



Excellent

High-Temperature

Lubricants



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In addition to UCON<sup>TM</sup> Calender Lubricants, The Dow Chemical Company also supplies a broad array of industrial lubricants, hydraulic fluids, plasticizers, resins, solvents, and heat transfer fluids to rubber and plastics processors and to related equipment manufacturers.



he large-scale mills and calenders employed by the rubber, textile, paper and plastic industries combine the lubricant requirements of large-diameter journal (or sleeve) bearings, anti-friction bearings, and several types of gearing. Equipment manufacturers have established that properly formulated petroleum oils satisfactorily meet their requirements for moderate temperatures of operation. However, at elevated temperatures [e.g., when calender roll temperaures exceed 177°C (350°F)], petroleum lubricants tend to develop carbonaceous residues that may contribute to lubrication problems and certainly add to a continuing maintenance program. UCON<sup>™</sup> Lubricants are formulated for hightemperature service.

UCON Calender Lubricants are specially compounded polyalkylene glycol derivatives that have high viscosity indexes and are chemically and thermally stable under conditions of normal use. They are watersoluble, and compatible with metals and many commonly used elastomers. Along with their superior high-temperature performance, they make the total calender operation more economical by minimizing wear and reducing maintenance.

Dow supplies UCON Calender Lubricants in a range of viscosity grades to meet the requirements of many rubber, textile, paper, and plastics mill and calender applications. UCON Calender Lubricants perform well under most operating conditions and excel when roll-face temperatures range from 150°C to 200°C (300°F-390°F). The grades offered may help solve some of the problems encountered in processing. For example, at low rotational speeds, UCON Calender Lubricant 51K considerably reduces the wear of bronze bearings.

The following pages discuss the special features and benefits of UCON Calender Lubricants. Provided also are procedures for converting from petroleum-based products to UCON Calender Lubricants and for monitoring the condition of the new lubricant to maximize its performance.

# Features and Benefits of UCON Calender Lubricants

- Long Service Life and Lower Maintenance Costs 1.
- 2. Easy Cleanup
- **Excellent Materials Compatibility** 3.
- 4. High Viscosity Indexes
- 5. Low Pour Points

# **1** Long Service Life and Lower Maintenance Costs:

UCON Calender Lubricants are chemically and thermally stable and are inhibited against oxidative degradation. Thus, the tendency to form sludge, varnish or carbonaceous residues is significantly less than with petroleumbased lubricants.

When calender roll temperatures exceed 180°C, petroleum lubricants develop carbonaceous residues. These tend to reduce lubricant flow and starve the rolls of their lubricant. To provide an adequate flow of lubricant in a circulating system under these conditions, the system may require continuous and costly maintenance. Because UCON Calender Lubricants do not form sludge or residue, they operate very well at elevated temperatures for long periods of time. This means overall lower operating costs because of less downtime and greater production under demanding operating conditions.

**2**Easy Cleanup: 2UCON Calender Lubricants are soluble in water, making equipment and shop cleanup easy.

# **TExcellent Materials Compatibility:**

**UCON** Calender Lubricants are compatible with common metals such as iron, steel, brass, bronze and aluminum as well as most natural and synthetic rubber compounds or gasket materials. Therefore, the maximum operating temperature, rather than construction material, becomes the main factor in selecting polymers for seals.

# High Viscosity Indexes:

Viscosities of UCON Calender Lubricants change less with temperature than do unmodified petroleum oils. In addition, their viscosities are suitable for use in high shear applications. Measured by ASTM Method D-2270, Viscosity Index values range between 248 and 287.

Figure 1 on page 5 illustrates the relatively flat viscosity-temperature characteristics of UCON Calender Lubricants (20, 35, 51 and 51K). These curves demonstrate that UCON Calender Lubricants provide useful viscosities at elevated temperatures, without unduly high viscosities that would reduce flow and pumpability at ambient temperatures. The viscosities of these lubricants in the 150°C to 200°C range also mean better hydrodynamic (load-carrying) fluid films in highly-loaded bearings. Even under thin film and boundary conditions, below the normally limiting value of ZN/P=1, UCON Calender Lubricants have demonstrated excellent load-bearing performance.

# **CLow Pour Points:**

OUCON Calender Lubricants contain no wax and require no pour-point depressants to remain fluid at low temperatures.

# **Typical Properties<sup>†</sup>**

		UCON Calen	der Lubricants			
	20	3	35	51 and 51K <sup>(1)</sup>		
Viscosity, Centistok	es <sup>(2)</sup>					
-20°C	(-4°F) 40,0	00 7	0,000	100,000		
0°C	(32°F) 5200	) 8	500	14,000		
40°C	(104°F) 475	7	40	1150		
100°C	(212°F)77	1	28	185		
150°C	(302°F) 34	5	5	80		
200°C	(392°F) 18.5	3	0	42		
Viscosity, Saybolt Universal Seconds <sup>(2)</sup>						
-20°C	(-40°F) 184,	000 3	22,000	460,000		
0°C	(32°F) 24,0	00 3	9,000	64,600		
40°C	(104°F) 2200	] 3	400	5300		
100°C	(212°F) 360	6	00	860		
150°C	(302°F) 160	2	60	380		
200°C	(392°F)93	1	44	200		
Viscosity Index, VI	(ASTM D2270)	2	78	287		
Pour Point, °C (°F)	(ASTM D 97)36	(-33) -:	33 (-27)	-30 (-22)		
Specific Gravity at	20/20°C1.05	7 1	.058	1.059		
Vapor Pressure at 2	20°C, mm Hg<<0.1	01 <	<0.01	<0.01		
Water Content, % I	ıy wt<0.2	25 <	<0.25	<0.25		
Weight per Gallon, Ib						
20°C	(68°F) 8.81	8	.80	8.82		
15.56°C	(60°F) 8.84	8	.83	8.85		
$\Delta$ Pounds per Gall	on, per °C 0.00	657 0	.00657	0.00657		
Coefficient of Expansion, per °C						
20°C	(68°F) 0.00	075 0	.00075	0.00074		
55°C	(131°F) 0.00	078 0	.00078	0.00078		
Flash Point, °C (°F)						
Pensky-Martens	Closed Cup (ASTM D 93). 232	(450) 2	16 (420)	241 (465)		
Cleveland Open	Cup (ASTM D 92) 288	(550) 3	02 (575)	282 (540)		

(1) For low roll rotational speeds, wear of bronze bearings is markedly reduced with UCON Calender Lubricant 51K.

(2) Kinematic viscosities were determined with Cannon-Fenske viscometers following ASTM Method D 445. Saybolt viscosities, obtained from the kinematic viscosities by means of ASTM Method D 2161, are provided for convenient reference. For viscosity-temperature relationships, see Figure 1 on page 5.

<sup>+</sup>The physical properties data listed are considered to be typical properties, not specifications.

# Figure 1 • Viscosity vs. Temperature



# **General Considerations**

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Manufacturers of mill and calender equipment usually provide detailed instructions for installing lubricant, for mill and calender start-up, and for maintenance procedures. Your equipment will perform best if you follow their instructions.

Regardless of the lubricant used, equipment manufacturers agree that regular changes are essential. Discard the break-in lubricant because it may contain contaminants introduced during installation or the initial phase of operation. Then, schedule regular lubricant changes to ensure that the equipment operates at peak levels and to avoid costly maintenance and repairs. Typically, lubricant is changed annually, but the time between changes may vary, depending upon operating conditions.

As the time between lubricant changes increases, proper inspection and analysis become increasingly important. If you decide not to make regularly scheduled changes and rely instead on inspection and analysis, we recommend that you carefully review the section on Lubricant Test Methods.

UCON Calender Lubricants, which are specially compounded polyalkylene glycol (PAG) derivatives, are incompatible with petroleumbased lubricants. That is why it is important to remove residual petroleum oil and related sludge before converting to a UCON Calender Lubricant. Always follow manufacturers' guidelines prior to converting to a UCON Calender Lubricant.

The following sections offer general advice on draining and flushing. But remember, no one knows better than you your specific operating conditions, equipment, and environment. Carefully review them to ensure that any chemical product is properly and safely used.

### Drain

Elevate the temperature of the old lubricant to reduce its viscosity and improve drainage. Drain the petroleum lubricant from the reservoir and circulation lines. Flush with a compatible fluid or solvent. UCON LB Series Lubricants are compatible with petroleum lubricants and may be used as a flush fluid. Consult your equipment manufacturer or lubricant supplier for guidance.

### Flush

If a solvent such as high-flash naphtha is used, carefully consider the hazards before handling. Take all necessary precautions to protect your personnel, property, and the environment. Always read and follow a chemical's MSDS (Material Safety Data Sheet) before using it. Use a solvent only as a flush without operating the equipment, since it provides little lubrication.

If using UCON LB Series Lubricant as a flush fluid, circulate in the system sufficiently long enough to remove all petroleum oil and to dissolve all sludge. If fluid is circulated at 70°C to 80°C this typically takes 6 to 12 hours. Use enough lubricant to fill circulating lines and to cover heating coils and the pump's suction port. Inspect journal box seals, making sure that all deposits have been removed. If you wish, turn the rolls over in a no-load condition.

## Drain

Drain the flushing fluid. Wipe the reservoir clean. Inspect the suction-line strainer and any in-line filters. Small amounts of UCON LB Series Lubricants will be fully miscible with UCON Calender Lubricants and will not diminish their performance.

# **Painted Surfaces**

UCON Calender Lubricants soften and lift many industrial coatings that petroleum lubricants do not. If the present coating seems intact, it probably was designed for petroleum service. If this is the case, remove the coating. If you cannot remove it conveniently, pay close attention to strainers and filters. Inspect them periodically during the first few months after converting. This will help keep lines from plugging and assure that adequate lubricant is circulating.

## **Seals and Packings**

UCON Calender Lubricants work well with the same seals and pump packings used with petroleum oil at the same operating temperatures. At higher temperatures, you may want to reevaluate the type of seals and packings you use. In either case, examine seals for wear and/or deterioration. Replace worn seals with new ones to prevent leaks and resulting damage or injury. Select an elastomer that is both compatible with UCON Calender Lubricants and can withstand anticipated operating temperatures.

### **Operation of Reservoir Heaters**

Mills and calenders are usually equipped with heating coils or immersion-type electric heaters. These heating units conveniently and rapidly lower the viscosity of the cold lubricant. This makes it easier for the lubricant to circulate during start-up after an extended shutdown at low ambient temperatures.

Adequate lubricant flow and satisfactory heat flux should exist at the heater surfaces.

Limit steam pressure to 15 psig. Maintain the watt density of electrical heaters below 20 watts per square inch. Install a suitable intercept to activate the lubricant circulating pump *before* the heater can be turned on. Initially, circulate the lubricant through a by-pass return line to assure an adequate flow in the reservoir.

# Five tests are particularly useful in monitoring the condition of UCON Calender Lubricants:

- 1. Appearance
- 2. Viscosity
- **3.** Ester Content
- 4. Antioxidant Content
- 5. Petroleum Oil Contamination

# **Appearance:**

**Appearance:** Visual inspection of a sample of used lubricant can frequently provide useful information. In service, UCON Calender Lubricants develop a characteristic deep-mahogany color to transmitted light. Nevertheless, samples should be clear. If they are turbid or contain sediment, they are either contaminated and/or the victim of inadequate filtration.

Closely inspect the sediment after washing away the lubricant with methanol. This may help you determine the sediment's origin. A lowpower magnifying glass frequently provides better resolution than higher-power microscopes.

Insoluble debris, for example, may represent residual contamination that was introduced into the system when the lubricant was installed. Metallicwear particles could indicate that not enough lubricant is reaching a vital part of your equipment.

2 Viscosity: 2 When the calender is in operation, viscosity changes in UCON Calender Lubricants may reflect how much the lubricant has degraded and/or how much it is contaminated. If the lubricant's viscosity is significantly higher or lower than when it was put into the system, consider recharging the system with fresh lubricant. Ask the calender manufacturer for advice. Periodic viscosity measurements will establish a base-line from which significant changes will be apparent.

Determination of viscosity can be a routine measurement, and the same methods used for petroleum products can be used with UCON Calender Lubricants. Kinematic values in centistokes (cSt), described in ASTM Method D 445, are internationally recognized. Although determining Saybolt viscosity (formerly ASTM Method D 88) is now obsolete, Saybolt viscosity numbers - in Saybolt Universal Seconds (SUS) - are still published for comparison with previous references.

Viscosity Index (VI) is related to the rate of change in viscosity between 40°C and 100°C. With their higher VI, UCON Calender Lubricants will lose viscosity as the temperature is increased at a much lower rate than petroleum oils of equivalent initial 40°C viscosity. As an example, a petroleum oil with the same 40°C viscosity as UCON Calender Lubricant 51 will often have a lower viscosity at 100°C than UCON Calender Lubricant 20. Therefore, it is often desirable to determine (or extrapolate) the viscosity of the lubricant at the actual temperature of use to predict performance under hydrodynamic conditions.

UCON Calender Lubricant	Typical Viscosity Range for Used Fluids, cSt at 100°F
20	388-648
35	648-1036
51	1036-1620
51K	1036-1620

**3** Ester Content: The ester content, expressed in milliequivalents per gram (meq/g) sample, indicate how much ester-type degradation products have dissolved in the lubricant. UCON Calender Lubricants have an initial ester content of 0.16 to 0.18 meq/g. The recommended upper limit of ester content is typically 0.5 meg/g, depending in part upon other characteristics. The following outlines the procedure used to determine ester content.

# **Reagents Required:**

- (a) Potassium hydroxide in 80 percent methanol, approximately 0.2N. Dissolve 11.2 g of potassium hydroxide in 200 mL of distilled water and dilute to 1 liter with methanol.
- (b) Standard hydrochloric acid of exactly known concentration near 0.1N.
- (c) A pH meter or a pH indicator such as a paranaphtholbenzein solution. Dissolve 1 gram of paranaphtholbenzein in 100 mL of isopropanol (99 percent grade).

# Procedure:

Prepare the lubricant sample and a "blank" in separate 250 mL Erlenmeyer flasks. Weigh, to the nearest 0.01 gram, 3 to 5 grams of the well-mixed lubricant sample in one flask. Pipet exactly 20 mL of 0.2N alcoholic potassium hydroxide into the flask. Add a few clean glass beads and reflux the solution for 1.5 to 2 hours.

Prepare the "blank" by pipetting exactly 20 mL of 0.2N alcoholic potassium hydroxide into the other flask. Also add a few clean glass beads to this flask and reflux the solution for 1.5 to 2 hours.

Next, wash down the condensers of both the lubricant sample and the blank with at least 50 mL of distilled water. Titrate the contents of each flask with standard hydrochloric acid. After they have been used, UCON Calender Lubricants usually have a dark color, which makes it impractical to use a colorimetric indicator. Use a pH meter instead (end point 8.5 pH units). Ten drops of the indicator should change the color from blue to orange.

# Calculation:

(B-A) x N grams of sample	=	milliequivalents of ester content per gram of lubricant sample
where A B N	= =	ml of hydrochloric acid required for sample ml of hydrochloric acid required for blank normality of the hydrochloric acid
N	-	normancy of the hydroemone actu

**Antioxidant Content:** All lubricants exposed to air at elevated temperatures oxidize and deteriorate. UCON Calender Lubricants contain antioxidant additives to stabilize them. You can gauge the lubricant's condition by determining how much antioxidant remains in the lubricant. To continue in service, the lubricant should have at least 10 percent of its original antioxidant level (sometimes referred to as inhibitors).

# **Option 1: Colorimetric Method**

# **Determination of Antioxidant Content:**

To determine the amount of antioxidant in used UCON Calender Lubricants, oxidize the antioxidant with ferric ammonium sulfate in an aqueous solution containing 50 percent sulfuric acid. If inhibitor is present, an intense blue color develops, indicating as little as 0.1 mg of antioxidant in the ferric sulfate reagent.

## **Reagents:**

- (a) 50 percent sulfuric acid. While stirring and cooling, slowly add concentrated (95 percent) sulfuric acid to an equal volume of water.
- (b) Ferric ammonium sulfate in 50 percent sulfuric acid. For each liter of reagent, dissolve 1.38 g of ferric ammonium sulfate (12H<sub>2</sub>0) in 500 mL of water. To this, slowly add 500 mL of concentrated sulfuric acid. Stir and cool as the acid is added.

Procedure: Weigh one gram of used lubricant sample (weighed to the nearest 0.01 g) into a 50 mL volumetric flask. Dilute to 50 mL with methanol. With a pipette, transfer 2.0 mL of the methanol solution to a 100 mL volumetric flask and add 20 mL of the ferric ammonium sulfate reagent. Let stand at room temperature for about 1.5 hours, but not more than 4 hours. Dilute to 100 mL with 50 percent sulfuric acid and mix.

Measure the optical density of this solution at 600 millimicrons, using distilled water for the zero setting. You may use a Bausch and Lomb Spectronic 20 Colorimeter or its equivalent.

Next, prepare a blank by using an equal aliquot of methanol solution. Dilute it to 100 mL with 50 percent sulfuric acid. Do **not** add ferric ammonium sulfate reagent because this blank represents the background color of the used fluid. Measure the optical density of this blank, using distilled water as the zero setting.

To determine the absorbance per gram of sample, subtract the blank's absorbance from the absorbance of the sample. Divide the remainder by the weight (in grams) of the sample.

You can then determine the percent concentration of antioxidant remaining in the used fluid. Simply read it directly from the graph (Figure 2).

### Calculation:



# **Option 2: Ultraviolet Spectroscopic Analysis**

Another way to determine the antioxidant level of used UCON Calender Lubricant is to use ultraviolet (UV) spectroscopic analysis, conducted at a wavelength of 254 mm. As a rule, use a 2 percent sample of fluid diluted in methanol.

Figure 2 • Antioxidant Level as Measure of Absorbance



# Petroleum Oil Contamination:

Because UCON Calender Lubricants are not miscible with petroleum oils and have a higher density, petroleum oil contamination can frequently be determined by separating the two layers. Usually, separation will occur by letting the lubricant stand undisturbed for a period of time. However, if the amount of contamination is very small or if the sample is dark or emulsified, this simple procedure may not work.

If this happens and you still suspect that the lubricant is contaminated, you can separate the contaminant from the UCON Calender Lubricant by taking advantage of the fact that UCON Calender Lubricants are soluble in methanol, while petroleum oils are not. And by diluting the sample with methanol, you can also measure the amount of petroleum-derived sludge and residue that has been cleaned out of equipment (that had previously been operating on petroleum lubricants) because of the solvent action of UCON Calender Lubricants.

# **Procedure:**

Prepare a solvent mixture containing (by volume) 80 parts methanol and 20 parts distilled (or deionized) water. Mix thoroughly 20 ml of well-mixed used lubricant sample with 80 ml solvent mixture. If this is carried out in a 100 ml graduated cylinder, separation into two layers will then provide an immediate measure of the hydrocarbon contamination. The indicated volume in the cylinder should be multiplied by five to give the percentage of petroleum oil present in the used lubricant sample.

# Product Stewardship

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ow encourages its customers and potential users to review their applications from the standpoint of human health and environmental aspects. To help ensure that Dow products are not used in ways for which they are not intended or tested, Dow personnel will assist customers in dealing with environmental and product safety considerations. Dow literature, including Material Safety Data Sheets, should be consulted prior to use.



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