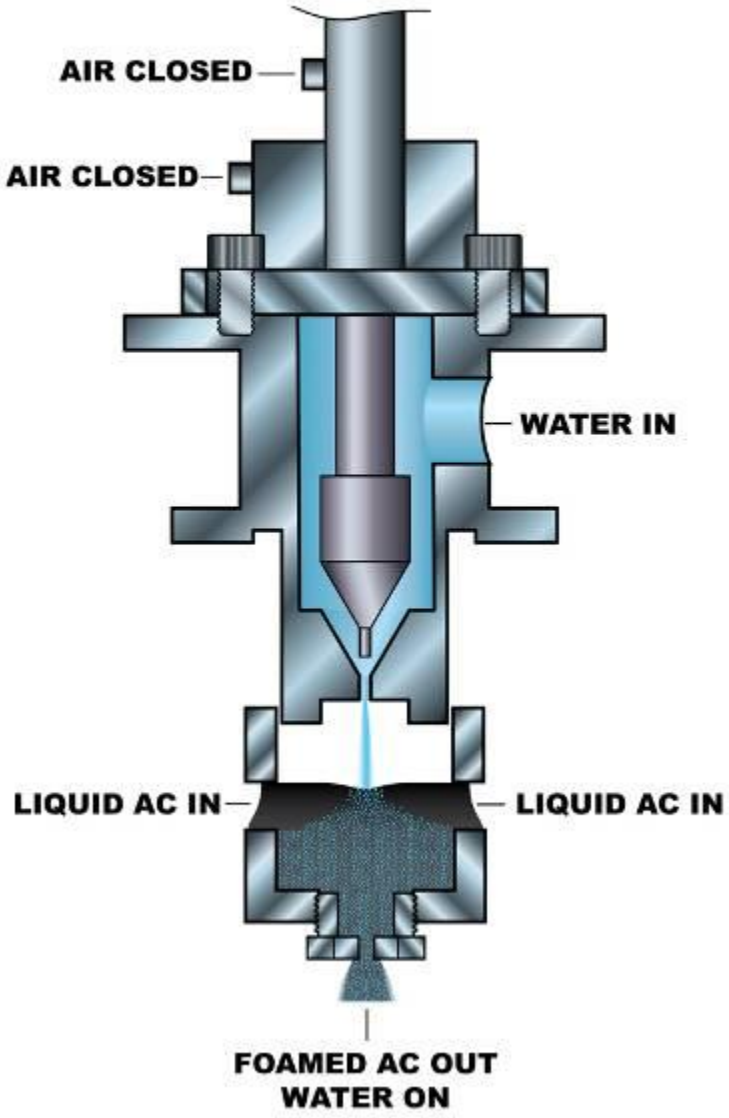
Therefore only 1/6 lb. of H_2O ends up in foam

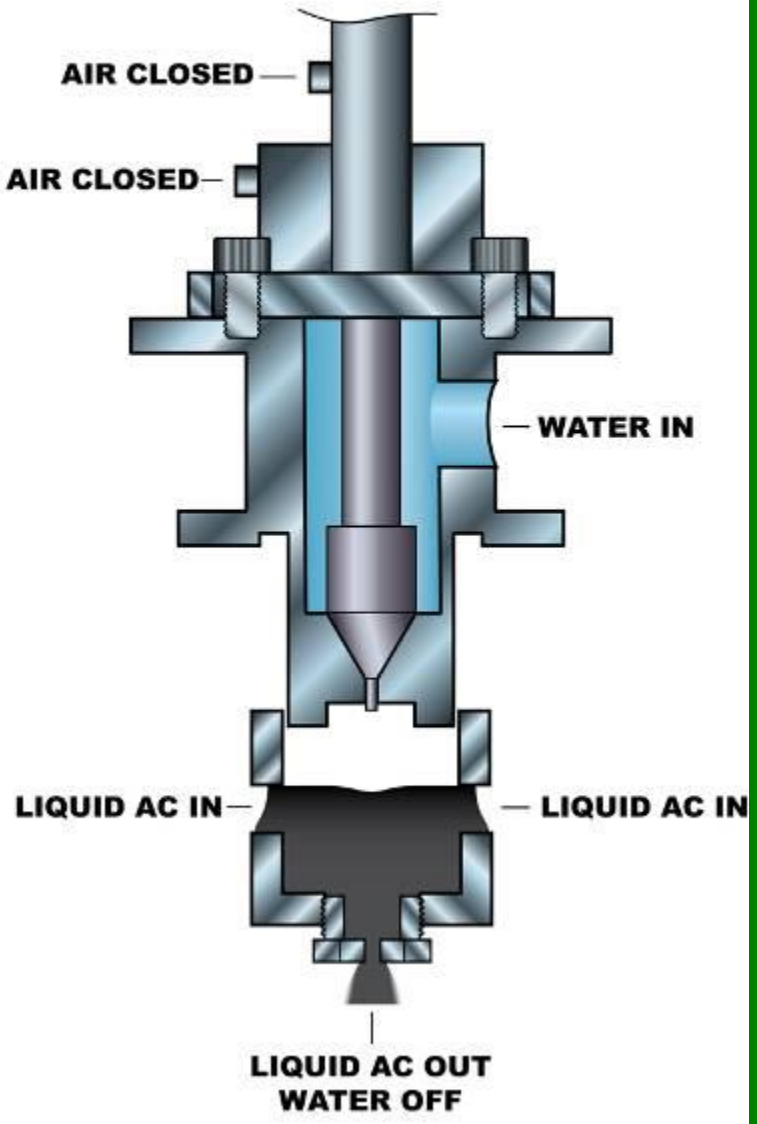
AFTER COMPACTIONS

Air voids = 5% or 1 cu. ft.

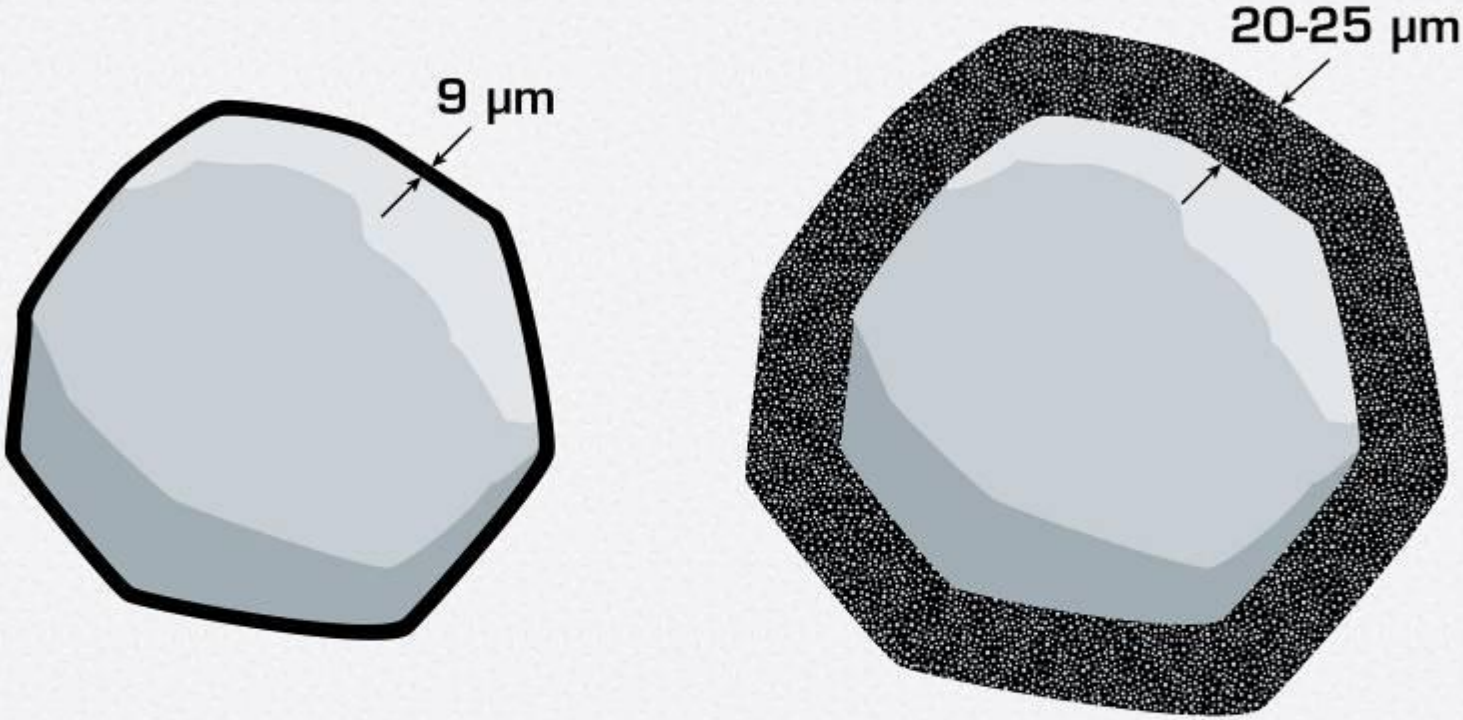
Therefore only 1/30 lb. of H_2O remains in liquid

DOUBLE BARREL GREEN® SYSTEM NOZZLE

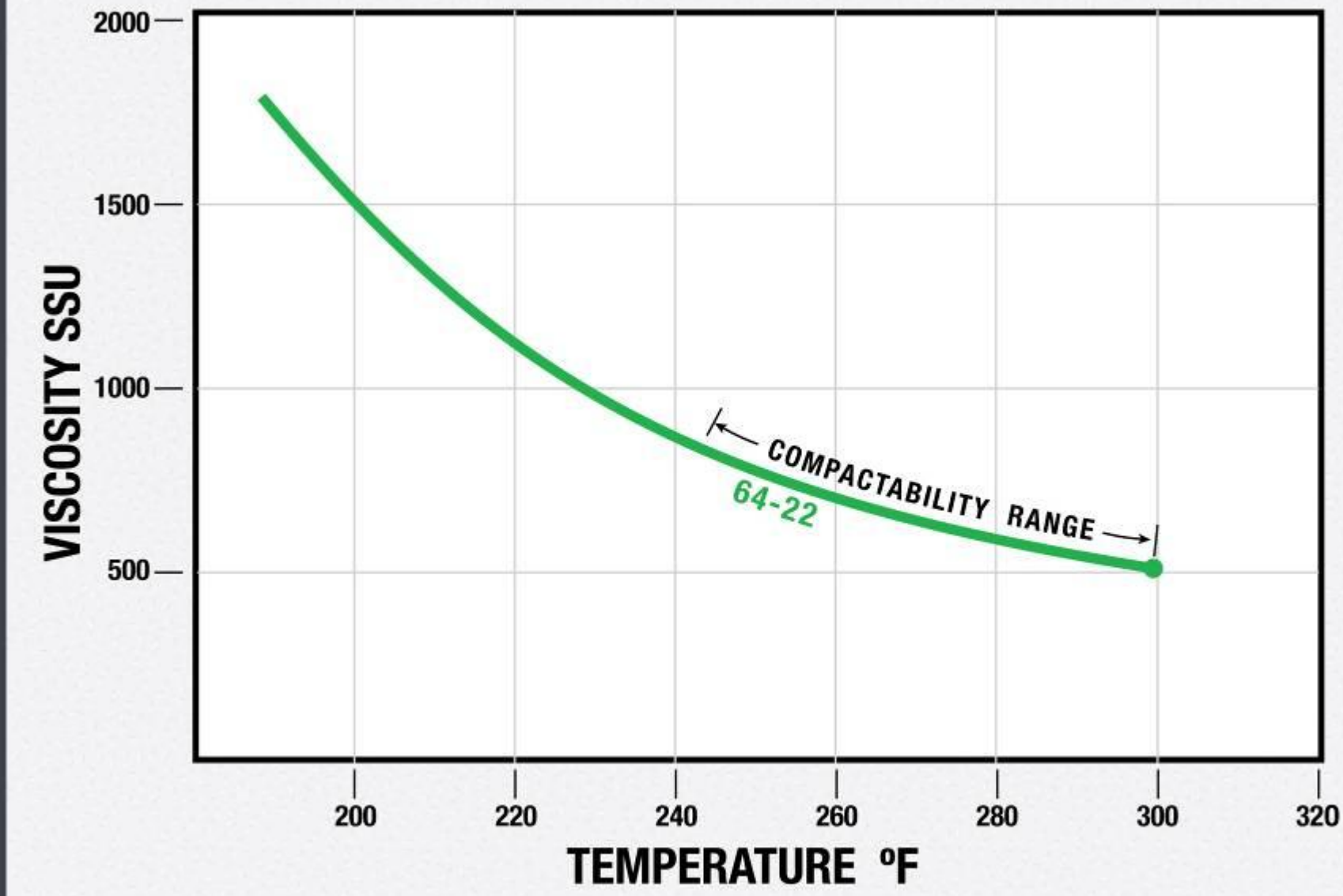




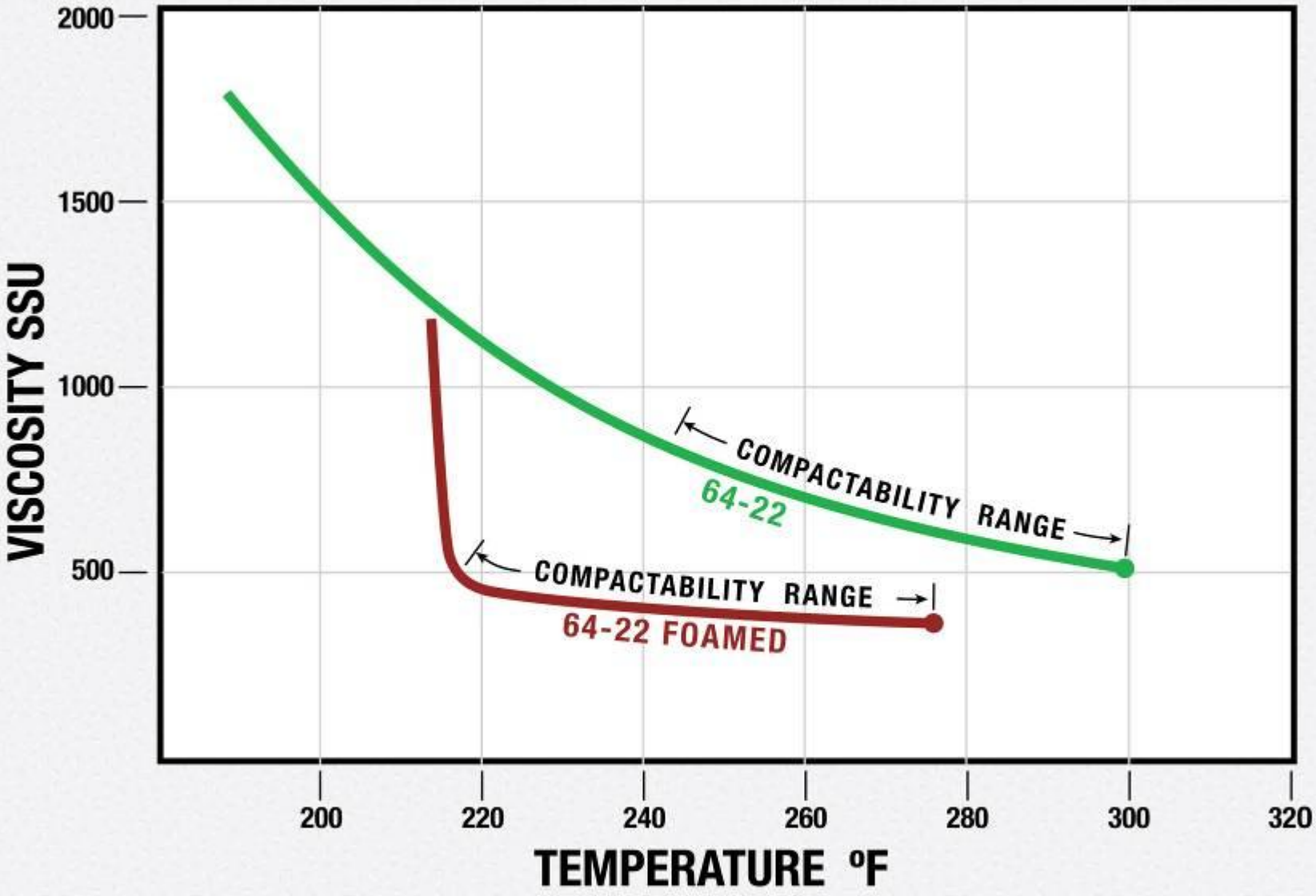
G2 GREEN SYSTEM



COATING THICKNESS



VISCOSITY / TEMPERATURE PG 64 -22 (Approx.)



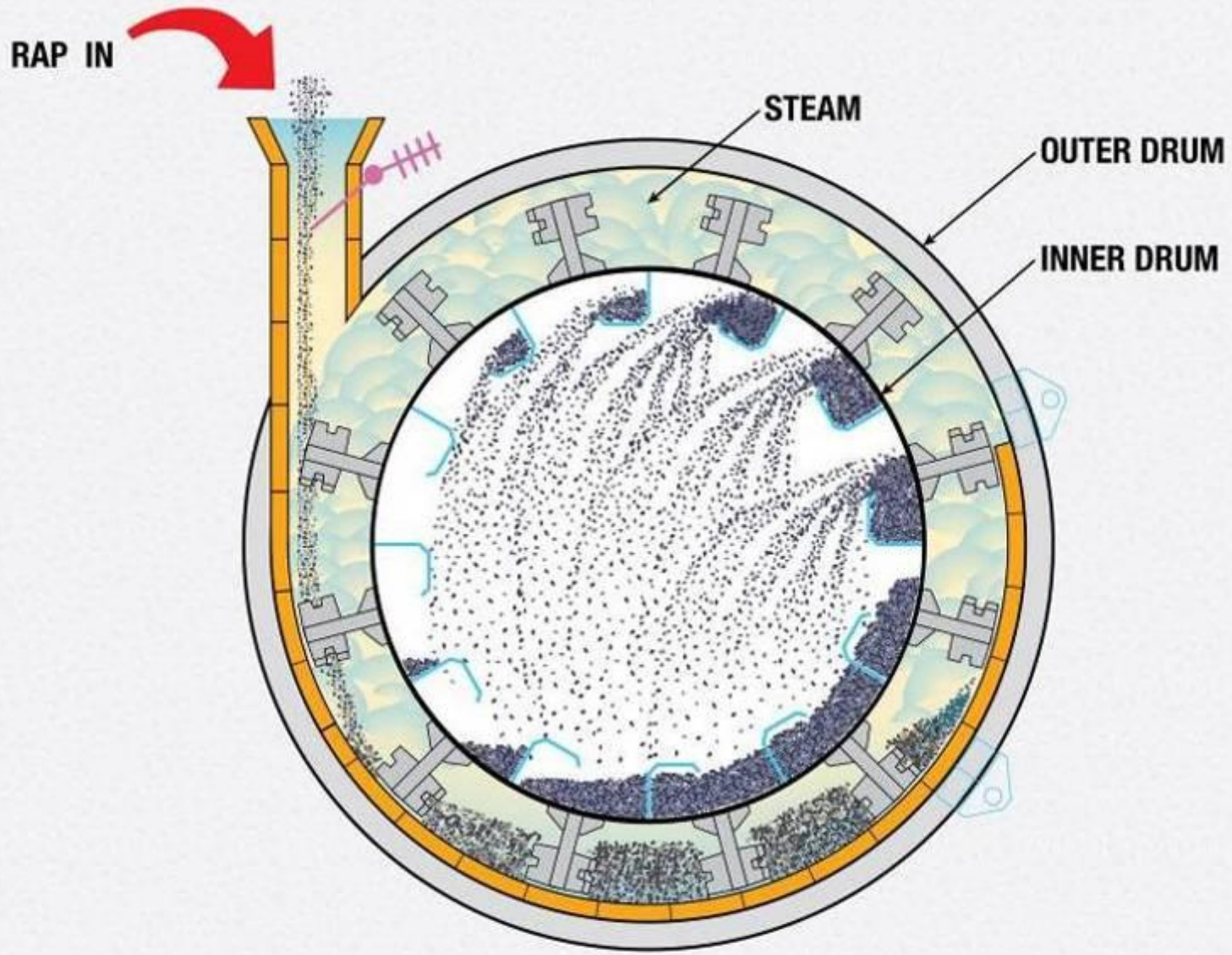
VISCOSITY / TEMPERATURE PG 64 -22 (Approx.)

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**

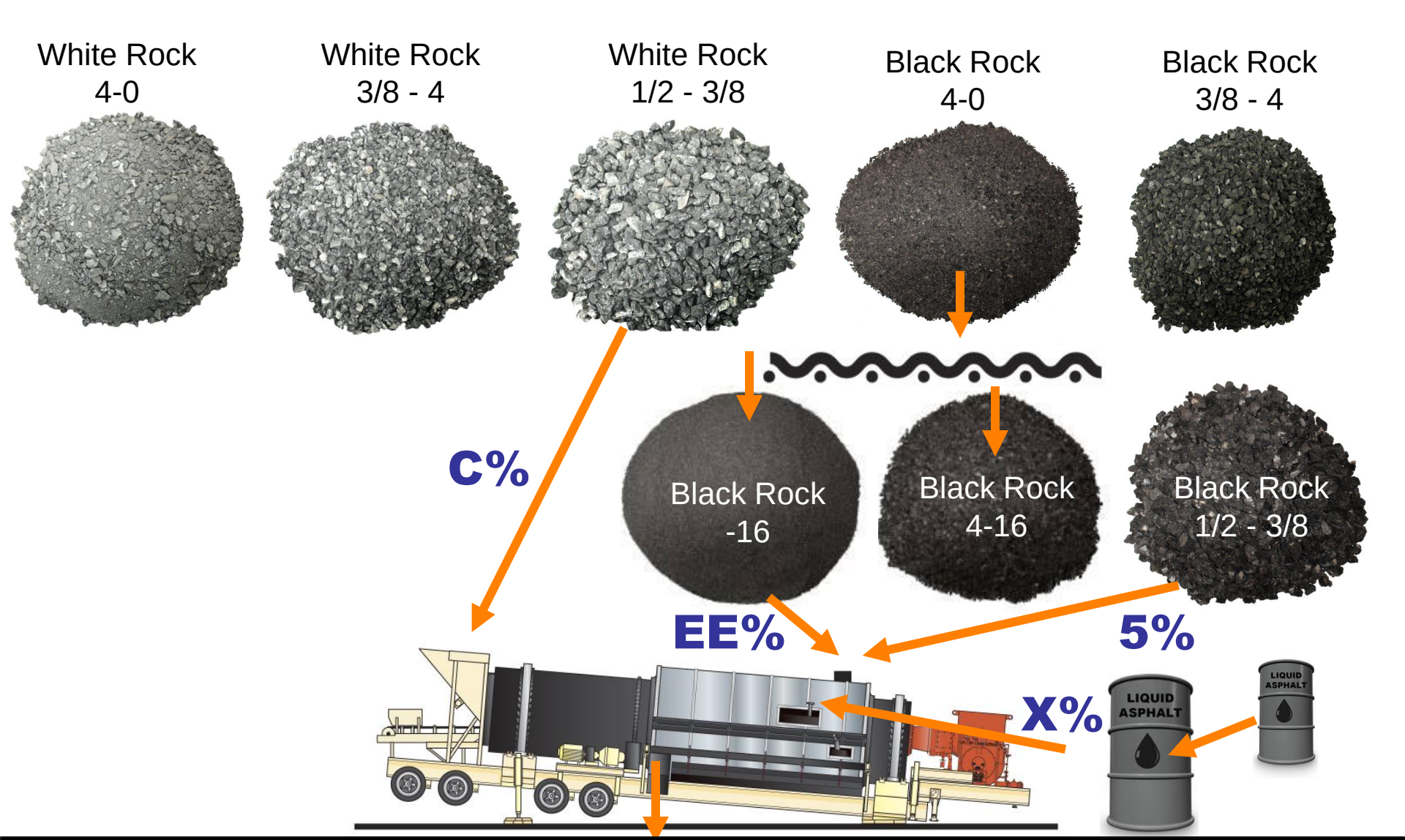
High Percentage Recycle Mix with Standard Grade of Asphalt

- **To achieve compaction (density)…run 275ºF and foam virgin liquid**
- **By using a standard liquid 64-22, you produce a much softer product than with virgin mix due to:**
  - **Lower temperature results in less oxidation**
  - **Light oil remains in liquid**
  - **Steam produced from drying the RAP creates an inert atmosphere**



RAP GENERATES STEAM IN OUTER DRUM

Can RAP be used in SMA mixes?



SUPERPAVE MIX WITH PROCESSED RAP - CHOICE #3

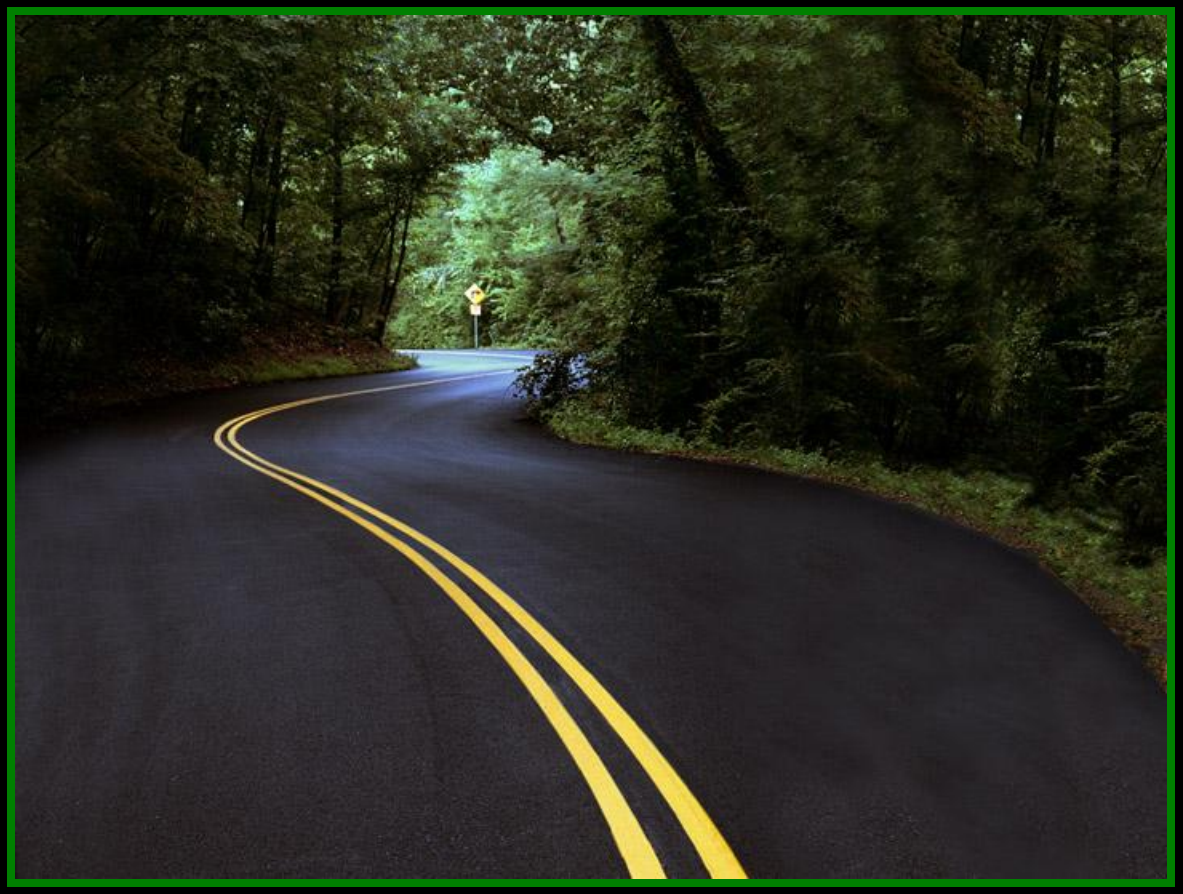
Benefits of High RAP & Warm Mix

For the Producer/Contractor

- Improved Workability
- No Smoke – No Smell
- High Percentage Recycle Mix with Standard Grade of Asphalt
- 14% Less Fuel
- 14% Higher Production
- Reduces Cost

For the Worker

- **Comfort & Safety**



For the DOT/Public

- Comfort & Safety of workers
- Improve Mixes

Why will we have a Longer Life Pavement?

- Less oxidation of mix
- More uniformity of compaction
- With fractionating RAP…more uniform

Is Warm Mix more Moisture Susceptible?

Mix Comparison From Franklin Plant

- 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%

Mix Comparison From Danley and Murfreesboro Plant

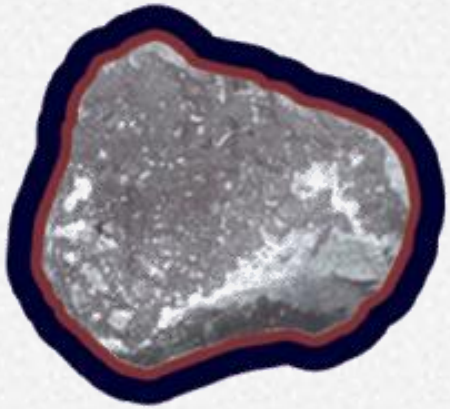
- Astec Green System
- 775 Tons Placed
- % AC 5.19 & 5.29
- % Air Voids 4.0
- Stability 2200
- TSR 84.3%
- Density 91.6%

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

Longer Life

VIRGIN
AGGREGATE

HARDER LIQUID
TRANSFERRED FROM
RAP PREVENTS
STRIPPING

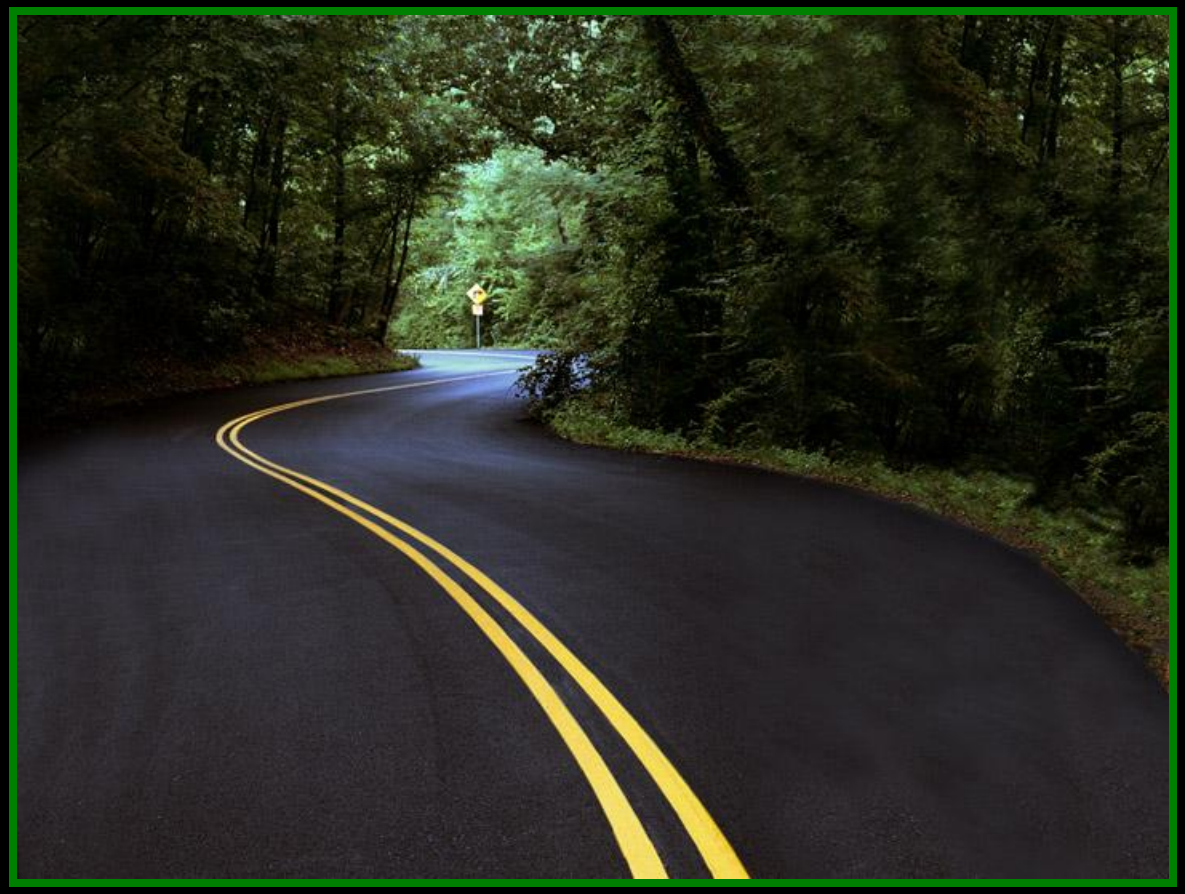


NEW
HOT FOAM AC
HELPS DURABILITY

Moisture Susceptibility

Mix Type	Average Air Void Content Dry (%)	Dry Indirect Tensile Strength (kPa)	Average Air Void Content Conditioned (%)	Conditioned Indirect Tensile Strength (kPa)	Tensile Strength Ratio (%)
Virgin	7.2	806.7	7.2	625.2	**77.5**
15% RAP	6.5	878.1	6.5	769.5	**87.9**
15% RAP / 5% MSM	6.8	985.1	6.5	818.6	**83.1**
50% RAP	7.2	1166.2	7.1	1124.7	**96.4**

- **ASHTO T-283**
- **Aggregate temperatures >200°C**
- **Aggregate moisture contents 0.04% - 0.1%**
- **Mix moisture contents <0.1%**

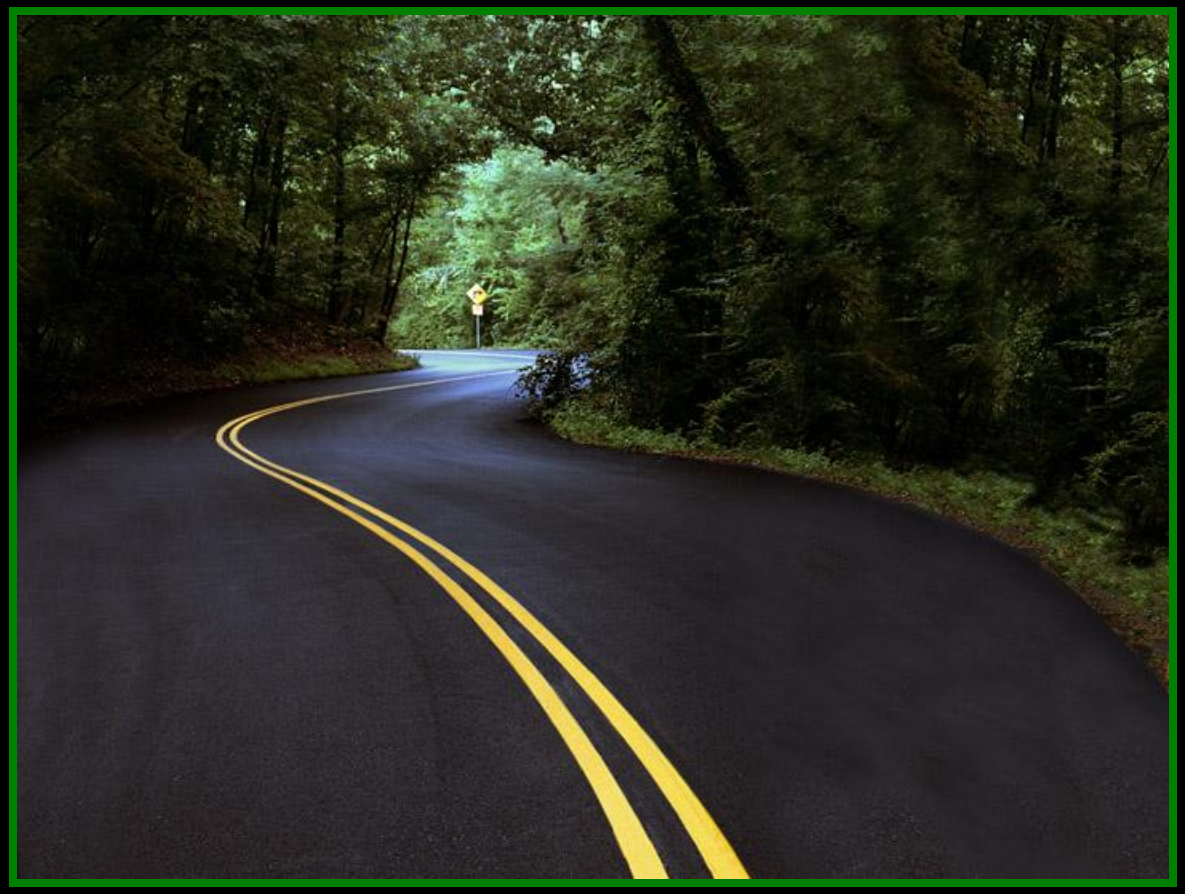


For the DOT/Public

- Comfort & Safety of workers
- Improve mixes
- Sustainability

Why Sustainability?

- By Milling & Recycling – 100% of the material can be re-used
- Reduce new aggregate requirement by 245,000,000 tons/year…annually (from 15% to 50%)
- Reduce oil consumption by 80,000,000 bbl/year…approximately 7 days of imported oil

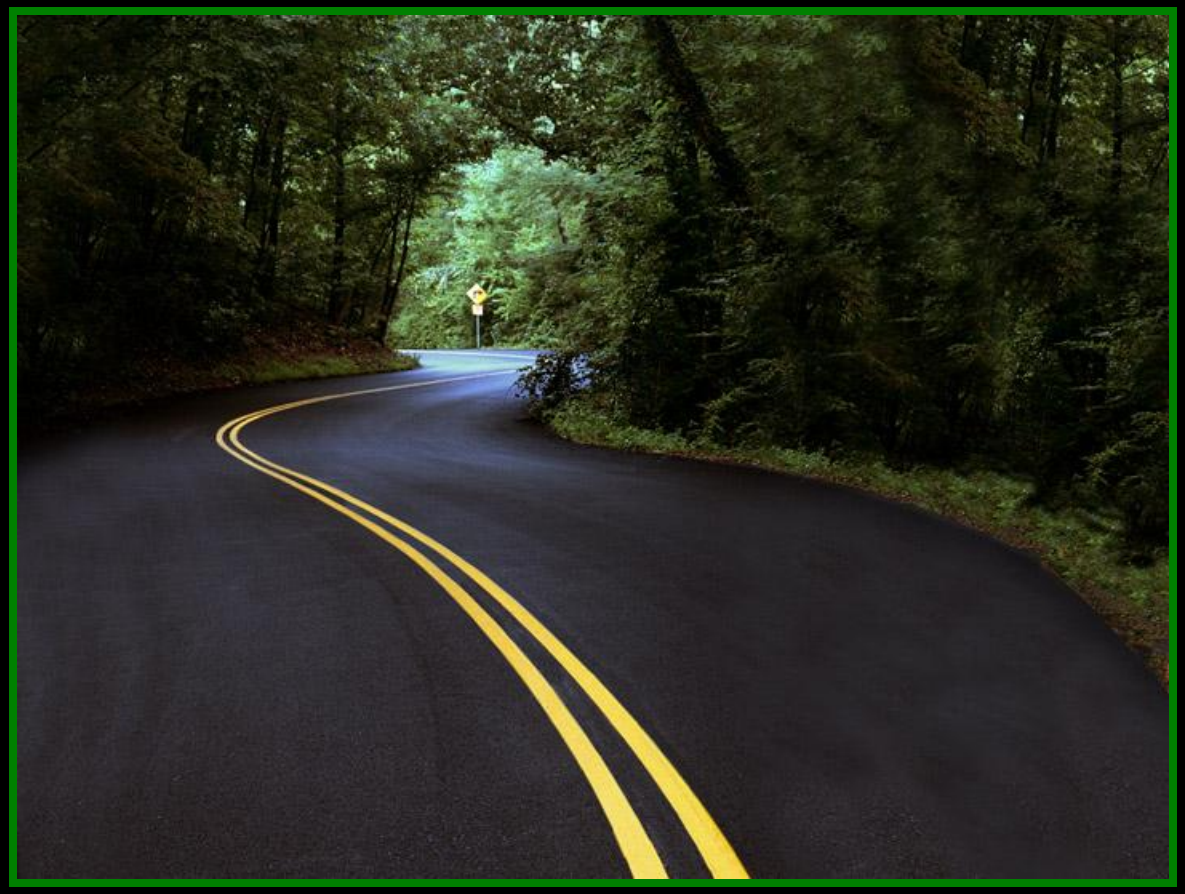


For the DOT/Public

- Comfort & Safety of workers
- Improve mixes
- Sustainability
- Green

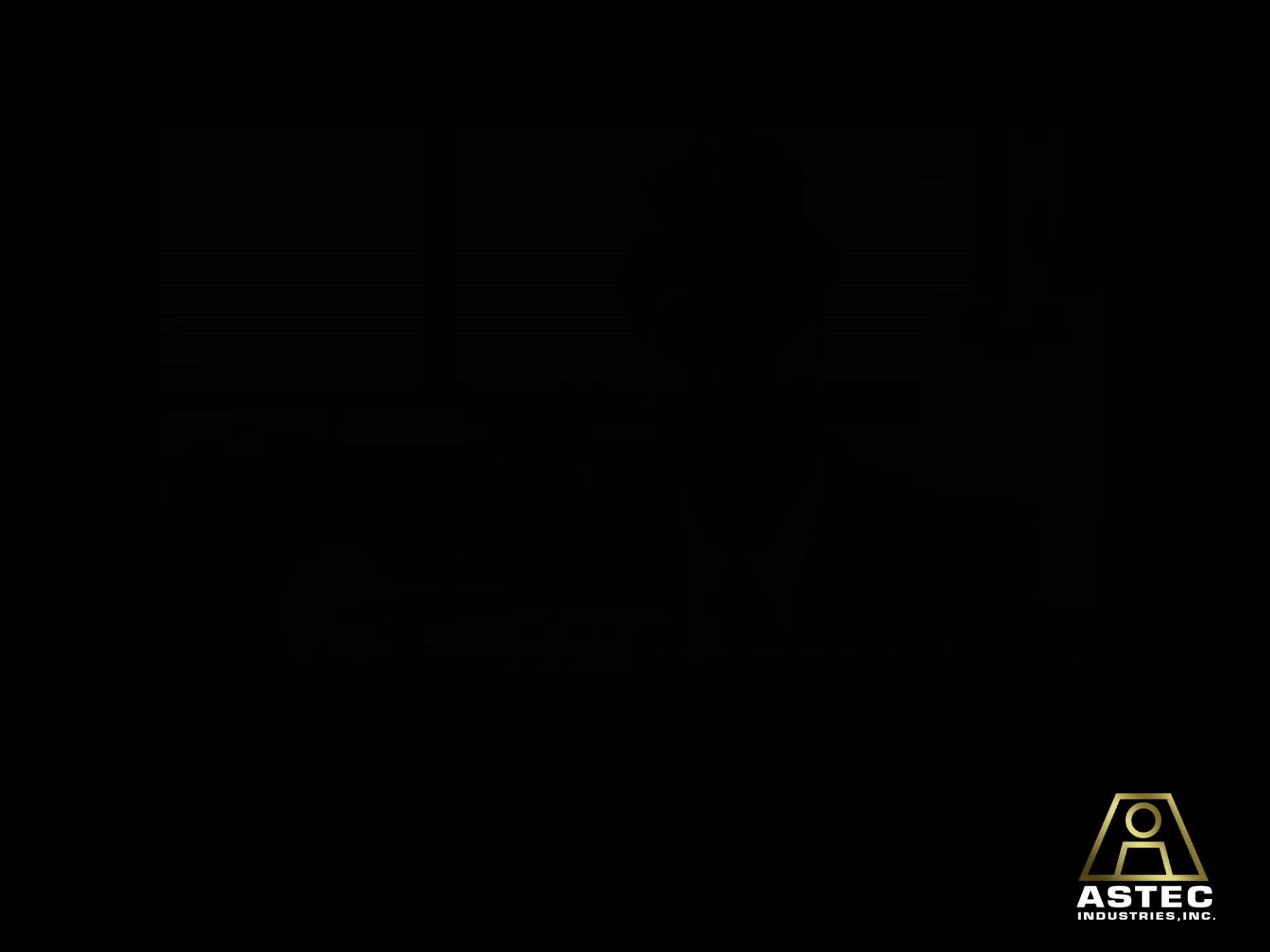
It's Green!

- Use 14% less fuel due to 50°F lower temperature
- No volatiles
- Use more recycle



For the DOT/Public

- Comfort & Safety of workers
- Improve mixes
- Sustainability
- Green
- Reduce Cost


ASTEC
INDUSTRIES, INC.

What we have done to date

- **Installed over 400 units to create hot foam mechanically … est. 600 units of all types operating in USA**
- **Produced more than 20 million tons from 20 to 50% RAP with warm mix**
- **Stored in silo for 4 days**
- **Produced 76-22 (Polymers) and placed at 270°F**
- **Produced rubber mix at 270°F**

Conclusions:

1. **HMA is 100% Recyclable**
2. **Milling corrects road profile, corrects drainage, eliminates raising shoulders and guardrails, and maintains bridge clearances…and generates RAP**
3. **By fractionating RAP and using Warm Mix (hot foam) with 50% RAP, it will produce a rut resistant, longer life pavement. It can be produced with a standard grade of AC. Density can be achieved with one less roller and centerline joint density is substantially improved**
4. **More miles can be paved at substantially less cost**
5. **Greenhouse emissions and imported oil are greatly reduced**