Technical Paper T-140

Heating and Storing Asphalt at HMA Plants

PREFACE

This technical paper is published by Heatec, Inc. of Chattanooga, Tennessee, a division of Astec Industries.

It is hoped that the information contained in the paper will benefit the hot mix asphalt paving industry as a whole. Individual copies may be obtained free of charge by contacting the company.

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The contributors have endeavored to provide factual information in an unbiased way. However, the statements and recommendations are strictly the opinions of the individuals and are not in any way intended as a warranty of the products or materials described.

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Abstract

Hot mix asphalt producers face numerous choices when buying heating and storage equipment for liquid asphalt. Making the right choices is not always easy because there are many things to consider. The first concern is usually the initial cost of the equipment—even when ample financial resources are available. Although production volume is usually a major factor in equipment costs, it's by no means the only one. Other factors include such things as whether the equipment needs to be moved frequently, how much land area it will occupy, whether mixes will include polymers, allowable emissions, restrictions on ground water pollution, the types of fuels or energy readily available, and operating costs.

This paper discusses all of these factors. We believe that contractors should have a good understanding of these subjects before purchasing equipment. That way the contractor can buy with confidence, without fear of costly surprises later.

It is easy to focus on the *initial* cost of equipment and overlook how much it will cost to *operate* over its life. The life expectancy of the better equipment sold today is 20 years or more. So, operating costs can add up to a lot of money over 20 years and may greatly exceed the initial cost of the equipment. Consequently, where there is a choice of equipment with different operating efficiencies, the possible savings in operating costs may significantly outweigh its higher initial cost.

Perhaps the most cost effective way of obtaining higher operating efficiencies is by the appropriate use of insulation. Insulation reduces heat loss significantly, especially on asphalt storage tanks and asphalt piping operating at temperatures of 325 degrees F. Thus, insulation reduces the amount of energy required to replace heat losses, thereby reducing energy costs. So, when there is a choice of insulation thickness, it usually pays for contractors to obtain equipment with the thickest insulation offered.

Contractors should also pay close attention to the thermal efficiencies of heaters. The better heaters offered today have thermal efficiencies of 80 percent and higher. If a plant has an old heater with an efficiency less than 80 percent it may pay to replace it with one of higher efficiency. This is especially true if the plant operates throughout most of the paving season each year.

The more a contractor knows about these many subjects, the more apt he is to get the right equipment and to be satisfied that he made the right decisions. Likewise, he is less likely to be duped into buying equipment that does not fully meet his needs.

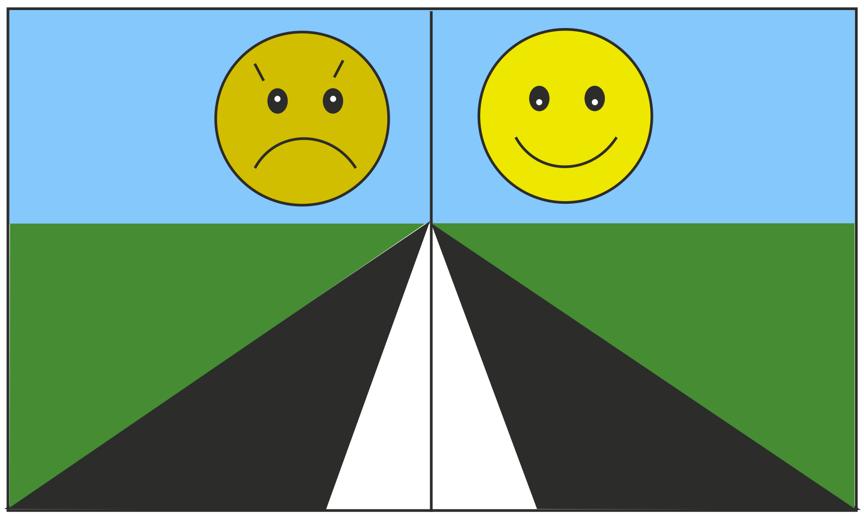
AMBIENT TEMPERATURE AND WIND

Please note that calculations for heat losses and heating requirements can vary widely depending upon the assumptions for weather conditions. Calculations in this document are based on an ambient temperature of 70 degrees F and a wind of 10 mph. We consider these conditions to be appropriate for general use. However, it may more appropriate to use a different ambient temperature and wind for a specific area or region. In any case, the reader should understand that the data presented in this document may not be the most appropriate for a specific location even though it is suitable for comparisons within the document.

Figure 1

Conservation of energy Is A Major Concern

Figure 2



We need To look Ahead

IF YOU OWN OR PLAN TO purchase HMA (hot mix asphalt) production equipment the information in this paper can help you understand many issues you face. It will give you insight into important issues that are often overlooked or little understood when planning the heating and storage of asphalt at a HMA plant.

Heat conservation

Perhaps the most fundamental issue concerned with heating and storage of asphalt is the conservation of energy (Figure 1). In recent years conservation of all natural resources—especially energy resources—ranks high. It is a major concern of governments and citizens alike, not only in the United States, but also in many other countries of the world. Fortunately, it is possible to conserve energy and save money at the same time when heating and storing asphalt. Any higher initial costs are quickly recovered and turned into savings.

Considerations

There are many important considerations whether replacing old equipment or purchasing an entirely new system. While some issues—such as the thermal efficiency of asphalt heating—may seem less important than considerations for drying aggregate, *all* are important in the long run. In just a few years what may have initially appeared to be insignificant may either result in significant savings or significant waste, depending on how the issue was initially addressed. So, it makes sense to take a close look at all issues that could in time have a positive or negative impact **(Figure 2).** Details are important!

There are now a number of new issues that have come about recently from the use of PMACs (polymer-modified asphalt cements). These asphalts require heating and storage significantly

Asphalt Is Usually Delivered By Tanker Truck

Figure 3

A Barrel Melter Is Used For Asphalt Shipped In Barrels

Figure 4

different from virgin or neat asphalts. They must usually be maintained at higher temperatures and must be continuously agitated or mixed to keep the polymers from separating. Moreover, they normally have a higher viscosity, which may affect piping and pumping needs.

For additional information on PMACs, please refer to Technical Paper T-133 entitled, *Heating, Mixing and Storing of Modified Asphalt.* This paper is available from Heatec.

Basic needs

Heating and storing asphalt is a basic function of all HMA facilities. Asphalt is normally delivered to the HMA facility in a liquid state, usually by tanker truck **(Figure 3).** The viscosity of the asphalt must be low enough to allow it to be pumped from the delivery truck into the storage tanks. Viscosity is a measure of a fluid's resistance to flow and is related to its temperature. The higher the temperature the lower the viscosity or resistance to flow. Viscosity is commonly expressed in units known as SSU (Saybolt Second Universal), poise and centipoise.

The actual temperature of the liquid asphalt at time of delivery may vary somewhat, depending upon the arrangements with the supplier. But most asphalt terminals deliver asphalt to HMA plants at a temperature suitable for making hot mix or slightly higher.

Some HMA facilities—mainly those in remote locations and on small islands—buy solidified asphalt in barrels. Thus, the solidified material must be melted into a liquid before it can be pumped into the asphalt storage tanks. This requires special equipment known as barrel melters **(Figure 4).** In some instances asphalt is transported aboard ships in

Figure 5

Shipping Containers May Be Used To Transport Asphalt

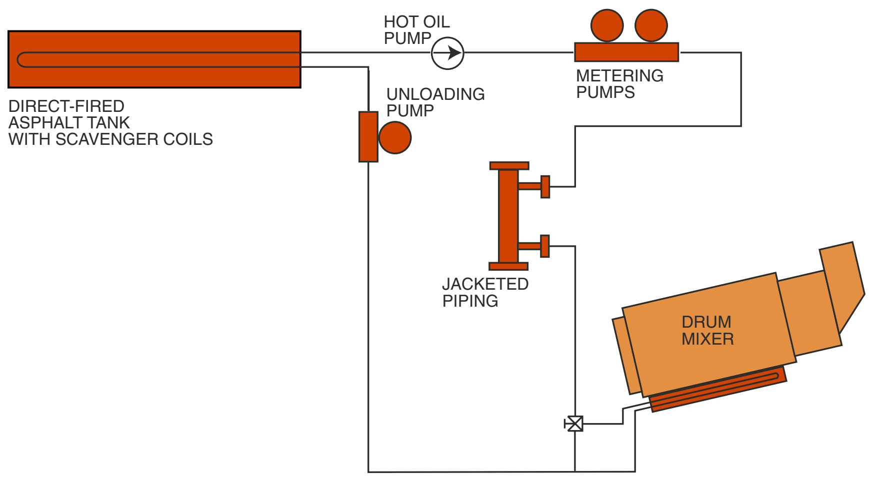
insulated shipping containers **(Figure 5).** The containers usually have heating coils or provisions for a burner so the asphalt can be re-heated in the container after it reaches its destination.

When asphalt is used to make hot mix it must be within a specified temperature range, usually from about 300 to 325 degrees F. However, as already noted, higher temperatures are usually required for PMACs. Accordingly, when asphalt is delivered to the plant at a temperature suitable for use, the role of the asphalt heating and storage equipment is to maintain that temperature until the material is used. Maintaining its temperature requires only enough heat to replace that lost during storage and pumping.

But when the asphalt is delivered to the plant at temperatures lower than required for making hot mix, the heating equipment must increase its temperature to meet that specified for use, in addition to replacing all heat lost during storage and pumping. This calls for more heating capacity, which may affect the choice of equipment.

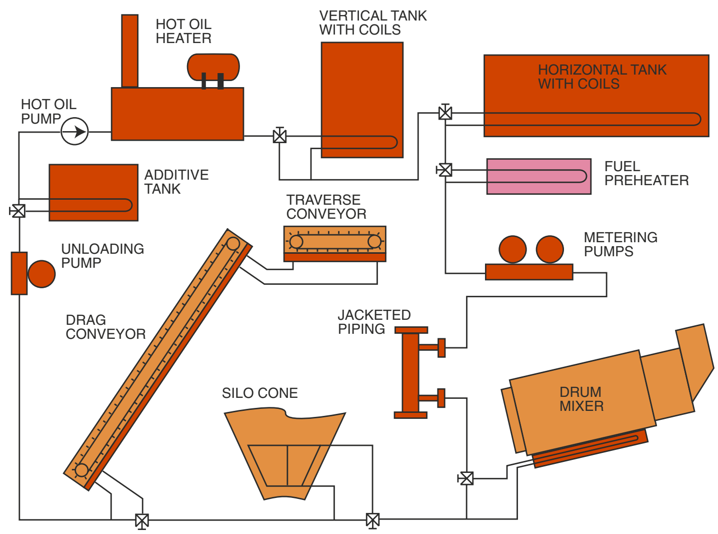
Moreover, heating equipment for some types of plants nearly always performs additional roles. On relocatable and stationary plants heating is needed to maintain the temperature of the hot mix after it leaves the mixer. This usually requires heating drag conveyors, traverse conveyors and the cones of hot mix storage silos. And sometimes it is necessary to heat hot mix additives and heavy fuel oil. Some of these added roles may require greater heating capacity. Again, this may affect the choice of equipment.

Whenever stored asphalt is to be left unused for an extended period, some operators allow it to cool down. This



Typical Heating And Storage For A Small HMA Plant

Figure 6



Typical Heating And Storage For A Large HMA Plant

Figure 7

conserves heating energy and minimizes oxidation of the asphalt. This practice is especially appropriate for PMACs that have been heated to higher temperatures than used for virgin asphalt. The heating system should be capable of restoring the temperature within a short period of time.

A typical heating and storage system for a small HMA plant is shown in **Figure 6.** A typical heating and storage system for a large HMA plant that uses PMACs is shown in **Figure 7.**

Increasing temperature Vs maintaining it

It costs less to maintain the temperature of asphalt than to increase its temperature. Accordingly, it pays to buy your asphalt at the temperature at which it can be used and to use it before it loses much of its heat. And it pays to

Figure 8

Quantity (Gallons)	Heat Required (Btu)			
	5 Degree F Increase	10 Degree F Increase	15 Degree F Increase	25 Degree F Increase
1,000	20,000	40,000	60,000	100,000
5,000	100,000	200,000	300,000	500,000
6,750	135,000	270,000	405,000	675,000
10,000	200,000	400,000	600,000	1,000,000
15,000	300,000	600,000	900,000	1,500,000
20,000	400,000	800,000	1,200,000	2,000,000
25,000	500,000	1,000,000	1,500,000	2,500,000
30,000	600,000	1,200,000	1,800,000	3,000,000
35,000	700,000	1,400,000	2,100,000	3,500,000

Heat required = weight x specific heat x temperature difference. Weight = 8.0 pounds per gallon. Specific heat (degrees F) = 0.5 Btu per pound per degree F. Heat required does not include extra heat to make up for heat lost while heating.

Heat Required To Raise Asphalt Temperatures

Figure 9

Energy Needed	Raise Temperature 25 Degrees F	Maintain Temperature @ 300 Degrees F
Btu	4,127,810	1,127,810
Gallons No. 2 Fuel	31.3	8.5

Temperature is raised and maintained for 24 hours. Heat to raise temperature includes heat to make up for heat loss during the 24 hours.
30,000 gallons AC @ 8 pounds per gallon = 240,000 lbs.
Heat required to raise one pound of AC one degree = 0.5 Btu.
Heat required to raise 240,000 pounds of AC one degr = 120,000 Btu.
One gallon No. 2 fuel produces 132,000 Btu LHV.
Tank has 3-inch insulation.

Energy to Raise Temperature Vs. Maintain Temperature Over 24 Hours

do everything possible to keep it from losing heat. Using well-insulated tanks and piping is the most cost-effective way of minimizing heat loss. The amount of heat required to raise the temperature of various quantities of asphalt is shown in **Figure 8** (and does not include any additional heat to make up for losses during heat up).

Suppose your asphalt is delivered to your plant at a temperature that is 25 degrees F lower than needed to make hot mix. Consider the energy required to heat a 30,000 gallon tank of asphalt to increase its temperature 25 degrees F (from 275 to 300 degrees F) over a period of 24 hours. Then compare that with the energy required to maintain a temperature of 300 degrees F over the same period. In both cases assume that the tank has 3 inches of insulation. It takes 4,127,810 Btu to increase the temperature 25 degrees F and to make up for losses that will occur during a 24 hour period. But it only takes 1,127,810 Btu to maintain a temperature of 300 degrees F for 24 hours, a difference of 3,000,000 Btu. Thus, raising the temperature requires more than three times the amount of fuel needed to maintain the temperature **(Figure 9).**

Energy Needed	Tank With No Insulation	Tank With 3-inch Insulation	Tank With 6-inch Insulation
Btu	1,034,653,248	33,834,296	18,475,382
Gallons No. 2 Fuel	9,798	320	175

30,000 gallon tank. Maintain AC temperature at 300 deg F for 30 days.

Energy Used By Insulated Vs. Non-insulated Tanks

Figure 10

Temperature & Energy	Tank With No Insulation	Tank With 3-inch Insulation	Tank With 6-inch Insulation
Bulk Temperature After 60-Hours	252 Degrees F	281 Degrees F	289 Degrees F
Btu To Restore After Shutdown	126,418,650	2,463,091	1,367,283
Gallons No. 2 Fuel To Restore	1197.1	23.3	12.9

Shutdown is for 60 hours. Assumes a 30,000 gallon tank of AC at a temperature of 300 deg F before shutdown. Assumes a 1.2 million Btu heater using 75 percent of its output to reheat the tank. Heat to restore temperature includes heat to make up for heat loss during restoration.

Energy Used To Restore Heat After Shutdown

Figure 11

Now, consider the energy needed to maintain a 30,000 gallon tank of asphalt at 300 degrees F for a month. Compare the energy needed to maintain a non-insulated tank for that length of time with a tank that has 3-inch insulation and one that has 6-inch insulation **(Figure 10).** It takes 33,834,296 Btu to maintain the tank with 3-inch insulation. It takes only 18,475,382 Btu for the tank with 6-inch insulation. But it takes over one U.S. billion (1,034,653,248) Btu to maintain the non-insulated one. These are significant differences.

Having well-insulated tanks and piping also makes it feasible to shut-off heating equipment over week ends or for other extended periods of non-operation. **Figure 11** shows the amount of heat required to restore the temperature. A 30,000 gallon tank of asphalt with 6-inches of insulation requires only 1,367,283 Btu to restore the temperature to 300 degrees F after a 60-hour shut-down. It will take about 1.5 hours, depending upon the size of the heater and how much of its heat is needed for other equipment. The same tank with 3 inches of insulation takes 2,463,091 Btu to restore the temperature and likewise takes about 2.7 hours. But the same tank with no insulation takes 126,418,650 Btu to restore the temperature and will take about 140 hours. An automatic timer can be used to start up the heating system to restore asphalt temperature in time for plant re-start.

Figure 12

Plant With Direct-Fired Tank

Figure 13

Large Stationary Plant With Hot Oil Heater And Tanks

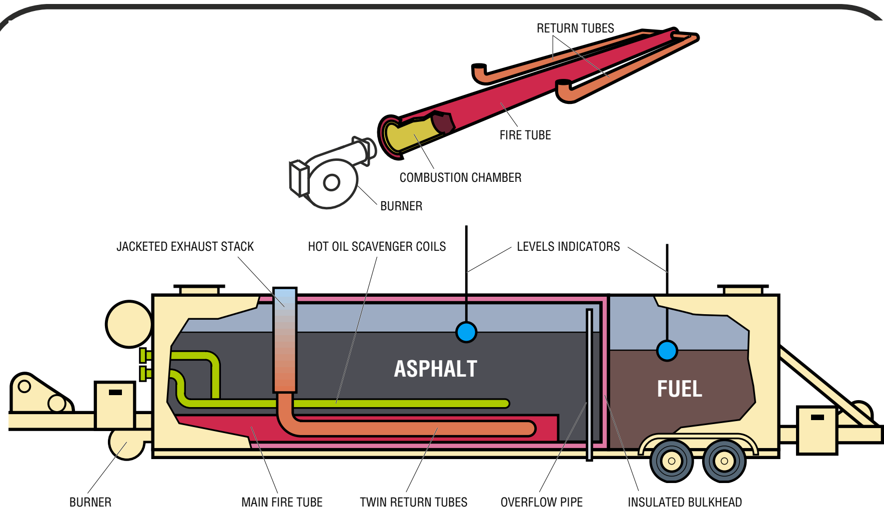
You may have noted that the table shows the bulk or average temperatures of the three tanks range from 252 to 289 after being off for 60 hours. You may have expected a greater temperature drop for the uninsulated tank. But an interesting phenomenon occurs as the asphalt cools. Asphalt in contact with tank inner surfaces solidifies, creating a highly effective insulation. This solidified layer retards heat loss to a major extent.

Moreover, asphalt in the uninsulated tank solidifies sooner than in the insulated ones.

Nevertheless, it takes considerably more heat to restore the temperature of both the uninsulated one and the one with 3 inches of insulation because they will lose more heat while being re-heated than the one with 6 inches of insulation.

Heating systems

Two basic types of heating systems are commonly used at HMA plants. Both use heating fuels. One system employs what is known as a direct-fired tank **(Figure 12).** The other system employs a hot oil heater and tanks with heating coils **(Figure 13).** An electric heating system (which does not use heating fuels) is sometimes used.



Cross-section Of Direct-Fired Tank With Scavenger Coils

Figure 14

The direct-fired tank is an asphalt storage tank that has a burner mounted on one end of the tank. The burner fires directly into a fire tube or heating chamber located inside the tank **(Figure 14).** One type of fire tube, known as a *single-pass* fire tube, runs the full length of the tank and exhausts on the end away from the burner. Another type, known as a *two-pass* fire tube, runs the full length of the tank and doubles back toward the burner. Its exhausts on the same end as the burner.

The burner heats the fire tube, which in turn heats the asphalt that surrounds it. If anything in addition to the asphalt needs to be heated, the tank can be equipped with scavenger coils. The coils are totally independent from the burner and fire tube. They are positioned above the fire tube so they are immersed in the asphalt, enabling them to scavenge heat from the asphalt. Oil is pumped through the coils, carrying the scavenged heat to other plant components.

The other type of heating widely used is an indirect system. It employs a hot oil heater and tanks equipped with heating coils The heater heats oil (thermal fluid) as it is pumped through the heater. The hot oil is piped to the asphalt storage tank where it heats the tank coils. And the coils heat the asphalt or contents of the tank. By simply using additional piping circuits the hot oil can be used to heat additional tanks and virtually any plant component. It is important to match the capacity of the heater with the heat load.

Systems with hot oil heaters often have a single hot oil heater and one or more coil tanks, all as separate units (**Figure 15**). Some systems have a trailer-mounted coil tank with the hot oil heater mounted on the gooseneck of the trailer.

The system using electric heat is very similar to the one using the direct-fired tank. The tank has an electric heating coil instead of the burner and fire tube. It can employ scavenger coils the same way as the direct-fired tank.

Direct-fired tanks

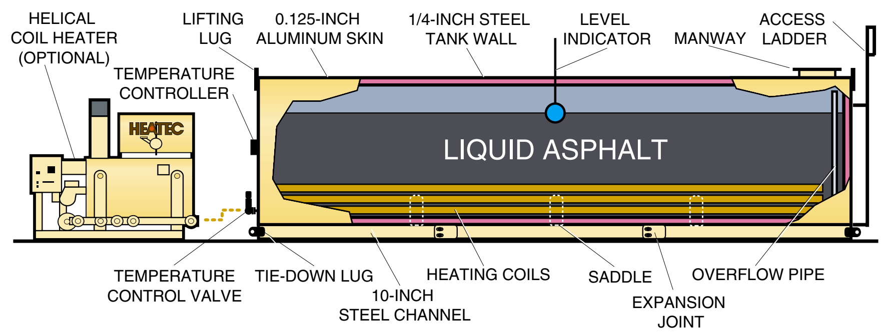
A heating system using a direct-fired tank has the advantage of lower initial cost than most other systems. The thermal efficiency of the tank is also very high, especially if it has a two-pass fire tube. Moreover, it has relatively few parts and requires very little maintenance. The direct-fired tank is well-suited for small portable asphalt plants using a surge bin and for small batch plants. These are plants that usually need only one asphalt storage tank. And they don't usually require heat for other plant components.

Direct-fired tanks are *not* well-suited for larger plants and for plants that use PMACs. Larger plants usually need more than one asphalt tank. Moreover, large plants usually need to heat a number of plant components such as drag conveyors, asphalt silos, and fuel tanks. The only way a direct-fired tank can heat other components is by use of scavenger coils or by use of a booster heater.

Scavenger coils are very limited in their ability to heat other components. Because the hot asphalt is the source of heat for the scavenger coil, the temperature of the oil flowing through it is limited by the temperature of the asphalt. This limits the amount of heat available for heating other equipment.

The maximum scavenged temperature of the thermal oil will be range from about 250 to 300 degrees F, or about 25 to 50 degrees below the asphalt temperature. Oil at this temperature is suitable for heating jacketed asphalt lines, metering systems, drag conveyors, emulsion tanks and heated fuel tanks. However,

Figure 15



Cross-section Of Coil Tank With Hot Oil Heater

oil at this temperature is not suitable for maintaining the heat of an asphalt storage silo because the oil temperature is lower than the temperature of the hot mix in the silo. Moreover, oil at a temperature lower than that of the hot mix would actually steal heat from the hot mix. However, some plants use scavenged heat to pre-heat the cone of a surge bin prior to its use.

Thus, if the direct-fired tank is unable to provide adequate heating for other purposes it becomes necessary to add a booster heater. At this point it may be more feasible to use a system with a hot oil heater in lieu of the direct-fired tank.

Another disadvantage of a direct-fired tank is a low rate of heat transfer because the fire tube has a limited amount of heating surface. An asphalt temperature recovery rate of 1 to 3 degrees F per hour is typical, depending on the volume stored in the tank. Accordingly, the direct-fired tank is better suited to maintain temperature rather than to raise temperature.

Another disadvantage of a direct-fired tank is the need to always retain enough asphalt in the tank to cover the fire tube and scavenger coils. This requires retaining anywhere from 12 to 20 percent of the tank's total volume. Allowing the level to drop below the fire tube and scavenger coils exposes their surfaces to air and will cause the film of asphalt on their surfaces to oxidize or coke. Layers of coke have insulating properties similar to fiberglass insulation. Accordingly, a build-up of coke on heating coils significantly reduces thermal efficiency or the ability of the heating surfaces to heat the asphalt.

Direct-fired tanks are not well suited for heating PMACs because of unfavorable film temperatures and mixing limitations. The outside surfaces of a fire tube are significantly hotter than the outside surfaces of coils heated by hot oil. The hotter surfaces cause the asphalt in contact with them to have a higher film temperature. The film temperature is the temperature of the thermal boundary layer in the asphalt or material surrounding the fire tube. When the film temperature exceeds the maximum recommended film temperature for the material, the material breaks down. This is not a problem with virgin asphalt because of its higher film temperature rating. However, polymers have lower film temperature ratings that would be exceeded when heated by a fire tube. (Please refer to Technical Paper T-133.)

Hot oil heaters

Systems with hot oil heaters are the most versatile systems. They can be used for virtually any type of plant, any size of plant and for any type of asphalt material including PMACs. Moreover, hot oil heaters rival direct-fired tanks in thermal efficiency.

However, this type of system may cost more than a direct-fired system for some plants. It is likely to cost more for a small portable plant that needs only one asphalt storage tank and little extra heating. Even a small hot oil heater is capable of heating several storage tanks along with several plant components. And because it is a more sophisticated system than a direct-fired tank it has more parts that are subject to maintenance. Even so, its maintenance is relatively low—not a matter of major concern.

The system may have several hot oil heating circuits, each controlled independently. Thus, it's possible to shut off any component not in use. Moreover, the temperatures of each component can be varied independently.

More heat is possible from a hot oil heater than a direct-fired tank due to burner limitations of a direct-fired tank.

Electrically Heated Tank

Figure 16

Direct-fired tanks employ fire tubes, which limit the size of the burners that can be used. Because hot oil heaters do not use fire tubes they can use larger burners. Moreover, the burner in a hot oil heater can raise the oil temperature higher than scavenger oil systems that are heated by the asphalt and limited by its temperature. The temperature of the oil in a hot oil heater is limited only by the properties of the oil, such as its flash point. For example, conventional hydrocarbon oil such as Exxon HT43 can be safely heated to 600 degrees F. Synthetic fluids such as Dowtherm or Therminol can be heated as high as 750 degrees F.

A hot oil heater can heat the oil to a temperature high enough to maintain the temperature of mix in storage silos. Its temperature needs to be at least 25 degrees F higher than the mix in the silos. The desired temperature can be preset on the temperature controller, which will automatically maintain the set temperature.

A hot oil heater system is always the one of choice where there is little or no difference in initial cost. And even when it costs more, its versatility may outweigh the additional cost.

Expansion tanks

Systems with hot oil heating circuits must have an expansion tank to allow for thermal expansion of the oil. This applies to systems using hot oil heaters as well as systems using direct-fired tanks with scavenger coils. The tank is usually incorporated on the heater or on the tank. The size of the tank varies according to the amount of heating oil in the system.

The tank should be filled with nitrogen to minimize oxidation of the hot oil. This significantly extends the life of the oil.

Electric heaters

It is possible to get electrically heated counterparts of fuel-fired systems. Thus, its possible to get an electric hot oil heater. And its possible to get an electrically heated asphalt storage tank. But electric heating systems are problematic. Heating with electricity *significantly* increases the power demand for a HMA plant. Increased demand may *dramatically* increase electricity rates **(Figure 16).** An electrically heated tank has virtually all the same limitations as a direct-fired tank, plus additional concerns. However, electric heating can be cost effective in a limited number of areas where electric power is available at extremely low rates.

Some may favor using electric heating out of concern for conserving natural resources and reducing environmental pollution. But therein lies a myth. Using electrical energy doesn’t always achieve that goal. That’s because one or more power plants in a network that supplies your electrical energy may use fossil fuels and may cause pollution of their own. Thus, using electricity for heating may merely displace one’s concerns. And it may prove to be the most expensive means of heating.

Heating fuels

Asphalt heating systems using direct-fired tanks and hot oil heaters work with a variety of fuels. The asphalt heating system often uses the same fuel as the aggregate dryer. And because the dryer uses significantly more fuel than the heating system, fuel choice is usually based on dryer usage.

Two key concerns are availability of the fuel and cost per Btu. However, the amount of emissions it produces when burned can be an overriding factor. Fuels that produce high levels of emissions are not well-suited for asphalt heating, even though those same fuels may be satisfactory for a dryer. That’s because there are some important differences

Figure 17

Heavy fuel preheater

in the ability of aggregate dryers to use such fuels and the ability of asphalt heaters to use those fuels.

Natural gas, LP gas, No. 1 fuel oil and No. 2 fuel oil are all highly appropriate fuels for both aggregate dryers and asphalt heaters. Natural gas produces very low emissions. Most LP gases produce low emissions, but some LPs may produce a higher level of NO_X than others. No. 1 and 2 fuel oils generally produce fairly low emissions. Federal, state and local ordinances governing allowable emissions may affect the choice between these fuels.

Other fuels, such as No. 4 fuel oil, heavy oil and waste oils are difficult to burn and produce high levels of emissions. (Heavy oil is also known as No. 6 fuel oil or Bunker C.) Consequently, these fuels are not suited for small (3 million Btu or less) asphalt heaters. Moreover, they are problematic even for large asphalt heaters. The first problem is getting a burner that will burn these fuels. Special burners are available. But the fuel must be preheated and the burners are subject to reliability and maintenance problems. Furthermore, these fuels leave heavy residues in the heater, requiring the heater to have a special lining to facilitate clean-out. The special provisions are not usually cost-effective.

Heavy fuel preheaters

A heavy fuel preheater is used to pre-heat heavy fuel oil so it can be burned by a fuel oil burner. Preheaters are typically used to heat No. 5 or No. 6 fuel oils for aggregate dryers. The pre-heating lowers the viscosity of the oil so it can be atomized by the burner.

A preheater is usually connected in the fuel supply line between the fuel tank and dryer. **(Figure 17).** Or, it can be mounted inside the fuel tank. It may be used to pre-heat the fuel flowing directly to the burner when a single pass through the heater raises its temperature adequately for atomization. The fuel may be recirculated to the fuel tank if additional heating is needed.

The preheater usually consists of a shell-and-tube heat exchanger with the capacity to increase the temperature of the fuel 100 degrees F at a rate of 1,000 gph. The fuel oil is heated as it passes through the shell surrounding the tubes. The tubes are heated by thermal fluid (hot oil) from a hot oil heater as it circulates through the tubes.

Fuel heating values

To determine the cost of fuel per Btu you must know its heating value, which is how many Btu are produced by a given amount of the fuel. Most liquid fuels, including propane, are purchased by the gallon. Natural gas is usually purchased by the cubic foot (CF) or by 100 cubic feet (CCF), but is sometimes purchased by the therm (100,000 Btu). Thus, you must know how many Btu the fuel produces per gallon, per pound, per cubic

Type of Energy	Gross or HHV	Net or LHV
No. 2 Fuel Oil	140,000 Btu/gal	132,000 Btu/gal
No. 5 Fuel Oil	150,000 Btu/gal	143,250 Btu/gal
Propane (LPG)	90,500 Btu/gal	84,345 Btu/gal
Natural Gas	1,040 Btu/Cu Ft	905 Btu/Cu Ft
	104,000 Btu/CCF	90,500 Btu/CCF
Electricity	3,413 Btu/Kwh	

CCF stands for 100 cu ft. The actual heating values of various fuels vary from one region to another. However, the values used here are for fuels commonly used in the US. Electrical energy is based on a resistive load. HHV and LHV do not apply to electricity.

High and Low Heating Values

Figure 18

Type of Energy	No. of Therms (100,000 Btu)		Amount Required For One Therm (100,000 Btu)	
	Gross or HHV	Net or LHV	Gross or HHV	Net or LHV
No. 2 Fuel Oil	1.400 per gal	1.320 per gal	0.714 gal	0.758 gal
No. 5 Fuel Oil	1.500 per gal	1.433 per gal	0.667 gal	0.698 gal
Propane (LPG)	0.905 per gal	0.843 per gal	1.105 gal	1.186 gal
Natural Gas	1.040 per CCF	0.905 per CCF	0.962 CCF	1.105 CCF
	0.010 per cu ft	0.009 per cu ft	96.154 cu ft	110.497 cu ft
Electricity	0.034 per Kwh		29.300 Kwh	

CCF stands for 100 cu ft. The actual heating values of various fuels vary from one region to another. However, the values used here are for fuels commonly used in the US. Electrical energy is based on a resistive load. HHV and LHV do not apply to electricity.

Working With Therms

Figure 19

foot, or per therm, as applicable. The heating values of various fuels are shown in **Figure 18.**

Two types of heating values are used to indicate the amount of heat a fuel can produce: LHV (low heating value) and HHV (high heating value). LHV is the *net* or useable amount of heat (Btu) produced by a fuel. HHV is the *gross* amount of heat (Btu) produced by a fuel. The difference between HHV and LHV is due to hydrogen in the fuel, which is normally lost as water vapor or moisture.

Unfortunately, the difference between the two values is not widely known or understood. Most suppliers of fuel oils and gas cite gross values for their fuels, but do state whether they are net or gross. Moreover, their representatives may not know that there is a difference. Thus, you should assume that Btu values shown on fuel bills are gross values unless specifically stated otherwise. And when calculating fuel costs you need to take the difference into account. Both values are sometimes used in calculating the amount of fuel required for heating asphalt and drying aggregate. However, it is usually more appropriate to use LHV.

To get an idea of the difference, compare the heating values of the most commonly used fuels. No. 2 fuel oil has a LHV of approximately 132,300 Btu per gallon. It has a HHV of approximately 140,000 Btu per gallon, a difference of 7700 Btu. One cubic foot of natural gas has a LHV of approximately 905 Btu. It has a HHV

Type of Energy	Heating Value (Net or LHV)		Billing Units	Cost Comparisons Based On Heating Values										
NO. 2 FUEL OIL	Btu/gal	132,000	Per Gallon	$0.20	$0.30	$0.40	$0.50	$0.60	$0.70	$0.80	$0.90	$1.00	$1.10	$1.20
NO. 5 FUEL OIL	Btu/gal	143,250	Per Gallon	$0.22	$0.33	$0.43	$0.54	$0.65	$0.76	$0.87	$0.98	$1.09	$1.19	$1.30
PROPANE (LPG)	Btu/gal	84,345	Per Gallon	$0.13	$0.19	$0.26	$0.32	$0.38	$0.45	$0.51	$0.58	$0.64	$0.70	$0.77
NATURAL	Btu/CCF (see note)	90,500	Per CCF	$0.14	$0.21	$0.27	$0.34	$0.41	$0.48	$0.55	$0.62	$0.69	$0.75	$0.82
GAS	Btu/Therm	100,000	Per Therm	$0.15	$0.23	$0.30	$0.38	$0.45	$0.53	$0.61	$0.68	$0.76	$0.83	$0.91
ELECTRICITY	Btu/Kwh	3,413	Per Kwh	$0.01	$0.01	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02	$0.03	$0.03	$0.03

Each column of cost comparisons relates the costs of various types of energy to each other based on heating values. For example, the cost of No. 2 fuel oil at $1.00 per gallon is equivalent to a cost of $1.09 for No. 5 fuel oil for the same Btu. Thus, if No. 2 fuel oil is $1.00 per gallon it doesn't pay to choose No. 5 fuel oil unless it is less than $1.09. Likewise, it wouldn't pay to use electricity unless it is less than $0.03 per Kwh when No. 2 fuel oil is $1.00 per gallon. The actual heating values of various fuels vary somewhat from one region to another. However, the values used here are for fuels commonly used in the US. CCF stands for 100 cubic feet. The net heating value of one cubic foot of natural gas is 905 Btu. However, natural gas is normally billed at its gross heating value, which is approximately 1,000 Btu per cubic foot.

Equivalent Energy Costs

Figure 20

of approximately 1,040 Btu per cubic foot, a difference of 135 Btu.

A therm is 100,000 Btu **(Figure 19).** It takes approximately 0.758 gallons of No. 2 fuel oil at LHV to produce one therm. It takes approximately 100 cubic feet (1 CCF) of natural gas at LHV to produce one therm. Suppliers of natural gas may bill their customers either by the hundred cubic feet (CCF) or by the therm. It is important to note that natural gas suppliers normally calculate a therm based on the HHV of natural gas, which takes approximately 96.154 cubic feet (0.961 CCF) per therm.

Figure 20 compares the cost of fuel per Btu. This can serve as a guide to selecting a fuel from those that have acceptable levels of emissions.

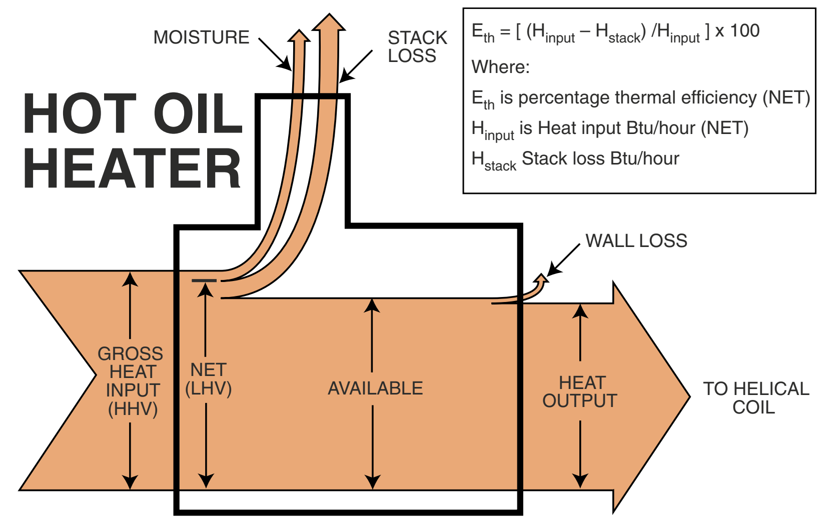
Monitoring fuel usage

It is smart to separate costs for drying aggregate from the costs for heating your asphalt. Installing a fuel, gas or electric meter solely for the asphalt heating system separates those costs. Knowing the true costs for asphalt heating makes it possible to accurately determine the cost benefits of upgrading heating equipment. It is especially helpful when comparing the costs of heaters with different thermal efficiencies as discussed in subsequent portions of this paper.

Heater thermal efficiency

Thermal efficiency affects the amount of fuel an asphalt heater uses. Fuel costs are a significant part of the overall operating costs of a HMA facility. Although the thermal efficiency of a direct-fired tank is very similar to that of a hot oil heater, this discussion applies specifically to hot oil heaters.

The thermal efficiency of a hot oil heater relates the amount of heat (Btu) that the



Heater Thermal Efficiency

Figure 21

HEATER EFFICIENCY	COST PER HOUR
50 PERCENT	1,000,000 Btu per hour / 132,000 Btu per gallon X 1 / 0.50 X $1.00 = $15.15
60 PERCENT	1,000,000 Btu per hour / 132,000 Btu per gallon X 1 / 0.60 X $1.00 = $12.63
70 PERCENT	1,000,000 Btu per hour / 132,000 Btu per gallon X 1 / 0.70 X $1.00 = $10.82
80 PERCENT	1,000,000 Btu per hour / 132,000 Btu per gallon X 1 / 0.80 X $1.00 = $9.47
85 PERCENT	1,000,000 Btu per hour / 132,000 Btu per gallon X 1 / 0.85 X $1.00 = $8.91

Heating load = 1,000,000 Btu per hour. No. 2 fuel oil LHV (low heating value) = 132,000 Btu per gallon. No. 2 fuel oil cost = $1.00 per gallon.

Calculating Heater Fuel Costs Per Hour

Figure 22

burner produces to the amount of heat actually transferred to the thermal fluid flowing through its coil (**Figure 21**). Thus, a heater that is 85 percent efficient uses 85 percent of the heat produced to heat the fluid and wastes 15 percent.

All heat that does not go into the thermal fluid is wasted. Consequently, all heat that goes out the exhaust stack is wasted heat. And so is any heat that is lost by air leakage or as the result of poor insulation of the heater shell.

Temperature of the exhaust gas is a good indication of efficiency where most wasted heat goes out the stack. The lower the temperature of the exhaust gas, the higher the efficiency.

The formula for calculating the net (LHV) thermal efficiency of a heater is shown in **Figure 21.** However, there is an easier method of determining a reasonably accurate indication of efficiency for hot oil heaters used in the asphalt industry. This can be done by measuring the stack temperature and using a bar chart that shows efficiencies for various stack temperatures (**Figure 28**).

Heaters that are 15 or 20 years old are apt to have efficiencies much lower than those available now. A more efficient one could save a lot of money on fuel costs and pay for itself in a very short time. One with an optional combustion air pre-heater will save even more.

The thermal efficiency of a direct-fired tank is very similar to a hot oil heater. It relates the amount of heat the burner

Figure 23

Heater Efficiency (%)	Gallons per hour	Total Gallons	Total cost
50	15.15	2,036,364	$2,036,364
60	12.63	1,696,970	$1,696,970
70	10.82	1,454,546	$1,454,546
80	9.47	1,272,727	$1,272,727
85	8.91	1,197,861	$1,197,861
88	8.61	1,157,025	$1,157,025

Heat demand = 1 million Btu. Fuel = No. 2 diesel oil (132,000 Btu per gallon).
Fuel cost = $1.00 per gallon.
Operation = 24 hours per day, 7 days a week, 40 weeks a year, 20 years (heater life).

Long Term Fuel Costs For Various Efficiencies

produces to the amount of heat actually transferred to the asphalt surrounding the fire tube. The efficiency of a direct-fired tank is about 2 percent higher than that of a hot oil heater because of operating temperatures.

Impact of efficiency

A small difference in efficiency makes a big difference in how much fuel a heater burns over its life. But it's easy to overlook the amount of fuel a heater uses. That's because many asphalt plants don't meter fuel for the heater separately from the dryer. Both are usually lumped together. Consequently, most operators probably don't know how much fuel the heater alone uses. And because the dryer burns fuel at a much higher rate than the heater, the heater is often ignored.

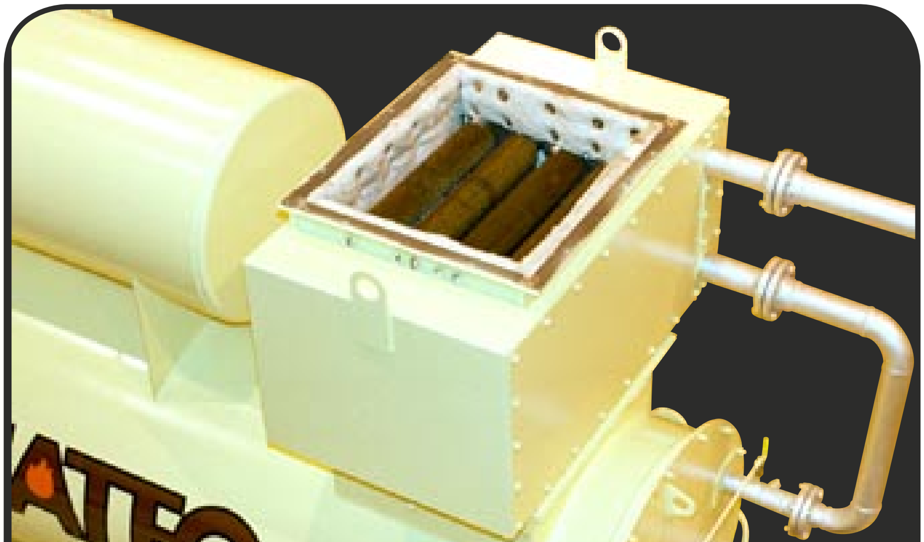
Its easy to calculate the operating cost of a heater when you know its thermal efficiency and input rating. **Figure 22** shows how to calculate the operating cost per hour for a heater that operates on No. 2 fuel oil.

The heater at a typical asphalt plant runs 24 hours a day, 7 days a week, about 40 weeks a year. It may easily run a total of **134,400** hours during its life-span of about 20 years. That's a lot of running hours, many times more than the dryer runs during those same years.

The amount of fuel a heater burns over its life and its cost depends on the heater's efficiency. **Figure 23** shows a comparison of fuel costs for heaters with efficiencies of 50 to 88 percent. Compare the differences in fuel costs over the life of the heaters. A heater with 85 percent efficiency saves a staggering $256,684 over one 70 percent efficient. Even more astounding, a heater that is 85 percent efficient saves $838,503 over one 50

Combustion Air Pre-heater On Helical Coil Heater

Figure 24



Thermal Fluid Pre-heater On Helical Coil Heater

Figure 25

percent efficient. And boosting efficiency from 85 percent to 88 percent with an air pre-heater saves an additional $40,836, far exceeding its extra cost.

Efficiency factors

Helical coil heaters are inherently efficient for a number of reasons. The spiral path of a helical coil imparts much higher turbulence to oil flowing through it than the straight sections of serpentine coils. Higher turbulence causes better heat transfer and lower film temperatures. Moreover, the oil always fully contacts its surfaces thereby eliminating stagnant zones, which can reduce efficiency and are common in other types of heaters.

But not all helical coil heaters have the same efficiency. Subtle design differences make significant differences in efficiency. Critical design factors include the flame pattern, combustion gas velocity, heat transfer surface area, thermal fluid turbulence, positioning of the helical coil, effectiveness of the insulation and how well the unit is sealed.

A secondary heat exchanger can be installed in the exhaust stack of a helical coil heater to recover heat from exhaust gases and use that heat to increase efficiency. Increases up to 4 percent can be expected. The choice is between two types of heat exchangers: a combustion-air preheater or an oil pre-heater.

The combustion-air preheater is an air-to-air heat exchanger **(Figure 24).** It uses the heat of the exhaust gases to preheat combustion air supplied to the burner to temperatures of 150–200 degrees F. This reduces the amount of heat that the burner has to produce. Thus, the burner operates at a lower firing rate.

Figure 26

Heatec Helical Coil Heater

The thermal fluid pre-heater is an air-to-oil heat exchanger and is commonly known as an *economizer* **(Figure 25).** It uses the heat of the exhaust gases to pre-heat the oil as it returns to the helical coil in the heater. This reduces the heat load on the burner allowing it to operate at a lower firing rate.

The actual effectiveness of both types of secondary heat exchangers depends on temperature differences. With the combustion air preheater it's the *difference* between the exhaust gases and the ambient air temperature, about 525 degrees F. With the economizer it's the *difference* between the exhaust gases and the temperature of the return oil, about 300 degrees F. The greater the difference the greater the increase in efficiency.

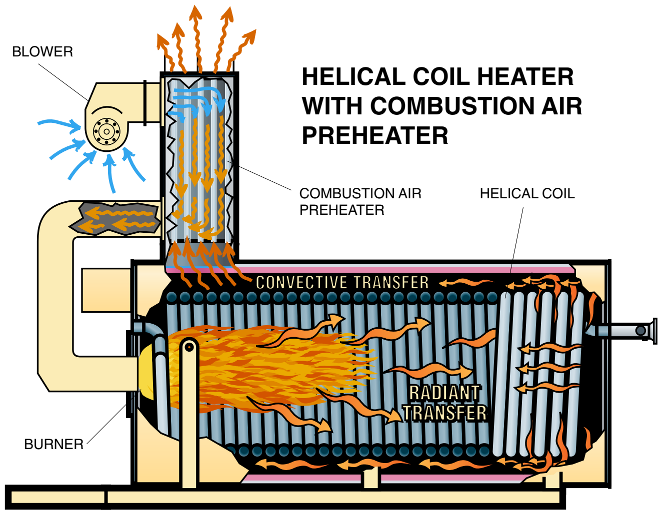
The combustion-air preheater usually has a somewhat higher temperature difference. Hence, it usually increases efficiency a little more than the economizer if sized properly. However, there are a couple of drawbacks for the air-preheater. It increases the back-pressure on the burner exhaust and that can make burner adjustments more sensitive and temperamental. And an air-preheater increases NO_x emissions to some extent. Apart from those issues the combustion-air preheater is usually more cost effective.

The economizer does not increase NO_x emissions and does not usually affect burner adjustments. But it is likely to cost more than an air pre-heater, despite being less efficient. The size of the economizer is governed mostly by the difference in temperature between the exhaust gases and return oil. Smaller temperature differences necessitate larger economizers. As you would expect, larger economizers cost more than smaller ones.

Heatec heaters

Our hot oil heaters are designed around a helical coil, the same as the very first heaters the company built in 1977. The thermal efficiency *rating* for the current generation of these heaters without pre-heaters **(Figure 26)** is 85 percent**.** Actually, the efficiency varies slightly, depending on capacity and fuel used.

Helical coil heaters are widely recognized for long life and low maintenance, in addition to their high efficiency. Moreover, we have continued to refine our helical coil heaters to take advantage of new technologies, especially those in electronics and insulation. Consequently, our heaters have always been among the most efficient heaters available.



Cross section of Heatec Helical Coil Heater

Figure 27

Equipping them with an optional heat exchanger boosts efficiency to 88 percent or more. Heatec offers the two types of secondary heat exchangers discussed above. They increase efficiency by recovering some of the exhaust gas heat that would otherwise be lost.

Figure 27 shows the construction of our helical coil heater. It has a steel cylindrical shell that houses a helical coil. Steel pads inside the shell support the coil leaving an annular space between coil and shell. The inner surface of the shell is covered with ceramic blanket insulation that has low thermal conductivity and low heat storage.

The burner fires through the center axis of the coil. Its flame produces radiant energy that heats the inner side of the coil without impinging on its surfaces. Radiant energy accounts for about 70 percent of the heat transferred to the coil.

Hot combustion gases turn outwards at the end of the coil. They double back into the annular space between the insulation and the exterior side of the coil, heating its outer surfaces by convection. Convection accounts for about 30 percent of the heat transferred to the coil.

The gases exit through the exhaust stack in the heater shell near the burner after traveling back the full length of the coil. Very little energy is lost through the shell.

Our heaters with an optional combustion air pre-heater have a heat exchanger built into the stack. The hot gases pass through tubes of the heat exchanger and exit the heater. The tubes are sealed so exhaust gases do not enter into the chamber surrounding them.

A blower forces fresh air into the chamber surrounding the hot tubes where it is heated. It then travels through a duct that carries it to the combustion chamber where it augments heat from the burner.

Thermal fluid is pumped through the hot helical coil and is heated by the process of conduction. The hot fluid exits the heater and flows through piping to asphalt tanks and other plant components.

Determining efficiency

The exhaust gas temperature of a heater gives a reasonably good indication of its efficiency. By measuring the temperature of the gases exiting the exhaust stack and looking it up on the chart shown in **Figure 28** you can learn the efficiency.

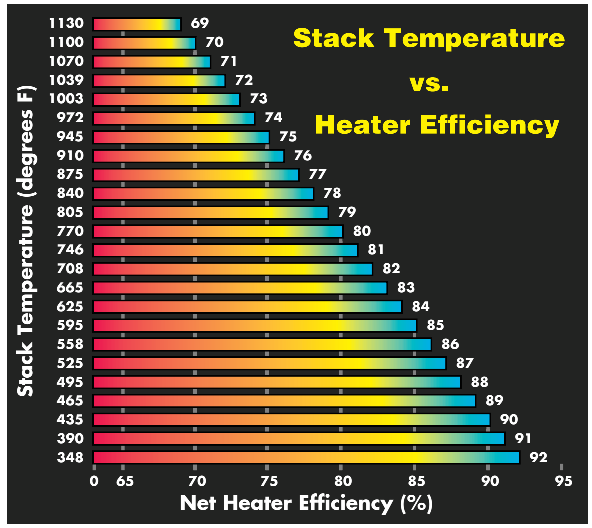
Heatec checks the efficiencies of heaters as a free service to HMA plant owners. So if you would like for Heatec to do this for you please give us a call. We will be happy to check the efficiency of your heater and tell you if savings are possible with a more efficient heater.

Case histories

We calculated the potential savings a HMA plant in Arizona could expect by replacing their old heater. It had an efficiency of about 52 percent. We estimated that a new Heatec heater would save them an average of $3882 per month. The total cost of the new heater installed was $42,072. The savings paid for the new heater in 11 months. The savings now increase the owner’s profits and will do so for the remainder of the heater’s 20-year life.

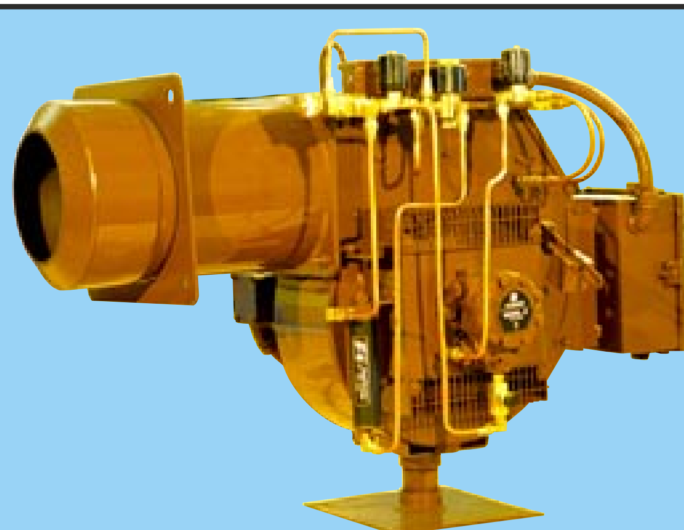
On another occasion we replaced an old Hopkins heater (6 million Btu/hr) at an asphalt terminal in Kansas City, MO. Estimated savings are $5852 a month. The new heater paid for itself in only 10 months.

Figure 28



Stack Temperature Vs. Heater Efficiency

Figure 29



High-Low Burner

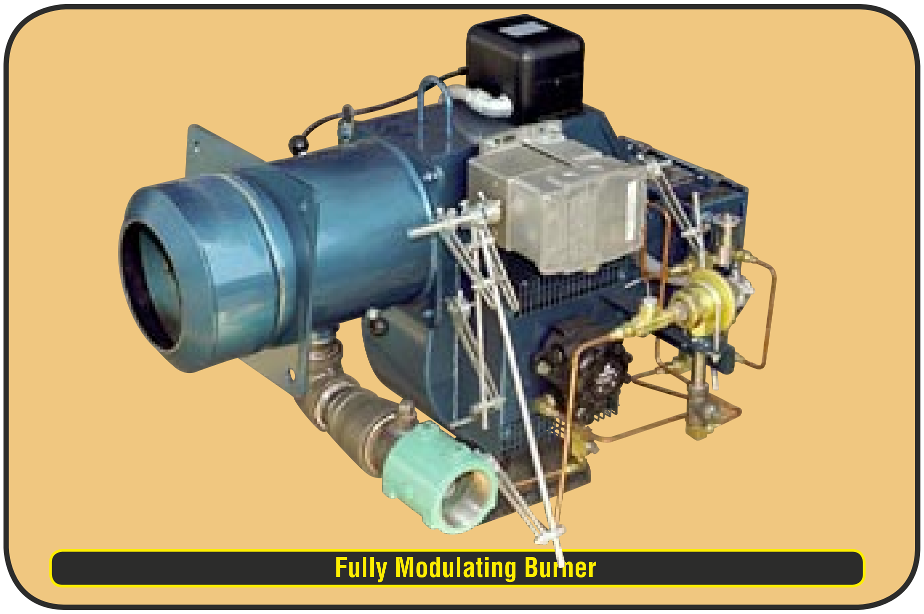
Burners

Burners on equipment used for asphalt heating can be either non-modulating, high-low, or fully modulating. A non-modulating burner has two operating states with no intermediate settings. It is either *on* or *off*. A high-low burner **(Figure 29)** has three operating states: *off, low,* and *high*. A fully modulating burner is one that can be fired at variable rates ranging from *off* to *high* with numerous intermediate rates.

The non-modulating burner has the advantages of being simple, reliable and cost less than the other types. It is well-suited for applications where it does not need to frequently cycle on and off. Frequent cycling reduces its efficiency because of temperature overshooting. The non-modulating burner is well-suited for direct-fired tanks because they lose heat very slowly, allowing the burner to remain off for long periods of time.

The non-modulating burner is *not* well-suited for hot oil heaters that are subject to frequent on-off cycling. Hot oil heaters are subject to frequent cycling when the plant heat load varies a lot. Heat loads tend to vary a lot on plants with several asphalt tanks and a number of other plant components that are heated.

The high-low burner is a compromise between a non-modulating burner and a fully modulating burner. It doesn't offer any real advantages for direct-fired tanks. And it is less suited for use with hot oil heaters than a fully modulating burner. Consequently, high-low burners are less popular for asphalt heating.



Fully Modulating Burner

Figure 30

Insulation On Coiled Tank

Figure 31

The fully modulating burner is the most efficient of the three types of burners **(Figure 30).** It can be fired at a rate that closely matches the heat demand. This conserves fuel, reduces temperature overshooting, and can eliminate constant on-off recycling. It is used extensively on hot oil heaters, especially larger ones that heat several asphalt tanks and other plant components.

Heat loss

Heat loss is the difference between the amount of heat energy produced and that used. It is heat produced without getting any benefit from it. Thus, it is wasted energy, which is costly. Because of the need to avoid wasted cost and to conserve our resources every effort should be made to avoid heat loss. This is especially true at a HMA facility because of the large amount of heat energy needed to produce hot mix. Heat losses can be minimized by proper use of insulation, a very cost effective solution **(Figure 31).**

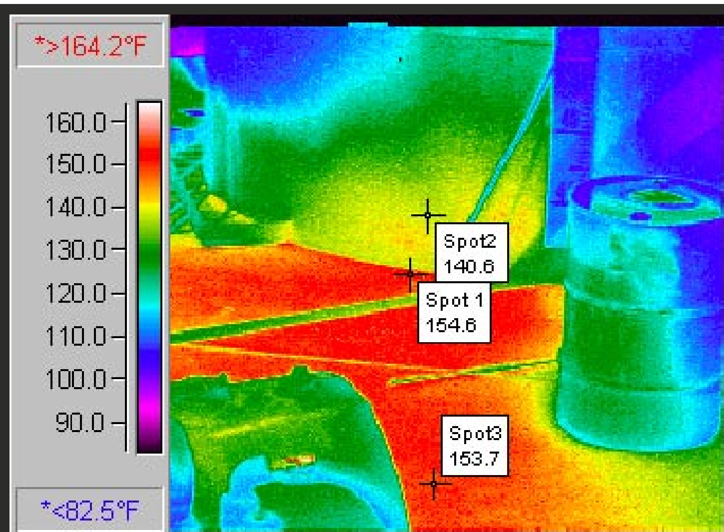
The cause of most heat loss in asphalt heating systems is too little insulation on some components and no insulation on others. **Figure 32** shows an infrared photo of a well-insulated vertical asphalt storage tank and depicts temperatures on the skin and on the concrete at its base. Compare this photo with **Figure 33**, which shows temperatures at similar points on a poorly insulated vertical tank. Thus, when components are purchased, proper insulation should be specified. And when the system is installed all asphalt piping and hot oil piping should be properly insulated.

Heat loss occurs when heat from materials and components in an asphalt system escapes into the atmosphere.

Figure 32

Infrared Photo Of A Well-Insulated Tank

Figure 33



Infrared Photo Of A Poorly-Insulated Tank

Figure 34

JACKETED ASPHALT PIPING

Asphalt Pipe Nominal Size	Hot Oil Jacket Nominal Size	Loss Per Linear Foot Btu Per Hour		Loss Per Flange Btu Per Hour	
		Uninsulated Jacket	Insulated Jacket	Uninsulated	Insulated
3 inches	4 inches	1598	86	1890	120
4 inches	6 inches	2349	122	2600	134
5 inches	8 inches	3057	148	3240	178

HOT OIL PIPING

Pipe Diameter	Loss Per Linear Foot Btu Per Hour		Loss Per Flange Btu Per Hour	
	Uninsulated	Insulated	Uninsulated	Insulated
1-1/2 inches	676	47	1205	97
2 inches	846	54	1660	115
2-1/2 inches	1024	55	2155	125
3 inches	1243	72	2485	130

Asphalt temperature = 300 degrees F. Hot oil temperature = 350 degrees F.
Pipe insulation = 1-1/2 inches (Figure 35).

Revised 11-24-03

Piping Heat Losses

Insulation Thickness For Various Operating Temperatures						
Pipe Diameter	150 Degrees F	200 Degrees F	300 Degrees F	400 Degrees F	500 Degrees F	600 Degrees F
1 inch	1 inch	1 inch	1 inch	1-1/2 inches	1-1/2 inches	2 inches
1-1/4 inches	1 inch	1 inch	1 inch	1-1/2 inches	1-1/2 inches	2 inches
1-1/2 inches	1 inch	1 inch	1 inch	1-1/2 inches	2 inches	2 inches
2 inches	1 inch	1 inch	1 inch	1-1/2 inches	2 inches	2-1/2 inches
2-1/2 inches	1 inch	1 inch	1 inch	1-1/2 inches	2 inches	2-1/2 inches
3 inches	1 inch	1 inch	1 inch	1-1/2 inches	2 inches	2-1/2 inches
3-1/2 inches	1 inch	1 inch	1 inch	1-1/2 inches	2 inches	2-1/2 inches
4 inches	1 inch	1 inch	1 inch	1-1/2 inches	2 inches	2-1/2 inches
5 inches	1 inch	1 inch	1 inch	1-1/2 inches	2-1/2 inches	2-1/2 inches
6 inches	1-1/2 inches	1-1/2 inches	1-1/2 inches	2 inches	2-1/2 inches	3 inches
8 inches	1-1/2 inches	1-1/2 inches	1-1/2 inches	2 inches	2-1/2 inches	3 inches

Thickness according to Turner/Malloy (emmisivity 0.05)

Minimum Recommended Insulation For Pipes

Figure 35

	Btu Per Hour		
Capacity (Gallons)	Horizontal Tank No Insulation	Horizontal Tank 3-inch Insulation*	Horizontal Tank 6-inch Insulation*
10,000	633,850	21,217	11,760
15,000	791,621	26,179	14,347
20,000	1,006,753	33,117	18,118
25,000	1,221,886	40,054	21,889
30,000	1,437,018	46,992	25,660
35,000	1,562,050	50,933	27,755
40,000	1,786,536	58,411	31,813

*Btu values are for new Heatec tanks and do not include heat for valves or connections. Old tanks may require double the heat or more. Asphalt temperature = 300 degrees F.

Asphalt Tanks—Maintaining Temperature

Figure 36

The greater the temperature differences between the ambient air and these materials and components, the greater the rate of heat loss. Thus, in locales with low temperatures the losses are greater than in areas of high temperature. But regardless of the locale, the following components should be insulated to minimize heat loss:

- All asphalt storage tanks
- Hot oil heaters
- All asphalt piping
- All hot oil piping
- Metering pumps
- Unloading pumps

While the need to insulate storage tanks and heaters is obvious to most people, many overlook the need to insulate piping. But it is one of those details that shouldn't be overlooked. Note the heat loss from various pipe sizes and temperatures as shown in **Figure 34**.

The *Thermal Insulation Handbook* by Turner and Malloy recommends insulation thickness for pipes as shown in **Figure 35.**

You can see just how important insulation is by comparing the heat required to maintain the temperatures of various sizes of insulated and non-insulated tanks. **Figure 36** compares asphalt tanks. **Figure 37** compares fuel tanks.

Proper insulation

Not all insulation can be considered as *proper* insulation. Proper insulation involves using the appropriate type of insulation, the appropriate thickness and using good workmanship when installing it. Generally, the thicker the insulation the better. In cold climates it is very important to use the thickest insulation available for the application. Moreover, the thickest insulation is appropriate even in warm climates, although not

Figure 37

Capacity (Gallons)	Btu Per Hour	
	No Insulation	3-inch Insulation*
10,000	170,952	5,941
15,000	213,504	7,330
20,000	271,526	9,273
25,000	329,548	11,215
30,000	387,570	13,158

*Btu values are for new Heatec tanks and do not include heat for valves or connections. Old tanks may require double the heat or more.
Type of fuel = No. 6 fuel oil. Fuel temperature = 150 degrees F

Fuel Tanks—Maintaining Temperature

as critical. The insulation will usually always pay for itself over a period of time. It may take a little longer in warm climates.

Using good workmanship means installing the insulation carefully. The insulation should cover virtually all hot surfaces exposed to ambient air. It should be installed so that it is not subject to being wetted by rain storms. And it should not be compressed any more than absolutely necessary. Compressing two inches of material to one inch cuts its insulating value to that of one inch of the material. And six inches of material compressed to three inches is no better than three inches uncompressed.

Five types of insulation are commonly used in asphalt heating equipment: 1) ceramic fiber blanket; 2) fiberglass blanket; 3) mineral wool blanket; 4) molded foamglass; and 5) calcium silicate. Refractory could also be regarded as a type of insulation. It is used in combustion chambers to protect metal parts from the burner flame and to shape the flame. However, it has almost no effect on heat loss.

The term most commonly used in asphalt heating to denote the efficiency of insulating materials is *thermal conductivity*. Thermal conductivity is a measure of the ability of a material to *conduct* heat flow. It is designated by the letter "**k**," and is usually called the **k**-factor. Thermal conductivity, **k,** is expressed in Btu per hour per square foot per degree F per inch of thickness of the material.

A measure of the ability of insulation to *resist* or *impede* heat flow is denoted by its **R**-value. This term is very common in the building industry. It is typically marked on the wrapper or container of insulating materials. Increasing **R**-values denote greater *resistance* to flow. Thus, the higher the **R**-value the better the insulation. **R**-values are very easy to use for comparing the insulating properties of various materials. Doubling the thickness of the material doubles the **R**-value.

R-value can be expressed either as resistance per inch of thickness, or as the resistance for the thickness stated. Both **R-value** per inch and **R**-value per stated thickness are used in actual practice when heat insulating materials are being specified.

R-value per inch is the reciprocal of **K**-value or 1/**k**.

HMA plant heating costs

Figure 38 shows the daily costs for heating asphalt, fuel and plant components at a typical stationary HMA plant. **Figure 39** shows the daily costs for heating asphalt and plant components at a typical relocatable HMA plant.

Figure 40 shows the daily costs for heating asphalt and plant components at a typical portable HMA plant.

Note that daily usage shown in figures 38, 39 and 40 is not equal to 24 times the hourly usage. This is because the heat load on the hot oil system drops while the plant is operating. We assumed that the plant was operating for 8 hours during the 24 hour period.

Heat requirements

The amount of heat (Btu/hr) needed for heating asphalt and components at an asphalt plant is known as *heat demand*. An estimate of the heat demand should be made when purchasing new asphalt heating equipment or upgrading old equipment. The estimate can provide important information for selecting new equipment. Heat demand is the key to choosing the appropriate capacity of the heating equipment and can enable you to closely estimate fuel costs.

Your estimate should include every heated component (including asphalt piping, and hot oil piping) along with the Btu required to maintain them at a specific temperature. Be sure to include an appropriate amount of extra heat demand for raising the temperature of asphalt that you buy at a temperature lower than required for the mix. (This assumes that you must raise its temperature in order to use it.) Also

	Hourly Usage			Daily Usage (24 hours)		
	Btu	Gallons No. 2 Fuel	CCF Natural Gas	Btu	Gallons No. 2 Fuel	CCF Natural Gas
Two 30,000 gallon horizontal coil tanks for virgin asphalt	93,984	0.8	1.2	2,255,620	20	29.3
One 25,000 gallon vertical asphalt tank for PMAC	40,054	0.4	0.5	961,305	9	12.5
Heavy fuel preheater	336,709	3.0	4.4	8,081,020	72	105.1
Double Barrel drum mixer 9 ft x 46 ft	43,520	0.4	0.6	1,088,000	10	14.1
Drag conveyor, 42 inch x 100 ft	68,250	0.6	0.9	1,706,250	15	22.2
Three 300-ton storage silos	99,649	0.9	1.3	2,391,570	21	31.1
Traverse conveyor, 36 inch x 33 ft	19,500	0.2	0.3	487,500	4	6.3
100 feet of asphalt piping, 4-inch dia jacket	9,940	0.1	0.1	238,560	2	3.1
230 feet of hot oil piping, 2-1/2 inch dia	14,920	0.1	0.2	358,080	3	4.7
Total Quantity	726,526	6.5	9.5	17,567,905	157	228.4
Cost		6.48	6.52		156.58	157.58

Asphalt temperature = 300 degrees F. Thermal oil temperature = 350 degrees F. Fuel temperature = 150 degrees F. Heater efficiency = 85%. Tank insulation = 3 inches. Pipe insulation = 1-1/2 inches. No. 2 fuel cost = $1.00 per gallon. Natural gas cost = $0.69 per CCF. Heavy fuel oil is used only for drum mixer. Usage includes heating for unloading pump and metering. Highlighted cells Include additional heat load for first hour cold start.

Heating Costs For A Typical Stationary Plant

Figure 38

	Hourly Usage			Daily Usage (24 hours)		
	Btu	Gallons No. 2 Fuel	CCF Natural Gas	Btu	Gallons No. 2 Fuel	CCF Natural Gas
Two 30,000 gallon horizontal coil tanks for asphalt	93,984	0.8	1.2	2,255,620	20.1	29.3
Double Barrel drum mixer 8ft x 39 ft	38,640	0.3	0.5	966,000	8.6	12.6
Drag conveyor, 36 Inch x 95 ft	55,575	0.5	0.7	1,389,375	12.4	18.1
Two 200-ton storage silos	51,439	0.5	0.7	1,234,533	11.0	16.1
Traverse conveyor, 36 Inch x 14 ft	9,750	0.1	0.1	243,750	2.2	3.2
100 feet of asphalt piping, 4-inch dia jacket	9,940	0.1	0.1	238,560	2.1	3.1
230 feet of hot oil piping, 2-1/2 inch dia	14,920	0.1	0.2	358,080	3.2	4.7
Total Quantity	274,248	2.5	3.6	6,685,918	59.6	86.9
Cost		2.45	2.46		59.58	59.97

Asphalt temperature = 300 degrees F. Thermal oil temperature = 350 degrees F. Fuel temperature = 150 degrees F. Heater efficiency = 85%. Tank insulation = 3 inches. Pipe insulation = 1-1/2 inches. No. 2 fuel cost = $1.00 per gallon. Natural gas cost = $0.69 per CCF. Heavy fuel oil is used only for drum mixer. Usage includes heating for unloading pump and metering. Highlighted cells Include additional heat load for first hour cold start.

Heating Costs For A Typical Relocatable Plant

Figure 39

	Hourly Usage			Daily Usage (24 hours)		
	Btu	Gallons No. 2 Fuel	CCF Natural Gas	Btu	Gallons No. 2 Fuel	CCF Natural Gas
One 30,000 gallon Heli-tank for asphalt	42,260	0.4	0.6	1,014,240	9.0	13.2
Double Barrel drum mixer 7 ft x 35 ft	35,200	0.3	0.5	880,000	7.8	11.4
Drag conveyor on surge bin, 24 inch x 50 ft	19,500	0.2	0.3	487,500	4.3	6.3
70 feet of asphalt piping, 4-inch dia jacket	7,360	0.1	0.1	176,640	1.6	2.3
150 feet of hot oil piping, 2-inch dia	10,600	0.1	0.1	254,400	2.3	3.3
Total Quantity	114,920	1.0	1.5	2,812,780	25.1	36.6
Cost		1.0	1.0		25.06	25.23

Asphalt temperature = 300 degrees F. Thermal oil temperature = 350 degrees F. Fuel temperature = 150 degrees F. Heater efficiency = 85%. Tank insulation = 3 inches. Pipe insulation = 1-1/2 inches. No. 2 fuel cost = $1.00 per gallon. Natural gas cost = $0.69 per CCF. Heavy fuel oil is used only for drum mixer. Usage includes heating for unloading pump and metering. Highlighted cells Include additional heat load for first hour cold start.

Heating Costs For A Typical Portable Plant

Figure 40

Figure 41

Equipment	Btu per Hour	
	Pre-Startup	Run
Double Barrel Drum Mixer 7 x 35 ft (hot oil jacket)	213,091	35,200
Double Barrel Drum Mixer 8 x 39 ft (hot oil jacket)	215,929	38,640
Double Barrel Drum Mixer 9 x 46 ft (hot oil jacket)	349,270	43,520
Metering Pkg, Drum Mix Plant, 100–300 tph	38,725	19,363
Metering Pkg, Drum Mix Plant, 400–600 tph	50,171	25,085
Weigh Bucket & Pugmill, 4,000 lb Batch Plant	117,000	90,962
Weigh Bucket & Pugmill, 6,000 lb Batch Plant	135,000	93,184
Weigh Bucket & Pugmill, 8,000 lb Batch Plant	168,000	101,884
Weigh Bucket & Pugmill, 10,000 lb Batch Plant	214,000	111,230
Weigh Bucket & Pugmill, 12,000 lb Batch Plant	275,000	120,752
Weigh Bucket & Pugmill, 14,000 lb Batch Plant	351,000	131,156
Weigh Bucket & Pugmill, 16,000 lb Batch Plant	442,000	142,618

Heat Demands For Key Components

Figure 42

Equipment	Btu per Hour	
	Pre-Startup	Run
Asphalt Storage Silo, 100-Ton	100,000	17,735
Asphalt Storage Silo, 150-Ton	150,000	21,635
Asphalt Storage Silo, 200-Ton	200,000	25,719
Asphalt Storage Silo, 250-Ton	250,000	30,590
Asphalt Storage Silo, 300-Ton	300,000	33,216
Traverse conveyor, 24 inches x 14 ft-8 inches	24,911	5,720
Traverse conveyor, 36 inches x 16 ft-8 inches	34,465	9,750
Drag conveyor, 300 tph, 24 Inch width (per foot)	3,736	390
Drag conveyor, 400 tph, 36 Inch width, (per foot)	4,377	585
Drag conveyor, 500 tph, 42 Inch width, (per foot)	4,698	683
Heavy fuel preheater 1000 gal/hour	3,593	336,709

Silos have heated cones and gates, 6-inch sidewall insulation, 8-inch cone insulation.

Heat Demands For Other Components

allow for asphalt tanks and storage silos you plan to add in the foreseeable future. Add a safety margin of about 20 percent to the estimated demand to allow for unknowns and contingencies.

Figures 38, 39 and 40 show hourly and daily Btu usage for typical stationary, relocatable and portable plants. The total hourly usage can be used as a starting point for estimating heat demand for such plants. But remember that the totals in those figures is only a sum of the heat required for the components listed. Moreover, the total hourly usage does not include the extra heat needed during the first hour of a cold start, before heat from hot aggregate supplements heat of the hot oil system.

So, the heat demand for your plant should start with the hourly usage for all of its specific components. To that you should add extra heat for startup plus all of the factors mentioned earlier. It would be virtually impossible to accurately calculate all those factors because of unknowns. So, it is appropriate to make a judgement based on experience.

We recommend increasing the total hourly usage by a factor of about 4 times. In some cases the factor could be up to 10 times.

Thus, we recommend a heater with an output of 2 million Btu/hour for the stationary plant described in Figure 38. We recommend a 1.2 milion Btu/hour heater for the relocatable plant described in Figure 39. And we recommend a 1million Btu/hour heater for the portable plant described in Figure 40.

Figure 41 shows heat demands for *key* components of drum mix plants and batch plants. **Figure 42** shows the heat demands for various *other* components of a plant. Heat demands are shown for *pre-startup* and *run.* In both cases this is the heat loss that *the hot oil system must replace.*

Heatec Heli-Tank Combines Coil Tank And Helical Coil Heater

Figure 43

Pre-startup means that the plant *is not* running HMA. Thus, the hot oil system replaces virtually all of the heat lost. *Run* means that the plant *is* running HMA. Consequently, heat from the HMA replaces much of the heat lost, thereby reducing the load on the hot oil system.

The goal of carefully estimating the heat demand is to get a heater that is neither too small nor too large. Correctly estimating the demand will enable you to pick a heater of the optimum size. A properly sized heater runs about 75 percent of the time while the plant is operating. If the demand is significantly underestimated you will get a heater that is too small to handle the plant temperature requirements. Moreover, heaters that are too small will cause over-firing, an undesirable operating condition. Over-firing is when the burner operates at a higher rate than the design capacity of the heater for extended periods in an attempt to maintain needed temperatures. Over-firing decreases efficiency and increases the film temperature of the thermal fluid, which shortens its life.

The reverse will happen when the heater is too large. It may constantly cycle on and off. Its run cycle may be too short for maximum efficiency. However, aside from the extra cost of the heater, moderate over-sizing is not a problem for hot oil heaters with fully-modulating burners. Fully-modulating burners can normally fire at a rate low enough to reduce frequent on-off cycling. Even so, hot oil heaters should not be grossly oversized.

Portability

Most asphalt heating equipment is available as units that are either trailer-mounted, skid-mounted or frame-mounted. Trailer-mounted tanks have wheels and suspensions to make them portable. They have a fifth-wheel towing pin so they can be pulled by the same types of tractors used to pull conventional trailers.

As an option they can include adjustable steel foundations that can be lowered to the ground to support the units at the job site. Cranes are not required when relocating these units. Heatec combines a coil tank and helical coil heater on the same trailer chassis to create a portable system known as a Heli-tank (**Figure 43).**

Skid mounted tanks and heaters do not have wheels and suspension, but can be transported by conventional tractor-trailers **(Figure 44).** Cranes or lift trucks are required to load and unload these units. The bottoms of the skids are designed to support the units and to rest on either soil or paved surfaces at the job site. The bottom surfaces of the skids have large bearing surfaces so as to keep ground-loading to no more than 2,500 pounds per square foot, a load normally supported by well-compacted soil.

Frame-mounted units are similar to the skid-mounted units. They can be transported by conventional tractor-trailers. However, the frames are designed to be supported by concrete pads or poured foundations.

All units are pre-wired and pre-piped, except for the wiring and piping between the units.

Equipment layout

Asphalt heating and storage equipment should be laid out or arranged in the most cost effective manner for piping. Good layouts can significantly decrease material and labor for installation of both asphalt and hot oil piping. Moreover, it can reduce operating costs long after the installation has been completed.

In a good layout, piping runs are as short as possible and pipes don't double back unnecessarily. Heatec constantly discovers layouts that are not cost-effective. Moreover, components should be positioned so they are easy to access

Figure 44

Skid-Mounted Tanks And Heaters Are Transported By Trailer

for routine maintenance and in the event a major component, such as a coil, has to be replaced.

Good layouts can be achieved only by close coordination among all parties involved. This is especially important on plants that will have two or more tanks and a heater skid. The following parties must work together as a team to achieve good layouts:

- The plant owner or operator.
- The HMA equipment salesman.
- Engineers who design the plant layout.
- Engineers who design the asphalt heating equipment .
- Those who manufacture the heating equipment and piping.

Two key factors govern good layout for piping. The first factor is the heights and positions of the tanks and heater in relation to each other. The second factor is the location of the inlets and outlets on the tanks and heater skid.

Heatec has developed standard layouts that greatly facilitate manufacturing the tanks and provide efficient piping. Moreover, the standard layouts reduce manufacturing costs and speed up delivery schedules. Thus, plant owners and equipment salesmen would do well to closely consider a standard layout unless there are special circumstances that necessitate a custom arrangement.

Piping

In addition to equipment layout there are several important factors to consider when choosing hot oil and asphalt piping. These factors affect setup and operating costs.

All asphalt lines should have outer heating jackets. Hot oil is pumped through the jackets to maintain the temperature of the liquid asphalt flowing through the lines when making HMA. And when the plant is idle the hot oil keeps the asphalt from solidifying.

Figure 45

Figure 46

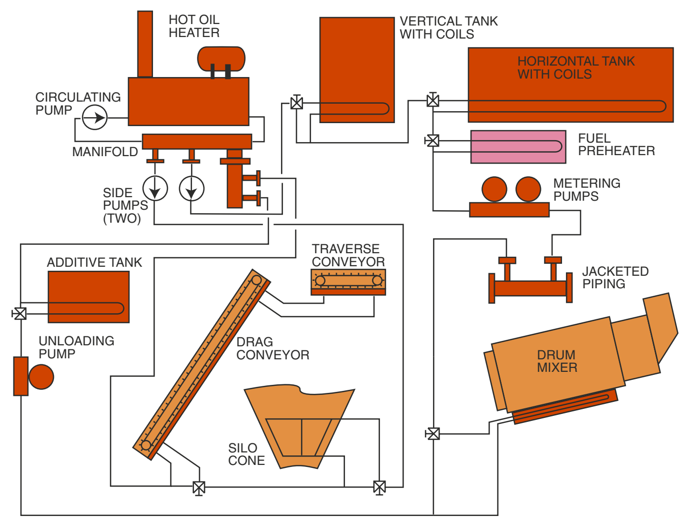
Heatec jackets for portable plants incorporate flexible jumpers at the joints **(Figure 45).** The jumpers provide fast heating on start-up and minimize unheated spots. The diameter of the jumpers is 1-1/2 inches, much larger than those provided by some manufacturers. Some use only 1/2-inch jumpers, which slow down the heating and make it difficult to obtain the desired temperature.

All hot oil lines and asphalt lines—including those that are jacketed—should be insulated to minimize heat loss. Heatec offers insulation with 1-1/2 inch pre-formed fiberglass material. The insulation is covered with a protective outer shell made of aluminum.

Ball joints are *highly* recommended in asphalt piping for portable asphalt plants. They make piping installation faster and easier **(Figure 46).** Moreover, they are stronger than flexible lines and less likely to rupture when stressed—an important safety precaution for lines carrying hot asphalt. A minimum of three ball joints are required. They allow up to 2 feet of misalignment between tank and mixer. As a result the units don't have to be positioned with as much accuracy as would be required without them. When traveling to another site, the lines stay attached and are simply rotated into transport position.

Small HMA plants with only one asphalt storage tank usually only need one

Figure 47



Using A Hot Oil Heater With A Manifold Facilitates Extra Circuits

hot oil circuit with one hot oil pump. The single pump circulates the hot oil through heated components and through the heater. Heatec helical coil heaters for single circuits are designated by the prefix HCS. HC stands for helical coil and S stands for *single* circuit.

Plants with HMA storage silos and two or more asphalt storage tanks can usually benefit from using two or more hot oil circuits, each with its own pump **(Figure 47).** One pump, known as the *circulating* or *main* pump, serves solely to re-circulate the oil through the heater. Each of the other pumps, known as *side* or *loop* pumps, only circulates oil through a single circuit.

A manifold is used on the hot oil heater to split off the extra circuits. Using extra circuits reduces the size of each pump, its operating pressure and the size of the motor that drives it. Operation of the system is much more *flexible* because each circuit can be operated independently. Thus, when some units are not in use, the hot oil to them can be shut off.

There are other important advantages to having a pump used solely for circulating the hot oil. It ensures that there is always an optimum flow of oil through the helical coil of the heater regardless of the heat demand. This ensures that the coil always operates at favorable wall temperatures, which can significantly extend the life of both the coil and the thermal fluid. It also allows adding or removing tanks or other heat users to the hot oil system without affecting the flow of oil through the coil of the heater.

Y-Strainer Is Commonly Used, But Requires Shut Down For Maintenance

Figure 48

Duplex Strainer For Heavy Fuel Eliminates Need To Shut Down

Figure 49

Filters and valves

HMA plant owners need to be informed about filters and valves to ensure that they get the ones most appropriate for their asphalt heating and storage system. This is especially true if all of the piping is to be fabricated at the job site by an independent contractor. Some of the factors that may affect their choice are as follows: the type of material being controlled, its temperature, protection from damage, maintenance requirements, how often asphalt samples are taken, etc.

A *strainer* is a type of filter used to remove debris or foreign material from hot oil, liquid asphalt and heavy fuel. One strainer should be used in the hot oil line to protect hot oil pump(s). Another should be used ahead of the unloading pump to protect it. And another should be used ahead of the metering system to protect it. Where a heavy fuel preheater is used, a filter should be used ahead of its pump.

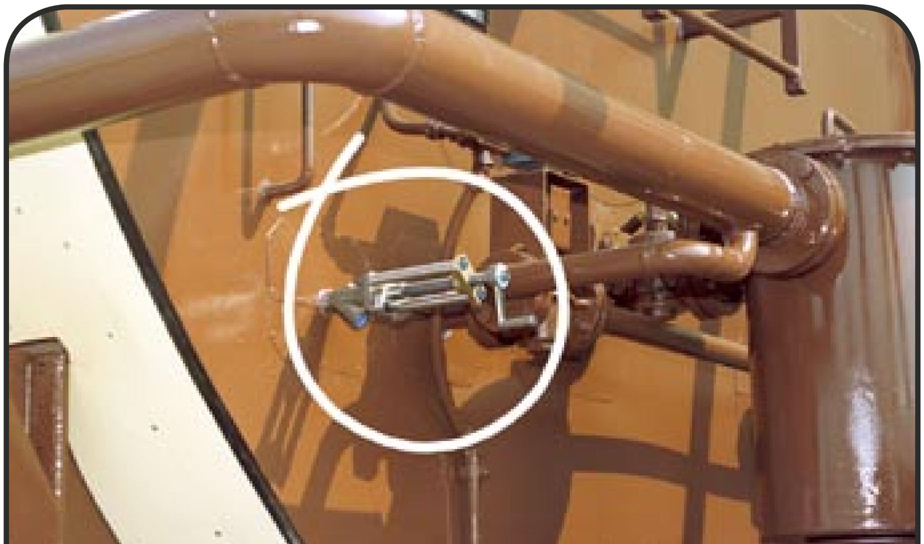
Strainers have a filter basket, either of perforated metal or wire mesh. A common mesh opening is 3/64-inch for hot oil and 9/64 for asphalt. A Y-strainer is the type most commonly used **(Figure 48).** In order to replace or clean the basket of a Y-strainer used in a hot oil line it is necessary to shut down the heater and to shut off the line to the filter.

A *duplex strainer* is commonly used where a heavy fuel preheater is installed **(Figure 49).** It has two independent strainers and a valve that allows switching from one to the other. One can be serviced while the other operates,

Figure 50

Sock Filter Protects Hot Oil Pump

Figure 51



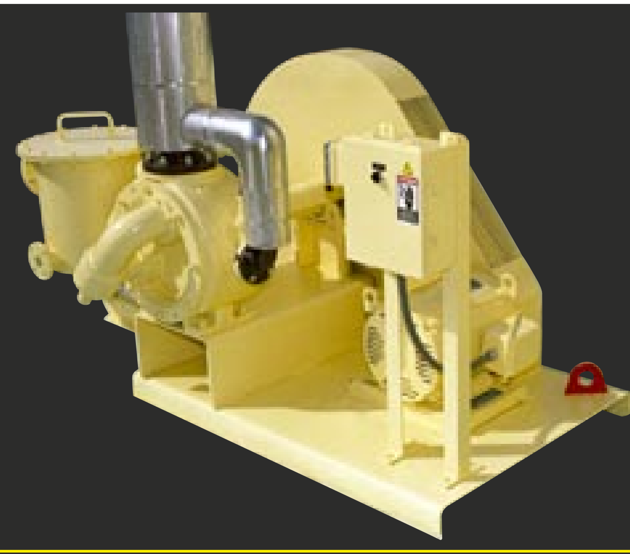
Sampling Valve Facilitates Frequent Asphalt Sampling

eliminating the need to shut down the system.

Sock filters are very effective and are highly recommended for use with hot oil heaters to protect the hot oil pump **(Figure 50).** They are especially recommended for new installations and when replacing an old heater with a new one. It is appropriate to use a sock filter *in addition to* a strainer in the hot oil line. The extra protection is worthwhile. The filter is long and shaped somewhat like a sock. It is made of a fine fabric mesh which collects dirt and debris from the hot oil flowing through it.

A *sampling valve* is a special type of valve that enables an operator to easily take samples of liquid from a tank **(Figure 51).** One should be installed in each asphalt storage tank, especially when asphalt samples must be taken frequently. In a horizontal asphalt tank the valve should be installed in one end, about 24 inches above the bottom. In a vertical asphalt tank it should be installed in the side, about the same height above the bottom. The valves are usually manually operated and feature a screw stem operated by a hand crank. They are virtually clog-free because of the way the valve is designed and mounted in the tank. (They do not need a hot oil jacket.) Moreover, they are usually leak-free and provide free-flow.

Gate valves and other types of valves are sometimes used for taking asphalt samples, even though such valves are not designed for sampling. They often clog and require use of a torch to heat them and their connections to get the material to flow. But valves specifically designed for sampling virtually eliminate the hazards and difficulty associated with valves not designed for that purpose.



Typical 3-Inch Asphalt Unloading Pump

Figure 52

Plug valves are commonly used in piping of hot oil heaters and asphalt storage tanks. They can be used in lines for hot oil, asphalt, or fuel oil. They are not recommended for gas. Two-way versions of the valve can be used to either shut off or regulate flow. Three-way versions can be used to switch flow from one circuit to another. When used for asphalt, the valve should have a hot oil jacket. Plug valves use a slotted cylindrical plug that rotates 90 degrees to control the flow. An actuator, such as a pneumatic cylinder, can be used to operate the valve through its 90 degree stroke. Plug valves can also be used in hydraulic and pneumatic circuits.

Gate valves are sometimes used in piping of hot oil heaters and asphalt storage tanks. They can be used in lines for hot oil, asphalt, fuel oil, or gas to shut off flow. A gate, similar to a guillotine, moves to close passage through the valve as it is actuated. However, gate valves are not recommended for use in lines carrying liquid that normally contains foreign matter or debris that can accumulate in their grooved seats and prevent complete shut off. When used for asphalt, the valve should have a hot oil jacket. Most gate valves are manually operated, requiring multiple turns of a wheel on a threaded shaft. Pneumatic or hydraulic actuating cylinders cannot be used to operate a gate valve.

Globe valves can be used in piping for hot oil heaters. They are used in lines for hot oil, fuel oil or gas to regulate flow. They are not recommended for piping carrying liquid asphalt. The valve has a globe-shaped plug that moves to restrict the flow as its spindle is actuated. Most globe valves are manually operated, requiring multiple turns of a wheel on a threaded shaft. A variety of configurations and plug shapes are available. Some plugs are conical-shaped. Others are parabolic-shaped. Pneumatic or hydraulic actuating cylinders cannot be used to operate a globe valve.

Check valves are commonly used in fuel oil and hot oil piping of heaters, asphalt storage tanks and hot mix storage silos. A check valve allows liquid or gas to flow only in one direction. A hinged gate in the valve automatically unseats and opens when pressure is applied to one side of it. The gate automatically seats and remains closed when pressure is applied to its opposite side. Some check valves use a spring-loaded ball instead of a hinged gate.

Ball valves are often used in piping of hot oil heaters and asphalt storage tanks. They are used in lines for hot oil, asphalt, fuel oil, or gas. Two-way versions of the valve are often used to either shut off or regulate flow. Three-way versions are sometimes used to switch flow from one circuit to another. All use a slotted ball that rotates 90 degrees to control the flow. An actuator, such as a pneumatic cylinder, can be used to operate the valve through its 90 degree stroke.

Butterfly valves are used in the fuel supply lines of modulating burners that operate on gas. The valve has a hinged gate that is controlled by a modulating motor. The valve controls the firing rate or modulation of the burner in response to the temperature sensors and controls. A butterfly valve cannot be used to totally shut off the fuel supply to the burner.

Asphalt pumps

Asphalt heating and storage systems at HMA plants require a variety of pumps. They are used to pump asphalt, hot oil and fuel. There are several issues concerning pumps.

Two asphalt pumps are usually required at all HMA plants. One is used to unload asphalt from delivery trucks. It is known as an *unloading* pump **(Figure 52).** The other is used to supply asphalt from the

Figure 53

Metering Package Using "A Pump Pushing A Pump"

storage tank to the drum mixer or batch plant. It is known as a *supply* pump. Plants with the asphalt metering system known as *"a pump pushing a pump"* has another pump, which is used passively for metering **(Figure 53).** Asphalt pumps should be carefully selected to avoid maintenance problems and down time.

The positive-displacement pump is the industry standard for pumping asphalt. Only those jacketed for hot oil heating should be used. Full-jackets are strongly recommended. In any case, the packing boxes should be heated. Otherwise, the packing will be short-lived and leaking will be a constant problem.

An asphalt unloading pump is used to transfer liquid asphalt from the tank of a delivery truck to a storage tank at a HMA facility. On portable plants the pump is usually mounted on the gooseneck of a portable storage tank. On relocatable plants the pump is sometimes mounted on the same skid as the hot oil heater. On stationary plants the pump is usually independently mounted at a location that will conveniently serve two or more storage tanks.

Unloading pumps used usually range in size from 3 to 5 inches, providing 200 to 450 gpm respectively. The time it takes to unload tanker trucks delivering liquid asphalt cement to a HMA facility depends upon the size of the unloading pump and connecting lines.

A 3-inch pump unloads 200 gpm and takes 30 minutes to unload a tanker with 6,000 gallons of liquid asphalt cement. But a 5-inch pump unloads 450 gpm and takes only 13.3 minutes to unload the same tanker. Thus, a 5-inch pumping system saves 16.7 minutes per truck load.

A facility that runs 150,000 tons of hot mix a year using 5 percent liquid AC can save about $4400 by switching from a 3-inch pump to a 5-inch pump. This is based on a savings of $13.88 per truck load, 320 truck loads and a trucking cost of $50.00 per hour.

But unloading time may not be a concern if you do not operate your own delivery trucks. And if the delivery truck has a 3-inch unloading line there is no advantage to having a 5-inch pump.

Supply pumps range in size from 2 to 5 inches, and are usually picked according to the rating of the drum mixer or batch plant. The size used most frequently is a 2-1/2 inch pump. Modified asphalt needs larger pumps and lines than used for virgin asphalts because it has a higher viscosity.

A problem can occur with a supply pump when its inlet is higher than the outlet of the storage tank. This is a condition that sometimes occurs with underground storage tanks. This makes the pump *lift* the liquid to its inlet before it can be pumped. Lifting the liquid creates a negative pressure or a vacuum at the inlet of the pump. Pumps should not be subjected to a vacuum in excess of 15" Hg (inches of mercury). Excessive vacuum will cause cavitation, which can severely damage the pump if allowed to continue. The solution is to either place the pump at a lower level or place the storage tank at a higher level.

Hot oil pumps

A potential problem at virtually every asphalt plant is oil leaks from the hot oil pump. The high operating temperatures (about 400 degrees F) takes its toll on pumps. Gear pumps often leak soon after the pump is put into service, regardless of the type of seal or packing used. For years leaking pumps were believed to be unavoidable and were accepted as a routine maintenance problem.

Centrifugal Pump Minimizes Hot Oil Leaks

Figure 54

But now environmental concerns have given more importance to solving the problem. Leaking oil must be contained so it cannot contaminate the soil and ground water. The federal government has put strict limits on the amount of oil allowed to spill on the ground. Oil leaks also need to be eliminated because they are a fire hazard. So, preventing oil leaks is an important goal.

Heatec has switched from gear pumps to centrifugal pumps as a solution to solving this problem **(Figure 54).** Our field trials revealed that seals in certain centrifugal pumps can go for years without leaking. The centrifugal pump Heatec uses has other advantages. It runs *much* quieter. It is air-cooled and runs cooler. And when seals wear to the extent that they leak, there is only a small leakage, which gradually increases over a period of time. Thus, seals can be replaced at a convenient time before maximum leakage occurs.

The use of a centrifugal pump brings on special design considerations. The pump is more sensitive to pressure variations at its inlet. So, if the system is not designed to limit these variations, the pump may not achieve its rated performance. Moreover, inadequate flow at its inlet can cause the pump to cavitate, thereby damaging the pump. The system must also be designed to avoid excessive starting loads and overloads.

Asphalt metering

Two methods are used to add the specified amount of asphalt cement to aggregate for making hot mix asphalt. Batch plants use a weigh pot to weigh liquid asphalt cement in the batch tower before the asphalt cement is dropped into a pugmill for mixing. The pot is mounted on load cells. It is essentially a batch metering system. Drum-mix plants use a continuous flow asphalt metering system.

The standard continuous metering system used by Heatec has two pumps **(Figure 53).** The system is commonly known as “a pump pushing a pump.” The system is very accurate and has proved to be *very* reliable, durable, and cost effective. The system can be calibrated to meet the most stringent accuracy requirements of plus or minus one-tenth of one percent (0.1 percent), as required by the state of Illinois and other states.

One pump is active and the other is passive. The active one is motor-driven and functions as a conventional supply pump. The passive one is forced to rotate by the liquid asphalt being pumped through it and functions solely as a flow meter. The asphalt flowing through the passive pump causes its drive shaft to turn at a speed proportional to the flow rate. An encoder on its shaft generates an electrical signal representing its revolutions. This signal is used by the computer in the control house to display the amount of asphalt cement used and its rate of flow. The system incorporates a temperature measuring system that compensates for changes in the volume of asphalt cement due to temperature variations.

Another continuous metering system sometimes used at drum mix plants is known as a mass flow meter. This is an electronic measuring system. Mass flow meters have a high degree of accuracy (plus or minus 0.15 percent) and virtually no moving parts. However, they are significantly more expensive than other systems used for asphalt metering and are hard to justify solely on the basis of their increased accuracy. The system has an electronic sensor and transmitter that measure flow rate, density, pressure, viscosity and temperature of the asphalt. It compensates for temperature variations in the material.

Still another type of continuous metering system used for drum mix plants is the *Brodie* meter. It uses a rotor assembly, an output register, and a signal generator that produces pulses in proportion to the rate of flow. It is compensated for temperature variations. The Brodie meter is more expensive than the “pump pushing a pump” system and is less durable. Consequently, Heatec does not use the Brodie meter unless specifically requested by the customer.

Figure 55

Vertical Calibration Tank

Figure 56

Horizontal Calibration Tank

Calibration

Calibration tanks are recommended for calibrating the liquid asphalt metering system of a drum mix asphalt plant. They save considerable time and money. The tanks are available in two styles, a vertical **(Figure 55)** and a horizontal **(Figure 56).** The choice between the two styles is mostly a matter of personal preference.

Using a calibration tank is far more efficient than using a distributor truck, a common practice in the industry. Efficiency becomes significant when calibration must be done frequently. It wasn't so bad when you only had to calibrate every month or two. But now some states now require it every week.

Heatec calibration tanks provide an efficient way to calibrate the metering system. The tank has built-in load

Heater Control Panel With Readouts And Status Lights

Figure 57

cells and a digital readout. The load cells are highly accurate. They are factory calibrated and furnished with a calibration certificate. The system provides a higher degree of accuracy than using a truck scale. Once the calibration tank is installed, there is no need to connect and disconnect asphalt lines each time the system is calibrated. Here's all you have to do using a Heatec calibration tank:

1. Open the valves to the calibration tank and pump about 1000 gallons of AC into the calibration tank as indicated by the asphalt metering system.

2. Note the weight shown on the readout of the calibration tank.

3. Adjust the metering system to agree with the weight shown on the readout. Switch the valves, then pump the AC back into the AC tank.

4. Repeat as many times as necessary.

You can run three cycles with the calibration tank in less time than it takes for one cycle with a distributor truck. You may save two or three hours every time you calibrate. Maybe more. And don't forget about improved accuracy. In any case, the savings in time and money is apt to be more than worthwhile.

Just compare using a truck with using calibration tanks. Here's what you have to do when using a truck to calibrate your metering system:

1. Get an empty asphalt distributor truck. Drive it across a truck scale, record its weight, and then drive it to your plant.

2. Connect the truck to your asphalt tank.

3. Pump one or two thousand gallons of asphalt into the truck as indicated by the metering system. Disconnect the lines.

4. Drive the truck back across the weigh scale and record its weight.

5. Subtract the truck's empty weight from its loaded weight. Adjust your metering system readouts to agree with the calculated weight.

6. Reconnect the truck to the asphalt tank and pump the asphalt back into the tank.

7. Repeat the whole process again. And again.

Heater controls

A burner management system is required for automatically-ignited fuel burners. Traditionally, a very simple, economical burner management system is used for the burners on direct-fired tanks. It opens the fuel valve and ignites the fuel when the thermostat calls for heat and closes the valve when the thermostat is satisfied. It has a sensor that shuts off the fuel if it does not detect the presence of a flame. This type of system works very well on direct-fired tanks because the burner does not usually cycle frequently.

On hot oil heaters the burner management system is usually more sophisticated. It uses a microprocessor to manage the burner controls and provide proper burner sequencing, ignition, and flame monitoring protection.

A control panel mounted on the heater houses key electronic components **(Figure 57).** Readouts and signal lights on the face of the panel indicate the current burner status and its operating history.

If a problem occurs that causes the burner to shut down, the lights identify all switches affected by the shutdown. You can normally tell from the lights which limit switch tripped *first*, setting off the chain reaction that caused the shutdown.

The control panels should always be UL approved and may be either NEMA 4 or NEMA 12. NEMA 12 panels are dust tight. But NEMA 4 panels give added protection and are preferred. They

Figure 58

Blue Smoke Condenser Minimizes Air Pollution

protect against windblown dust and rain, splashing water and hose-directed water.

Emissions

A blue smoke condenser is a heat exchanger sometimes used as a vent in tanks of heated asphalt cement to minimize air pollution **(Figure 58).** It condenses gas vapors, commonly known as blue smoke, produced by heating light ends (volatile organic compounds) often present in the liquid asphalt cement. Condensing the vapors turns them into a liquid state wherein they return to the liquid asphalt cement instead of escaping into the atmosphere through the tank vent or exhaust stack.

Condensers used on asphalt storage tanks usually have a number of tubes with external fins. The tubes are cooled by ambient air circulating through the fins. Thus, gasses exiting the tank are cooled as they flow through the tubes. The cooling causes vapors of the VOCs to condense and to drain back into the tank. This greatly minimizes the release of pollutants into the atmosphere.

Containment

Containment refers to a secondary enclosure for tanks that contain liquids, usually fuel or asphalt cement. It functions to keep the liquid from escaping in the event of a leak or rupture in the primary tank. The main concern is for the environment. However, a containment can also minimize the impact that an accidental spill can have on operation of the HMA facility.


Concrete Wall Containment Encloses Several Tanks

Figure 59


Tank With Built-In Containment Shell

Figure 60

Containment enclosures are often no more than concrete walls built around a group of tanks **(Figure 59).** However, Heatec offers containment enclosures for individual tanks fabricated from steel **(Figure 60).** On portable tanks the containment enclosure consists of a second tank that fully encloses the main tank—a double-walled tank. On a stationary or relocatable tank the containment enclosure usually encloses only the bottom portion of the tank.

Horizontal Vs vertical tanks

Heated asphalt storage tanks are cylindrical and may be either horizontal or vertical. Horizontal tanks are installed so their long axes are horizontal and they occupy a ground area equal to their diameter times their length. They are easily equipped with wheels and suspension for highway travel.

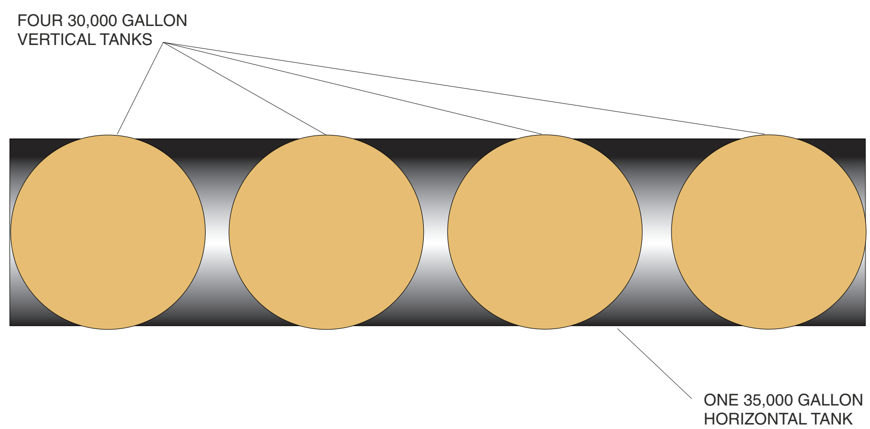
Vertical tanks are installed so that their long axes are upwards and they occupy a ground area only the size of their diameter **(Figure 61**). Consequently, you can fit four vertical tanks in the space of one horizontal tank **(Figure 62**).

Another advantage is that the surface area of asphalt cement exposed to atmosphere inside a vertical tank is smaller than that inside a horizontal tank for the same amount of liquid. Thus, there is less oxidation of asphalt cement in a vertical tank. Moreover, when mixers are installed to keep polymers in suspension, the liquid in vertical tanks

Figure 61

Vertical Tanks Have Small Footprints

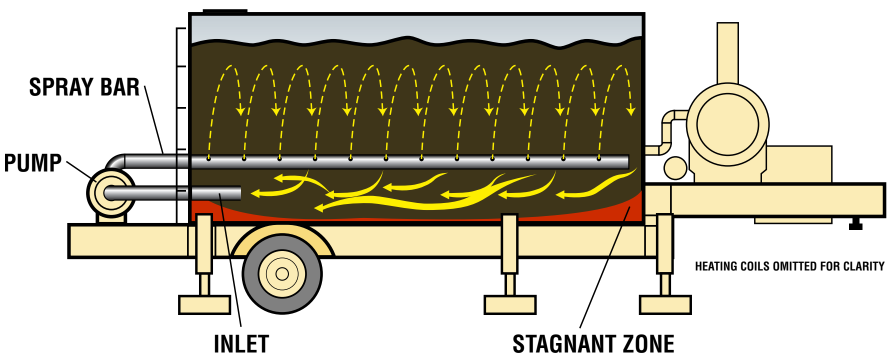
Figure 62



Ground Area Of Vertical Tanks Vs. Horizontal Tanks

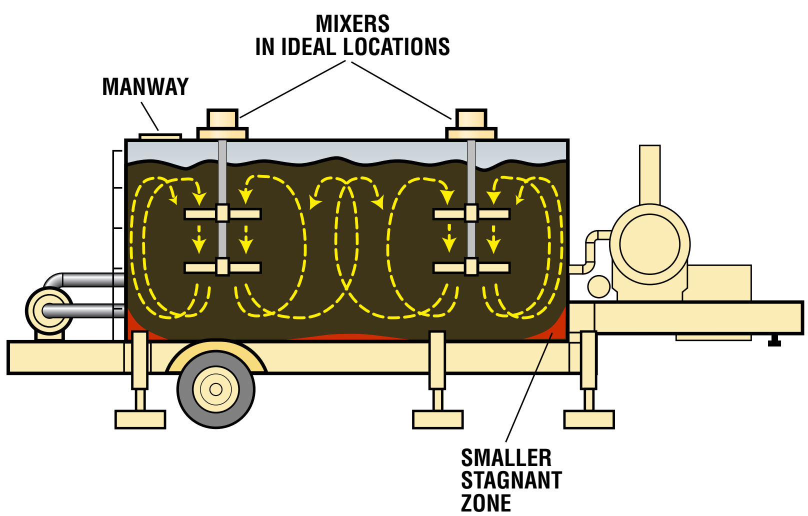
has better flow patterns than in horizontal tanks.

However, there are other considerations when polymers are used and the tanks must *also* be portable. Horizontal tanks are best-suited for *portability*. But, as already noted, direct-fired tanks are not recommended for polymer-modified asphalts, even though they can be portable. So, the best-suited tanks for both portability *and* polymer asphalts are horizontal tanks that have coils heated by hot oil. And where only a single tank is needed, a unit that combines a coil tank with a heater, such as a Heli-Tank, is an excellent choice.



Horizontal Tank With Re-circulation System For PMAC

Figure 63



Horizontal Tank With Mixers For PMAC

Figure 64

Heli-Tanks and other horizontal tanks heated with hot oil can incorporate either a spray bar re-circulation system (**Figure 63**) or mixers (**Figure 64**) to keep the polymer from separating from the asphalt. Although the mixing action in a horizontal tank is not as good as in a vertical tank, current experience indicates that the mixing is quite satisfactory. (Please refer to Heatec Technical Paper T-133.)

NOTES

NOTES

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