Steam Cylinder Oil Specifications:

how to read them and what they mean.

by Bill Petitjean

HISTORICAL BACKGROUND

Steam cylinder oils are a family of specialty oils that were originally formulated about 150 years ago to lubricate the moving parts within the valve chests and cylinders of reciprocating steam engines. Early steam engine operators quickly learned that their machines required some form of lubrication. They discovered that beef tallow, a component of early hand made soaps, was an excellent lubricant when introduced into the valve chests of their engines. Unfortunately, tallow has an undesirable characteristic though. The early tallows were full of free fatty acids that form corrosive acids when decomposed in the presence of steam. These acids attacked the metal parts of steam engines.

When Colonel Drake discovered oil in Pennsylvania in 1859 the introduction of refined mineral oils as less expensive and better lubricants rapidly followed the development of the modern petroleum industry. Early refineries used simple distillation towers to separate out different crude oil fractions such as kerosene, light lubricating oils and heavy lubricating oils. It was found that the residuum at the bottom of the distillation towers formed an excellent lubricating film in hot steam cylinders. This residue became known as “cylinder stock” and has been called this name ever since. Further refining cylinder stock produces more desirable characteristics and a whole series of heavy, high viscosity products is extracted from the basic cylinder stocks.

It is important to note here that the crude oils produced from the fields in Pennsylvania, New York, Ohio and West Virginia have peculiar characteristics that are unique in the oil industry. They are “paraffinic” crude oils that have many

desirable characteristics as lubricating oils. They are particularly desirable for steam cylinder oils because they exhibit the greatest stability in high temperature applications and change viscosity less per degree of temperature change than “asphalt” based crude oils. When asphalt based crude oils are distilled heavy tarry residuum is found at the bottom of the distillation towers and this residue is typically used to make asphalt for road paving and roofing tars.

Therefore, the best cylinder oils have always been made from “Pennsylvania Grade Crude Oil”. Green Velvet Steam Cylinder Oil is manufactured from pure Pennsylvania Grade base stocks that come from local fields in Pennsylvania, New York, Ohio and West Virginia.

The use of heavy mineral oils in steam engine cylinder lubrication was quickly found to be less than perfect because, unlike tallow, mineral oils will not mix with water. In steam engine cylinders using saturated steam large quantities of condensed steam form water droplets that move at high velocities with the rapidly traveling steam throughout the engine passages. This condensate constantly washes the rubbing surfaces and does not allow the oil to establish a stable, long lasting lubricating film. Nineteenth century engine operators found that they had to feed large quantities of mineral oil to get reasonable performance out of the new oils. Experimentation proved if a small amount of tallow (or some other animal fat such as lard oil or sperm oil) was mixed with the mineral oils a nice compromise was formed. The tallow “saponifies”, or forms a sticky, soapy emulsion when heated by the steam and agitated by the turbulence in the cylinders and valve chests. The mineral oil gets caught up in this emulsion and, in effect, a crude grease is formed where the soapy emulsion “holds” the oil against the cylinder walls and other rubbing surfaces.

The result is a “compounded” oil that will “wet”, or spread over all the rubbing surfaces and resist the washing effect of water droplets in the steam. This is analogous to washing your hands with soap. The soapy emulsion helps “wet” your hands, cut through the natural oils and lift impurities from the skin. It was quickly found that only a small amount of tallow was needed to form adequate emulsions and today’s compounded oils generally use 10% or less compounding. The small amount of tallow in the oil significantly reduced the amount of corrosion found when

100% tallow was used for lubrication prior to the introduction of mineral oils. Yet, it was enough to help significantly reduce the amount of oil required to lubricate saturated steam cylinders.

Tallow is produced as a byproduct of animal carcass rendering and this industry has evolved refining processes that have gradually produced better beef tallows for cylinder oil compounding. The primary improvements have removed most of the corrosive free fatty acids and today's tallow products have almost eliminated this component entirely.

Green Velvet Steam Cylinder Oil compounding is fortified with a synthetic copolymer known as a "tackifier". This is a modern, non-toxic, non-hazardous additive that helps stabilize the emulsions in hot applications and improves the "tackiness" of the oil. Both the compounding and tackifier are excellent lubricants by themselves and both components help improve the lubricity of the base mineral oil stocks.

SPECIFICATIONS – HOW THEY HAVE EVOLVED

Today, most lubricating oils are manufactured in compliance with some type of standard specification. In many cases specifications are generic and are developed by an association that is formed by the manufacturers of the machinery lubricated by a specific type of oil or grease. The Society of Automotive Engineers (SAE) is such an association. It is familiar to everyone who uses motor oil in automobile engines.

Steam cylinder oils have never been formulated to a standard specification that has been agreed upon by a consortium of steam engine manufacturers. It is a curious mystery of history that such a specification was never developed, but the stubborn independence of early American industrialists is probably mostly to blame. However, the Skinner Engine Company developed generic guidelines for steam cylinder lubricants applicable to their line of steam engines. Skinner was the last of the steam engine builders and built their last unaflow steam engine in 1983. Their guidelines are the best available and Green Velvet Steam Cylinder Oils are based on the Skinner recommendations.

One of the significant generic lubricant specifications is the heavy gear oil specifications developed by the American Gear Manufacturer's Association (AGMA) over 50 years ago. Many gear drives require a heavy, viscous lubricant. Additionally, when water or moisture is present some type of animal fat compounding is necessary to prevent the heavy lubricant from washing off the sliding gear surfaces. It was found that compounded steam cylinder lubricants also made excellent gear lubricants.

Over the last 50 years the gradual demise of steam engines in all types of service has shrunk the steam cylinder oil market to a pitiful remnant of its original proportions. This has caused most specialty blenders that specialized in steam engine lubricants to go out of business. Today the major oil companies and one or two specialty blenders are the only makers of steam cylinder oils and this business is a small fraction of their total lubrication operations. Indeed, many of these oil companies have discontinued, or are in the process of discontinuing their cylinder oil product lines.

More importantly, the only identifiable commercial market that really remains for steam cylinder oils is for gearbox lubrication. Almost all the major oil companies have stopped calling these lubricants cylinder oils and now advertise them as gear oils. Their specifications all claim compliance with the AGMA specifications and their product designations call out the appropriate AGMA specification number. The primary differences between gear lubrication service and steam cylinder lubrication service are the lower temperatures found in gear boxes and the requirement that enclosed gearboxes re-circulate the lubricant many times for extended periods before change out. In steam cylinders the oil is applied once then is replaced as more is required to maintain adequate lubrication films.

The improvement in lubrication technology and chemistry has evolved many chemical additives that improve the stability and life of lubricants in re-circulating service. Gear lubricants are no exception and most gear oils have additives such as oxidation inhibitors, rust inhibitors and viscosity improvers. While these additives improve the lubricant's performance in gearboxes they are not stable at elevated temperatures and tend to come out of the oil as undesirable deposits in hot steam

cylinders. In extreme cases where viscosity improvers have been added the base oils fail completely in steam cylinder service.

It is difficult to serve two masters and steam engine operators should be aware that most of the gear oils available as steam cylinder lubes are not being manufactured for steam cylinder service even though many specifications still call out steam cylinder lubrication as an appropriate application. This does not mean that these lubricants will not work in steam cylinders, but most lubrication engineering offices have no steam engine lubrication experience any more and there are almost no lubrication engineers who can assist with steam cylinder lubrication applications.

Green Velvet Steam Cylinder Oil was developed to fill this widening gap. While industrial steam engine applications have all but disappeared there is a vigorous heritage and recreational steam engine industry that is struggling to find true steam cylinder oils that are blended specifically for steam engine service. Green Velvet blending formulations and specifications are not intended to fulfill any type of gear oil requirement and are manufactured exclusively for steam engine service. The oil components are obtained from traditional sources and the specifications are developed from the traditional recommendations the Skinner Engine Company engineers found worked the best. Therefore, Green Velvet Steam Cylinder Oil is a simple steam cylinder oil that predates most of the “improved” gear oils that are now being used. Furthermore, Green Velvet is available to end users in 1 pint, 1 quart, 1 gallon, 5 gallon and 50 gallon containers. Whether end users need a lot of oil or a very small amount, Green Velvet has a container size to fit everyone’s needs.

SPECIFICATIONS – HOW TO READ THEM AND WHAT THEY MEAN

Green Velvet Steam Cylinder Oil specifications are based on formulations that are generally not published and are retained as trade secrets.

Because steam cylinder oils have never been manufactured to a standard generic specification that is published there are a wide range of cylinder oils that create confusion when the proper type of oil is being sought for a particular application. Additionally, major oil companies tend to change ingredients without notice because their lubrication operations utilize byproducts from their primary fuel

making refineries. Sometimes such changes cause problems in steam cylinders and end users get blindsided because these changes come without any notice or warning.

In an effort to standardize formulations and reduce confusion, Green Velvet lists all ingredients in its oils, identifies formulations with a formula designation like Formula 1 or Formula 2 and tabulates a standard set of specifications across all oil types. Green Velvet specifications also contain some general application guidelines to help determine which oil type is appropriate for different heritage and recreation steam engine applications. Finally, Green Velvet's developer, William Petitjean, P.E. has over 40 years experience with steam engines and he is happy to discuss applications with end users.

There are nine specification parameters listed for all Green Velvet Steam Cylinder oils. They are explained below.

Base Oil: The base oil is the dominant component in cylinder oil and generally makes up 90% or more of the final product. The viscosity and lubricating characteristics of the base oil represent these characteristics in the final product. Choice of the proper base oil is a key part of manufacturing good quality steam cylinder oils.

Compounding: The amount of compounding is listed as a percent by volume of the total product. The amount of compounding determines how resistant the oil is to water washing and determines the amount of emulsion that is generated in the valve chest and steam cylinder. More compounding improves an oil's "wetting ability", or its ability to spread evenly across rubbing surfaces in the presence of water. Green Velvet Steam Cylinder Oil uses a maximum of 10% compounding. This compounding is formulated especially for steam cylinders.

Tackifier: The synthetic copolymer tackifier is identified as an additive so Green Velvet customers know every ingredient in their oil. There are no mystery ingredients in Green Velvet Steam Cylinder Oils to gum up customers' steam engines.

Compounding: This is the percentage of the total product volume that is made up of compounding. This is an important parameter to list because it helps determine which engine applications are appropriate for a particular oil. The basis for application is steam pressure, temperature, engine type, engine size and load factor.

Color: The color is a perceptive parameter that helps identify steam cylinder oil by color and texture when oil cans and lubricators are being filled with different oils. Steam cylinder oil is traditionally a green opaque color. Engine bearing oils are generally a more neutral translucent or tan color. This helps prevent putting the wrong oil in a lubricator. Green Velvet Steam Cylinder Oil is the traditional dark green color in all its grades.

Viscosity: This is a measurement of how "fluid" a liquid is at a particular temperature. It determines how much "body" or film building capacity the oil has at the high temperatures prevailing inside steam cylinders. The higher the viscosity the higher the ability to build stable films that withstand high pressures, high temperatures and the scuffing of heavy, fast moving parts inside the valve chests and cylinders. As a general rule, the lowest possible viscosity should be used in each application. This rule allows the easiest handling of heavy oils, improves atomization and application of oil into the steam circuit and builds films that are stable enough to adequately lubricate the moving parts at the conditions prevailing in a particular application. Two viscosity units are listed. SUS (Saybolt Universal Seconds) is an older unit that can be found in many older oil specifications. Centistokes is a more modern unit that is used more frequently today. 210º F is nearly equal to 100º C.

Flash Point: This is the temperature where the vapors driven from a heated sample of cylinder oil will "flash" into flame, but will not support a continuous burn. A continuous burn of vapors is called the Fire Point. This "flash" test is performed according to the American Society

of Testing Materials (ASTM) Test Protocol D-92. This is a comparative parameter that helps determine how much a particular cylinder oil can resist the vaporizing effects of high steam temperatures. The higher the flash point the more resistant the oil is to evaporation that destroys its ability to build a stable lubricating film on the rubbing surfaces.

Carbon Residue: This is the amount of carbon residue that remains after a sample of cylinder oil has been heated to a high temperature that evaporates and burns all components except a carbon residue that is left at the bottom of the test cup. The final amount of residue is listed as a percentage of the total weight of the original sample. The test is performed according to the ASTM Test Protocol D-189 and is called the Conradson Carbon Residue. This parameter helps determine how well the base oils are refined and also helps determine which additives contribute to the overall carbon residue content. Low carbon residue numbers below 2% are desirable because they indicate the oil will not precipitate as much hard or gummy deposits in the lubricators, valve chests and cylinders. Another test called the Ramsbottom test is also sometimes used. This test uses carbon residue as a percentage of the total sample weight too. But, the test protocol is different and Ramsbottom numbers are lower than comparable Conradson numbers. Always ask for the test type before interpreting carbon residue numbers.

The above explanations of the specification parameters for Green Velvet Steam Cylinder Oil are intended to give a better understanding of their use in defining good cylinder oils and helping choose the correct lubricant for a particular application. There are many good sources of information for those who wish to learn more about these parameters. Finally, the best criteria of a good cylinder oil is in its performance because so many different conditions exist in steam engine lubrication it is impossible to be very precise about which oil is best.

The Green Velvet Steam Cylinder Oil organization is always interested in customer feedback that helps further perfect the oil offerings. This discussion of specifications

and how to read and understand them is a result of a customer request. We strive to make Green Velvet Steam Cylinder Oils the preferred lubricant for all steam engine operators.

Southern Steam Trains LLC thanks Bill Petitjean for sharing his article on Steam Oil to post on our website. ©June, 2002 by Lubrication Specialties Corporation. Green Velvet Steam Cylinder Oil is a registered U.S. Trademark

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