Shay Operation - Fluids, Lubricants & Capacities

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As the day that the locomotive would be running approached I started to think about operational details. Recall that I'd never actually run a live steam locomotive so I started to collect information from others and to be more observant when others fired up and ran their steamers. It soon became apparent that there was much more information than I could remember so I started to write it down. Several others asked what lubricant or boiler treatment I was going to use (like I knew what I was doing) so I decided to put together this webpage.

Lubrication: There are a number of lubrication passages in the engine and drive train. It's not like your auto where you can go to the local auto parts store or can check the maintenance manual. I had concluded that light motor oil should work for the bearings, etc. and I had already purchased a small bottle of steam cylinder oil for the lubricator.

Being a novice, Kenneth's advice was solicited. His response was:

I use Chevron Vistac 68 for the cross heads and any sliding part. This is the same oil I use on the bed of my lathe and Mill. It is a real tacky oil and sticks well.

For the u-joints and rotating parts I use hydraulic oil 46. Chevron used to make both turbine oil and hydraulic oil but discontinued their turbine oil years ago because they said it was the same as their hydraulic oil. They said that the two oils were almost one in the same, just with different labels, at least that is what the distributor told me.

Kenneth's advice made a lot of sense. Chevron products aren't common in the eastern US so I went to webpage http://www.ccoilco.com/webpage/crossreference.html to find equivalents for Vistac. It turns out that Vistac is a Way Oil like I had used on the lathe bed and mill column. It's good for sliding surfaces as suggested by Kenneth. I tried the local machine tool supply shop and found they didn't carry Way Oil so I checked McMaster- Carr online. They have the following descriptive information at the start of their section on lubricating oil.

About Oil

Viscosity is the thickness, or resistance to flow, of an oil. Various organizations have different scales on which oil viscosity is measured. The **International Organization for Standardization (ISO)** assigns an ISO grade number. Oils with higher numbers are thicker than those with lower numbers. The **Saybolt Universal Seconds (SUS)** viscosity test measures the number of seconds it takes for 60 cc (cubic centimeters) of oil to flow through a specified diameter hole. The **American Gear Manufacturers Association (AGMA)** has its own grading system specific to industrial gear oil.

Additives help improve specific characteristics of an oil, such as load capacity and corrosion resistance. **Detergent additives** help prevent sludge and other engine deposits by keeping unwanted particles suspended in the oil. These suspended particles are later removed when the oil passes through a filter. Detergents are most commonly found in engine oils. **Nondetergent oils** are used where sludge formation is not a problem or with other additives, such as oxidation inhibitors, to combat contamination.

McMaster -Carr had the following listing for their brand of Way Oil:

Way Oil

Tackifiers in this nondetergent oil help it adhere to machine tool ways and slides to lubricate between metal surfaces. Color is brown.

ISO Grade	SUS @ 100° F	1 Gallon Each•		5 Gallon Each	
68	310	1017K11	$8.84	1017K12	$35.53
220	1000	1017K21	8.84	1017K22	35.53

The ISO grade 68 is an equivalent to the Vistac 68.

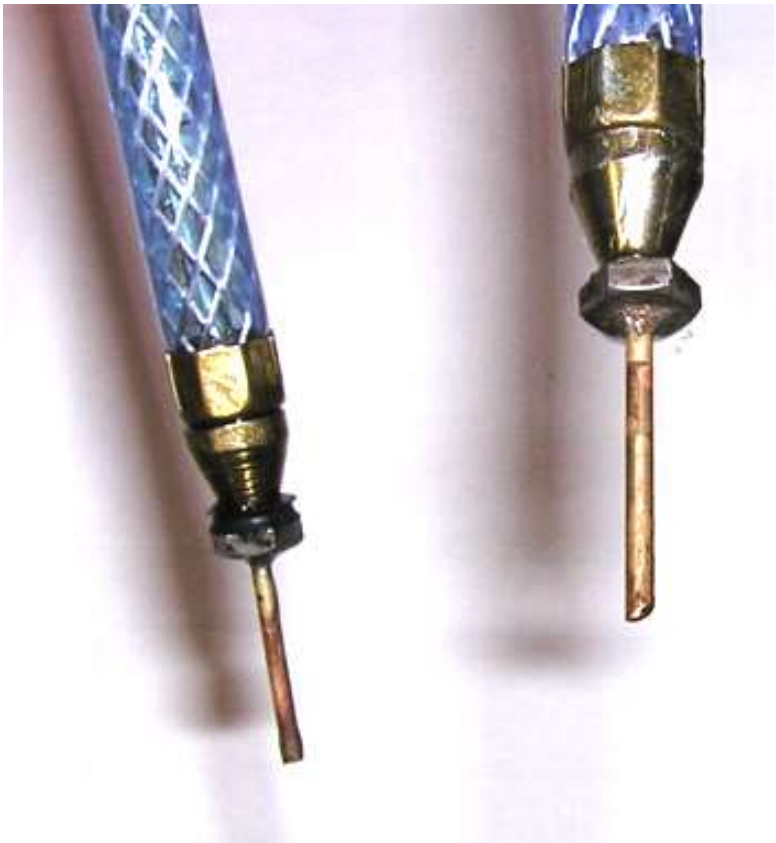
I also checked out McMaster-Carr's Turbine Oil and found:

Machine and Turbine Oil

High-quality, nondetergent oil handles a variety of applications. Additives help resist rust and oxidation and extend the service life. Use on light duty hydraulic systems, reciprocating air compressors, electric motors, machine tools, and circulating systems. Color is yellow.

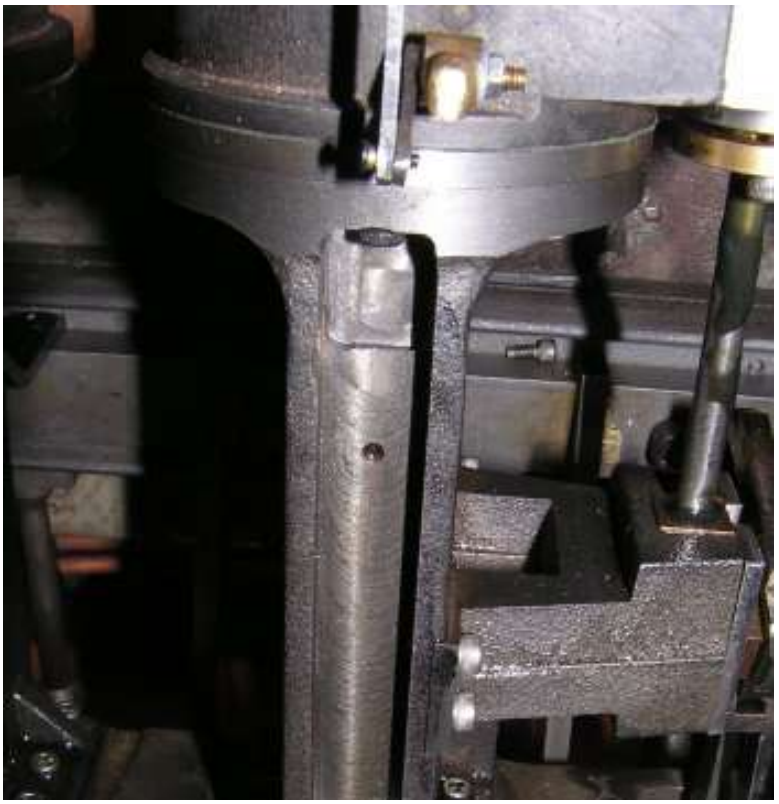
ISO Grade	SUS @ 100° F	1 Gallon Each‡		5 Gallon Each	
22	105	3025K21	$9.03	3025K23	$34.87
32	150	3025K25	9.03	3025K27	34.87
46	215	3025K29	9.03	3025K32	34.87
68	315	3025K34	9.03	3025K36	34.87
100	465	3025K38	9.03	3025K41	34.87
150	695	3025K43	9.03	3025K45	34.87

The ISO 46 should be a close match for the Hydraulic Oil 46 that Kenneth uses. I bought a gallon of the Machine/Turbine Oil 46 and a gallon of the Way Oil 68 (the last Way Oil I had ran out years ago). I also bought a couple inexpensive squirt oil cans with the intent of modifying them with needle tips.



Oil Can Tips: The spouts on the oil cans are plastic tubes with a stiffing wire inside and a tapered tip with ~3/32" hole. The tip was drilled and tapped 6-32.

Needle point tips were made from 3/16" long 6-32 hex head screws and pieces of 1/16" OD brass tube. The screws were center drilled 1/16" and then the tubes soldered into the holes. A Neoprene washer was used under the 6-32 screw heads. The photo shows the two tips.



Crosshead Lubrication Hole: When the engine was out to deal with the steam leaks a 1/16" lubrication hole was drilled in the front of each crosshead guide. The hole is about 1" below the top of the slot as shown on the right. The hole is to lubricate the front side of the crosshead and mating surface on the guide. The back side can easily be lubricated by squirting the oil directly on the inside guide surface. (While editing the photo I spotted the screw I lost the other day.)

The ISO 68 Way Oil is used on the crossheads, valve stems, reverse links and slip joints. The ISO 46 Machine/Turbine Oil is used on the bearings universals, eccentric straps and the axel pump eccentric strap. The ISO 68 is noticeably thicker then the ISO 46 as expected, Both oils seem suited to the application. The oil can needle tips worked great, permitting dispensing one drop at a time.

Steam Cylinder Oil: A pint of steam cylinder had been purchased some time ago but never opened. The lubricator was finished by installing the 1/8" output tube to the steam header. The next thing was to add the steam oil. The pump had been tested with some motor oil so the the really thick steam seemed strange. The engine was started on compressed air to observe the pump action which turned out to be big bubbles up through the thick oil in the lubricator tank. The output tube was then disconnected from the header and the engine run again. The bubbling stopped and the oil made it to the end of the tube after a short period. The problem was that oil wouldn't flow into the pump cylinder when the output pipe was pressurized with air --- the little ball check in the pump output probably leaked under air pressure.

When running the locomotive on the test stand in the basement workshop (powered by compressed air) I wondered where the steam cylinder oil went. I held my hand over the smokestack and didn't find the exhaust air to be oily (probably good news in the basement). A few hours later I noticed a few drops on the floor under the smoke box so the oil must have made it through the cylinders and then ran down the exhaust pipe to the smoke box which served as a separator. When powered by steam I assume the oil will mix with the steam, exit the smokestack and be deposited on the engineer. (I later determined the the pump was supplying about twice the oil it should. The pump was modified.)

The pint of oil on hand will run out at some point so a source of a larger more economical quantity was desired. An Internet search on *steam cylinder oil* turned up a nice article on steam cylinder oil for novice live steamers at http://www.southernsteamtrains.com/notes/steam%20oil.htm. One of the points made in the article is that steam cylinder oil

must contain some animal oil (tallow) to allow it to mix with the steam. The point was also made that the lower pressure steam (~100 psi) should have a different formulation that the higher pressure (~200 psi) full size engine because 100 psi steam is about 340 degrees F and 200 psi steam is hotter at about 390 degrees F.

The webpage for Green Velvet Steam Cylinder Oil (http://www.steamenginelube.com/) was next. Of interest is their 5 page note on the history of steam oil at http://www.steamenginelube.com/PDFdocuments/SpecificationsandHowtoread.pdf. They stress the importance of using Pennsylvania grade oil (paraffin based) with beef tallow additive for a steam cylinder oil. (Note that our Ohio oil is the same type as Pennsylvania grade.) They also mention the similarity between gear oil and steam cylinder oil with the point that the tallow is missing from gear oil. For lower temperature wet steam they recommend 10% additives (I assume the additives are mostly tallow) while for higher pressure dry steam like found in the full sized locomotives they recommend 5% additives. The Sapon-A-Max Formula 1 ISO460 (click for info) is the product they recommend for lower pressure wet steam found in the small live steam locomotive. Green Velvet sells the oil in quarts, half gallons, gallons, five gallons , drums, etc and will accept credit cards. The current (2003) price including shipping to anyplace in the US is $34.14 for one gallon and $111.28 for 5 gallons.

WD40: I don't know whether WD40 is a lubricant (WD stands for water displacement) but decided to include it here for completeness. The cylinder head drawing contains a suggestion that 1/4" MTP holes be made in the center of the upper cylinder heads. The holes are normally plugged. A quote from Kenneth: *The one thing that is important is to pull the plug in the cylinder heads after running on steam and shooting some WD40 into the cylinder to keep the piston rings free and from sticking to the cylinder walls. I generally roll the engine back and forth on its stand a couple of times, a day or two apart after putting the WD40 into the cylinders.*

I had neglected to make those center holes in the heads because I didn't have a 1/4" MTP tap when the heads were fabricated. Now that I have a tap I decided that a 1/4" hole looks a little oversize so I went with a 6-32 hole and used hex head screws with copper washers for the plugs. If the holes prove too small, they can be enlarged later. The plug for the rear cylinder is under the shelf so an access hole was drilled in the shelf. A screw with a ~1" high head that sticks through the hole in the shelf was made from a piece of 1/4" brass hex bar. That rear cylinder plug is just in front of the steam brake valve as shown in the photo at the right.

Boiler Water Treatment: There is a lot of chemistry involved with boiling water to generate steam without generating deposits or eating holes through the boiler. I was never fond of chemistry so decided to not get into the details of water quality, etc. Instead I decided to use a boiler treatment and hope it takes care of everything. The treatment many of the locals use is LSB8000 from Terlyn Industries. Terlyn claims that LSB will remove deposits from a boiler and prevent the build up of deposits and also prevent corrosion. The LSB8000 application parameters are provided at http://www.terlyn.com/html/appparameters.html. For my small Shay I need to add about 1 oz to the boiler when initially filling and 1 oz to the tender water tank at every fill up. A photo of a bottle of LSB800 is shown on the right.

Fuel Additive: Burning oil can cause soot to collect in the tubes, smoke box and smokestack. Adjusting the fuel feed such that there is little or no smoke probably minimizes the soot buildup. I've been told that many live steamers who burn oil add a small quantity of Red Devil Soot Remover to the fuel. An Internet search revealed that Red Devil is a recommended additive to the fuel of power washer hot water heaters. I've not tried it yet but plan to in the future.

Approximate Capacities:

The boiler water capacity is 1.5 gallons to the bottom of the water gauge and 2 gallons to the middle of the glass.

The tender usable water capacity (from outlet pipe to overflow pipe) is 7.5 gallons.

The fuel tank capacity is 2.5 gallons.

The lubricator tank capacity is 2 fluid oz.

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