

COAL TAR PITCHES STILL MAKE THE GRADE IN LOW-SLOPE BUR



BY JAMES P. WEIDEMAN AND BARRY H. BAUGHN

Typical built-up coal tar roof.

*Coal tar traces its roots back —
for a few hundred million years...*

Nature began manufacturing coal tar by forming coal 200 to 300 million years ago, when much of the earth was covered with great swamps and bogs.

As primitive trees and plants died, they partially decayed through chemical and bacterial action. As time progressed, this material became buried under tremendous weights of soil, sediment, and rock. This pressure induced heat and chemical reactions, resulting in the beds of carbon we call coal.

From Coal to Coal Tar

When coal is heated to high temperatures in the absence of air, chemical changes take place. Its components separate and, under suitable conditions, produce coal tar. This process is sometimes referred to as "destructive distillation" of coal. Coal is a vital product in the manufacture of steel and iron. For this purpose, bituminous coal is converted to coke in arrays of slot-type ovens, where it is heated at 1800° F to 2200° F in the absence of air. This process drives off the volatile compounds in the coal, leaving the residue, coke. The volatile compounds and gases are collected and cooled to condense, to separate the tar and other products from the gas phase. The resulting crude coke-oven coal tar is then transported to by-product coal tar refining plants for

conversion into a variety of coal tar chemicals, including roofing-grade pitch.

At the refining plant, coal tar goes through a distillation process which begins with a series of preheating steps and continues through a battery of fractionation columns. The residue from distillation is called coal tar pitch. The particular grade of the coal tar pitch depends upon the amount of volatiles removed in the distillation process. The more volatiles removed, the harder the pitch and the higher its softening point temperature. The various grades of pitch obtainable from coal tar are used as road materials, roofing pitch, protective coatings, and a variety of industrial products. Coal tar roofing-grade pitch is normally classified as a medium-soft pitch.

Coal Tar Chemistry

Coal tar pitch is primarily composed of ring-like hydrocarbon molecules. These closed-ring structures are relatively small and compact. They develop a tenacious bond between the carbon and hydrocarbon atoms and, therefore, are very difficult to split apart. The strong molecular attraction in these ring-like compounds provides excellent resistance to reaction with sunlight, water, oxygen, and many of the common chemicals found in today's environment. Additionally, coal tar pitch is not attached by, or supportive of growth of bacteria, fungi or plant life.

The tightly compact nature of the ring-like coal tar pitch molecule is the characteristic that provides coal tar pitch with

some of the properties important to its performance in roofing. For example, viscosity changes in coal tar pitch are directly proportional to temperature changes and are evident at temperatures experienced on built-up roofs.

This property has been described in the field as "cold flow" or "self-healing." Although a somewhat imprecise description, it does describe the action that has been witnessed on the roof which has, accordingly, become a part of the roofing industry's vocabulary.

Coal Tar Roofing Evolves

The primary use of today's roofing-grade coal tar pitch is on dead-level and low-sloped roofs. Nature has provided coal tar with the correct chemical and physical characteristics for such use: resistance to degradation from all of the most menacing atmospheric conditions, combined with long-term durability against one of the most devastating of nature's solvents—water—in all its forms.

In 1941, the American Society for Testing and Materials (ASTM) developed the first standard for coal tar roofing and waterproofing pitches. During the development period, a task force of coal tar scientists determined that the standard would provide specifications that would retain proven characteristics for life:

- Maximum resistance to leaching or alteration by water.
- Sufficient cold-flow property to provide a "self-healing" property.
- Sufficient rigidity at elevated atmospheric temperatures to resist excess flow.
- Minimum volatility at atmospheric temperatures to avoid early embrittlement.
- Low volatility at high temperatures to provide maximum fire resistance.

The specification which evolved in 1941 was ASTM D-450 for Roofing and Waterproofing Pitches.

EVT Testing

In a series of testing programs, Koppers, in conjunction with the National Roofing Contractors Association (NRCA), conducted studies on the application quantities of ASTM D-450 Type I roofing grade coal tar pitch. Hand mopping and mechanical spreading techniques were both used to apply the coal tar roofing (BUR) to test decks. The testing program was based upon and similar to the National Institute of Science and Technology

(NIST) program described in the publication, *The Viscosities of Roofing Asphalts at Application Temperature*.

The point of application temperatures for these tests ran from 300° F to 425° F, at 25° F intervals. Application temperature affected interply applied quantity. At the lower point-of-application temperatures, the interply pitch quantities, on average, were heavier in mass; at the higher temperatures, the quantities were lighter. For each set of temperatures, the average interply quantity of pitch in the test specimens decreased as the temperature increased.

However, there were irregularities in the average interply quantity of pitch in each of the test deck runs, though there was less inconsistency in the EVT range. Even though the pitch application was continuous, it was not necessarily "uniform" (identical) in mass across every square foot applied. Of the test coupons evaluated in this series, based on an average of each of the test set temperatures, the interply quantities ranged from approximately 30 pounds per square at 300° F to 15 pounds per square at 425° F.

Equiviscous Temperature

The testing revealed that the ideal viscosity of roofing grade coal tar pitch should be between 15 and 35 centipoise (12 to 28 centistokes) to achieve appropriate interply quantities. Thus the viscosity for the equiviscous temperature (EVT) for coal tar pitch was determined: the temperature at which the viscosity is 25 centipoise (20 centistokes).

Additionally, it was further revealed that the ideal point-of-application temperature range is 335° F to 385° F for Type I coal tar pitch. These temperatures then provide an EVT range for roofing grade pitch—the point-of-application temperatures which provide the desired viscosity for the installation of coal tar BUR systems.

EVT viscosity values are much lower for coal tar pitch than EVT viscosity values for asphalts. As promulgated by the roofing industry, the EVT for asphalts is that temperature at which the viscosity is 125 centistokes, and provides for an EVT range of plus-or-minus 25° F. This value is considerably higher than the EVT for coal tar pitch.

Use of asphalt EVT viscosity values would provide far too viscous a material for application of coal tar BUR systems, with a resultant heavy mass of interply material. This viscosity variation evolves from the difference in molecular structure of the two types of material and the resulting inherent differences in temperature susceptibility.

Testing evaluations performed by E.W. McGovern and E.O. Rhodes determined that the primary aging or weathering process of coal tar materials is the evaporation of the oils. Oxidation and water solubility are minor aging factors. This fact raises the question of loss of coal tar after application. The evaporation of oils from coal tar pitch is a relatively slow process and should be thought of in terms of years rather than weeks or months. For example, in what might be classified as full-term BUR systems—an age of approximately 20 years—the top-pour softening point temperature may increase during the roof's life by

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as much as 35° F; that is, to as high as 175° F.

To evaluate the loss of quantity of material in this rise in softening point, research scientists developed and performed rapid-aging tests that simulated job-site temperatures. They determined the mass loss as approximately 3.25% for Type I coal tar roofing pitch—a rather minuscule amount when evaluated on a year-to-year basis (less than .25% per year).

Roof Slopes for Coal Tar

As previously mentioned, nature has made coal tar roofing materials especially suitable for dead-level and low-sloped roofs. Although many architects and builders are aware of this and design their roofs accordingly, there seems to be a trend toward greater roof slopes. In this regard, some of the strengths of coal tar can also be weaknesses under certain circumstances.

Coal tar pitch has excellent “self-healing” properties. It also has a ring-like molecular structure which provides excellent resistance to water and chemical degradation. But these attributes also impart a certain temperature susceptibility.

When roof slopes are too steep (more than 1/4" per foot when fiberglass felts are used with coal tar pitch, and more than 1/2" when organic felts are used with the coal tar pitch), felt slippage or pitch migration may occur. When slope is combined with very heavy interply moppings, as often occurs with cold weather applications, the potential is increased for felt slippage or pitch migration during the succeeding months of spring and summer.

As a rule of thumb, coal tar BUR systems pose little problem of slippage on slopes up through 1/4" per foot. On slopes between 1/4" per foot through 1/2" per foot, there is normally no major problem, provided the interply application is less than 30 pounds per square per felt layer, the use of the proper type felt as recommended by the manufacturer is observed, and the felts are firmly embedded into the hot pitch during application.

Coal tar built-up systems are very successful on low-sloped roofs, provided all parties involved (owner, architect, specifier, roofing consultant, general contractor, and roofing contractor) understand the material and work as a team to design, supply, and build a long-lasting roof system.

Trends in Coal Tar Pitch

With the infusion of single-ply systems into the roofing industry over the past two decades, the overall volume of all BUR has decreased, including coal tar. However, there has been a renewed interest in hot-applied coal tar BUR beginning in the mid-1980s, continuing through the 1990s and, as expected, progressing into the 2000s.

The coal tar roofing industry is seeing the return of former coal tar users, building owners, and specifiers. Will these trends continue? Only time will tell. Several major roofing-products firms now describe various coal tar systems in their specifications. Internet web sites such as www.koppers.com (Koppers Industries, Inc.) and www.alliedroof.com (AlliedSignal) offer full availability to product descriptions and application specifications.

A critical aspect of the move toward single-ply systems has been the irregularity in which the installers work with hot-applied BUR. Because a roofing crew, in a relatively short peri-



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od, may have to apply two or three different types of single-ply systems interspersed with a few hot-applied built-up roofs (both asphalt and coal tar), they may lose some "edge" in their technique of applying a particular roofing system.

The degree to which this variety may be a problem is not certain, but roofing of whatever type needs an experienced and regularly practiced crew of applicators for long-term success of the systems they apply.

Health and Safety

In passing the Occupational Safety and Health Act in 1970, the U.S. Congress determined the law should be administered in the Department of Labor by the Occupational Safety and Health Administration (OSHA). One of OSHA's responsibilities is the development of health and safety standards.

OSHA's Permissible Exposure Limit (PEL) for the volatiles that evolve from materials such as roofing-grade coal tar was set at two-tenths milligrams per cubic meter (.2 mg/m³;) of the benzene soluble fraction of airborne particulate matter (that quantity of particulate matter in the air which can be dissolved in benzene). This standard has remained the same to date and, at the time of this writing, OSHA contemplates no change.

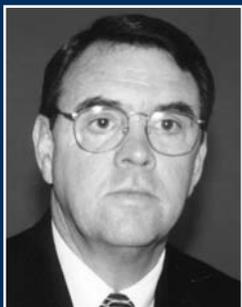
In a study conducted during 1979 and 1980 under the auspices of the NRCA, Dr. Jerome Thomas of the University of California evaluated the extent of roofing workers' exposure to emissions originating from hot asphalts and coal tar. Thomas' studies show that not all applicators working with both bitumens were within the OSHA standard. Most of these cases originated from overheating the asphalt or coal tar, poor working practices, and undersized and broken equipment.

Summary

In summary, it is important to remember that coal tar built-up roofing is a system that has experienced over a century of long-term success. It is still modern and contemporary in the sense that it continues to work well and can provide successful roofing performance for 20 years and more when applied by proficient roofing firms on properly designed roofs. ■

James P. Weideman, former Manager of Technical Services for Koppers Industries, Inc., authored the original content of the preceding article published in RSI Magazine in May 1986. This updated article as revised by B.H. Baughn is currently in use by RIEI in the "Built-up Roofing Systems" Presentation.

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