COLD APPLIED COAL TAR PAINTS

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Coal tar and coal tar pitch base coatings probably date back to the first production of these black viscous materials in gas plants and by-product coke ovens. It can safely be said that historically they have been manufactured and used for at least one hundred years. Early in their production they found wide use as water or moisture proofing paints and so even today we find them specified frequently by the marine and water works industries.

Tar and pitch are sticky materials which when compounded into paints show excellent wetting and adhesive properties over all types of surfaces and while sand or grit blasted substrates give the best results, a considerable degree of protection is still obtained with the tar paints over tight mill scale and wire brushed steel.

Tar paints are not recommended for severe chemical exposures, but they are inert enough to withstand most soil acid and alkali concentrations in underground installations and salt conditions encountered aboveground, in shore installations, fertilizer plants and sewerage works.

Coal tar paints and coatings, like other systems have limitations which can be pointed out here before discussing their general composition. First, they, like the old Ford cars, come in only one color - black. It is extremely difficult to pigment or dye a coal tar paint to get any other color with one exception. The exception is an aluminum color which can be obtained by incorporating about 1.5 pounds of leafing aluminum powder to a gallon of paint. The coal tar paints cannot usually be overcoated with a colored topcoat without bleed through nor for that matter can they be used as a topcoat over old paints without softening and wrinkling of the undercoat.

One other aesthetic consideration is that of alligatoring. Most coal tar paints alligator severely in sunlight exposure, but in many cases no bare metal is exposed and the moisture barrier is still performing successfully after years of exposure. One other objection sometimes encountered is that the coal tars have a rather sharp and strong odor.

In all of the above, the cut-back or solvent-type coal tar paints have been referred to. There is one coal tar coating which has fewer of these handicaps and that is the so-called coal tar emulsion which will be discussed later.

Classification of Coal Tar Paints

There are perhaps hundreds of proprietary formulations in which coal tar or coal tar pitch has been used either as a major or minor component with varying degrees of success. The voluminous patent literature attests to this, but here I would like to limit the classification shown below to the few products which have attained a fairly high volume of commercial use over the past fifty years and are still marketed by the four or five major tar processors. Where possible, an applicable published specification is included which will serve as a guide to the general composition of the coating rather than trying to list the limitless minor modifications, some of which are unpublished and unknown to the author, of the various manufacturers.

1) Refined Coal Tar

Under this classification are road tars of various consistencies and while in the broad sense they may be considered coatings, they are in general beyond the scope of this paper. The basic coal tar vehicle is included here, however, because it is a logical starting point and occasionally it is specified as an ingredient for, say, an anti-fouling coating, an asbestos-filled coating or caulking compound, or more recently as the coal tar component of a tar-epoxy system. Published tar specifications are as follows:

a) ASTM - Standard Specifications for Tar - ASTM-D490-47
b) Federal - Road Tar #R-T-143, 1940
c) AASHO - American Association of State Highway Officials #M52-42
d) MIL-T-15194 (Ships) May 1950 Tar, Coal - This specification covers coal tar to be used as an ingredient for ship bottom paints and lists the following requirements:

Specific Gravity at 25°C.	-	1.14 to 1.24
Water	-	1% Maximum
Carbon Content (Free)	-	15% Maximum
Ash	-	0.5% Maximum
Viscosity, Engler Specific at 50°C.	-	15 - 35

2) Coal Tar Pitch - Solvent Cutbacks

These coal tar paints are similar to a varnish and are manufactured of coal tar pitch and solvent to a brushing consistency. They can be applied by brush, spray or roller much as any other paint. Coverage rates are normally about 400 square feet per gallon, giving a dried film thickness of about 2 mils per coat. Two to three coats are usually specified. There are two types, a) a general maintenance paint made with a heavy coal tar naphtha solvent and b) a potable water tank paint made with a highly refined solvent (xylene) to reduce residual odor and taste. Specifications are as follows:

Coal Tar Pitch Base Paints

	Type a Military Spec. No. MIL-P-6883 Aug. 1950 Supersedes AN-P-31a	Type b American Water Works Association AWWA D 102-62 T Sec. 3.11
Color	Jet Black	-
Specific Gravity at 25°C.	1.07 to 1.12	-
Weight per Gallon, Lbs.	-	8.7 to 9.7
Viscosity at 25°C.	1 to 1.5 poises	60 - 75 sec. (Stormer)
Flash Point	95°F. Min.	70°F. Min.
Moisture, %	.05 Max.	-
Acid No.	3.0 Max.	-
Ash, % by Wt.	0.5 Max.	0.5 Max.
Non-Volatile, % by Wt.	53 Min.	-
Softening Pt. of Non-Volatile	55 - 65°C.	-
Free Carbon, % by Wt.	15 Max.	-
Unsaponifiable, % by Wt.	99.5 Min.	-
Volatiles, to 140°C. Wt. %	None	-
To 200°C. Wt. %	-	45 Max.
140 to 235°C., Wt. %	43 Max.	-
Drying	High Gloss 1 Hr. to Touch 8 Hrs. to Handle	After 24 hours at 77°F. and flushing shall impart no objectionable taste or odor to water
With Aluminum Powder	1.3#/Gallon	Shall contain no added filler, pigments, fibrous materials or asphalt.

3) Medium Bodied Coal Tar Paints

These intermediate coal tar paints contain mineral filler as well as pitch and solvent and are used where corrosive conditions require a heavier coating film than that obtainable with the varnish-type coatings.

They are somewhat easier to apply than the heavy bodied coatings and are often more successfully used on concrete with little or no tendency to mud-crack. Normal coverage is about 150 - 200 square feet per gallon which gives about 6 to 8 mils dry film per coat. Two coats are generally specified.

To the author's knowledge there are no Government specifications for this coating but it is believed that the following characteristics will describe their general composition:

Medium Bodied Coal Tar Paints

Weight per Gallon	10.5 - 11.5 Lbs.
Consistency	Viscous - (40 poises or more)
Moisture	1.0% Max.
Per Cent Solids	70 - 80
Filler (Ash), %	15 - 25
Volatiles to 235°C., %	20 - 30
Flash Point	95°F. Min.
Drying Time Between Coats	Overnight

4) Heavy Bodied Coal Tar Coatings

Of all the cold applied coal tar coatings, the one that is most widely known and used is the thixotropic heavy bodied paint made from processed or plasticized pitch, solvent and mineral fillers. By plasticized pitch is meant the more highly flexible material which is made by incorporating pulverized coal, heavy oils and pitch in a special high temperature processing operation. The coal appears to be suspended in a matrix of oil and pitch in a colloidal state, yielding high melting points but none of the brittleness associated with the straight distilled coal tar pitch. When this pitch is cut back with solvent, and put through a colloid mill a highly thixotropic coating material is obtained. After standing a day or so, the material in the container appears to be solid - in fact the can can be tipped upside down without causing the material to flow out. On dipping a stirring rod into it, it has the consistency (100 poises or more) of black mayonnaise which breaks down on vigorous stirring to a suitable application consistency.

This coating is applied without thinning, by brush, roller or heavy duty spray equipment at a coverage rate of 50 to 70 square feet per gallon and gives a dry film thickness of 15 to 20 mils per coat which will not sag from a vertical surface while wet. Two coats are normally specified. It is used on marine piling and other steel structures in wet environments such as underground piping and penstocks, and on cement, masonry, and galvanized steel, in pickling plants, sewerage and water works and chemical plants as a heavy duty maintenance paint.

In normal application thickness (35 mils in two coats) the coating remains flexible for years either submerged or underground. However, it does tend to embrittle in sunlight exposure and to overcome this a final coat of a tar-emulsion is often used.

The coating, being so widely used, has many published specifications, some of which are:

Bureau of Reclamation	- Spec. No. CA-50, Oct. 1956
Navy - Bureau of Yards & Docks	- Spec. No. 34 yd, May 1963
Steel Structures Painting Council	- Spec. No. PS 10.02 64 T, July 1964
Military - Docks	- Spec. No. MIL-C-18480A, Oct. 1961
American Water Works Assoc.	- Spec. No. AWWA C-203-62 Sec. 2.10

The Military Specification is fairly representative and often referred to, so the requirements shown there will act as a reliable guide as to the composition of the heavy bodied coal tar paint. They are shown as follows:

Coating Compound - Coal Tar Base
Spec. No. MIL-C-18480A Docks October 1961

Specific Gravity (77°F.)	1.2 - 1.5
Flash Point	95°F. Min.
Ash, % by Wt.	15 - 25
Water, % by Wt.	1.0 Max.
Distillate, % by Wt.	
To 150°C.	0
To 235°C.	18 - 30%
Asphalt	None
Free Carbon, %	5 - 25
Softening Point of Residue, R&B	205 - 240°F.
Penetration of Residue, 100 g., 5 sec., 77°F.	5 Min.
Coverage	55 - 70 sq.ft./gal.
Dry to Touch	6 Hrs.
Dry for Recoating	24 Hrs.

5) Coal Tar Emulsions

Coal tar pitch and water dispersions or emulsions form interesting coating systems whose properties are distinctly different from any of the previously mentioned solvent cutbacks. In the first place, water is the external or continuous phase so they may be diluted with water (not usually recommended) and clean up of equipment is facilitated. The emulsifying agent is usually a Bentonite clay and the pitch used is fairly soft, 50°C. R&B or lower. On drying, the soft pitch absorbs some of the clay forming a lattice-like structure which does not re-emulsify when wet, will not run or alligator in direct sunlight and is fairly flame resistant. The flexible dry films will withstand wide temperature fluctuations (minus 50°F. to over 180°F.) without becoming brittle or sagging. The coating, however, does reabsorb some water when immersed, so it is seldom used or specified for underwater or underground service. Its main use has been as a topcoat over other bituminous systems to prevent embrittlement and improve weathering properties. It in turn can be topcoated with aluminum or other fast drying color coats because the clay prevents the bleed-out so often encountered with coal tar paints.

The coal tar emulsion is also the common driveway and pavement sealer recommended for asphalt or tar macadam surfaces where resistance to gasoline spillage is required. One precaution in the use of the emulsion is that it should not be applied if rain or freezing conditions are anticipated before it has dried. Coverage is normally 50 to 60 square feet per gallon giving a 10 to 15 mil dry film thickness per coat.

Recently a combination rubber latex/coal tar emulsion has appeared on the market and claims are made that it is much tougher and more ductile than the straight coal tar emulsion. Other properties are similar.

There are two published specifications for the coal tar emulsion which are fairly descriptive of the coating composition. These are (1) Federal #R-P-00355a (GSA-F.S.S. dated October 16,1957) and (2) Military Specification No. MIL-C-15203c (Ships) dated November 1959. Requirements of the latter are:

MIL-C-15203c (Ships)
Coating Compound-Bituminous Emulsion

Solids	Min. 45%
Ash	Min. 25%
Moisture Content	Max. 50%
Moisture Absorption	Not more than 10%

Both the Steel Structures Painting Council Specification #PS 10.02 64T and AWWA #C-203-62 Section 2.11 refer back to the military specification for the use of coal tar emulsion as a top-coat for exposed steel structures.

6) Fibrated Coal Tar Coatings

These materials are more properly classified as caulking compounds because of their extremely heavy consistencies, but a brief mention of them can be made here. They are basically a mixture of asbestos fibers, mineral fillers and straight coal tar or coal tar pitch and solvent. They find wide application as roofing and flashing cements, as a seal coat between steel tanks and concrete pads, as pipe joint coatings usually with an open mesh fabric, and sometimes on marine piers and pilings where their perpetual stickiness is not a drawback. Many of them will meet the Federal Specification SS-C-153 Type II Coal Tar Base which lists the following requirements:

Federal Specification SS-C-153

Non-Volatile (24 Hrs. at 105-110°C.)	-	70% Min.
Filler by Ignition	-	15 - 45%
Sag at 140°F., 5 Hrs.	-	1/4" Max.
Flexibility at 32°F.	-	No cracking

7) Coal Tar-Epoxy Coatings

Of all the recent developments in coal tar paints, the one which has aroused the most interest has been the epoxy modified composition. As the patent literature shows, almost every resin, polymer or elastomer, has been tried with coal tar in an attempt to make an improved product with varying degrees of success. Some, like the phenolics when mixed with tar and cured, have formed water as a by-product in the coating. Others, like the rubbers, have markedly improved the toughness and elasticity of the system but have added almost impossible restrictions on application characteristics.

The epoxy resins, especially the low molecular weight ones, were found to be miscible in all practical proportions with coal tar and coal tar pitches. No by-products are formed during the cure and viscosity is not seriously affected so that high solids (70 to 100%) coatings can be made. In many respects the addition of epoxy resin eliminates most of the major faults of the coal tar paints. The coal tar epoxy system is semi-thermosetting and thus shows no tendency to run or sag at high temperatures. It hardens but does not become brittle enough to crack or disbond at temperatures as low as 50°F. below zero - it shows no signs of alligatoring or crazing in sunlight and it retains the low water absorption characteristics

and good adhesion of the coal tar paints. The high solids content of the system permits application of thick films (10 - 15 mils per coat) which harden by chemical reaction rather than by solvent loss. The coal tar-epoxies bleed far less than other coal tar paints and so can be overcoated with color coats or aluminum. The coal tar residual odor problem is minimized and in some instances where special precautions have been taken in the formulation or a heating or baking cure resorted to, the system has been considered suitable for coating potable water tanks and pipelines. In general, however, they are not recommended for use around food or beverage processing plants.

They are resistant to fresh and sea water, fairly strong mineral acids and alkalis, many salt solutions, aliphatic oils, gasoline, kerosene, diesel oils, JP-4 fuel and lubricating oils. In the case of water-white gasoline and fuels, some discoloration may occur and resistance to gum formation should be considered and checked out before using them in this service.

It must be stated here that the improved coating characteristics of the coal tar-epoxies are no cure-all - they have limitations like any other paint system and while, as it has been indicated before, they do eliminate many of the problems common to coal tar paints, they introduce a whole new set of problems of their own. In the first place, the epoxy resin is chemically crosslinked, usually with amines or amides and this introduces a pot-life problem. Most coal tar-epoxies have a usable pot-life of something less than two hours. Another associated problem is that of shelf life - the epoxy and coal tar tend to react to form a copolymer with a viscosity build-up that can be troublesome. In commercial practice, this problem is minimized either by careful selection of the tar or pitch component, or by putting the curing agent into the coal tar and keeping the epoxy resin as a separate component. The general composition of two such products representing the polyamide and the polyamine cured coal tar-epoxies can be illustrated by the requirements extracted from the following published specifications:

A) Polyamide Cured Coal Tar-Epoxy

Steel Structures Painting Council Specification
No. SSPC-PS1164P (July 1964)
(Similar to Paint C-200 - U. S. Army Corps of Engineers)

Component A

Ingredient	% by Wt.	Lbs. for 3.5 Gal. Batch	Gal.
Coal Tar Pitch (70-75°C. Softening Pt. % Volatile under 250°C.	35.0	13.46	1.28
Liquid Polyamide Resin (97% N.V. Amine Value 330-360)	11.5	4.43	0.55

Ingredients	% by Wt.	Lbs. for 3.5 Gal. Batch	Gal.
Magnesium Silicate	31.0	11.95	0.51
Xylene	18.7	7.20	1.00
Ethyl Alcohol (denatured)	1.0	0.39	.06
Gelling Agent (organic montmorillonite)	1.5	0.57	.04
Catalyst: 2,4,6 (dimethyl-aminomethyl) phenol	1.3	0.50	.06
	100.0	38.50	3.50

Viscosity of Component A - 160 poises Max. (Brookfield)

Component B

Liquid Epoxy Resin (99% N.V. Epoxide Equivalent)	-	9.7	1.0

B) Amine-Cured Coal Tar-Epoxy

An amine-cured system which has been specified under the Military Specification MIL-P-23236 (Ships) June 1962, Class 2, Coal Tar-Epoxy Coating is described as being composed of a refined coal tar pitch and a minimum of 17% (by weight of coating) of an epoxy resin converted with amines or other suitable materials. It is described as being suitable as a ballast tank coating for fuel (non water-white) and salt water ballast service.

A typical composition for such a system would be as follows:

Component A (20 Parts by Volume)

	Per Cent by Weight
Epoxy Resin, Liquid	30
Selected Coal Tar Pitch	25
Solvent - Coal Tar Hi-Flash	20
Pigment	25

Component B (Curing Agent 1 Part by Volume

Polyfunctional Aliphatic Amine (Diethylene Triamine or Tetra-ethylene Pentamine)	66.6
Solvent	33.4

The pigment in Component A usually contains a gelling agent to permit the application of heavy vertical films without curtaining or sagging. The two components are mixed just prior to use and applied

by brush, spray or roller to a wet film thickness of 12 to 14 mils (100 square feet/gallon). The dry film thickness then will be 8 to 10 mils. Two coats are generally specified and usually the second coat is applied as soon as possible after the first coat has set to minimize intercoat adhesion problems.

It will be noted that both coating systems are about 80% solids by weight. Some recent specialty coatings used for concrete pipe linings and for non-skid road toppings approach 100% solids by the use of more liquid tars and pitches and epoxy resins. Such systems are very dense, having no solvent pinholes and when loaded with graded aggregate show very little shrinkage on curing, which promotes good adhesion on concrete substrates. More details on the properties and characteristics of one such system will be given in another paper at this Symposium - "A Coal Tar Epoxy Reinforced Concrete Product/System Composite Pipe Structure." One recent innovation has been in the development of a 100% solids pitch-resin combination which is furnished in a powder form. For this material the steel plate or pipe is heated above the melting point of the compound and the powder is applied from a flocking gun, fluidized bed or with an electrostatic gun. The powder melts on hitting the pipe and flows out to form a smooth continuous film. Thickness is controlled by the residence time in the fluidized powder bed and is usually in the range of 10 to 15 mils. Both thermosetting and thermoplastic powders have been tried. Cooling of the thermoplastic coating is accomplished by water spray for quicker handling. In the case of the thermosets, heating often is extended with no water cooling to obtain optimum cure.

The powder is rather costly to manufacture but offers advantages in better physical properties of the coating system. Also where the electrostatic dusting method is employed, there is practically no overspray loss and odd shapes can be coated with ease.

This system is still in its infancy but looks extremely promising for many special applications.

Future Trends

It is believed that future improvements and modifications of the cold applied coal tar coatings will probably follow the trends of the recent past. Low molecular weight coal tar pitch definitely requires an assist from the high molecular weight resins and polymers to increase its toughness, flexibility, and temperature sensitivity while retaining the already well established special properties of low cost, low water absorption, high microbial resistance and long-time service performance.