This booklet is intended primarily as a field manual to help a plant operator trouble shoot the hot-mix asphalt exhaust system with particular attention to ways and means of saving energy, either through lower horsepower on the fan motors, or through lower fuel consumption by the dryer burner.

First, take the time to review the following NAPA publications:

IS 43  “Good Housekeeping”
IS 52  “Operation and Maintenance of
IS 52A “Exhaust Systems in the Hot-Mix Plant”
IS 61  “Theoretical Computations of the Fuel used and the Exhaust produced in Drying Aggregates”

Next, become acquainted with the instruments in the “NAPA #24 Energy Analysis Kit”.
NAPA #24 Energy Analysis Kit

RS3 amprobe to determine motor amperage (See table on page 18 to convert to horsepower.)

Thermometer to relate gas temperature to motor amperage and static pressure readings (See table on page 6 to convert to 70° air.)

#1211-24 manometer to take static pressure readings and check resistance through Ductwork Elbows Collectors

Tachometer to check fan speed (RPM)
Typical check of a fan while running with venturi wet collector

Outlet Reading
+18.0′′ @ 200°F

Manometer

Inlet Reading
−6.0′′ @ 200°F

Tachometer

Fan located ahead of secondary collector.

AmpProbe
276 amps @ 200°F

Static pressure of a fan is the total of the inlet and outlet.
6.0′′ inlet
18.0′′ outlet
24.0′′ total S.P. @ 200°F

Note -
• High outlet S.P.
• High fan R.P.M.
• High motor amps
Typical check of a fan while running with baghouse

Note -
Same air volume but
• Less static pressure
• Slower fan speed
• Less horsepower

(All readings must be taken at duct wall.)
When checking motor amperage and taking static pressure readings, air temperature must be recorded. Fan performance tables are based on 70°F exhaust gas temperature. Therefore the actual temperature must be converted to 70°F.

To convert to 70°F air, use table below.

<table>
<thead>
<tr>
<th>TEMP.</th>
<th>FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>.87</td>
</tr>
<tr>
<td>20°</td>
<td>.91</td>
</tr>
<tr>
<td>40°</td>
<td>.94</td>
</tr>
<tr>
<td>60°</td>
<td>.98</td>
</tr>
<tr>
<td>70°</td>
<td>1.00</td>
</tr>
<tr>
<td>80°</td>
<td>1.02</td>
</tr>
<tr>
<td>100°</td>
<td>1.06</td>
</tr>
<tr>
<td>120°</td>
<td>1.09</td>
</tr>
<tr>
<td>140°</td>
<td>1.13</td>
</tr>
<tr>
<td>160°</td>
<td>1.17</td>
</tr>
<tr>
<td>180°</td>
<td>1.21</td>
</tr>
<tr>
<td>200°</td>
<td>1.25</td>
</tr>
<tr>
<td>225°</td>
<td>1.29</td>
</tr>
<tr>
<td>250°</td>
<td>1.34</td>
</tr>
<tr>
<td>275°</td>
<td>1.39</td>
</tr>
<tr>
<td>300°</td>
<td>1.43</td>
</tr>
<tr>
<td>325°</td>
<td>1.48</td>
</tr>
<tr>
<td>350°</td>
<td>1.53</td>
</tr>
<tr>
<td>375°</td>
<td>1.58</td>
</tr>
<tr>
<td>400°</td>
<td>1.62</td>
</tr>
</tbody>
</table>

If the stack temperature is over 300°F you’re wasting excessive heat and fuel to the atmosphere.

Examples:

- 7.5'' sp @ 250°F × 1.34 (Factor) Becomes 10.0'' sp @ 70°F
- 75 amps @ 250°F × 1.34 (Factor) Becomes 100 amps @ 70°F
“HOT” air makes for happy motors

When air is cold the fan motor works harder.

When the air is hot life becomes a joy for the fan motor.

The reason: Each cube of 250° air weighs less than each cube of 70° air.
One cfm @ 600° weighs one half of one cfm @ 70°.

When air is heated it expands.

One cfm @ 70° becomes two cfm @ 600°.

The weight remains the same.
With each revolution, a fan wheel moves a specified volume of air regardless of temperature.

A fan wheel is similar to a shovel.

If a fan will move 1000 cfm @ 70°

1000 cfm @ 70°

becomes

it will also move 1000 cfm @ 600°

2000 cfm @ 600°

but since air @ 600° weighs just half as much as it does @ 70°, it requires just half the horsepower.
Summation of the three fan laws

Two-four-eight.
What should we appreciate?

When you double the exhauster speed (rpm)
"WATCH OUT"

Twice the rpm means 2 times the cfm,
4 times the sp, and 8 times the hp.
As an operator of a plant more and more of your time is being devoted to fine tuning the asphalt plant air system. Closely related however is the proper use of energy throughout the whole plant. The #24 Static Pressure Kit and this booklet have been put together to make your job a little easier, and to encourage you to obtain the data needed to analyze areas of energy savings.

With the #24 Static Pressure Survey Kit you can trouble shoot an air system to determine:

1. Resistance in undersized duct.
2. Resistance in sharp turning elbows.
3. Resistance across dry & wet collectors (also referred to as pressure drop.)
4. Static pressure of fans. (see page 3)
5. Blockage of any sort in ductwork or collectors.
6. Dryer draft problems
7. Fugitive system problems
9. Stack exhaust temperatures.  
   (Will vary with gradation & burner setting)

If you do not have good dryer draft, and if there is no other blockage or leaks in the ductwork, then you may need a larger exhauster or if the manufacturers recommendation allows it, more fan speed to increase system gas volume.

Since a fan is constructed to withstand a certain centrifugal force, great care must be taken to assure the stability of the fan at the higher speed.

1. Check the motor amps to determine if there is horsepower to spare.
2. Be aware that a slight increase in fan speed requires a much greater increase in horsepower. (See next page.)
3. Make sure the fan is strong and smooth running.
4. Digest the material in this booklet and other NAPA publications before attempting a sheave change.
Conversion factors for the determination of fan rpm, static pressure (sp), and horsepower (hp) for changing the air volume through an exhaust system.

<table>
<thead>
<tr>
<th>% CHANGE</th>
<th>CFM</th>
<th>RPM</th>
<th>SP</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 40%</td>
<td>.6</td>
<td>.6</td>
<td>.4</td>
<td>.2</td>
</tr>
<tr>
<td>- 30%</td>
<td>.7</td>
<td>.7</td>
<td>.5</td>
<td>.3</td>
</tr>
<tr>
<td>- 20%</td>
<td>.8</td>
<td>.8</td>
<td>.6</td>
<td>.5</td>
</tr>
<tr>
<td>- 10%</td>
<td>.9</td>
<td>.9</td>
<td>.8</td>
<td>.7</td>
</tr>
<tr>
<td>0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>+ 10%</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>+ 20%</td>
<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
<td>1.7</td>
</tr>
<tr>
<td>+ 30%</td>
<td>1.3</td>
<td>1.3</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>+ 40%</td>
<td>1.4</td>
<td>1.4</td>
<td>2.0</td>
<td>2.7</td>
</tr>
<tr>
<td>+ 50%</td>
<td>1.5</td>
<td>1.5</td>
<td>2.3</td>
<td>3.4</td>
</tr>
<tr>
<td>+ 60%</td>
<td>1.6</td>
<td>1.6</td>
<td>2.6</td>
<td>4.1</td>
</tr>
<tr>
<td>+ 70%</td>
<td>1.7</td>
<td>1.7</td>
<td>2.9</td>
<td>4.9</td>
</tr>
<tr>
<td>+ 80%</td>
<td>1.8</td>
<td>1.8</td>
<td>3.2</td>
<td>5.8</td>
</tr>
<tr>
<td>+ 90%</td>
<td>1.9</td>
<td>1.9</td>
<td>3.6</td>
<td>6.9</td>
</tr>
<tr>
<td>+100%</td>
<td>2.0</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Stop! Before proceeding check page 50, “Glossary of Terms” in IS 52 A and re-read pages 36 to 49.

Putting the theory to one side, it now falls on the plant operator to start observing his hot mix plant, and gathering facts using the NAPA Energy Analysis Kit.

1. Inserting the thermometer at the fan inlet start recording the exhaust gas temperatures through a range of aggregate sizes from base mix to surface mix.

2. With the thermometer, record the temperature on high fire, medium fire, and low fire.

3. Observing the amprobe on one of the motor leads, take note of
the drop in amperage as the gas temperatures increase.

4. Inserting the manometer tubing in the same fan inlet hole as the thermometer observe the ups and downs of the static pressure reading as the gas temperature changes.

5. If a fan damper is operable, it is interesting to note the changes in the static pressure readings and motor amperage as the damper is alternately opened and closed.

6. Now let's begin a theoretical survey of the plant exhaust system.

As discussed on previous pages, more power is needed to overcome increased static pressure (for instance when a low energy washer is replaced by a venturi). Less power is needed when static pressure is reduced (for instance when a medium to high energy washer is replaced by a baghouse). The permanent closing of dampers does not reduce power demand in the long run. Slowing down the fan's rpm's or a smaller fan should be considered as alternatives for a permanent solution.

Example:

A 70'' x 30' dryer is handling 18,000 CFM, and an increase of 20% is calculated as necessary to achieve better performance. The static pressure reads 6.0'' H_2O; the fan speed 666 RPM; and the horsepower is 30 BHP.

<table>
<thead>
<tr>
<th>Existing</th>
<th>18,000 cfm</th>
<th>666 rpm</th>
<th>6.0'' sp</th>
<th>30 bhp</th>
</tr>
</thead>
<tbody>
<tr>
<td>20% increase</td>
<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
<td>1.7</td>
</tr>
</tbody>
</table>

| New System | 21,600 cfm | 799 rpm | 8.4'' sp | 51 bhp |

The above table of conversion factors was prepared by application of the "THREE BASIC FAN LAWS".

rpm = revolutions per minute
cfm = cubic feet per minute
sp = static pressure
hp = horsepower
A representative exhaust system survey with static pressure readings

Total sp 30.0' @ 70°
Est. cfm 43,500
(See table on page 18.)

* See page 21 for system with baghouse.
Checking a typical cyclone or primary collector

Subtract:
5.5'' Outlet
\[\frac{-2.5''}{3.0''}\] Inlet

Pressure Drop is 3.0'' H₂O

Valve

Note:
Pressure drop decreases as temperature increases. Use table to convert to 70° air.
Venturis have high horsepower requirements so as to overcome resistance while maintaining air volume.
A baghouse

Outlet Reading -9.5"

Subtract:
9.5" Outlet
-6.0" Inlet
P.D. = 3.5"

Ductwork P.D. = 5"

10.0" @200°
Repeating the message on page 6

When checking motor amperage and taking static pressure readings, air temperature must be recorded.

To convert to $70^\circ$ air, use the table reproduced from page 6.

<table>
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<th>TEMP.</th>
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</tr>
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<td>$0^\circ$</td>
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<td>$325^\circ$</td>
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</tr>
<tr>
<td>$160^\circ$</td>
<td>1.17</td>
<td>$400^\circ$</td>
<td>1.62</td>
</tr>
</tbody>
</table>

Examples:

12.0'' S.P. @ 200°F
$x \times 1.25$ Factor
Becomes 15.0'' S.P. @ 70°F

138 AMPS @ 200° F
$x \times 1.25$ Factor
Becomes 172 Amps @ 70° F

Have your electrician determine the amperage-horsepower ratio. For this example, we have chosen a service factor of 1.15.

To convert amperage to horsepower, take the motor service factor (460V) and divide into the amperage.

Examples: 172 amps ÷ 1.15 sf = 150 hp

Use static pressure and horsepower data to get approximate air volume on next page.
Example:
- Static Pressure = 15.0"
- Horsepower = 150
- Therefore:
- Air Volume = 43,500 CFM
- Universal Air Volume Table
- Accuracy = ±10%

CFM

Horsepower

Static Pressure

30"
25"
20"
15"
10"
5"
Purposely long detailed analyses have not been part of this booklet because it is a field manual written in such a way, that you, the plant operator, would be encouraged to seize the initiative and start investigating your plant operation.

Energy and gas flow are related elements in the plant operation. Often, in the past, they seemed to have an elusive quality, but with the many NAPA publications on the subject, much of the mystery has evaporated.

However, there is no better way to broaden one's knowledge of energy and gas flow than actual field investigation and that effort must be made by you, the plant operator.

So go to it, and don't be concerned if many of the mysteries of energy and air don't seem to be cleared up immediately. Get the readings and you'll find many questions being answered.