



Paul N. Gardner Company

PARLIN VISCOSITY CUP VISCOMETERS

Instructions for measuring the viscosity
of liquids with Parlin Viscosity Cup.



Parlin Viscosity Cup



MEETS ASTM D1084A



Dimensions:
1.50" Dia. x 3.687" Tall
without drip well

- Viscosity Range of cups 1-4 (7-15000 Centistokes)
- Accuracy - #1 Cup ($\pm 3\%$), #2 Cup ($\pm 3\%$)
#3 Cup ($\pm 3\%$), #4 Cup ($\pm 5\%$)
- Meets and exceeds ASTM D1084 method A and Federal Specifications MMM - A - 189C
- Includes Gardco conversion table relating drain time in seconds to viscosity in centistokes
- Calibration traceable to NIST standard oils in accordance with ISO/IEC 17025, ISO/IEC Guide 34, ISO 9001
- Calibration and certification procedures qualify under ANSI/NCSL Z540-1 or ISO/IEC 17025, ISO 9001 as applicable

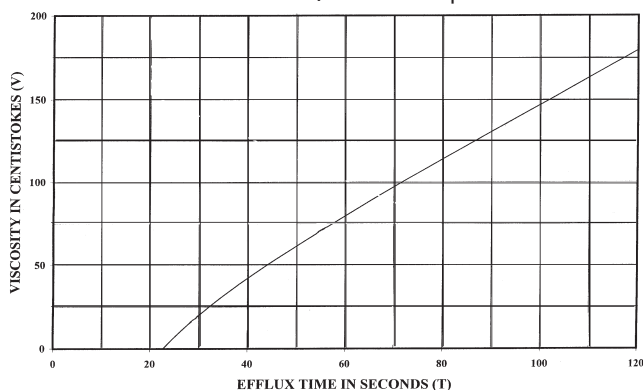
The Parlin cup was originally developed by the E.I. DuPont de Nemours Company in Parlin, New Jersey, for consistency measurement of cellulosic lacquers. Today this cup is cited in the ASTM designation D1084 under method A of the Standard Test Methods for Viscosity of Adhesives as well as Federal Specification MMM-A-189C. This particular apparatus, though a flow cup for the viscosity determination of Newtonian and near Newtonian materials, differs from the conventional viscosity cup in that the final determination is established at a volumetric point of 50 mL and not the breaking point of the efflux stream upon the completion of draining. Machined from solid brass the flat bottom of the cup has a press-fitted stainless steel orifice 0.0625 inches long (1.588mm) which is available in four different diameter sizes ranging from 0.070 to 0.250 inches (1.78 to 6.35mm).

PROCEDURE

Bring the sample to be tested and the Gardco/Parlin viscosity cup to a temperature of $23 \pm 0.5^\circ\text{C}$ ($73.4 \pm 0.9^\circ\text{F}$) (preferably in a constant-temperature room). Then mount the viscosity cup in a suitable clamp holder for this purpose and place the receiving cylinder in position so that the distance from the Parlin cup base is 8" above the base of a low form graduate. With the outlet of the cup closed by means of a finger, pour the sample into the cup until it is filled to overflowing. Strike off the excess with a straightedge, and then remove the finger from over the outlet and allow the sample to flow into a clean, empty 90-100mL graduated glass receiving cylinder(not supplied). With a stopwatch, determine the number of seconds from the time the finger is removed from the orifice until the top of the meniscus in the receiving cylinder reaches the 50-mL mark on the cylinder. Record as the viscosity time of the material. Note in the case of the high viscosity range #4 cup, formation of air bubbles in the viscosity standard after just one test run makes repeat runs inaccurate unless done at another time. Typically, with heavier bodied liquids, a settling period of 24 hours is necessary for air bubbles to dissipate. With due care, this precaution need not be observed with cups 1, 2, & 3.

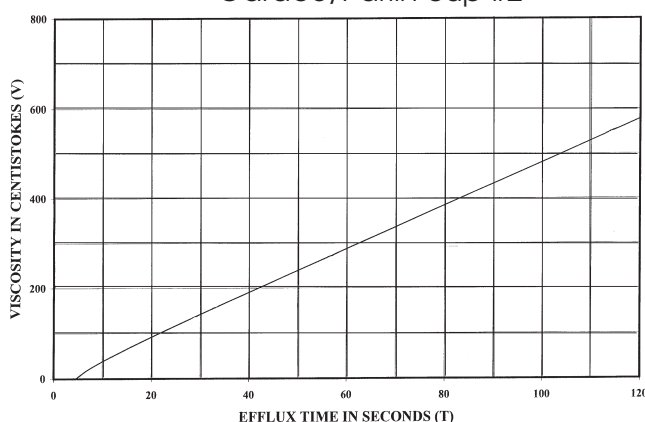


Gardco/Parlin cup #1



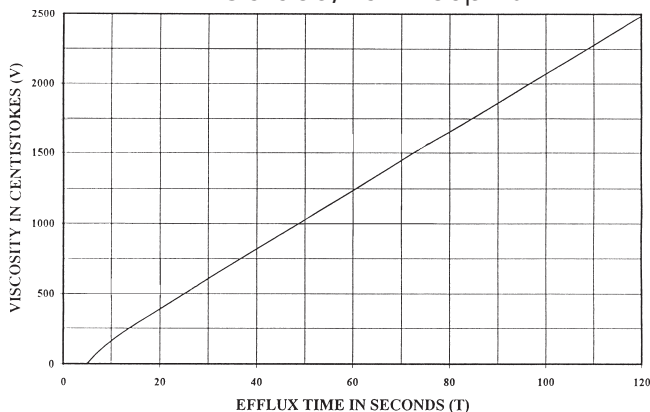
Gardco/Parlin cup #1
Centistokes,
 $V = 1.55T - 800 \div T$
Where T is in seconds
and
Tenths of Seconds,
 $T = (V + \sqrt{V^2 + 4960}) \div 3.1$
Where V is in centistokes

Gardco/Parlin cup #2



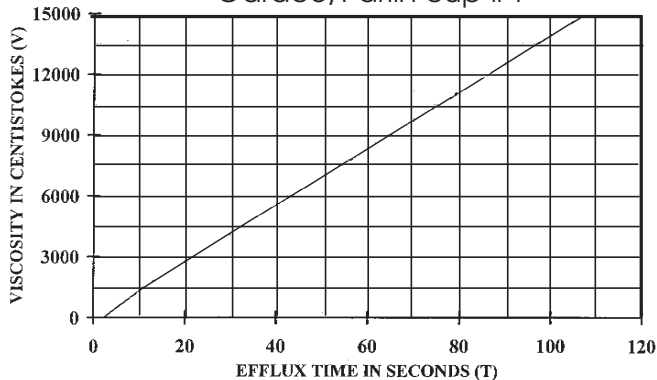
Gardco/Parlin cup #2
Centistokes,
 $V = 4.82T - 100 \div T$
Where T is in seconds
and
Tenths of Seconds,
 $T = (V + \sqrt{V^2 + 1928}) \div 9.64$
Where V is in centistokes

Gardco/Parlin cup #3



Gardco/Parlin cup #3
Centistokes,
 $V = 20.75T - 500 \div T$
Where T is in seconds
and
Tenths of Seconds,
 $T = (V + \sqrt{V^2 + 41500}) \div 41.5$
Where V is in centistokes

Gardco/Parlin cup #4



Gardco/Parlin cup #4
Centistokes,
 $V = 139T - 750 \div T$
Where T is in seconds
and
Tenths of Seconds,
 $T = (V + \sqrt{V^2 + 417000}) \div 278$
Where V is in centistokes

SPECIFICATION TABLE

CUP NUMBER	SECONDS RANGE	CENTISTOKE RANGE	MIDRANGE SENSITIVITY (**)	CALIBRATION OIL NUMBER/ CENTISTOKES (*)
1	25 TO 110	7 TO 165	1.6	G-35-P/64
2	25 TO 120	117 TO 582	4.8	G-100-P/270
3	25 TO 110	498 TO 2297	20.6	G-350-P/1020
4	25 TO 110	3445 TO 15408	138.9	G-J3000-P/10800

(*) CENTISTOKE VALUES ARE NOMINAL - ACTUAL VALUES PRINTED ON LABELS

(**) STATED AS CENTISTOKES PER SECOND OF EFFLUX TIME

VISCOSITY CUPS

VI-9002	Gardco/Parlin #1 0.070" (1.78mm) orifice 7 -165 cs
VI-9004	Gardco/Parlin #2 0.100" (2.54mm) orifice 117 - 582 cs
VI-9006	Gardco/Parlin #3 0.150" (3.81mm) orifice 498 - 2297 cs
VI-9008	Gardco/Parlin #4 0.250" (6.35mm) orifice 3445 -15408 cs

VISCOSITY STANDARDS

VI-3811	G-35-P Certified Viscosity Standard (for use with #1 Parlin Cup) Pint
VI-3819	G-100-P Certified Viscosity Standard (for use with #2 Parlin Cup) Pint
VI-3826	G-350-P Certified Viscosity Standard (for use with #3 Parlin Cup) Pint
VI-3842	G-J3000-P Certified Viscosity Standard (for use with #4 Parlin Cup) Pint

RECOMMENDED APPARATUS

LA-9012	Ring Support, 2"
LA-9014	Clamp to 1-1/2" diameter
LA-9020	Clamp Holder fixed Aluminum alloy
LA-9010	Support Stand, 5-1/2 x 9"
LA-7622	Low Form Pyrex Graduate (highly recommended)



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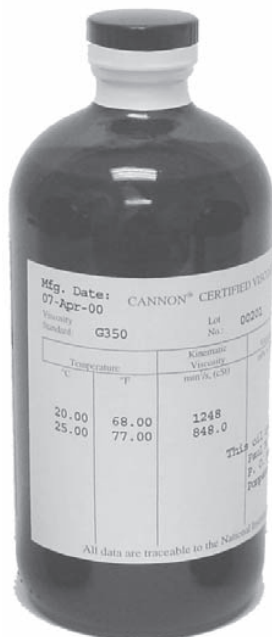
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FOR USE WITH GARDCO VISCOSITY CUPS



These standard oils are prepared expressly by the Cannon Instrument Company, a A2LA accredited calibration lab, for the Paul N. Gardner Company and are produced in accordance with:

ISO/IEC 17025

ISO 17025 and Guide 34

ISO 9001

These standards provide the greatest possible accuracy in viscosity measurements with Gardco produced and calibrated viscosity cups. A list of "G" Series viscosity standards is available for periodic checking of these measuring instruments. See list on following page.

PACKAGING - LABELING

All viscosity standards are packaged in sealed, dark glass bottles. Net content of each bottle is 0.47 Liter (1 Pint). A label on each bottle gives the Standard Name, Lot No., Termination Date, Viscosity in Centistokes at 25.00°C (77.00°F)* and a statement that the standard "is prepared expressly for Paul N. Gardner Co., Inc., 9104 Guilford Road, Suite H, Columbia MD, 21046" by the Cannon Instrument Company and that data on the standard is traceable to the National Institute of Standards and Technology. A Material Safety Data Sheet (M.S.D.S.) accompanies each bottle of oil.

* With the exception of the Parlin Cups whose Viscosity in Centistokes is measured at 23°C.

USE OF STANDARD OILS

Recommended use of a standard oil to check the calibration of a Gardco produced viscosity cup is as follows: Conversion formulas are either provided with the cup to be checked or are available in the Product Leaflet for the cup.

IMPORTANT LIMITATIONS

Use of standard oils available from the Paul N. Gardner Company are NOT recommended for use with cups produced by other suppliers unless the conversion formula between centistoke viscosity and efflux time as well as cup production tolerance for the particular cup in question has been furnished.

G SERIES VISCOSITY STANDARDS

Standard Oil	Centistoke* Viscosity @25°C	EZ™ Cup No	S90 Zahn Cup No	Mini Ford Dip Cup No	Gardco/ Fisher Dip Cup No	Fisher Standard Cup No	Std. Ford & Std. Ford Dip Cup No	Gardco/ ISO & ISO Dip Cup mm	Gardco/ Din & Din Dip Cup mm	Parlin Cup No
G-6	8.9	-	-	0	-	-	0	-	-	-
G-10	19	1	-	1	-	-	1	3	-	-
G-20	34	-	1	-	1	1	-	-	-	-
G-35	64	-	-	2	2	2	2	4	-	-
† G-35-P	64	-	-	-	-	-	-	-	-	1
G-60	120	2	2	3, 4	3	3	3, 4	-	-	-
G-100	230	-	3	-	-	-	-	6	4	-
† G-100-P	270	-	-	-	-	-	-	-	-	2
G-200	450	3, 4	-	5	4	4	5	-	-	-
G-350	880	5	4, 5	-	-	-	-	**8	-	-
† G-350-P	810	-	-	-	-	-	-	-	-	3
† G-J3000-P	10,800	-	-	-	-	-	-	-	-	4

*These are nominal values. For the actual centistoke value of the standard, refer to the value on the bottle label.

* *NOTE: The 8mm ISO Cup is not available in the Dip version.

† **Special temperature @ 23°C.**

The information contained herein, or supplied by us or on our behalf in any other manner is based on data obtained by our own research and is considered accurate. However, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA, THE RESULTS TO BE OBTAINED FROM THE USE THEREOF, OR THAT ANY SUCH USE WILL NOT INFRINGE ANY PATENT. This information is furnished upon the condition that the person receiving it shall make his own tests to determine the suitability thereof for his particular purpose.



Parlin Viscosity Cup



EFFLUX TIME TO THE NEAREST 0.1 SECOND CAN BE READ FROM THE CONVERSION CHART FURNISHED WITH EACH GARDCO PRODUCED CUP, OR A FORMULA CAN BE USED AS FOLLOWS:

1. Select the formula relating viscosity to time of efflux in seconds when viscosity in centistokes is known.
2. Substitute the standard label value for centistokes for "V" in the equation and solve the equation. The resulting value is design efflux (drain) time in seconds.

NOTE: This determined efflux time is for the standard at 25.00°C (77.00°F) only.*

3. Make a minimum of three determinations with the cup in question on the applicable standard, adhering to the method of use prescribed in the product leaflet or in the applicable ASTM method, and calculate the average efflux time.

NOTE: Pay particular attention to temperature at time of measurement. Use a thermometer that can be read to the nearest 0.1°C or 0.2°F. Experimental results should NOT be compared against determined design efflux time unless temperature at time of measurement was within $\pm 0.2^\circ$ of 25.0°C or $\pm 0.4^\circ$ of 77.0°F. The standard oils change in viscosity between 3% and 8%, depending on the viscosity of the standard, for each degree change in temperature from 25°C*.*

4. Compare the experimentally determined efflux time with the design efflux time. If experimental results were at 25.0°C or 77.0°F*, the comparison should be within the following limits:

* With the exception of the Parlin Cups whose Viscosity in Centistokes is measured at 23°C.

Gardco EZ™ Zahn (ASTM) Dip Cups	3%	Gardco/ISO Cups	2%
Gardco S90/Zahn Sig. Dip Cups	5%	Gardco/ISO 8mm Cup	3%
Gardco Mini Ford Dip Cups	4%	Gardco/ISO Dip Cup	3%
Gardco/Fisher Dip Cups	2%	Gardco/DIN Cup	3%
Gardco/Fisher Standard Cup	2%	Gardco/DIN Dip Cup	3%
Gardco Standard Ford Cups	2%	Gardco Parlin #1 Cup	3%
Gardco Standard Ford Dip #3	3%	Gardco Parlin #2 Cup	3%
Gardco Standard Ford Dip #4	2%	Gardco Parlin #3 Cup	3%
Gardco Standard Ford Dip #5	3%	Gardco Parlin #4 Cup	5%

MANUAL TEMPERATURE ADJUSTMENT

For the technician who does not have automatic temperature control equipment the following procedure may be useful with dip type cups: If the oil to be used is below temperature, place the bottle with the cap slightly loosened no closer than about one foot from an incandescent desk lamp. This will slowly raise the temperature of the oil. When within about one degree of measuring temperature, transfer the required amount of the oil to a glass container of sufficient height and diameter to accommodate the viscosity cup. (Glass is recommended due to its low rate of temperature conductance.) Place the viscosity cup to be used in the oil in the glass container so that it comes to the same temperature as the oil and place a thermometer, preferably glass, in the oil which can also be used as a stirring rod. If necessary to elevate the temperature slightly, simply hold the glass snugly in the hand while stirring the contents gently and observing the change in temperature. If necessary to lower the temperature, dip the bottom of the glass container for a few seconds in water that is 10 to 20 degrees lower than measuring temperature and continue gentle stirring while the temperature slowly lowers. With a little practice it is possible to make measurements very close to the target temperature.

CARE OF STANDARD OILS

The viscosity standards available from Gardco are precision materials. They are accurate to within 0.25% of the label value at specified temperature. This is a much closer tolerance than viscosity measuring devices normally available to users of viscosity cups. Therefore, there is no easy means of checking the standard to insure that it remains at the value listed on the label except through very careful use of the standard to insure its integrity. Included in this care should be making sure that any container used to receive the standard, as well as the cup to be checked, the thermometer and any other stirring device, be absolutely free of contaminants. Immediately following use, the standard should be returned to its labeled container and capped. If there is valid reason to question the original value of the standard, it should be replaced.

The below listed standards are used by the producer of Gardco viscosity cups not only to calibrate the cups but also to certify such calibration under **ANSI/NCSL Z540 or ISO/IEC 17025, ISO Guide 34, ISO 9001**, as applicable, and in conformance with ISO 9000, which is available as an extra cost service. One of the requirements under such certification is the replacement of the standard on or before the termination date. Experience has shown, however, that in the absence of contamination, the standards do not materially deteriorate over an extended period of time.

CAUTION: Silicone fluids should not be used to calibrate viscosity cups. These materials change the interface between the cup surface and the test material and therefore change the cup calibration. The following is taken from ASTM D445; Viscometers used for silicone fluids should be reserved for the exclusive use of such fluids. Solvent washings from these viscometers should not be used for cleaning other viscometers.

PRICE

Cat. No.	Description	Approx. Centistokes	Call for Pricing
VI-3801	G-6 Viscosity Standard	9	
VI-3803	G-10 Viscosity Standard	19	
VI-3805	G-20 Viscosity Standard	35	
VI-3810	G-35 Viscosity Standard	64	
VI-3811	G-35-P Viscosity Standard	64	
VI-3815	G-60 Viscosity Standard	120	
VI-3819	G-100-P Viscosity Standard	270	
VI-3820	G-100 Viscosity Standard	230	
VI-3821	G-200 Viscosity Standard	450	
VI-3825	G-350 Viscosity Standard	880	
VI-3826	G-350-P Viscosity Standard	810	
VI-3842	G-J3000-P Viscosity Standard	10800	

A Material Safety Data Sheet is furnished with each bottle of "G" Series Standard Oils.

The information contained herein, or supplied by us or on our behalf in any other manner is based on data obtained by our own research and is considered accurate. However, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA, THE RESULTS TO BE OBTAINED FROM THE USE THEREOF, OR THAT ANY SUCH USE WILL NOT INFRINGE ANY PATENT. This information is furnished upon the condition that the person receiving it shall make his own tests to determine the suitability thereof for his particular purpose.



CLEANING VISCOSITY CUPS AFTER USE

Guide for removing the G-series calibrating oil from Gardco viscosity cups.

Any remaining material in the cup must be removed by flushing with a suitable solvent. Light naphtha, heptane, octane, highly aromatic solvents, and or any other petroleum-derived hydrocarbon solvent can be used. Varsol® is a commercial solvent that works very well for this purpose.

Completely dry the viscosity cup with a lint free cloth. Use a highly volatile solvent for a second cleaning as since any remaining hydrocarbon solvents from the first process will evaporate quickly after the sample has been flushed from the cup. Hypersolve, MEK and Alcohol can be used in aluminum cups and Hypersolve and Alcohol for the stainless steel cups. Acetone is commonly used as the second solvent because of its high volatility and its ability to dissolve traces of petroleum solvents and water.

In the third process a low velocity stream of clean air will be sufficient to evaporate remaining traces of any volatile solvent. Be aware, avoid rapid evaporation of these solvents as this can cool the surface to such an extent that humid air may be brought below the dew point, causing a film of water to form on the cup.

Varsol is a registered trademark of the Exxon Company



PROCEDURE FOR CALIBRATION FOR **GARDCO** LABORATORY STAND CUPS

THIS INFORMATION PERTAINS ONLY TO VISCOSITY CUPS MADE BY
THE PAUL N. GARDNER COMPANY, INC. (GARDCO)

EXAMPLE OF MATERIALS NEEDED FOR CALIBRATION OF A LABORATORY STAND VISCOSITY CUP

- One GARDCO Laboratory Stand Viscosity Cup.
- The Conversion Grid sheet (for cup chosen) to convert seconds efflux time (to nearest tenth of a second) to centistoke viscosity. Every Gardco Cup is furnished with such a data sheet.
- One pint of certified calibration oil (appropriate to cup chosen, see chart below)

Standard Oil	Centistoke* Viscosity	Std. Ford Cup No	Gardco ISO Cup No	Gardco Din Cup No	Fisher Std. Cup No	Parlin Cup No
G-6	8.9	0	-	-	-	-
G-10	19	1	3	-	-	-
G-20	34	-	-	-	1	-
G-35/G-35-P	64	2	4	-	2	1
G-60	120	3, 4	-	-	3	-
G-100/G-100-P	230	-	6	4	-	2
G-200	450	5	-	-	4	-
G-350	880	-	8	-	-	-
† G-350-P	1,020	-	-	-	-	3
G-J3000-P	10,800	-	-	-	-	4

*These are nominal values. For the actual centistoke value of the standard, refer to the value on the bottle label.

† Special temperature @ 23°C.

- To insure highest accuracy of calibration, we recommend the use of ASTM mercury filled glass type thermometers having an accuracy of 0.1°C (0.2°F). Use any of the following:
 - Gardco Cat. No. VI-3130 glass mercury filled thermometer, 4-1/2" length, 20-30°C. range.
 - Gardco Cat. No. TH-17C ASTM mercury filled glass thermometer, 10.8" length, 19-27°C. range.
 - Gardco Cat. No. TH-17F ASTM mercury filled glass thermometer, 10.8" length, 66-80°F. range.
- Container, 250 ml capacity.
- Gardco Cat. No. TM-705 digital electronic stopwatch, 0.01 second.
- Reference literature:
 - Gardco Viscosity cup leaflet (for cup chosen)
 - Viscosity Cups-Common Questions and Their Answers leaflet
 - Gardco Viscosity Cup Equivalent Wall Chart (VI-VCC) or Slide Chart (VI-9939)
 - Gardco General Catalog



**THIS INFORMATION PERTAINS ONLY TO VISCOSITY CUPS
(EXCLUDING PARLIN CUPS*) MADE BY
THE PAUL N. GARDNER COMPANY, INC. (GARDCO)**

** Please refer to the Parlin Viscosity Cup Literature for procedure for calibration specific to this cup. Meets ASTM D1084, Test Method A*

PROCEDURE

1. Examine the cup for obvious obstruction or damage to the orifice area and general cleanliness of cup.
2. Place cup in stand and level the top edge. The bottom of the cup should be approximately 6" above the container bottom.
3. Select the recommended Certified Viscosity Standard for the cup to be calibrated. Make sure the expiration date for the standard has not passed.
4. Pour a sufficient amount of oil into a 250 ml container to exceed the capacity of the cup.
5. Proper temperature is very important. Bring oil to target temperature of $25.0^{\circ}\text{C} \pm .5^{\circ}\text{C}$. Use a calibrated ASTM mercury-filled thermometer to monitor this process. By wrapping a hand around the container and slowly stirring oil, the temperature can be slightly raised.
6. Fill cup to the top edge (slightly overfill cup and remove excess with a straight edge or glass plate), while holding a finger over the orifice. Pour slowly to minimize air bubble formation.
7. Simultaneously release finger from the orifice and start timing with a stopwatch with accuracy of 1/10th second or better.
8. Hold the thermometer in the efflux stream to insure the temperature remains constant throughout the run.
9. Stop the timer when the first definite break in the efflux stream occurs near the bottom of the cup. Be sure to keep air bubbles at a minimum; they will sometimes cause an apparent break prematurely.
10. Record time and temperature and repeat. Keep temperature drift between runs at $\pm .2^{\circ}\text{C}$. Disregard any runs that are more than .5 seconds apart.
11. Adjust times for temperature deviation and average three valid runs.
12. Divide the design time by the average and determine the correction factor.
13. Determine if the cup is in or out of tolerance according to manufacturer's specification.

**THIS PROCEDURE MEETS THE REQUIREMENTS OF
ASTM D1200 & D5125**



EXAMPLE OF VISCOSITY CUP CALIBRATION CHECK SHEET

DATE 7/31/17
 CUP NAME **GARDCO EZ™ Zahn (ASTM)** CUP NO. 2
 CUP RING TAG SERIAL NO. 44263
 STATED TOLERANCE ± 3%

CERTIFIED OIL DATA

CALIBRATION OIL NO. G60 LOT NO. 90102
 LABEL DUE DATE 5/30/17
 DATE OIL FIRST USED ** 7/31/17
 CENTISTOKE VISCOSITY ON LABEL 118.4 CS

CALIBRATION DATA *

RUN NO. 1	<u>47.53</u>	SECS @ 25.0°C	RUN NO. 3	<u>47.65</u>	SECS @ 25.0°C
RUN NO. 2	<u>47.63</u>	SECS @ 25.0°C	AVERAGE	<u>47.60</u>	SECS @ 25.0°C

DESIGN EFFLUX TIME (FROM GARDCO CONVERSION GRID CHART)
47.86 SECS @ 25.0°C

IN TOLERANCE (☒) OUT OF TOLERANCE (☐)

CORRECTION FACTOR 1.005

CALIBRATED BY A.B. Smith CHECKED BY L.A. Dawn

(Only For Cups Made By GARDCO)

- * When many different determinations are to be made on similar products in the same viscosity range, it may be helpful to produce a graph for converting measured temperature and viscosity cup efflux time in seconds to seconds at a specified temperature, normally 25.0° C (77.0°F). Refer to "Temperature" in Viscosity Cup leaflet in this manual for a suggested method of preparation for such a graph.

When finished with standard oil examine it for contamination of any kind. A fine wire mesh filter may be used if dirt specks are noticed. If oil is accidentally contaminated with water settled in bottom of tumbler, pour off clean portion of oil and discard contaminated water portion. Pour oil back into bottle and record the date of first use on the label. Stored in normal ambient temperature the oil is good for a year after date of first use, provided it does not become contaminated.

CLEANING

After use of cup, allow to drain and then clean with suitable solvent and dry cup with soft lint-free cloth. Be sure that orifice is clean and dry. Do not use metal object to clean the orifice. Use care not to score or scratch orifice. A length of nylon fishing line is suitable in many cases to clean the orifice. Clean thermometer with suitable solvent and dry with lint-free cloth before storage. Clean container in suitable solvent and mark for future "viscosity cup calibration use only".

CAUTION

A point of caution: Even the standard oils change in viscosity in the range of 3% - 8% per degree Celsius at the 25° normal measuring range. Temperature of products being measured should be adjusted to within 0.1° of specified temperature if accurate results are to be obtained.

The information contained herein, or supplied by us or on our behalf in any other manner is based on data obtained by our own research and is considered accurate. However, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA, THE RESULTS TO BE OBTAINED FROM THE USE THEREOF, OR THAT ANY SUCH USE WILL NOT INFRINGE ANY PATENT. This information is furnished upon the condition that the person receiving it shall make his own tests to determine the suitability thereof for his particular purpose.

GARDCO/PARLIN VISCOSITY CUP #1

CONVERSION FORMULAS AND TABLES

The original characteristics of the Parlin or "P-Cup" developed in the Parlin, NJ laboratories of the E.I. DuPont de Nemours Company are brought forth in the Gardco/Parlin cup in exact conformance with ASTM D 1084 and MMM-A-189C specifications. Cup dimensions are carefully controlled and cup calibration conditions comply with ANSI/NCSL Z540-1 or MIL-STD-45662A as applicable. Standard viscous oils traceable to the National Institute of Standards and Technology are used in calibration procedures to insure specified efflux time tolerance.

Use this formula, derived by Paul N. Gardner Company research, to find viscosity (V) in centistokes when cup efflux time in seconds (T) is known:

$$V = 1.55T - 800 \div T$$

Use this formula to find cup efflux time in seconds (T) when viscosity (V) in centistokes is known:

$$T = (V + \sqrt{V^2 + 4960}) \div 3.1$$

Results from the above formulas, solved for each tenth of a second within the cup range, are shown on the reverse side of this page. To find centistoke viscosity for a given cup efflux time in seconds, read down the column on the left to find the nearest second. Then, read to the right to the nearest tenth of a second column to find centistoke value. The chart may be read in reverse to find efflux time in seconds when viscosity is known.

The GARDCO/PARLIN series of four viscosity cups are produced, calibrated and sold only by the Paul N. Gardner Company and licensed agents.



PARLIN CUP - #1

EFFLUX TIME - CENTISTOKES CONVERSION TABLE

(Accurate for True Liquids Only)
GARDCO TM © Copyright 1997, Paul N. Gardner Co., Inc.

DRAIN TIME SECONDS	(Accurate for True Liquids Only)									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	← VISCOSITY IN CENTISTOKES →									
25	6.8	7.0	7.3	7.6	7.9	8.2	8.4	8.7	9.0	9.3
26	9.5	9.8	10.1	10.3	10.6	10.9	11.2	11.4	11.7	12.0
27	12.2	12.5	12.7	13.0	13.3	13.5	13.8	14.1	14.3	14.6
28	14.8	15.1	15.3	15.6	15.9	16.1	16.4	16.6	16.9	17.1
29	17.4	17.6	17.9	18.1	18.4	18.6	18.9	19.1	19.3	19.6
30	19.8	20.1	20.3	20.6	20.8	21.0	21.3	21.5	21.8	22.0
31	22.2	22.5	22.7	23.0	23.2	23.4	23.7	23.9	24.1	24.4
32	24.6	24.8	25.1	25.3	25.5	25.8	26.0	26.2	26.4	26.7
33	26.9	27.1	27.4	27.6	27.8	28.0	28.3	28.5	28.7	28.9
34	29.2	29.4	29.6	29.8	30.1	30.3	30.5	30.7	31.0	31.2
35	31.4	31.6	31.8	32.1	32.3	32.5	32.7	32.9	33.1	33.4
36	33.6	33.8	34.0	34.2	34.4	34.7	34.9	35.1	35.3	35.5
37	35.7	35.9	36.2	36.4	36.6	36.8	37.0	37.2	37.4	37.6
38	37.8	38.1	38.3	38.5	38.7	38.9	39.1	39.3	39.5	39.7
39	39.9	40.1	40.4	40.6	40.8	41.0	41.2	41.4	41.6	41.8
40	42.0	42.2	42.4	42.6	42.8	43.0	43.2	43.4	43.6	43.8
41	44.0	44.2	44.4	44.6	44.8	45.0	45.2	45.5	45.7	45.9
42	46.1	46.3	46.5	46.7	46.9	47.1	47.3	47.4	47.6	47.8
43	48.0	48.2	48.4	48.6	48.8	49.0	49.2	49.4	49.6	49.8
44	50.0	50.2	50.4	50.6	50.8	51.0	51.2	51.4	51.6	51.8
45	52.0	52.2	52.4	52.6	52.7	52.9	53.1	53.3	53.5	53.7
46	53.9	54.1	54.3	54.5	54.7	54.9	55.1	55.3	55.4	55.6
47	55.8	56.0	56.2	56.4	56.6	56.8	57.0	57.2	57.4	57.5
48	57.7	57.9	58.1	58.3	58.5	58.7	58.9	59.1	59.2	59.4
49	59.6	59.8	60.0	60.2	60.4	60.6	60.8	60.9	61.1	61.3
50	61.5	61.7	61.9	62.1	62.2	62.4	62.6	62.8	63.0	63.2
51	63.4	63.5	63.7	63.9	64.1	64.3	64.5	64.7	64.8	65.0
52	65.2	65.4	65.6	65.8	66.0	66.1	66.3	66.5	66.7	66.9
53	67.1	67.2	67.4	67.6	67.8	68.0	68.2	68.3	68.5	68.7
54	68.9	69.1	69.2	69.4	69.6	69.8	70.0	70.2	70.3	70.5
55	70.7	70.9	71.1	71.2	71.4	71.6	71.8	72.0	72.2	72.3
56	72.5	72.7	72.9	73.1	73.2	73.4	73.6	73.8	74.0	74.1
57	74.3	74.5	74.7	74.9	75.0	75.2	75.4	75.6	75.7	75.9
58	76.1	76.3	76.5	76.6	76.8	77.0	77.2	77.4	77.5	77.7
59	77.9	78.1	78.2	78.4	78.6	78.8	79.0	79.1	79.3	79.5
60	79.7	79.8	80.0	80.2	80.4	80.6	80.7	80.9	81.1	81.3
61	81.4	81.6	81.8	82.0	82.1	82.3	82.5	82.7	82.8	83.0
62	83.2	83.4	83.5	83.7	83.9	84.1	84.3	84.4	84.6	84.8
63	85.0	85.1	85.3	85.5	85.7	85.8	86.0	86.2	86.4	86.5
64	86.7	86.9	87.0	87.2	87.4	87.6	87.7	87.9	88.1	88.3
65	88.4	88.6	88.8	89.0	89.1	89.3	89.5	89.7	89.8	90.0
66	90.2	90.4	90.5	90.7	90.9	91.0	91.2	91.4	91.6	91.7
67	91.9	92.1	92.3	92.4	92.6	92.8	92.9	93.1	93.3	93.5
68	93.6	93.8	94.0	94.2	94.3	94.5	94.7	94.8	95.0	95.2
69	95.4	95.5	95.7	95.9	96.0	96.2	96.4	96.6	96.7	96.9
70	97.1	97.2	97.4	97.6	97.8	97.9	98.1	98.3	98.4	98.6
71	98.8	99.0	99.1	99.3	99.5	99.6	99.8	100.0	100.1	100.3
72	100.5	100.7	100.8	101.0	101.2	101.3	101.5	101.7	101.9	102.0
73	102.2	102.4	102.5	102.7	102.9	103.0	103.2	103.4	103.5	103.7
74	103.9	104.1	104.2	104.4	104.6	104.7	104.9	105.1	105.2	105.4



PARLIN CUP - #1

EFFLUX TIME - CENTISTOKES CONVERSION TABLE

(Accurate for True Liquids Only)

DRAIN TIME SECONDS	(Accurate for True Liquids Only)									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	VISCOSITY IN CENTISTOKES									
75	105.6	105.8	105.9	106.1	106.3	106.4	106.6	106.8	106.9	107.1
76	107.3	107.4	107.6	107.8	107.9	108.1	108.3	108.5	108.6	108.8
77	109.0	109.1	109.3	109.5	109.6	109.8	110.0	110.1	110.3	110.5
78	110.6	110.8	111.0	111.1	111.3	111.5	111.7	111.8	112.0	112.2
79	112.3	112.5	112.7	112.8	113.0	113.2	113.3	113.5	113.7	113.8
80	114.0	114.2	114.3	114.5	114.7	114.8	115.0	115.2	115.3	115.5
81	115.7	115.8	116.0	116.2	116.3	116.5	116.7	116.8	117.0	117.2
82	117.3	117.5	117.7	117.8	118.0	118.2	118.3	118.5	118.7	118.8
83	119.0	119.2	119.3	119.5	119.7	119.8	120.0	120.2	120.3	120.5
84	120.7	120.8	121.0	121.2	121.3	121.5	121.7	121.8	122.0	122.2
85	122.3	122.5	122.7	122.8	123.0	123.2	123.3	123.5	123.7	123.8
86	124.0	124.2	124.3	124.5	124.7	124.8	125.0	125.2	125.3	125.5
87	125.7	125.8	126.0	126.2	126.3	126.5	126.6	126.8	127.0	127.1
88	127.3	127.5	127.6	127.8	128.0	128.1	128.3	128.5	128.6	128.8
89	129.0	129.1	129.3	129.5	129.6	129.8	130.0	130.1	130.3	130.4
90	130.6	130.8	130.9	131.1	131.3	131.4	131.6	131.8	131.9	132.1
91	132.3	132.4	132.6	132.8	132.9	133.1	133.2	133.4	133.6	133.7
92	133.9	134.1	134.2	134.4	134.6	134.7	134.9	135.1	135.2	135.4
93	135.5	135.7	135.9	136.0	136.2	136.4	136.5	136.7	136.9	137.0
94	137.2	137.4	137.5	137.7	137.8	138.0	138.2	138.3	138.5	138.7
95	138.8	139.0	139.2	139.3	139.5	139.6	139.8	140.0	140.1	140.3
96	140.5	140.6	140.8	141.0	141.1	141.3	141.4	141.6	141.8	141.9
97	142.1	142.3	142.4	142.6	142.8	142.9	143.1	143.2	143.4	143.6
98	143.7	143.9	144.1	144.2	144.4	144.6	144.7	144.9	145.0	145.2
99	145.4	145.5	145.7	145.9	146.0	146.2	146.3	146.5	146.7	146.8
100	147.0	147.2	147.3	147.5	147.7	147.8	148.0	148.1	148.3	148.5
101	148.6	148.8	149.0	149.1	149.3	149.4	149.6	149.8	149.9	150.1
102	150.3	150.4	150.6	150.7	150.9	151.1	151.2	151.4	151.6	151.7
103	151.9	152.0	152.2	152.4	152.5	152.7	152.9	153.0	153.2	153.3
104	153.5	153.7	153.8	154.0	154.2	154.3	154.5	154.6	154.8	155.0
105	155.1	155.3	155.5	155.6	155.8	155.9	156.1	156.3	156.4	156.6
106	156.8	156.9	157.1	157.2	157.4	157.6	157.7	157.9	158.0	158.2
107	158.4	158.5	158.7	158.9	159.0	159.2	159.3	159.5	159.7	159.8
108	160.0	160.2	160.3	160.5	160.6	160.8	161.0	161.1	161.3	161.4
109	161.6	161.8	161.9	162.1	162.3	162.4	162.6	162.7	162.9	163.1
110	163.2	163.4	163.6	163.7	163.9	164.0	164.2	164.4	164.5	164.7

GARDCO™

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GARDCO/PARLIN VISCOSITY CUP #2

CONVERSION FORMULAS AND TABLES

The original characteristics of the Parlin or "P-Cup" developed in the Parlin, NJ laboratories of the E.I. DuPont de Nemours Company are brought forth in the Gardco/Parlin cup in exact conformance with ASTM D 1084 and MMM-A-189C specifications. Cup dimensions are carefully controlled and cup calibration conditions comply with ANSI/NCSL Z540-1 or MIL-STD-45662A as applicable. Standard viscous oils traceable to the National Institute of Standards and Technology are used in calibration procedures to insure specified efflux time tolerance.

Use this formula, derived by Paul N. Gardner Company research, to find viscosity (V) in centistokes when cup efflux time in seconds (T) is known:

$$V = 4.82T - 100 \div T$$

Use this formula to find cup efflux time in seconds (T) when viscosity (V) in centistokes is known:

$$T = (V + \sqrt{V^2 + 1928}) \div 9.64$$

Results from the above formulas, solved for each tenth of a second within the cup range, are shown on the reverse side of this page. To find centistoke viscosity for a given cup efflux time in seconds, read down the column on the left to find the nearest second. Then, read to the right to the nearest tenth of a second column to find centistoke value. The chart may be read in reverse to find efflux time in seconds when viscosity is known.

The GARDCO/PARLIN series of four viscosity cups are produced, calibrated and sold only by the Paul N. Gardner Company and licensed agents.



PARLIN CUP - #2

EFFLUX TIME - CENTISTOKES CONVERSION TABLE

GARDCO™

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DRAIN TIME SECONDS	(Accurate for True Liquids Only)									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	VISCOSITY IN CENTISTOKES									
25	116.5	117.0	117.5	118.0	118.5	119.0	119.5	120.0	120.5	121.0
26	121.5	122.0	122.5	123.0	123.5	124.0	124.5	124.9	125.4	125.9
27	126.4	126.9	127.4	127.9	128.4	128.9	129.4	129.9	130.4	130.9
28	131.4	131.9	132.4	132.9	133.4	133.9	134.4	134.8	135.3	135.8
29	136.3	136.8	137.3	137.8	138.3	138.8	139.3	139.8	140.3	140.8
30	141.3	141.8	142.3	142.7	143.2	143.7	144.2	144.7	145.2	145.7
31	146.2	146.7	147.2	147.7	148.2	148.7	149.1	149.6	150.1	150.6
32	151.1	151.6	152.1	152.6	153.1	153.6	154.1	154.6	155.0	155.5
33	156.0	156.5	157.0	157.5	158.0	158.5	159.0	159.5	160.0	160.4
34	160.9	161.4	161.9	162.4	162.9	163.4	163.9	164.4	164.9	165.4
35	165.8	166.3	166.8	167.3	167.8	168.3	168.8	169.3	169.8	170.3
36	170.7	171.2	171.7	172.2	172.7	173.2	173.7	174.2	174.7	175.1
37	175.6	176.1	176.6	177.1	177.6	178.1	178.6	179.1	179.6	180.0
38	180.5	181.0	181.5	182.0	182.5	183.0	183.5	184.0	184.4	184.9
39	185.4	185.9	186.4	186.9	187.4	187.9	188.3	188.8	189.3	189.8
40	190.3	190.8	191.3	191.8	192.3	192.7	193.2	193.7	194.2	194.7
41	195.2	195.7	196.2	196.6	197.1	197.6	198.1	198.6	199.1	199.6
42	200.1	200.5	201.0	201.5	202.0	202.5	203.0	203.5	204.0	204.4
43	204.9	205.4	205.9	206.4	206.9	207.4	207.9	208.3	208.8	209.3
44	209.8	210.3	210.8	211.3	211.8	212.2	212.7	213.2	213.7	214.2
45	214.7	215.2	215.7	216.1	216.6	217.1	217.6	218.1	218.6	219.1
46	219.5	220.0	220.5	221.0	221.5	222.0	222.5	223.0	223.4	223.9
47	224.4	224.9	225.4	225.9	226.4	226.8	227.3	227.8	228.3	228.8
48	229.3	229.8	230.2	230.7	231.2	231.7	232.2	232.7	233.2	233.7
49	234.1	234.6	235.1	235.6	236.1	236.6	237.1	237.5	238.0	238.5
50	239.0	239.5	240.0	240.5	240.9	241.4	241.9	242.4	242.9	243.4
51	243.9	244.3	244.8	245.3	245.8	246.3	246.8	247.3	247.7	248.2
52	248.7	249.2	249.7	250.2	250.7	251.1	251.6	252.1	252.6	253.1
53	253.6	254.1	254.5	255.0	255.5	256.0	256.5	257.0	257.5	257.9
54	258.4	258.9	259.4	259.9	260.4	260.9	261.3	261.8	262.3	262.8
55	263.3	263.8	264.3	264.7	265.2	265.7	266.2	266.7	267.2	267.6
56	268.1	268.6	269.1	269.6	270.1	270.6	271.0	271.5	272.0	272.5
57	273.0	273.5	274.0	274.4	274.9	275.4	275.9	276.4	276.9	277.4
58	277.8	278.3	278.8	279.3	279.8	280.3	280.7	281.2	281.7	282.2
59	282.7	283.2	283.7	284.1	284.6	285.1	285.6	286.1	286.6	287.0
60	287.5	288.0	288.5	289.0	289.5	290.0	290.4	290.9	291.4	291.9
61	292.4	292.9	293.4	293.8	294.3	294.8	295.3	295.8	296.3	296.7
62	297.2	297.7	298.2	298.7	299.2	299.7	300.1	300.6	301.1	301.6
63	302.1	302.6	303.0	303.5	304.0	304.5	305.0	305.5	305.9	306.4
64	306.9	307.4	307.9	308.4	308.9	309.3	309.8	310.3	310.8	311.3
65	311.8	312.2	312.7	313.2	313.7	314.2	314.7	315.2	315.6	316.1
66	316.6	317.1	317.6	318.1	318.5	319.0	319.5	320.0	320.5	321.0
67	321.4	321.9	322.4	322.9	323.4	323.9	324.4	324.8	325.3	325.8
68	326.3	326.8	327.3	327.7	328.2	328.7	329.2	329.7	330.2	330.6
69	331.1	331.6	332.1	332.6	333.1	333.6	334.0	334.5	335.0	335.5
70	336.0	336.5	336.9	337.4	337.9	338.4	338.9	339.4	339.8	340.3
71	340.8	341.3	341.8	342.3	342.7	343.2	343.7	344.2	344.7	345.2
72	345.7	346.1	346.6	347.1	347.6	348.1	348.6	349.0	349.5	350.0
73	350.5	351.0	351.5	351.9	352.4	352.9	353.4	353.9	354.4	354.8
74	355.3	355.8	356.3	356.8	357.3	357.7	358.2	358.7	359.2	359.7



PARLIN CUP - #2

EFFLUX TIME - CENTISTOKES CONVERSION TABLE

DRAIN TIME SECONDS	(Accurate for True Liquids Only)									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	VISCOSITY IN CENTISTOKES									
75	360.2	360.7	361.1	361.6	362.1	362.6	363.1	363.6	364.0	364.5
76	365.0	365.5	366.0	366.5	366.9	367.4	367.9	368.4	368.9	369.4
77	369.8	370.3	370.8	371.3	371.8	372.3	372.7	373.2	373.7	374.2
78	374.7	375.2	375.6	376.1	376.6	377.1	377.6	378.1	378.5	379.0
79	379.5	380.0	380.5	381.0	381.4	381.9	382.4	382.9	383.4	383.9
80	384.4	384.8	385.3	385.8	386.3	386.8	387.3	387.7	388.2	388.7
81	389.2	389.7	390.2	390.6	391.1	391.6	392.1	392.6	393.1	393.5
82	394.0	394.5	395.0	395.5	396.0	396.4	396.9	397.4	397.9	398.4
83	398.9	399.3	399.8	400.3	400.8	401.3	401.8	402.2	402.7	403.2
84	403.7	404.2	404.7	405.1	405.6	406.1	406.6	407.1	407.6	408.0
85	408.5	409.0	409.5	410.0	410.5	410.9	411.4	411.9	412.4	412.9
86	413.4	413.8	414.3	414.8	415.3	415.8	416.3	416.7	417.2	417.7
87	418.2	418.7	419.2	419.6	420.1	420.6	421.1	421.6	422.1	422.5
88	423.0	423.5	424.0	424.5	425.0	425.4	425.9	426.4	426.9	427.4
89	427.9	428.3	428.8	429.3	429.8	430.3	430.8	431.2	431.7	432.2
90	432.7	433.2	433.7	434.1	434.6	435.1	435.6	436.1	436.6	437.0
91	437.5	438.0	438.5	439.0	439.5	439.9	440.4	440.9	441.4	441.9
92	442.4	442.8	443.3	443.8	444.3	444.8	445.3	445.7	446.2	446.7
93	447.2	447.7	448.2	448.6	449.1	449.6	450.1	450.6	451.0	451.5
94	452.0	452.5	453.0	453.5	453.9	454.4	454.9	455.4	455.9	456.4
95	456.8	457.3	457.8	458.3	458.8	459.3	459.7	460.2	460.7	461.2
96	461.7	462.2	462.6	463.1	463.6	464.1	464.6	465.1	465.5	466.0
97	466.5	467.0	467.5	468.0	468.4	468.9	469.4	469.9	470.4	470.9
98	471.3	471.8	472.3	472.8	473.3	473.8	474.2	474.7	475.2	475.7
99	476.2	476.7	477.1	477.6	478.1	478.6	479.1	479.6	480.0	480.5
100	481.0	481.5	482.0	482.4	482.9	483.4	483.9	484.4	484.9	485.3
101	485.8	486.3	486.8	487.3	487.8	488.2	488.7	489.2	489.7	490.2
102	490.7	491.1	491.6	492.1	492.6	493.1	493.6	494.0	494.5	495.0
103	495.5	496.0	496.5	496.9	497.4	497.9	498.4	498.9	499.4	499.8
104	500.3	500.8	501.3	501.8	502.3	502.7	503.2	503.7	504.2	504.7
105	505.1	505.6	506.1	506.6	507.1	507.6	508.0	508.5	509.0	509.5
106	510.0	510.5	510.9	511.4	511.9	512.4	512.9	513.4	513.8	514.3
107	514.8	515.3	515.8	516.3	516.7	517.2	517.7	518.2	518.7	519.2
108	519.6	520.1	520.6	521.1	521.6	522.0	522.5	523.0	523.5	524.0
109	524.5	524.9	525.4	525.9	526.4	526.9	527.4	527.8	528.3	528.8
110	529.3	529.8	530.3	530.7	531.2	531.7	532.2	532.7	533.2	533.6
111	534.1	534.6	535.1	535.6	536.1	536.5	537.0	537.5	538.0	538.5
112	538.9	539.4	539.9	540.4	540.9	541.4	541.8	542.3	542.8	543.3
113	543.8	544.3	544.7	545.2	545.7	546.2	546.7	547.2	547.6	548.1
114	548.6	549.1	549.6	550.1	550.5	551.0	551.5	552.0	552.5	552.9
115	553.4	553.9	554.4	554.9	555.4	555.8	556.3	556.8	557.3	557.8
116	558.3	558.7	559.2	559.7	560.2	560.7	561.2	561.6	562.1	562.6
117	563.1	563.6	564.1	564.5	565.0	565.5	566.0	566.5	566.9	567.4
118	567.9	568.4	568.9	569.4	569.8	570.3	570.8	571.3	571.8	572.3
119	572.7	573.2	573.7	574.2	574.7	575.2	575.6	576.1	576.6	577.1
120	577.6	578.0	578.5	579.0	579.5	580.0	580.5	580.9	581.4	581.9



GARDCO/PARLIN VISCOSITY CUP #3 CONVERSION FORMULAS AND TABLES

The original characteristics of the Parlin or "P-Cup" developed in the Parlin, NJ laboratories of the E.I. DuPont de Nemours Company are brought forth in the Gardco/Parlin cup in exact conformance with ASTM D 1084 and MMM-A-189C specifications. Cup dimensions are carefully controlled and cup calibration conditions comply with ANSI/NCSL Z540-1 or MIL-STD-45662A as applicable. Standard viscous oils traceable to the National Institute of Standards and Technology are used in calibration procedures to insure specified efflux time tolerance.

Use this formula, derived by Paul N. Gardner Company research, to find viscosity (V) in centistokes when cup efflux time in seconds (T) is known:

$$V = 20.75T - 500 \div T$$

Use this formula to find cup efflux time in seconds (T) when viscosity (V) in centistokes is known:

$$T = \left(V + \sqrt{V^2 + 41500} \right) \div 41.5$$

Results from the above formulas, solved for each tenth of a second within the cup range, are shown on the reverse side of this page. To find centistoke viscosity for a given cup efflux time in seconds, read down the column on the left to find the nearest second. Then, read to the right to the nearest tenth of a second column to find centistoke value. The chart may be read in reverse to find efflux time in seconds when viscosity is known.

The GARDCO/PARLIN series of four viscosity cups are produced, calibrated and sold only by the Paul N. Gardner Company and licensed agents.



PARLIN CUP - #3

EFFLUX TIME - CENTISTOKES CONVERSION TABLE

(Accurate for True Liquids Only)

DRAIN TIME SECONDS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	<----- VISCOSITY IN CENTISTOKES ----->									
25	498.8	500.9	503.1	505.2	507.4	509.5	511.7	513.8	516.0	518.1
26	520.3	522.4	524.6	526.7	528.9	531.0	533.2	535.3	537.4	539.6
27	541.7	543.9	546.0	548.2	550.3	552.4	554.6	556.7	558.9	561.0
28	563.1	565.3	567.4	569.6	571.7	573.8	576.0	578.1	580.2	582.4
29	584.5	586.6	588.8	590.9	593.0	595.2	597.3	599.4	601.6	603.7
30	605.8	608.0	610.1	612.2	614.4	616.5	618.6	620.7	622.9	625.0
31	627.1	629.2	631.4	633.5	635.6	637.8	639.9	642.0	644.1	646.3
32	648.4	650.5	652.6	654.7	656.9	659.0	661.1	663.2	665.4	667.5
33	669.6	671.7	673.8	676.0	678.1	680.2	682.3	684.4	686.6	688.7
34	690.8	692.9	695.0	697.1	699.3	701.4	703.5	705.6	707.7	709.8
35	712.0	714.1	716.2	718.3	720.4	722.5	724.7	726.8	728.9	731.0
36	733.1	735.2	737.3	739.5	741.6	743.7	745.8	747.9	750.0	752.1
37	754.2	756.3	758.5	760.6	762.7	764.8	766.9	769.0	771.1	773.2
38	775.3	777.5	779.6	781.7	783.8	785.9	788.0	790.1	792.2	794.3
39	796.4	798.5	800.6	802.8	804.9	807.0	809.1	811.2	813.3	815.4
40	817.5	819.6	821.7	823.8	825.9	828.0	830.1	832.2	834.3	836.5
41	838.6	840.7	842.8	844.9	847.0	849.1	851.2	853.3	855.4	857.5
42	859.6	861.7	863.8	865.9	868.0	870.1	872.2	874.3	876.4	878.5
43	880.6	882.7	884.8	886.9	889.0	891.1	893.2	895.3	897.4	899.5
44	901.6	903.7	905.8	907.9	910.0	912.1	914.2	916.3	918.4	920.5
45	922.6	924.7	926.8	928.9	931.0	933.1	935.2	937.3	939.4	941.5
46	943.6	945.7	947.8	949.9	952.0	954.1	956.2	958.3	960.4	962.5
47	964.6	966.7	968.8	970.9	973.0	975.1	977.2	979.3	981.4	983.5
48	985.6	987.7	989.8	991.9	994.0	996.1	998.2	1000.3	1002.4	1004.5
49	1006.5	1008.6	1010.7	1012.8	1014.9	1017.0	1019.1	1021.2	1023.3	1025.4
50	1027.5	1029.6	1031.7	1033.8	1035.9	1038.0	1040.1	1042.2	1044.3	1046.4
51	1048.4	1050.5	1052.6	1054.7	1056.8	1058.9	1061.0	1063.1	1065.2	1067.3
52	1069.4	1071.5	1073.6	1075.7	1077.8	1079.9	1081.9	1084.0	1086.1	1088.2
53	1090.3	1092.4	1094.5	1096.6	1098.7	1100.8	1102.9	1105.0	1107.1	1109.1
54	1111.2	1113.3	1115.4	1117.5	1119.6	1121.7	1123.8	1125.9	1128.0	1130.1
55	1132.2	1134.3	1136.3	1138.4	1140.5	1142.6	1144.7	1146.8	1148.9	1151.0
56	1153.1	1155.2	1157.3	1159.3	1161.4	1163.5	1165.6	1167.7	1169.8	1171.9
57	1174.0	1176.1	1178.2	1180.2	1182.3	1184.4	1186.5	1188.6	1190.7	1192.8
58	1194.9	1197.0	1199.1	1201.1	1203.2	1205.3	1207.4	1209.5	1211.6	1213.7
59	1215.8	1217.9	1220.0	1222.0	1224.1	1226.2	1228.3	1230.4	1232.5	1234.6
60	1236.7	1238.8	1240.8	1242.9	1245.0	1247.1	1249.2	1251.3	1253.4	1255.5
61	1257.6	1259.6	1261.7	1263.8	1265.9	1268.0	1270.1	1272.2	1274.3	1276.3
62	1278.4	1280.5	1282.6	1284.7	1286.8	1288.9	1291.0	1293.1	1295.1	1297.2
63	1299.3	1301.4	1303.5	1305.6	1307.7	1309.8	1311.8	1313.9	1316.0	1318.1
64	1320.2	1322.3	1324.4	1326.4	1328.5	1330.6	1332.7	1334.8	1336.9	1339.0
65	1341.1	1343.1	1345.2	1347.3	1349.4	1351.5	1353.6	1355.7	1357.8	1359.8
66	1361.9	1364.0	1366.1	1368.2	1370.3	1372.4	1374.4	1376.5	1378.6	1380.7
67	1382.8	1384.9	1387.0	1389.0	1391.1	1393.2	1395.3	1397.4	1399.5	1401.6
68	1403.6	1405.7	1407.8	1409.9	1412.0	1414.1	1416.2	1418.2	1420.3	1422.4
69	1424.5	1426.6	1428.7	1430.8	1432.8	1434.9	1437.0	1439.1	1441.2	1443.3
70	1445.4	1447.4	1449.5	1451.6	1453.7	1455.8	1457.9	1460.0	1462.0	1464.1



PARLIN CUP - #3 EFFLUX TIME - CENTISTOKES CONVERSION TABLE

(Accurate for True Liquids Only)

DRAIN TIME SECONDS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	<----- VISCOSITY IN CENTISTOKES ----->									
71	1466.2	1468.3	1470.4	1472.5	1474.5	1476.6	1478.7	1480.8	1482.9	1485.0
72	1487.1	1489.1	1491.2	1493.3	1495.4	1497.5	1499.6	1501.6	1503.7	1505.8
73	1507.9	1510.0	1512.1	1514.2	1516.2	1518.3	1520.4	1522.5	1524.6	1526.7
74	1528.7	1530.8	1532.9	1535.0	1537.1	1539.2	1541.2	1543.3	1545.4	1547.5
75	1549.6	1551.7	1553.8	1555.8	1557.9	1560.0	1562.1	1564.2	1566.3	1568.3
76	1570.4	1572.5	1574.6	1576.7	1578.8	1580.8	1582.9	1585.0	1587.1	1589.2
77	1591.3	1593.3	1595.4	1597.5	1599.6	1601.7	1603.8	1605.8	1607.9	1610.0
78	1612.1	1614.2	1616.3	1618.3	1620.4	1622.5	1624.6	1626.7	1628.8	1630.8
79	1632.9	1635.0	1637.1	1639.2	1641.3	1643.3	1645.4	1647.5	1649.6	1651.7
80	1653.8	1655.8	1657.9	1660.0	1662.1	1664.2	1666.2	1668.3	1670.4	1672.5
81	1674.6	1676.7	1678.7	1680.8	1682.9	1685.0	1687.1	1689.2	1691.2	1693.3
82	1695.4	1697.5	1699.6	1701.6	1703.7	1705.8	1707.9	1710.0	1712.1	1714.1
83	1716.2	1718.3	1720.4	1722.5	1724.6	1726.6	1728.7	1730.8	1732.9	1735.0
84	1737.0	1739.1	1741.2	1743.3	1745.4	1747.5	1749.5	1751.6	1753.7	1755.8
85	1757.9	1759.9	1762.0	1764.1	1766.2	1768.3	1770.4	1772.4	1774.5	1776.6
86	1778.7	1780.8	1782.8	1784.9	1787.0	1789.1	1791.2	1793.3	1795.3	1797.4
87	1799.5	1801.6	1803.7	1805.7	1807.8	1809.9	1812.0	1814.1	1816.2	1818.2
88	1820.3	1822.4	1824.5	1826.6	1828.6	1830.7	1832.8	1834.9	1837.0	1839.1
89	1841.1	1843.2	1845.3	1847.4	1849.5	1851.5	1853.6	1855.7	1857.8	1859.9
90	1861.9	1864.0	1866.1	1868.2	1870.3	1872.4	1874.4	1876.5	1878.6	1880.7
91	1882.8	1884.8	1886.9	1889.0	1891.1	1893.2	1895.2	1897.3	1899.4	1901.5
92	1903.6	1905.6	1907.7	1909.8	1911.9	1914.0	1916.1	1918.1	1920.2	1922.3
93	1924.4	1926.5	1928.5	1930.6	1932.7	1934.8	1936.9	1938.9	1941.0	1943.1
94	1945.2	1947.3	1949.3	1951.4	1953.5	1955.6	1957.7	1959.7	1961.8	1963.9
95	1966.0	1968.1	1970.1	1972.2	1974.3	1976.4	1978.5	1980.6	1982.6	1984.7
96	1986.8	1988.9	1991.0	1993.0	1995.1	1997.2	1999.3	2001.4	2003.4	2005.5
97	2007.6	2009.7	2011.8	2013.8	2015.9	2018.0	2020.1	2022.2	2024.2	2026.3
98	2028.4	2030.5	2032.6	2034.6	2036.7	2038.8	2040.9	2043.0	2045.0	2047.1
99	2049.2	2051.3	2053.4	2055.4	2057.5	2059.6	2061.7	2063.8	2065.8	2067.9
100	2070.0	2072.1	2074.2	2076.2	2078.3	2080.4	2082.5	2084.6	2086.6	2088.7
101	2090.8	2092.9	2095.0	2097.0	2099.1	2101.2	2103.3	2105.4	2107.4	2109.5
102	2111.6	2113.7	2115.8	2117.8	2119.9	2122.0	2124.1	2126.2	2128.2	2130.3
103	2132.4	2134.5	2136.6	2138.6	2140.7	2142.8	2144.9	2147.0	2149.3	2151.1
104	2153.2	2155.3	2157.4	2159.4	2161.5	2163.6	2165.7	2167.7	2169.8	2171.9
105	2174.0	2176.1	2178.1	2180.2	2182.3	2184.4	2186.5	2188.5	2190.6	2192.7
106	2194.8	2196.9	2198.9	2201.0	2203.1	2205.2	2207.3	2209.3	2211.4	2213.5
107	2215.6	2217.7	2219.7	2221.8	2223.9	2226.0	2228.1	2230.1	2232.2	2234.3
108	2236.4	2238.4	2240.5	2242.6	2244.7	2246.8	2248.8	2250.9	2253.0	2255.1
109	2257.2	2259.2	2261.3	2263.4	2265.5	2267.6	2269.6	2271.7	2273.8	2275.9
110	2278.0	2280.0	2282.1	2284.2	2286.3	2288.4	2290.4	2292.5	2294.6	2296.7



GARDCO/PARLIN VISCOSITY CUP #4 CONVERSION FORMULAS AND TABLES

The original characteristics of the Parlin or "P-Cup" developed in the Parlin, NJ laboratories of the E.I. DuPont de Nemours Company are brought forth in the Gardco/Parlin cup in exact conformance with ASTM D 1084 and MMM-A-189C specifications. Cup dimensions are carefully controlled and cup calibration conditions comply with ANSI/NCSL Z540-1 or MIL-STD-45662A as applicable. Standard viscous oils traceable to the National Institute of Standards and Technology are used in calibration procedures to insure specified efflux time tolerance.

Use this formula, derived by Paul N. Gardner Company research, to find viscosity (V) in centistokes when cup efflux time in seconds (T) is known:

$$V = 139T - 750 \div T$$

Use this formula to find cup efflux time in seconds (T) when viscosity (V) in centistokes is known:

$$T = \left(V + \sqrt{V^2 + 417000} \right) \div 278$$

Results from the above formulas, solved for each tenth of a second within the cup range, are shown on the reverse side of this page. To find centistoke viscosity for a given cup efflux time in seconds, read down the column on the left to find the nearest second. Then, read to the right to the nearest tenth of a second column to find centistoke value. The chart may be read in reverse to find efflux time in seconds when viscosity is known.

The GARDCO/PARLIN series of four viscosity cups are produced, calibrated and sold only by the Paul N. Gardner Company and licensed agents.

Parlin Viscosity Cup



PARLIN CUP - #4 EFFLUX TIME - CENTISTOKES CONVERSION TABLE

(Accurate for True Liquids Only)

DRAIN TIME SECONDS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	<----- VISCOSITY IN CENTISTOKES ----->									
25	3445	3459	3473	3487	3501	3515	3529	3543	3557	3571
26	3585	3599	3613	3627	3641	3655	3669	3683	3697	3711
27	3725	3739	3753	3767	3781	3795	3809	3823	3837	3851
28	3865	3879	3893	3907	3921	3835	3949	3963	3977	3991
29	4005	4019	4033	4047	4061	4075	4089	4103	4117	4131
30	4145	4159	4173	4187	4201	4215	4229	4243	4257	4271
31	4285	4299	4313	4327	4341	4355	4369	4383	4397	4411
32	4425	4439	4453	4466	4480	4494	4508	4522	4536	4550
33	4564	4578	4592	4606	4620	4634	4648	4662	4676	4690
34	4704	4718	4732	4746	4760	4774	4788	4802	4816	4830
35	4844	4858	4871	4885	4899	4913	4927	4941	4955	4969
36	4983	4997	5011	5025	5039	5053	5067	5081	5095	5109
37	5123	5137	5151	5165	5179	5193	5206	5220	5234	5248
38	5262	5276	5290	5304	5318	5332	5346	5360	5374	5388
39	5402	5416	5430	5444	5458	5472	5485	5499	5513	5527
40	5541	5555	5569	5583	5597	5611	5625	5639	5653	5667
41	5681	5695	5709	5723	5736	5750	5764	5778	5792	5806
42	5820	5834	5848	5862	5876	5890	5904	5918	5932	5946
43	5960	5973	5987	6001	6015	6029	6043	6057	6071	6085
44	6099	6113	6127	6141	6155	6169	6183	6197	6210	6224
45	6238	6252	6266	6280	6294	6308	6322	6336	6350	6364
46	6378	6392	6406	6420	6433	6447	6461	6475	6489	6503
47	6517	6531	6545	6559	6573	6587	6601	6615	6629	6642
48	6656	6670	6684	6698	6712	6726	6740	6754	6768	6782
49	6796	6810	6824	6837	6851	6865	6879	6893	6907	6921
50	6935	6949	6963	6977	6991	7005	7019	7033	7046	7060
51	7074	7088	7102	7116	7130	7144	7158	7172	7186	7200
52	7214	7228	7241	7255	7269	7283	7297	7311	7325	7339
53	7353	7367	7381	7395	7409	7422	7436	7450	7464	7478
54	7492	7506	7520	7534	7548	7562	7576	7590	7604	7617
55	7631	7645	7659	7673	7687	7701	7715	7729	7743	7757
56	7771	7785	7798	7812	7826	7840	7854	7868	7882	7896
57	7910	7924	7938	7952	7966	7979	7993	8007	8021	8035
58	8049	8063	8077	8091	8105	8119	8133	8147	8160	8174
59	8188	8202	8216	8230	8244	8258	8272	8286	8300	8314
60	8328	8341	8355	8369	8383	8397	8411	8425	8439	8453
61	8467	8481	8495	8508	8522	8536	8550	8564	8578	8592
62	8606	8620	8634	8648	8662	8676	8689	8703	8717	8731
63	8745	8759	8773	8787	8801	8815	8829	8843	8856	8870
64	8884	8808	8912	8926	8940	8954	8968	8982	8996	9010
65	9023	9037	9051	9065	9079	9093	9107	9121	9135	9149
66	9163	9177	9190	9204	9218	9232	9246	9260	9274	9288
67	9302	9316	9330	9344	9357	9371	9385	9399	9413	9427
98	9441	9455	9469	9483	9497	9511	9524	9538	9552	9566
69	9580	9594	9608	9622	9636	9650	9664	9678	9691	9705
70	9719	9733	9747	9761	9775	9789	9803	9817	9831	9845



PARLIN CUP - #4 **EFFLUX TIME - CENTISTOKES CONVERSION TABLE**

(Accurate for True Liquids Only)

DRAIN TIME SECONDS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	<----- VISCOSITY IN CENTISTOKES ----->									
71	9858	9872	9886	9900	9914	9928	9942	9956	9970	9984
72	9998	10011	10025	10039	10053	10067	10081	10095	10109	10123
73	10137	10151	10165	10178	10192	10206	10220	10234	10248	10262
74	10276	10290	10304	10318	10332	10345	10359	10373	10387	10401
75	10415	10429	10443	10457	10471	10485	10498	10512	10526	10540
76	10554	10568	10582	10596	10610	10624	10638	10652	10665	10679
77	10693	10707	10721	10735	10749	10763	10777	10791	10805	10818
78	10832	10846	10860	10874	10888	10902	10916	10930	10944	10958
79	10972	10985	10999	11013	11027	11041	11055	11069	11083	11097
80	11111	11125	11138	11152	11166	11180	11194	11208	11222	11236
81	11250	11264	11278	11291	11305	11319	11333	11347	11361	11375
82	11389	11403	11417	11431	11444	11458	11472	11486	11500	11514
83	11528	11542	11556	11570	11584	11598	11611	11625	11639	11653
84	11667	11681	11695	11709	11723	11737	11751	11764	11778	11792
85	11806	11820	11834	11848	11862	11876	11890	11904	11917	11931
86	11945	11959	11973	11987	12001	12015	12029	12043	12057	12070
87	12084	12098	12112	12126	12140	12154	12168	12182	12196	12210
88	12223	12237	12251	12265	12279	12293	12307	12321	12335	12349
89	12363	12376	12390	12404	12418	12432	12446	12460	12474	12488
90	12502	12516	12529	12543	12557	12571	12585	12599	12613	12627
91	12641	12655	12669	12682	12696	12710	12724	12738	12752	12766
92	12780	12794	12808	12822	12835	12849	12863	12877	12891	12905
93	12919	12933	12947	12961	12975	12988	13002	13016	13030	13044
94	13058	13072	13086	13100	13114	13128	13141	13155	13169	13183
95	13197	13211	13225	13239	13253	13267	13281	13294	13308	13322
96	13336	13350	13364	13378	13392	13406	13420	13434	13447	13461
97	13475	13489	13503	13517	13531	13545	13559	13573	13587	13600
98	13614	13628	13642	13656	13670	13684	13698	13712	13726	13740
99	13753	13767	13781	13795	13809	13823	13837	13851	13865	13879
100	13893	13906	13920	13934	13948	13962	13976	13990	14004	14018
101	14032	14045	14059	14073	14087	14101	14115	14129	14143	14157
102	14171	14185	14198	14212	14226	14240	14254	14268	14282	14296
103	14310	14324	14338	14351	14365	14379	14393	14407	14421	14435
104	14449	14463	14477	14491	14504	14518	14532	14546	14560	14574
105	14588	14602	14616	14630	14643	14657	14671	14685	14699	14713
106	14727	14741	14755	14769	14783	14796	14810	14824	14838	14852
107	14866	14880	14894	14908	14922	14936	14949	14963	14977	14991
108	15005	15019	15033	15047	15061	15075	15088	15102	15116	15130
109	15144	15158	15172	15186	15200	15214	15228	15241	15255	15269
110	15283	15297	15311	15325	15339	15353	15367	15381	15394	15408

CALIBRATION OIL STATEMENT

EFFLUX VISCOSITY CUPS

The National Institute of Standards and Technology traceable standard oils used in the calibration of all certified efflux type viscosity cups made and sold by The Paul N. Gardner Company, Inc. (GARDCO) are standard oils prepared expressly for the Paul N. Gardner Company, Inc. (GARDCO) by the Cannon Instrument Company and are produced in accordance with A2LA accredited laboratory, ISO 9001, ISO/IEC 17025, ISO 17025 and Guide 34 accreditation.

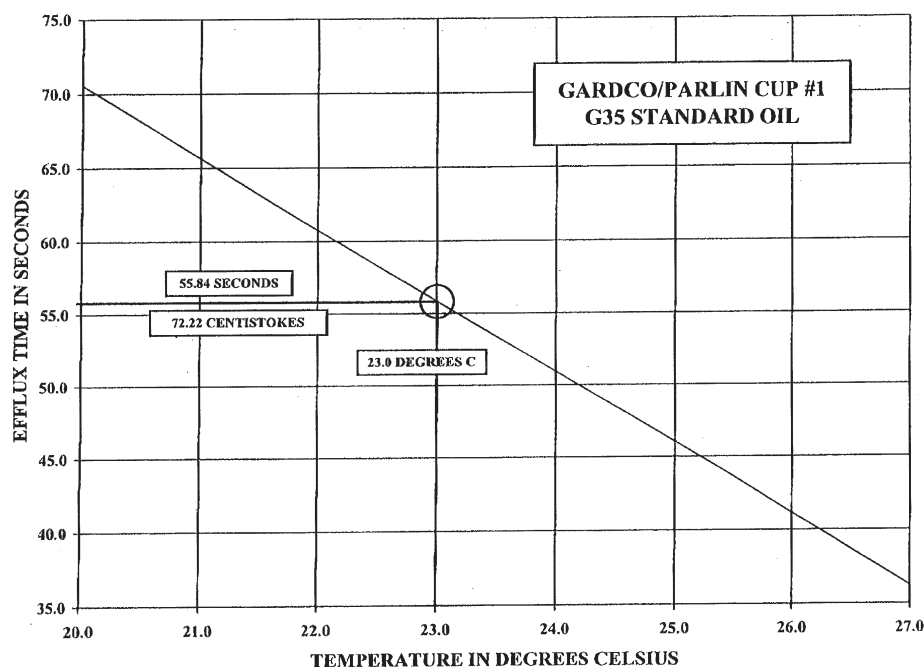
The following viscosity cups are calibrated with oils produced in accordance with ISO:

GARDCO Standard Ford Cups.....Cups #0, #1, #2, #3, #4 and #5
GARDCO/ISO Cups 3mm, 4mm, 6mm, and 8mm Cups
GARDCO/DIN Cup4mm Cup
GARDCO/Parlin Cups.....#1, #2, #3 and #4 Cups
GARDCO/Fisher Standard Cups.....#1, #2, #3 and #4 Cups
GARDCO Standard Ford Dip Cups.....Cups #3, and #4
GARDCO Mini Ford Dip CupsCups #0, #1, #2, #3, #4 and #5
GARDCO/Mini ISO Dip Cups3mm, 4mm, and 6mm Cups
GARDCO/Mini DIN Dip Cup.....4mm Cup
GARDCO/Fisher Dip Cups.....Cups #1, #2, #3 and #4
GARDCO EZ™ Zahn (ASTM) Dip Cups Cups #1, #2, #3, #4 and #5
GARDCO S90 Zahn Signature Dip Cups Cups #1, #2, #3, #4 and #5



GARDCO/PARLIN VISCOSITY CUPS

EFFLUX TIME VERSUS TEMPERATURE



Gardco produced viscosity cups are calibrated with standard "G" Series oils. Centistoke viscosity of these oils is traceable to the National Institute of Standards and Technology. These oils are available from the Paul N. Gardner Company.

Shown in the above graph is the viscosity cup number and the standard "G" oil used for its calibration. In the case of the Parlin cup calibration is at 23°C as shown on the graph by bold lines intersecting with the curve in the circle.

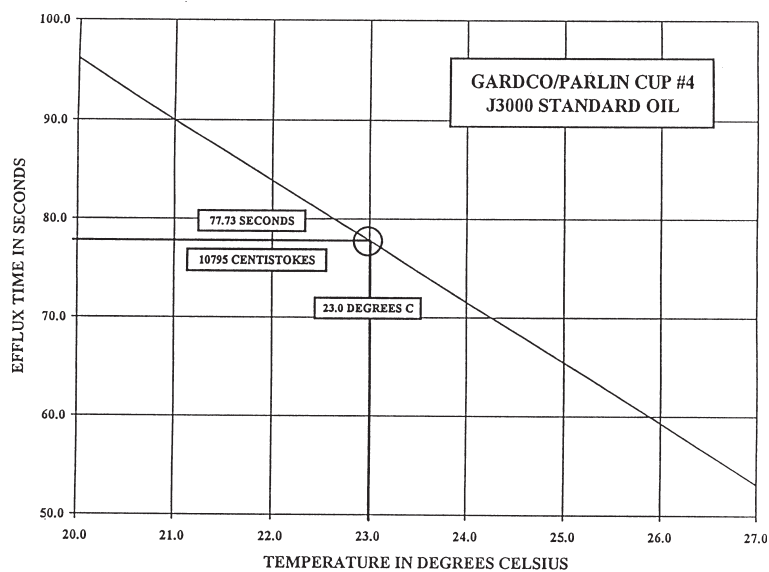
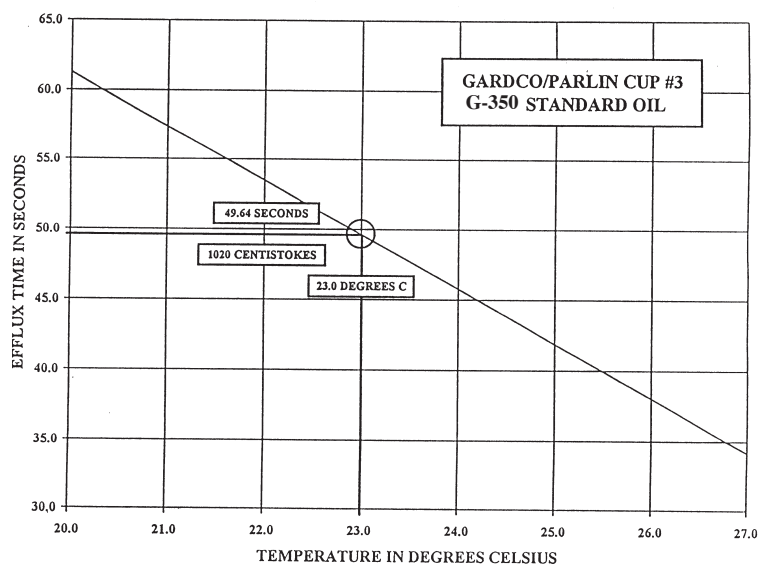
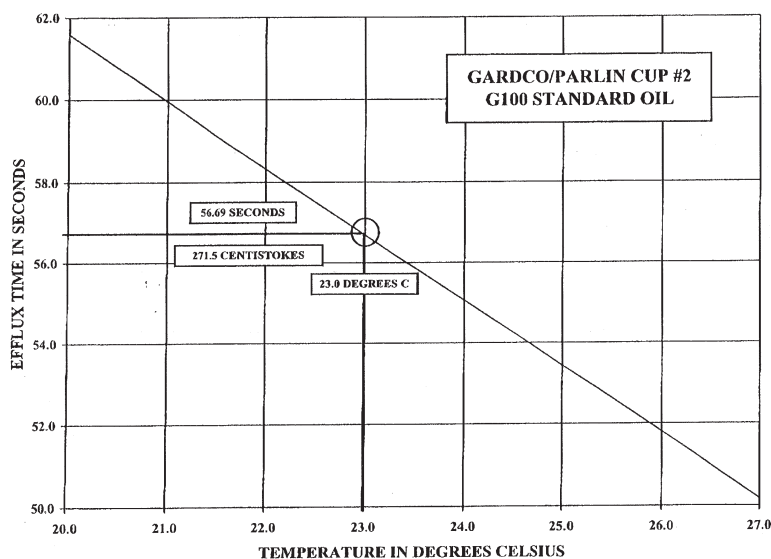
Viscosity of most liquids, including the standard oils, are dependent on temperature. Efflux time in seconds for the indicated cup-oil combination from twenty (20) to twenty-seven (27) degrees Celsius is shown in the above graph. The cup may be checked with the indicated "G" oil with reasonable accuracy within these limits. For best accuracy, the viscosity of the standard oil in Centistokes, as printed on the standard oil bottle label, at a temperature of 23° Celsius should be used such as item number (VI-3810) G-35 Oil. Conversion from viscosity to efflux time in seconds is by the formula or table furnished with the cup.

This information, furnished as an additional customer service, is included with each viscosity cup sold by the Paul N. Gardner Company or by licensed distributors.

Parlin Viscosity Cup



EFFLUX TIME VERSUS TEMPERATURE



TEMPERATURE SCALE CONVERSION BETWEEN CELSIUS AND FAHRENHEIT



DEGREES		DEGREES	
CELSIUS	FAHRENHEIT	CELSIUS	FAHRENHEIT
20.0	68.0	23.6	74.5
20.1	68.2	23.7	74.7
20.2	68.4	23.8	74.8
20.3	68.5	23.9	75.0
20.4	68.7	24.0	75.2
20.5	68.9	24.1	75.4
20.6	69.1	24.2	75.6
20.7	69.3	24.3	75.7
20.8	69.4	24.4	75.9
20.9	69.6	24.5	76.1
21.0	69.8	24.6	76.3
21.1	70.0	24.7	76.5
21.2	70.2	24.8	76.6
21.3	70.3	24.9	76.8
21.4	70.5	25.0	77.0
21.5	70.7	25.1	77.2
21.6	70.9	25.2	77.4
21.7	71.1	25.3	77.5
21.8	71.2	25.4	77.7
21.9	71.4	25.5	77.9
22.0	71.6	25.6	78.1
22.1	71.8	25.7	78.3
22.2	72.0	25.8	78.4
22.3	72.1	25.9	78.6
22.4	72.3	26.0	78.8
22.5	72.5	26.1	79.0
22.6	72.7	26.2	79.2
22.7	72.9	26.3	79.3
22.8	73.0	26.4	79.5
22.9	73.2	26.5	79.7
23.0	73.4	26.6	79.9
23.1	73.6	26.7	80.1
23.2	73.8	26.8	80.2
23.3	73.9	26.9	80.4
23.4	74.1	27.0	80.6
23.5	74.3		

$$F^{\circ} = (C^{\circ} \times 1.8) + 32$$

$$C^{\circ} = (F^{\circ} - 32^{\circ}) \div 1.8$$



A Service To Industry

GARDCO VISCOSITY CUP CERTIFICATION and GARDCO INSTRUMENT CERTIFICATION

QUALIFIES UNDER ANSI/NCSL Z540 OR
ISO/IEC 17025, ISO 9001
AS APPLICABLE
CALIBRATION OILS TRACEABLE TO N.I.S.T.

GARDCO-produced viscosity cups are calibrated with standard "G" Series oils. Centistoke viscosity of these oils is traceable to the National Institute of Standards and Technology. These standard oils, prepared expressly by the Cannon Instrument Company for the Paul N. Gardner Company, are produced in accordance with **A2LA accredited laboratory, ISO 9001, ISO/IEC 17025, ISO 17025 and Guide 34 accreditation.**



PAUL N. GARDNER COMPANY, INC.



GARDCO VISCOSITY CUP CERTIFICATION

QUALIFIES UNDER ANSI/NC SL Z540 OR ISO/IEC 17025, ISO 9001 AS APPLICABLE

STANDARD "G" CALIBRATING OILS ARE TRACEABLE TO NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

GARDCO VISCOSITY CUP NAME	SIZE	STANDARD "G" OIL NUMBER	CUP FORMULA CONSTANTS		CUP TOLER- ANCE ± %
			K	C	
GARDCO STANDARD FORD CUP	0	G-6	0.133	313	2
GARDCO STANDARD FORD CUP	1	G-10	0.372	600	2
GARDCO STANDARD FORD CUP	2	G-35	1.24	770	2
GARDCO STANDARD FORD CUP	3	G-60	2.31	550	2
GARDCO STANDARD FORD CUP	4	G-60	3.70	400	2
GARDCO STANDARD FORD CUP	5	G-200	11.80	408	2
GARDCO/ISO CUP	3mm	G-10	0.443	200	2
GARDCO/ISO CUP	4mm	G-35	1.37	200	2
GARDCO/ISO CUP	6mm	G-100	6.90	570	2
GARDCO/ISO CUP	8mm	G-350	21.78	306	3
GARDCO/DIN CUP	4mm	G-100	4.57	452	3
GARDCO/FISHER STANDARD CUP	1	G-20	0.85	175	2
GARDCO/FISHER STANDARD CUP	2	G-35	2.32	190	2
GARDCO/FISHER STANDARD CUP	3	G-60	5.39	185	2
GARDCO/FISHER STANDARD CUP	4	G-200	18.90	210	2
GARDCO STANDARD FORD DIP CUP	3	G-60	2.31	550	3
GARDCO STANDARD FORD DIP CUP	4	G-60	3.70	400	2
GARDCO STANDARD FORD DIP CUP	5	G-200	11.80	408	3
GARDCO MINI FORD DIP CUP	0	G-6	0.266	157	4
GARDCO MINI FORD DIP CUP	1	G-10	0.744	300	4
GARDCO MINI FORD DIP CUP	2	G-35	2.48	385	4
GARDCO MINI FORD DIP CUP	3	G-60	4.62	275	4
GARDCO MINI FORD DIP CUP	4	G-60	7.40	200	4
GARDCO MINI FORD DIP CUP	5	G-200	23.60	204	4
GARDCO/ISO DIP CUP	3mm	G-10	0.886	100	3
GARDCO/ISO DIP CUP	4mm	G-35	2.74	100	3
GARDCO/ISO DIP CUP	6mm	G-100	13.80	285	3
GARDCO/DIN DIP CUP	4mm	G-100	9.14	226	3
GARDCO/FISHER DIP CUP	1	G-20	0.85	175	2
GARDCO/FISHER DIP CUP	2	G-35	2.32	190	2
GARDCO/FISHER DIP CUP	3	G-60	5.39	185	2
GARDCO/FISHER DIP CUP	4	G-200	18.90	210	2
GARDCO EZ™ ZAHN (ASTM) DIP CUP	1	G-10	0.875	993	3
GARDCO EZ™ ZAHN (ASTM) DIP CUP	2	G-60	2.80	747	3
GARDCO EZ™ ZAHN (ASTM) DIP CUP	3	G-200	10.09	587	3
GARDCO EZ™ ZAHN (ASTM) DIP CUP	4	G-200	13.26	673	3
GARDCO EZ™ ZAHN (ASTM) DIP CUP	5	G-350	23.56	744	3
GARDCO S90 ZAHN SIGNATURE DIP CUP	1	G-20	1.59	1070	5
GARDCO S90 ZAHN SIGNATURE DIP CUP	2	G-60	4.18	760	5
GARDCO S90 ZAHN SIGNATURE DIP CUP	3	G-100	10.23	575	5
GARDCO S90 ZAHN SIGNATURE DIP CUP	4	G-350	15.13	545	5
GARDCO S90 ZAHN SIGNATURE DIP CUP	5	G-350	27.27	540	5
GARDCO /PARLIN CUP	1	G-35-P	1.55	800	3
GARDCO /PARLIN CUP	2	G-100-P	4.82	100	3
GARDCO /PARLIN CUP	3	G-350-P	20.75	500	3
GARDCO /PARLIN CUP	4	G-J3000-P	139.00	750	5
CONVERSION BETWEEN CENTISTOKES "V" AND CUP DRAIN SECONDS "T": $V = KT - C \div T \text{ or } T = (V + \sqrt{V^2 + 4KC}) \div 2K$ WHERE "K" AND "C" ARE THE ABOVE LISTED CONSTANTS					



COMPLIMENTS OF

Viscosity measurement

Understanding various types of equipment and the influencing factors in the measurement.

M.R. Euverard, Paul N. Gardner Co., Pompano Beach, FL

■ All fluids resist forces to change their form. Many solids, such as tar, show a gradual yielding to forces tending to change their form. This property (like an internal friction) is called viscosity. Classical physics defines the viscosity of a substance as the tangential force per unit area of either of two horizontal planes at unit distance apart. One is fixed, while the other moves at unit velocity. The space is filled with the substance. It is expressed in dynes/cm² per square centimeter or poises. One poise equals 100 centipoises.

Rotational instruments

Many of the instruments used in measuring viscosity are rotational type—"bob in a cup," "cone and plate" or variations of these forms. The results gathered from these instruments read in basic units or poises. They are obtained through a knowledge of the surface area in contact with the substance being measured and the separation of these surfaces.

Rotational instruments can be engineered to accommodate a very wide range of viscosity values. The more elaborate devices provide values at different rates of shear. This provides a thorough study of the viscous properties of a sub-

stance. Auxiliaries such as automatic recorders may be used.

There are some disadvantages to the rotational instruments. They are very complex and costly. Though usually large and bulky, they may be delicate and require practiced techniques for good results. Probably one of their biggest problems lies in temperature control. At high rates of shear the substance being measured heats up. To retain a given temperature, an elaborate temperature sensing and control system is required.

Orifice—capillary instruments

Capillary tube type instruments are limited to measurements on relatively low-viscosity substances. There are many different configurations. In simple form, they consist of a reservoir with a capillary tube of known length and internal diameter connecting another reservoir at a lower level. The substance to be measured is filled into the upper reservoir.

The time for this exact amount to flow to the lower reservoir is determined. Another factor is now introduced—density of the substance. A material of high density should flow through the capillary tube faster than one of low density (at the same viscosity).

The volume of flow of a substance through a tube is directly proportional to: the time of flow; pressure across the tube; and the fourth power of the tube radius. It is inversely proportional to the length of the tube and the viscosity of the substance. Also, by definition, kinematic viscosity (the stoke) is the ratio of poise viscosity to density. The stoke equals 100 centistokes.

The capillary tube-type instruments also tie directly to basic units of measurement. However, if gravity is the driving force creating the pressure drop across the tube, then density is a factor and the results are in stokes.

The capillary tube type instrument is an accurate device for measurement in the lower part of the viscosity spectrum. But, again, there are limitations. They are fragile and limited to very low rates of shear. These instruments are not easily adaptable to field use.

Orifice flow instruments—known as viscosity cups—are an outgrowth of the capillary tube instruments. In the cups, the tube is much shorter in length and larger in diameter. Normally, they accommodate a larger sample than the reservoir of the capillary tube. There is a deviation from linearity at the low end of each cup range. The degree of deviation is more pronounced in cups with the shorter effective length of tube. This is due to the formation of eddy currents at higher rates of flow.

Since gravity is the driving force for the flow of a material from a viscosity



Figure 1. Standard Ford viscosity cup.



cup—and density is a factor—the measurement is in terms of kinematic viscosity, or stokes.

There are many reasons why viscosity cups are so widely used: they are very accurate, rugged and suitable for field use, relatively easy to clean and inexpensive.

Development of viscosity cups has taken place in two directions: one type for use in the control laboratory and the other, usually in simpler form, for use in the field. The biggest problem with this class of device is probably the absence of standardization and a tieback to basic units of measurement.

Liquid-solid mixtures

Liquid-solid mixtures introduce a very complex dimension to viscosity measurement. Some materials will not flow at all until a force exceeding a certain minimum is imposed. Some will reflect a lowering and some an increase in viscosity as the rate of shear is increased.

Evaluation of the flow properties of these mixtures (where the solid component is relatively high) is best done on rotational type equipment. Here, the rate of shear is variable.

Temperature

Temperature influences most physical measurements. In the range of room temperature, a soft iron bar will change in length by 0.00121 percent for each degree Centigrade change in temperature. This small amount can be neglected for most purposes. The influence of temperature in viscosity measurements of liquids is much more severe. Consider a volume of water under the same conditions. The change is over 20 times greater and must be considered in most accurate volume measurements. This includes the calibration of weight per gallon cups. One group of refined mineral oils used for the calibration of viscosity measuring instruments changes considerably in actual viscosity. An average change of more than five percent for each degree centigrade change in temperature in the range of 25°C is common. This is over 200 times the influence of temperature on a volume of water. It is also over 4,000 times the influence on the length of a soft iron bar.

Errors that are often made in temperature measurement (and therefore in viscosity measurement) involve one or more of the following:

- The thermometer may cover too wide a range and therefore is not sensi-

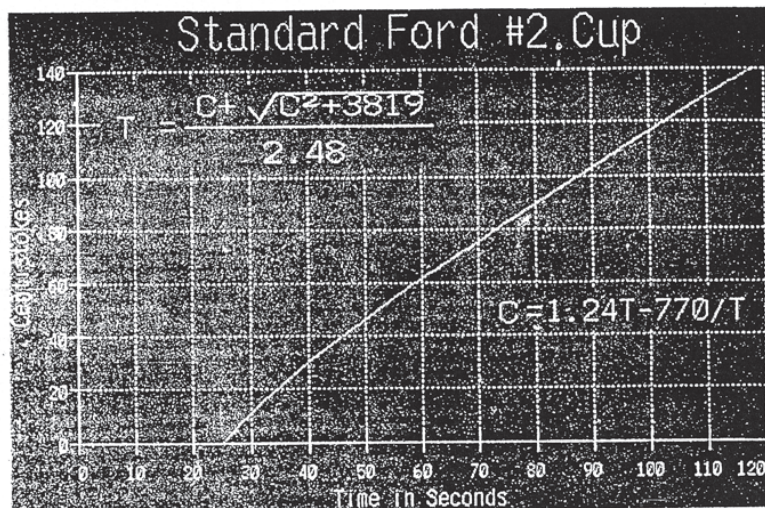


Figure 2. Standard Ford viscosity cup #2.

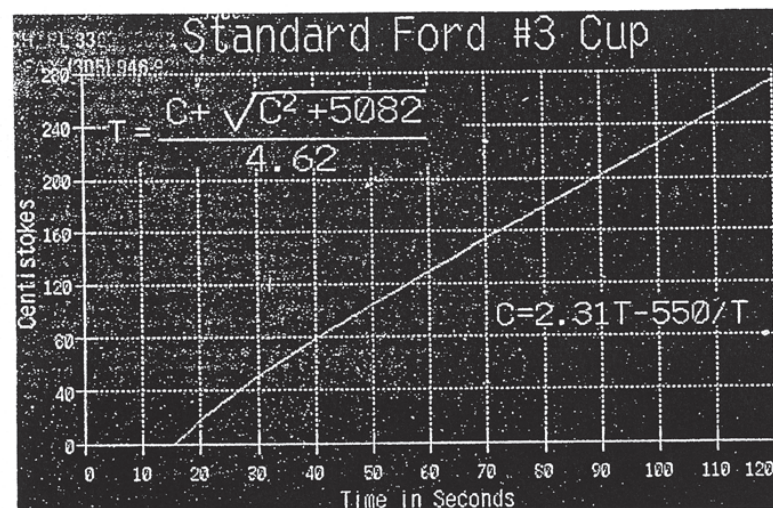


Figure 3. Standard Ford viscosity cup #3.

tive enough.

- The time lag of the thermometer is too great for the application.
- The "thermal well" effect of the thermometer is too great for the application.
- The sample is not thoroughly mixed and uniform throughout in temperature.
- There is temperature change during the measurement. Surfaces of equipment are a different temperature from that of the sample.

Ford cup series history

The volume and general flow characteristics of the Ford viscosity cup have not changed over the years. Specifications and definition by mathematical formula now make it a valued tool. It's

useful not only for product development, but also for production control.

The first known industry attempt to relate the results of various types of viscosity cups was by a subcommittee of ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products. The results of this work were published in the October, 1950 ASTM Bulletin No. 169.

The work included mathematical formulas that accommodated the nonlinearity at the lower range of each cup (due to eddy current turbulence at the orifice). This permitted comparison of results between the 17 different types of cups listed above stated time minimums.

Also included in the work were the results of an industry survey on the preference of viscosity measuring devices.

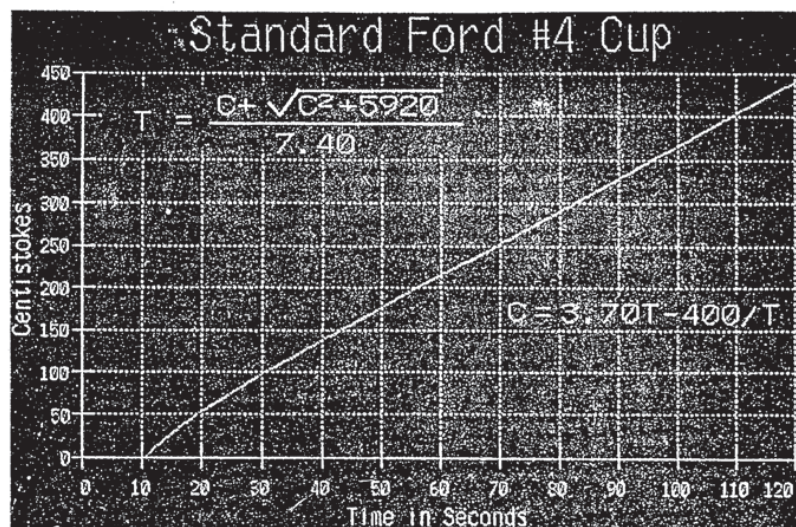


Figure 4. Standard Ford viscosity cup #4.

Where the cup type instruments were applicable, the preference was heavily weighted in favor of the Ford viscosity cup series.

An ASTM Standard Method of Test for Viscosity of Paints, Varnishes and Lacquers by Ford viscosity cups was adopted in 1954. It is carried under ASTM designation D 1200. There was a minor revision to this method in 1958, with reapproval in 1965.

In D 1200-58 (1965), the dimensions of the cup and the orifice were shown. A graph replaced the flow formula that was developed in the earlier work. The graph related viscosity in stokes to time in seconds for the numbers 2, 3 and 4 Ford viscosity cups. The lines in the graph for cup numbers 3 and 4 were in close conformity to the earlier work, except near the lower useable range.

There was a change in the ASTM method in 1970, and it was published in following standards as D 1200-70. The dimensions of the series were changed to metric, but there was no intended change in actual magnitude. The change with probably the greatest effect was the reduction to quarter size of the graph of "Standard Viscosity Curves for Ford Cups."

It seems that a flow formula included in the appendix of D 1200-70 was intended to match the curves in the graph of D 1200-58. In this attempt, there was a greater divergence with respect to the work published in 1950.

There is one major supplier of the Ford cup series that has adhered to its definition as detailed in the 1950 work. Others meet the definition of D 1200-70.

It is important to analyze the magnitude of the difference.

In D 1200-70, the time range recommended for the numbers 3 and 4 cups is 20 to 100 seconds. It is 40 to 100 seconds for the number 2 cup. A major supplier recommends a minimum of 39 seconds for the number 2, 27 seconds for the number 3 and 23 seconds for the number 4. By imposing these higher minimums, there is less difference between the cups of all suppliers. The percent difference between the published 1950 work (D 1200-58 for cup #2) and D 1200-70 is as follows:

Seconds	Cup #2	Cup #3	Cup #4
20		242	7
25		44	0
30		15	2
35	10	4	3
40	3	2	5
60	3	9	3
80	2	10	2
100	4	10	2

The new standard Ford Cup Series

A new design in viscosity cups combines the desirable features and eliminates the undesirable ones. To have maximum use, however, the new design should not add to the present lengthy list. Rather, it should replace one or more of the most popular cups. Prototypes have been tested and the advantages have been confirmed:

- A mathematical formula has been developed for each cup in the series. The formulas relate viscosity in centistokes to time in seconds.
- The flow formula for each cup in

the series has been selected. It provides results that are as close as possible to an average of other similar Ford cups.

- The flow formula (as applied to the physical dimensions of each cup in the series) has been confirmed. Using standard oils (traceable to National Bureau of Standards) and other liquids, the formula covers from zero viscosity to a viscosity proportional to 150 seconds flow time.

- Cup dimensions influencing flow time conform to those specified in ASTM D 1200-70 (except for very minor adjustment of orifice diameter).

- Weight of the cup has been reduced by 20 percent. This also reduces the influence of cup temperature on the temperature of the material being measured.

- The top interior of the orifice has been reshaped. It now provides a sharper break in the stream as the cup empties.

- The taper fit of the orifice eliminates hard-to-clean areas.

- The orifice is readily removable and inserted without tools.

- Design of the bottom of the cup gives increased protection to the orifice.

- A deepened drip well accommodates more material.

- A tripod support enhances the use of the cup.

Graphical representation of the flow characteristics for each of the three cups of the series are shown in Figures 2, 3 and 4. Also shown are the applicable mathematical formulas. In the formulas, "T" is time in seconds and "C" is viscosity in centistokes.

In each of the Figures the curve starts at zero viscosity. At very low levels, at least a half of the time value is due to turbulence at the orifice. The minimum seconds for each cup in actual practice should be 150 percent of the seconds shown at zero viscosity or:

Cup number	Minimum seconds
2	37
3	23
4	16

The maximum seconds shown in the Figures relating seconds to centistokes are 120. This is to emphasize the shape of the curve at lower time intervals. The cups have been checked with standard oils as high as 150 seconds. The results have been just as accurate as those at 120 seconds. Cups can be used as high as 150 seconds on materials that display a steady rate of discharge from the orifice. ■