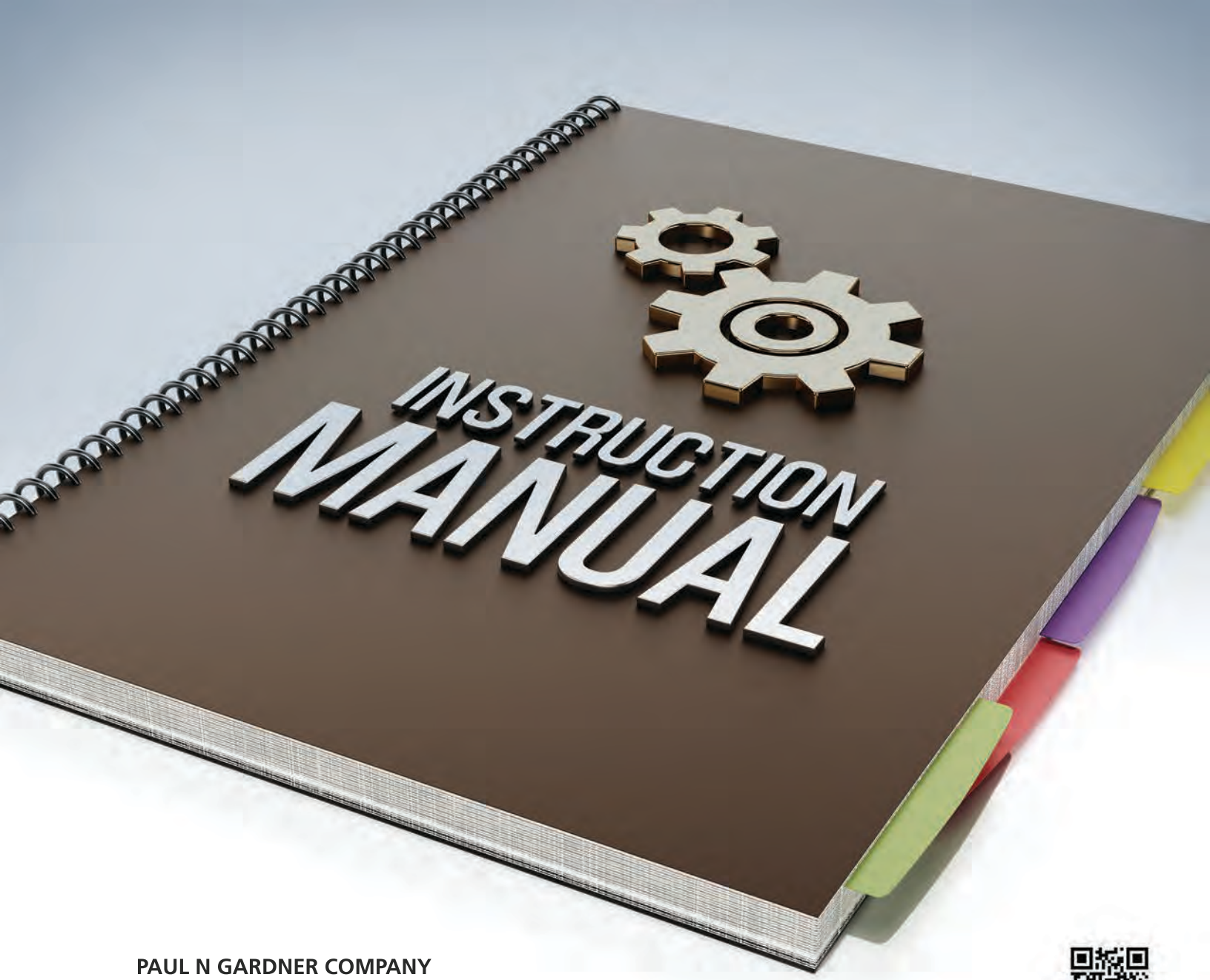

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INSTRUCTIONS

GARDCO DISTRIBUTED PRODUCTS

Mini DIN Dip Viscosity Cup

Instruction Manual

- ☐ **Parlin Viscosity Cups**
- ☐ **Standard Ford Viscosity Cups**
- ☐ **I.S.O. Viscosity Cups**
- ☐ **Din Viscosity Cup**
- ☐ **Fisher Standard Cups**
- ☐ **Standard Ford Dip Viscosity Cups**
- ☐ **Mini Ford Dip Viscosity Cups**
- ☐ **Mini I.S.O. Dip Viscosity Cups**
- ■ **Mini Din Dip Viscosity Cup**
- ☐ **Fisher Dip Viscosity Cup**
- ☐ **EZ™/ZAHN (ASTM) Dip Viscosity Cups**
- ☐ **S-90 ZAHN Signature Dip Viscosity Cups**

GARDCO/MINI DIN DIP VISCOSITY CUP

WITH 4MM ORIFICE

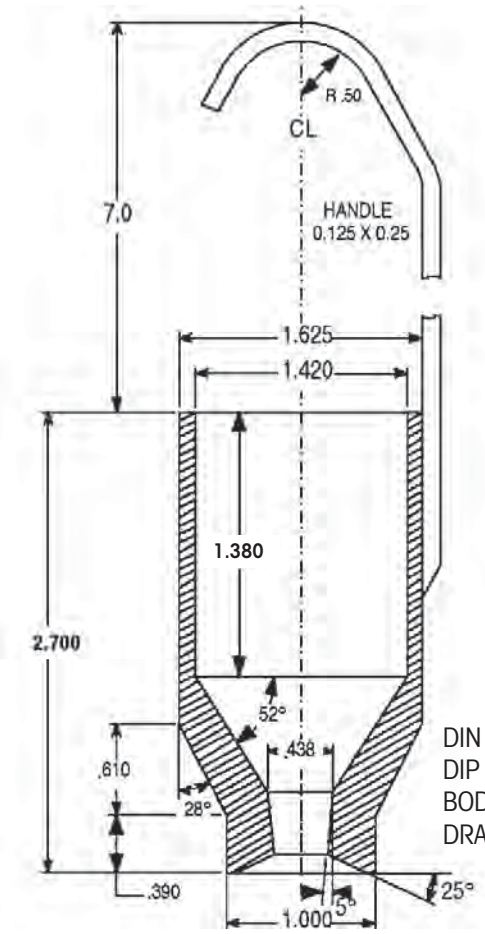
The Gardco/Mini DIN Dip viscosity cup is produced from hard aluminum with a removable stainless steel orifice of the Gardco "snap-in","snap-out" type. Cup and orifice production tolerance permits removal of orifice for cleaning without loss of acceptable cup accuracy.

ADVANTAGES

- **The Gardco/Mini DIN Dip viscosity cup is compatible to Deutsche Normen DIN 53211.**
- Conversion formulas and tables relating efflux time in seconds, to the nearest tenth of a second, to viscosity in centistokes are furnished with each Gardco/Mini DIN Dip viscosity cup.
- Calibration of the Gardco/Mini DIN Dip cup is traceable to the National Institute of Standards and Technology.
- The Gardco/Mini DIN Dip viscosity cup is machined from solid aluminum bar stock with a removable stainless steel orifice.
- The Gardco/Mini DIN Dip cup is not matched by any other cup with respect to the advantages listed above, in highest quality of workmanship, and in continuing quality control procedures.
- The Gardco/Mini DIN Dip viscosity cup was designed, developed, manufactured and calibrated by the Paul N. Gardner Company, Inc.

VISCOSITY

The physical dimensions of the new Gardco/Mini DIN Dip viscosity cup have been chosen to provide just one half of the efflux time in seconds of the Gardco Standard DIN cup of the same number and orifice. The inverted cone shaped bottom of the cup terminating in the removable stainless steel orifice is retained to insure a sharp end point and best possible comparable accuracy.



DIN
DIP CUP
BODY
DRAWING

For the first time a dip cup has been developed primarily for field use which is a direct counterpart of the cup used in the laboratory. Gardco is pleased to have made this contribution and to introduce the Gardco/Mini DIN Dip cup along with the new Gardco Standard DIN Cup Series.

The Gardco Mini Dip Cup has all of the advantages listed for the Standard Cup Series except it does not have a drip ring at the top of the cup and a handle is attached for support. The Mini Dip cup capacity is one-half that of the Standard cup.

ORIFICE INTERCHANGE

Not applicable to certified cups

Production tolerance on the Gardco Standard DIN cup and the Gardco/Mini DIN Dip cup and the orifice is sufficiently close to permit interchange of orifices between cups. For convenience and for best possible results, however, it is recommended that such interchanges be held to a minimum.

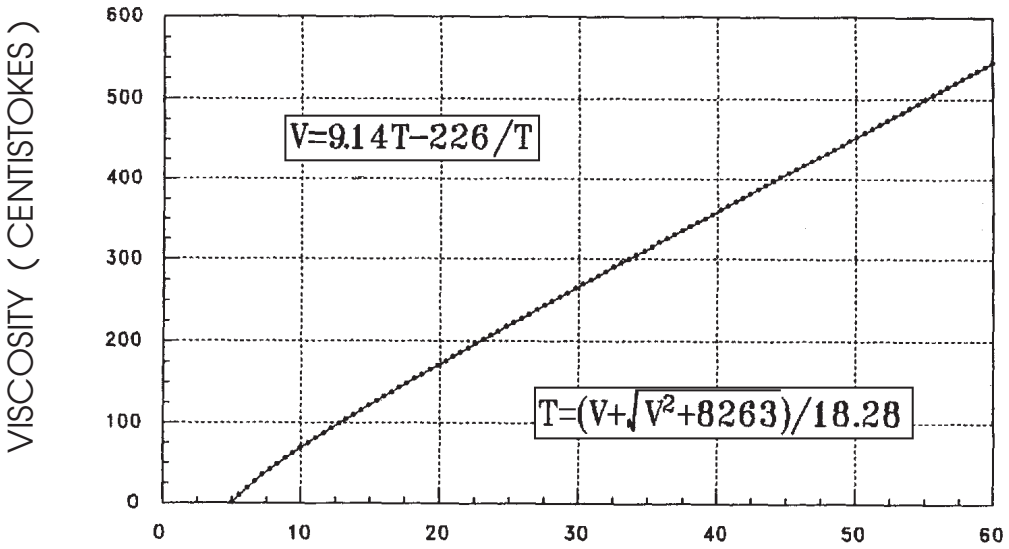
The orifice for the cup is machined from stainless steel with the exact conical exterior to match the opening in the base of the cup.

TECHNICAL INFORMATION

The POISE is the fundamental unit of viscosity. It is a defined mechanical measurement of the resistance of a liquid to flow where gravity is not a factor. 100 CENTIPOISE = 1 POISE. However, gravity is the driving force causing liquid in a viscosity cup to flow through the orifice. A high density material will flow from a cup in a shorter time than a low density material of the same viscosity. The STOKE is defined as the POISE divided by specific gravity (or weight per gallon in pounds times 0.120). 100 CENTISTOKES = 1 STOKE. The CENTISTOKE is the unit of reference in all viscosity cup measurements.

T = Efflux Time in Seconds
V = Viscosity
C = Temperature

MINI DIN DIP 4MM CUP



The graph relates efflux time in SECONDS to viscosity in CENTISTOKES for the Gardco/Mini DIN Dip cup series. The graph may be used for determining the rough relationship between these factors, but usually reference will be made to the table that is furnished with each cup which provides values to the nearest tenth of a second. If there is a necessity to determine the relationship beyond the range of the table, the mathematical formulas shown on the graphs may be used.

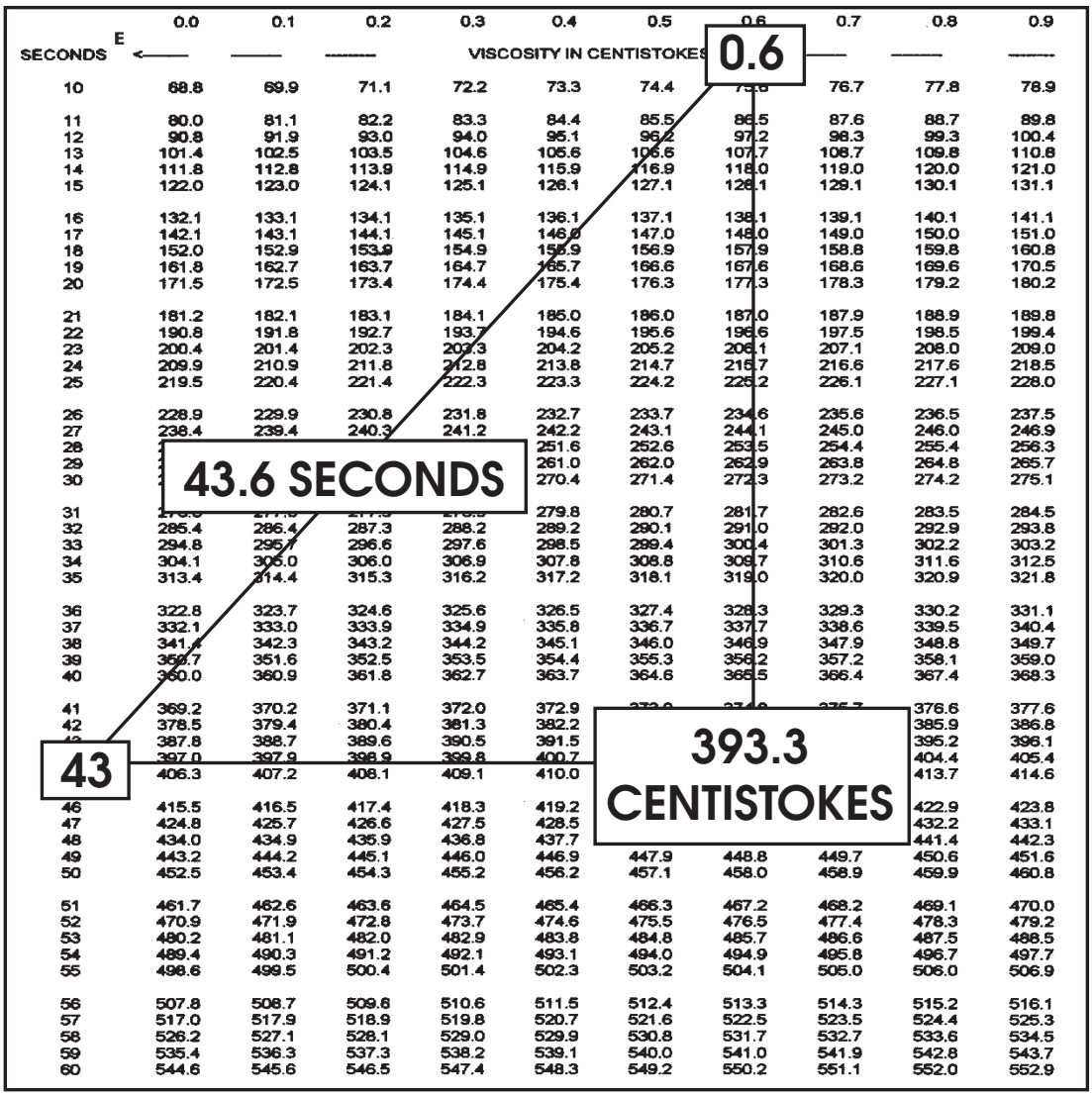
The top formula shown on the 4mm DIN DIP Cup graph is used when efflux time in SECONDS is known. As an example, assume 28.9 SECONDS in the 4mm DIN Dip cup. Multiply 28.9 by 9.14 and the result is 264.15. Divide 226 by 28.9, which is 7.82, and subtract this value from 264.15. The result is 256.33 CENTISTOKE for 28.9 SECONDS efflux time from this cup.

The lower formula shown on the DIN DIP Cup graph is used when the CENTISTOKE value is known. As an example, assume 317.0 CENTISTOKES in the 4mm DIN Dip cup. Square 317 which is 100,489 and add 8263 for a total of 108,752. Take the square root of this value, which is 329.8 and add 317 for a total of 646.8. Divide 646.8 by 18.28 and the result is 35.4 SECONDS, efflux time for 317.0 CENTISTOKE viscosity material from this cup.

VISCOSITY

CONVERSION TABLE
BETWEEN EFFLUX TIME IN SECONDS AND CENTISTOKES

Accurate for true liquids only



SECONDS E	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	←			VISCOSITY IN CENTISTOKES						
10	68.8	69.9	71.1	72.2	73.3	74.4	[illegible]	76.7	77.8	78.9
11	80.0	81.1	82.2	83.3	84.4	85.5	86.5	87.6	88.7	89.8
12	90.8	91.9	93.0	94.0	95.1	96.2	97.2	98.3	99.3	100.4
13	101.4	102.5	103.5	104.6	105.6	106.6	107.7	108.7	109.8	110.8
14	111.8	112.8	113.9	114.9	115.9	116.9	118.0	119.0	120.0	121.0
15	122.0	123.0	124.1	125.1	126.1	127.1	128.1	129.1	130.1	131.1
16	132.1	133.1	134.1	135.1	136.1	137.1	138.1	139.1	140.1	141.1
17	142.1	143.1	144.1	145.1	146.0	147.0	148.0	149.0	150.0	151.0
18	152.0	152.9	153.9	154.9	155.9	156.9	157.9	158.8	159.8	160.8
19	161.8	162.7	163.7	164.7	165.7	166.6	167.6	168.6	169.6	170.5
20	171.5	172.5	173.4	174.4	175.4	176.3	177.3	178.3	179.2	180.2
21	181.2	182.1	183.1	184.1	185.0	186.0	187.0	187.9	188.9	189.8
22	190.8	191.8	192.7	193.7	194.6	195.6	196.6	197.5	198.5	199.4
23	200.4	201.4	202.3	203.3	204.2	205.2	206.1	207.1	208.0	209.0
24	209.9	210.9	211.8	212.8	213.8	214.7	215.7	216.6	217.6	218.5
25	219.5	220.4	221.4	222.3	223.3	224.2	225.2	226.1	227.1	228.0
26	228.9	229.9	230.8	231.8	232.7	233.7	234.6	235.6	236.5	237.5
27	238.4	239.4	240.3	241.2	242.2	243.1	244.1	245.0	246.0	246.9
28	[illegible]	[illegible]	[illegible]	[illegible]	251.6	252.6	253.5	254.4	255.4	256.3
29	[illegible]	[illegible]	[illegible]	[illegible]	261.0	262.0	262.9	263.8	264.8	265.7
30	[illegible]	[illegible]	[illegible]	[illegible]	270.4	271.4	272.3	273.2	274.2	275.1
31	[illegible]	[illegible]	[illegible]	[illegible]	279.8	280.7	281.7	282.6	283.5	284.5
32	285.4	286.4	287.3	288.2	289.2	290.1	291.0	292.0	292.9	293.8
33	294.8	295.7	296.6	297.6	298.5	299.4	300.4	301.3	302.2	303.2
34	304.1	305.0	306.0	306.9	307.8	308.8	309.7	310.6	311.6	312.5
35	313.4	314.4	315.3	316.2	317.2	318.1	319.0	320.0	320.9	321.8
36	322.8	323.7	324.6	325.6	326.5	327.4	328.3	329.3	330.2	331.1
37	332.1	333.0	333.9	334.9	335.8	336.7	337.7	338.6	339.5	340.4
38	341.4	342.3	343.2	344.2	345.1	346.0	346.9	347.9	348.8	349.7
39	350.7	351.6	352.5	353.5	354.4	355.3	356.2	357.2	358.1	359.0
40	360.0	360.9	361.8	362.7	363.7	364.6	365.5	366.4	367.4	368.3
41	369.2	370.2	371.1	372.0	372.9	[illegible]	[illegible]	[illegible]	376.6	377.6
42	378.5	379.4	380.4	381.3	382.2	[illegible]	[illegible]	[illegible]	385.9	386.8
[illegible]	387.8	388.7	389.6	390.5	391.5	[illegible]	[illegible]	[illegible]	395.2	396.1
[illegible]	397.0	397.9	398.9	399.8	400.7	[illegible]	[illegible]	[illegible]	404.4	405.4
[illegible]	406.3	407.2	408.1	409.1	410.0	[illegible]	[illegible]	[illegible]	413.7	414.6
46	415.5	416.5	417.4	418.3	419.2	[illegible]	[illegible]	[illegible]	422.9	423.8
47	424.8	425.7	426.6	427.5	428.5	[illegible]	[illegible]	[illegible]	432.2	433.1
48	434.0	434.9	435.9	436.8	437.7	[illegible]	[illegible]	[illegible]	441.4	442.3
49	443.2	444.2	445.1	446.0	446.9	447.9	448.8	449.7	450.6	451.6
50	452.5	453.4	454.3	455.2	456.2	457.1	458.0	458.9	459.9	460.8
51	461.7	462.6	463.6	464.5	465.4	466.3	467.2	468.2	469.1	470.0
52	470.9	471.9	472.8	473.7	474.6	475.5	476.5	477.4	478.3	479.2
53	480.2	481.1	482.0	482.9	483.8	484.8	485.7	486.6	487.5	488.5
54	489.4	490.3	491.2	492.1	493.1	494.0	494.9	495.8	496.7	497.7
55	498.6	499.5	500.4	501.4	502.3	503.2	504.1	505.0	506.0	506.9
56	507.8	508.7	509.6	510.6	511.5	512.4	513.3	514.3	515.2	516.1
57	517.0	517.9	518.9	519.8	520.7	521.6	522.5	523.5	524.4	525.3
58	526.2	527.1	528.1	529.0	529.9	530.8	531.7	532.7	533.6	534.5
59	535.4	536.3	537.3	538.2	539.1	540.0	541.0	541.9	542.8	543.7
60	544.6	545.6	546.5	547.4	548.3	549.2	550.2	551.1	552.0	552.9

Flow characteristics of the DIN Dip Viscosity cup are very accurately defined by a mathematical formula relating it to the viscosity of standard oils which are traceable to the National Institute of Standards and Technology. The formula is shown on the cup graph on prior page. For convenience, the formula has been solved for each tenth of a second within the normal cup range. Results are available in table form as shown above and are furnished with each cup.

Use the table as follows: Assume an efflux time of 43.6 seconds. Read down the left column to the 43rd (second) line and then to the right on this line to the 0.6 column. The value at the intersection is 393.3 centistokes. The tables may be read in reverse to find efflux seconds from a known centistoke value.

USE OF GARDCO/MINI DIN DIP SERIES CUPS

The Gardco/Mini DIN Dip cups should have the same care as the Gardco Standard DIN Cup since they are produced to the same close tolerance.

- Adjust the temperature of the material to be measured if necessary. Lower the cup into the material so that the top rim is submerged. Place a thermometer into the cup as it is immersed and determine the temperature of the confined sample.
- Remove thermometer. Hold cup vertically by inserting index finger into handle ring. In a quick, steady motion, lift the cup out of the sample material, starting the timer when the cup breaks the surface. During the flow time, hold the cup no more than 6" above the level of the sample material. Stop the timer when the first definite break in the stream at the base of the cup is observed.
- Record the cup used such as 4mm Gardco/Mini DIN Dip cup, the measured temperature and the efflux time. If the efflux time is immediately converted to Standard Gardco/DIN Cup time by multiplying by 2, it should be so noted.
- Promptly clean the cup with close attention to the orifice. (Use a short length of nylon fishing line to clean the orifice.)

CARE OF CUP

Gardco/Mini DIN Dip viscosity cups are precision instruments. They are ruggedly constructed and, with reasonable care, will give many years of satisfactory service, requiring only thorough cleaning following each use. Particular care should be used in cleaning the orifice to avoid leaving deposits or scratches on internal surfaces.

Never strike the orifice directly when removing it from the cup. Place the dowel rod furnished with the cup against the orifice and strike the dowel with a heavy object such as a paper weight, catch orifice. Prior to inserting an orifice into the cup, insure that the exterior of the orifice and the receiving cone of the cup are clean.

It is good practice to retain one or more standard oils which can be used to periodically insure that the cup retains its initial calibration. Such oils are available from the Paul N. Gardner Company.

VISCOSITY STANDARD RECOMMENDED FOR CALIBRATION OF GARDCO/MINI DIN DIP VISCOSITY CUP

Catalog No.	Calibration Liquid Description
VI-3820	G-100

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

VISCOSITY CUP EQUIVALENT CHART

The Paul N. Gardner Company also makes available a wall chart that converts seconds efflux time to centistokes viscosity for 39 different viscosity cups made by GARDCO. Our chart is based on conversion formulas and parameters referenced in "The Encyclopedia of Polymer Science and Engineering" (Vol. 14, Second Edition, by C. K. Schoff; John Wiley & Sons Inc.). All experimental work in developing these formulas was done with standard oils traceable to the National Institute of Standards and Technology.

VISCOSITY

STANDARD "G" SERIES OILS MEET ISO 9002

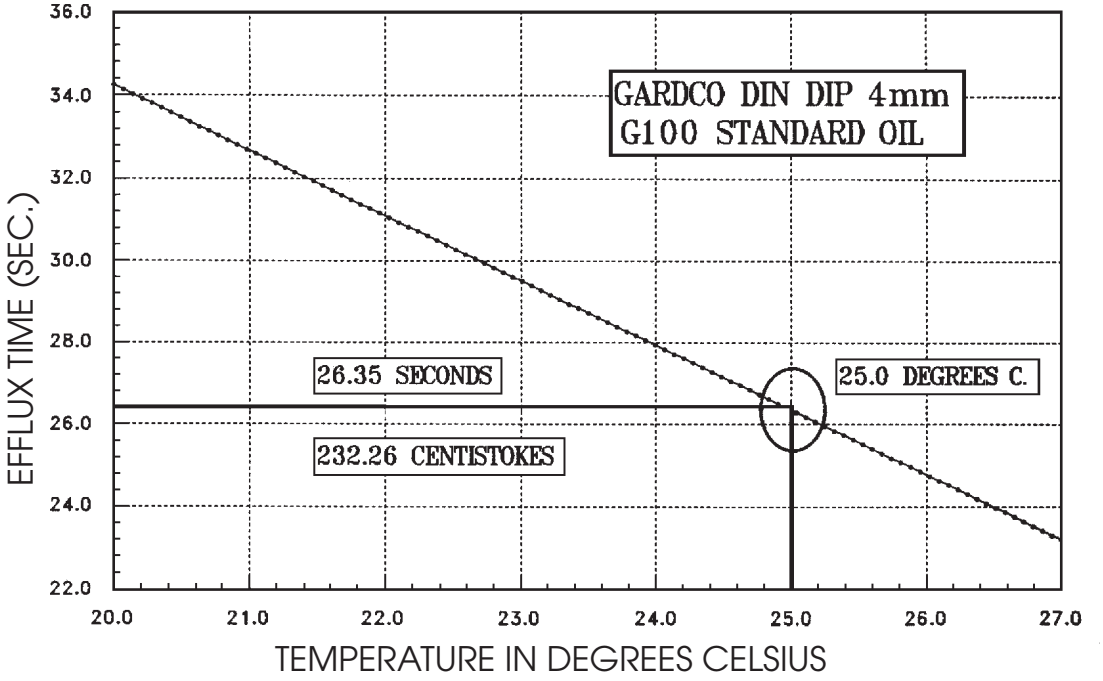
Gardco produced viscosity cups are calibrated with standard "G" Series oils. Centistoke viscosity of these oils is traceable to the National Institute of Standards and Technology. These standard oils, prepared expressly by the Cannon Instrument Company for the Paul N. Gardner Company, are produced in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

TEMPERATURE

Shown in the graph is the viscosity cup number and the standard "G" Series oil used for its calibration. Normally, cup calibration is at 25.0° Celsius, shown on the graph by bold lines intersecting with the curve in the circle. Temperature/Efflux Time Seconds Graphs for all cups in the series are included with each cup sold by the Paul N. Gardner Company.

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 graph. The cup may be checked with the indicated "G" oil with reasonable accuracy within these limits. For best accuracy, the standard oil label viscosity with temperature at 25.0° Celsius should be used. Conversion from centistoke 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.



CERTIFICATION

Any particular Gardco Standard DIN Cup or Gardco/Mini DIN Dip cup - orifice combination will be certified, as an extra cost service, to within 0.1 seconds and 0.1 degrees Centigrade on a standard oil selected for the combination midrange. Both the viscosity of the oil and the temperature measuring devices are traceable to National Institute of Standards and Technology. This certification complies to the requirements of ANSI/NCSL Z5401 or MIL-STD-45662A as applicable. Such certification is voided by the replacement of the cup orifice.

AUXILIARIES

A suitable timer is a stopwatch, which has a seven-jewel movement and indicates to 1/10 second. This suitable timing device is a digital electronic timer, Catalog No. TM-705, which has a range of 60 minutes and indicates to 0.01 second.
The thermometer used should be readable to the nearest 0.1 degrees Celsius. The glass thermometer recommended by Gardco is so scaled and has

a range from 20 to 30 degrees C (Catalog No. TH-0482). See following page for other expanded scale glass thermometers.

TM-705 Electronic Timer

A 250ml stainless steel beaker is a convenient receiver for the efflux stream of the Gardco/MiniDIN Dip cup. Being metal, it conducts heat rapidly for any temperature adjusting of the sample that may be necessary. It is also of adequate size to accept the body of the cup for draining or cleaning (Catalog No. SS-80250).

SS-80250 Stainless Steel Receiving Beaker

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.

PRICES

VI-7024	Gardco/Mini DIN Dip Cup with 4mm Orifice
VI-7014	4mm Replacement Orifice
VI-3820	G100 Certified Viscosity Standard - Pint
VI-VCC-4	*Viscosity Cup Equivalent Chart (Covers 45 Gardco Cups)
VI-DINMDGS	MINI DIN Dip Conversion Set
VI-7000C	Calibration Certificate ANSI/NCSL Z5401 or MIL-STD-45662A as applicable, & NIST
TM-AX705	Digital (LCD) Stopwatch, 1/100 Second
LA-2029060	Griffen Receiving Beaker, 600ml
TH-16100860	Thermometer, Stainless 8" Stem, 25° to 125°F
TH-16100875	Thermometer, Stainless 8" Stem, 0° to 50°C
TH-0482	Thermometer, Glass, blue spirit filled, 20° to 30°C

ASTM Mercury In Glass Thermometers	
TH-02232	Celsius Thermometer, 19 to 27°C
TH-02233	Fahrenheit Thermometer, 66 to 80°F
TH-02272	Celsius Thermometer, 23.6 to 26.4°C
TH-02273	Fahrenheit Thermometer, 74.5 to 79.5°F

G SERIES VISCOSITY STANDARDS

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., P.O. Box 10688, Pompano Beach, FL 33061-6688" 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.

VISCOSITY

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 ± 0.2° of 25.0°C or ± 0.4° 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.

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 *DIP-TYPE* VISCOSITY 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 *DIP-TYPE* VISCOSITY CUP

a. One GARDCO Dip-Type Viscosity Cup.

b. 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.

c. One pint of certified calibration oil (appropriate to cup chosen, see chart below)

Standard Oil	Centistoke* Viscosity	EZ™ Cup No	S90 Zahn Cup No	Mini Ford Dip Cup No	Gardco/ Fisher Dip Cup No	Std. Ford Dip Cup No	Gardco/ISO Dip Cup mm	Gardco/Din Dip Cup mm
G6	8.9	-	-	0	-	-	-	-
G10	19	1	-	1	-	-	3	-
G20	34	-	1	-	1	-	-	-
G35	64	-		2	2	-	4	-
G60	120	2	2	3, 4	3	3, 4	-	-
G100	230	-	3	-	-	-	6	4
G200	450	3, 4	-	5	4	5	-	-
G350	880	5	4, 5	-	-	-	* * 8	-

*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.

d. 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:

1. Gardco Cat. No. TH-02232 °C ASTM mercury filled glass thermometer, 10.8" length, 19-27°C. range.
2. Gardco Cat. No. TH-02233 °F ASTM mercury filled glass thermometer, 10.8" length, 66-80°F. range.

e. Container, 600 ml capacity glass beaker LA-2029060. LA-2029100 1000 ml glass beaker is recommended for the Fisher Dip Cup.

f. Gardco Cat. No. TM-AX705 digital electronic stopwatch, 0.01 second.

g. Reference literature:

1. Gardco Viscosity cup leaflet (for cup chosen)
2. Viscosity Cups-Common Questions and Their Answers leaflet
3. Gardco Viscosity Cup Equivalent Wall Chart (VI-VCC) or Slide Chart (VI-9939)

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

PROCEDURE

1. Examine the cup for obvious obstruction or damage to the orifice area and general cleanliness of cup.
2. Select the recommended Certified Viscosity Standard for the cup to be calibrated. Make sure the expiration date for the standard has not passed.
3. Pour a sufficient amount of oil into a 500 ml container to totally submerge the cup.
4. Using a calibrated ASTM mercury-filled thermometer bring oil to target temperature, 25.0°C ± .5°C. Proper temperature is very important. By wrapping a hand around the beaker and slowly stirring oil, the temperature can be slightly raised.
5. Place cup in oil and allow 1 to 5 minutes for cup and oil to reach thermal equilibrium.
6. Raise the cup vertically to a distance of no more than 6" from the surface of the oil. Start timing with a stop watch with accuracy of one tenth second or better as the top edge of the cup breaks the surface of the oil.
7. Leave the thermometer in the beaker to insure the temperature remains constant throughout the run.
8. 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.
9. Record time and temperature and repeat. Keep temperature drift between runs at ±.2°C. Disregard any runs that are more than .5 seconds apart.
10. Adjust times for temperature deviation and average three valid runs.
11. Divide the design time listed on the viscosity standard by the average and determine the correction factor.
12. Determine if the cup is in or out of tolerance according to manufacturer's specification.

** THIS PROCEDURE MEETS THE REQUIREMENTS OF **ASTM D4212** **

EXAMPLE OF VISCOSITY CUP CALIBRATION CHECK SHEET

DATE **7/31/17**
CUP NAME **GARDCO S90 Zahn Signature** 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 **32.85** SECS @ 25.0°C RUN NO.3 **33.55** SECS @ 25.0°C
RUN NO. 2 **33.09** SECS @ 25.0°C AVERAGE **33.16** SECS @ 25.0°C

DESIGN EFFLUX TIME (FROM GARDCO CONVERSION GRID CHART)
33.72 SECS @ 25.0°C
IN TOLERANCE (√) OUT OF TOLERANCE ( )
CORRECTION FACTOR **1.017**
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 accidently 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 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

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.

GARDCO/MINI DIN DIP VISCOSITY CUPS
4mm CUP
CONVERSION FORMULAS AND TABLE©

The GARDCO/DIN Dip viscosity cup with 4mm orifice is designed to be compatible with requirements of Deutsche Normen, DIN 53211. This German standard covers the DIN 4mm cup only and references ISO cups if an orifice of different size is required. Cup dimensions are carefully controlled and cup calibration conditions comply with
MIL STD 45662A. 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 specified in DIN 53211 to find viscosity (V) in centistokes when cup efflux time in seconds (T) is known.

$$V = 9.14T - 226 \div T$$

time in seconds (T) when viscosity (V) in centistokes is known:
Results from the above formulas, solved for each tenth of a

$$T = \left(V + \sqrt{V^2 + 8263} \right) \div 18.28$$

Use this formula to find cup efflux

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/MINI DIN Dip viscosity cup with 4mm removable orifice of conical design is produced, calibrated and sold only by the Paul N. Gardner Company and licensed agents.

DIN DIP VISCOSITY CUP - 4MM
EFFLUX TIME - CENTISTOKES CONVERSION TABLE©

(Accurate for True Liquids Only)

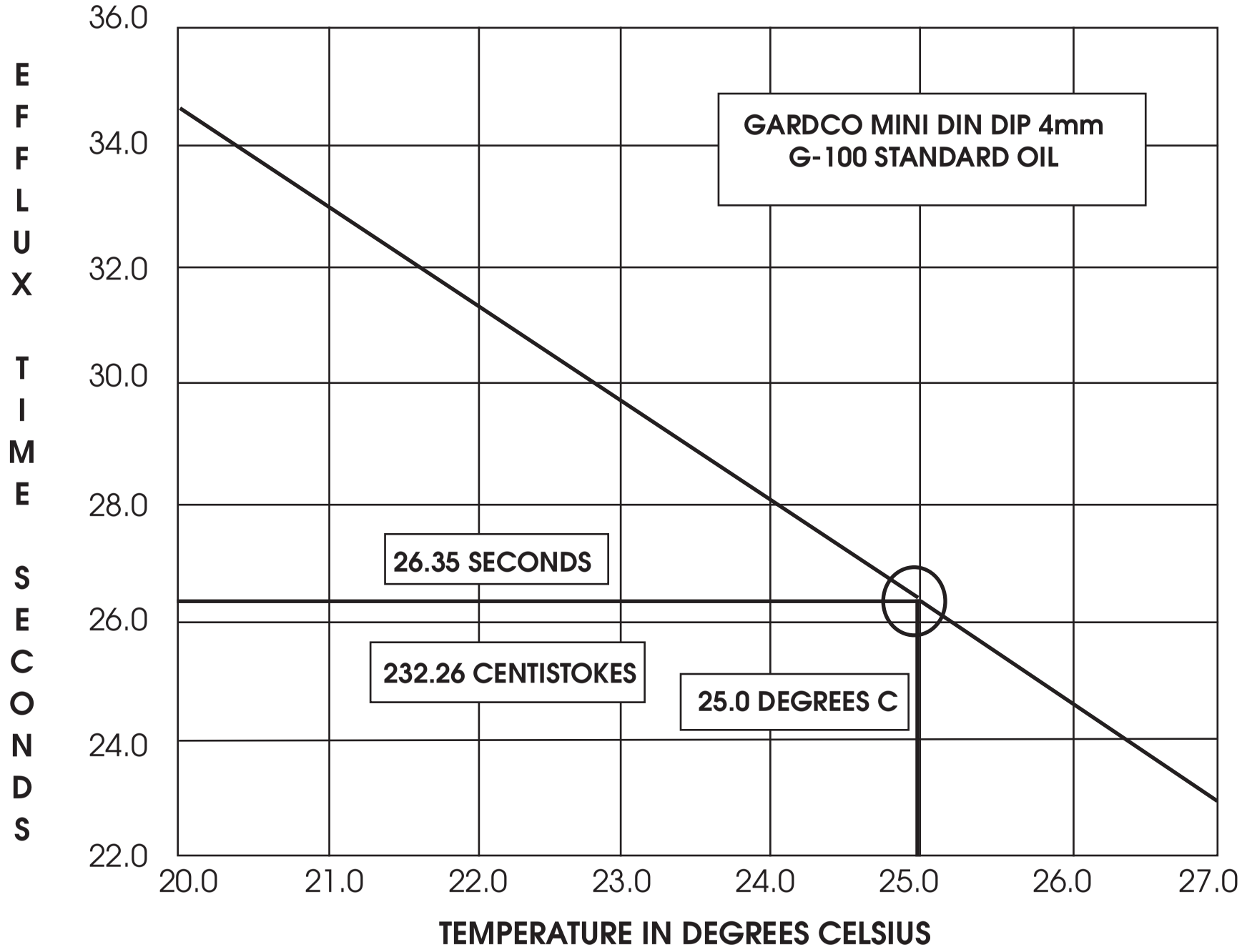
SECONDS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	< — — — — — — — — — — VISCOSITY IN CENTISTOKES									>
10	6838	69.9	71.1	72.2	73.3	74.4	75.6	76.7	77.8	78.9
11	80.0	81.1	82.2	83.3	84.4	85.5	86.5	87.6	88.7	89.8
12	90.8	91.9	93.0	94.0	95.1	96.2	97.2	98.3	99.3	100.4
13	101.4	102.5	103.5	104.6	105.6	106.6	107.7	108.7	109.8	110.8
14	111.8	112.8	113.9	114.9	115.9	116.9	118.0	119.0	120.0	121.0
15	122.0	123.0	124.1	125.1	126.1	127.1	128.1	129.1	130.1	131.1

DIN MINI DIP VISCOSITY CUP - 4MM
EFFLUX TIME - CENTISTOKES CONVERSION TABLE©

(Accurate for True Liquids Only)

SECONDS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	< — — — — — — — — — — VISCOSITY IN CENTISTOKES — — — — — — — — — — >									
16	132.1	133.1	134.1	135.1	136.1	137.1	138.1	139.1	140.1	141.1
17	142.1	143.1	144.1	145.1	146.0	147.0	148.0	149.0	150.0	151.0
18	152.0	152.9	153.9	154.9	155.9	156.9	157.9	158.8	159.8	160.8
19	161.8	162.7	163.7	164.7	165.7	166.6	167.6	168.6	169.6	170.5
20	171.5	172.5	173.4	174.4	175.4	176.3	177.3	178.3	179.2	180.2
21	181.2	182.1	183.1	184.1	185.0	186.0	187.0	187.9	188.9	189.8
22	190.8	191.8	192.7	193.7	194.6	195.6	196.6	197.5	198.5	199.4
23	200.4	201.4	202.3	203.3	204.2	205.2	206.1	207.1	208.0	209.0
24	209.9	210.9	211.8	212.8	213.8	214.7	215.7	216.6	217.6	218.5
25	219.5	220.4	221.4	222.3	223.3	224.2	225.2	226.1	227.1	228.0
26	228.9	229.9	230.8	231.8	232.7	233.7	234.6	235.6	236.5	237.5
27	238.4	239.4	240.3	241.2	242.2	243.1	244.1	245.0	246.0	246.9
28	247.8	248.8	249.7	250.7	251.6	252.6	253.5	254.4	255.4	256.3
29	257.3	258.2	259.1	260.1	261.0	262.0	262.9	263.8	264.8	265.7
30	266.7	267.6	268.5	269.5	270.4	271.4	272.3	273.2	274.2	275.1
31	276.0	277.0	277.9	278.9	279.8	280.7	281.7	282.6	283.5	284.5
32	285.4	286.4	287.3	288.2	289.2	290.1	291.0	292.0	292.9	283.8
33	294.8	295.7	296.6	297.6	298.5	299.4	300.4	301.3	302.2	303.2
34	304.1	305.0	306.0	306.9	307.8	308.8	309.7	310.6	311.6	312.5
35	313.4	314.4	315.3	316.2	317.2	318.1	319.0	320.0	320.9	321.8
36	322.8	323.7	324.6	325.6	326.5	327.4	328.3	329.3	330.2	331.1
37	332.1	333.0	333.9	334.9	335.8	336.7	337.7	338.6	339.5	340.4
38	341.4	342.3	343.2	344.2	345.1	346.0	346.9	347.9	348.8	349.7
39	350.7	351.6	352.5	353.5	354.4	355.3	356.2	357.2	358.1	359.0
40	360.0	360.9	361.8	362.7	363.7	364.6	365.5	366.4	367.4	368.3
41	369.2	370.2	371.1	372.0	372.9	373.9	374.8	375.7	376.6	377.6
42	378.5	379.4	380.4	381.3	382.2	383.1	384.1	385.0	385.9	386.8
43	387.8	388.7	389.6	390.5	391.5	392.4	393.3	394.2	395.2	396.1
44	397.0	397.9	398.9	399.8	400.7	401.7	402.6	403.5	404.4	405.4
45	406.3	407.2	408.1	409.1	410.0	410.9	411.8	412.8	413.7	414.6
46	415.5	416.5	417.4	418.3	419.2	420.1	421.1	422.0	422.9	423.8
47	424.8	425.7	426.6	427.5	428.5	429.4	430.3	431.2	432.2	433.1
48	434.0	434.9	435.9	436.8	437.7	438.6	439.6	440.5	441.4	442.3
49	443.2	444.2	445.1	446.0	446.9	447.9	448.8	449.7	450.6	451.6
50	452.5	453.4	454.3	455.2	456.2	457.1	458.0	458.9	459.9	460.8
51	461.7	462.6	463.6	464.5	465.4	466.3	467.2	468.2	469.1	470.0
52	470.9	471.9	472.8	473.7	474.6	475.5	476.5	477.4	478.3	479.2
53	480.2	481.1	482.0	482.9	483.8	484.8	485.7	486.6	487.5	488.5
54	489.4	490.3	491.2	492.1	493.1	494.0	494.9	495.8	496.7	497.7
55	498.6	499.5	500.4	501.4	502.3	503.2	504.1	505.0	506.0	506.9
56	507.8	508.7	509.6	510.6	511.5	512.4	513.3	514.3	515.2	516.1
57	517.0	517.9	518.9	519.8	520.7	521.6	522.5	523.5	524.4	525.3
58	526.2	527.1	528.1	529.0	529.9	530.8	531.7	532.7	533.6	534.5
59	535.4	536.3	537.3	538.2	539.1	540.0	541.0	541.9	542.8	543.7
60	544.6	545.6	546.5	547.4	548.3	549.2	550.2	551.1	552.0	552.9

Example: 38.4 Seconds = 345.1 Centistokes.


GARDCO MINI DIN DIP 4mm
G-100 STANDARD OIL
26.35 SECONDS
232.26 CENTISTOKES
25.0 DEGREES C
EFFLUX TIME SECONDS
36.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
TEMPERATURE IN DEGREES CELSIUS

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, ISO17025 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 Cup .....4mm Cup
GARDCO/Parlin Cup.....#1, #2, #3 and #4 Cups
GARDCO/Fisher Standard Cup .....#1, #2, #3 and #4 Cups
GARDCO Standard Ford Dip Cups.....Cups #3, #4 &#5
GARDCO Mini Ford Dip Cups .....Cups #0, #1, #2, #3, #4 and #5
GARDCO/Mini ISO Dip Cups .....3mm, 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

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.**

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®

GARDCO VISCOSITY CUP CERTIFICATION

QUALIFIES UNDER **ANSI/NCSL 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 K	C	CUP TOLERANCE ± %
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	G200	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":

$V = KT - C \div T$ or $T = (V + \sqrt{V^2 + 4KC}) \div 2K$

WHERE "K" AND "C" ARE THE ABOVE LISTED CONSTANTS

Calibration Certificate
US21071233047998

Customer: **Paul N. Gardner Company**
316 N E 1st Street
Pompano Beach, FL 33060
USA

Product: Gardco Standard No. 4 Ford Viscosity Cup

Catalog number: VI-3304

Serial number: 7998

Short description: Instrument for determination of flow time

Certified values:

Target Value [Seconds]	Value As Adjusted/ As Left [Seconds]	Expanded Measurement Uncertainty [Seconds]
37.8	37.3	±2.6

Measurement uncertainty: The expanded measurement uncertainty indicated is derived through multiplication of the standard measurement uncertainty by the coverage factor k = 2. The value of the measurand is within the allocated measurement range at 95 % probability.

Test setup:
Standard oil G60 lot number 21101
Cup Timer model 98766-03 / 210364339
Digital Thermometer 90000-29 / 192018451
Reference temperature of measuring fluid: 24.8 °C
The standards used for testing are constantly controlled by inspection.
Location of calibration: BYK-Gardner Service Point Pompano Beach, FL
This calibration performed in accordance with work instruction WI-12, UT78

Test conditions: Room temperature: 24.3°C – Relative humidity: 44.6%
The measurement results were obtained at the indicated location of calibration under the conditions shown above and pertain exclusively to the calibrated specimen.

Note:
Calibration was carried out July 12, 2021.
This certificate expires on July 12, 2022.
The certificate expiration date is set at the customer's request.
BYK-Gardner recommends regular intermediate checks to verify proper function and accuracy of measurement results.

Pompano Beach, FL
July 12, 2021

BYK USA dba Paul N. Gardner

Signature:
.....
(Alex Brown, Service Administrator)

INSTRUMENT CERTIFICATION

QUALIFIES UNDER ANCI/NCSL Z540 OR **ISO/IEC 17025, ISO 9001** AS APPLICABLE AND CONFORMS TO ISO 9000 WHEN ORDERED WITH CALIBRATION CERTIFICATION

GARDCO INSTRUMENT ITEM AND RANGE	ITEM TOLERANCE	ITEM CHECK POINTS	MINIMUM GRADUATIONS
WEIGHT PER GALLON CUPS			
U.S. STANDARD CUP	0.5%	83.205gr	NA
CUP WITH TARE WEIGHT	0.2G	Cup Wt	NA
BRITISH STANDARD CUP	0.5%	99.925gr	NA
CUP WITH TARE WEIGHT	0.2G	Cup Wt	NA
U.S. MINI CUP	1.2%	8.321gr	NA
CUP WITH TARE WEIGHT	0.1G	Cup Wt	NA
TARELITE WEIGHT PER GALLON CUPS			
U.S. STANDARD CUP	2%	83.205gr	NA
CUP WITH TARE WEIGHT	0.2G	Cup Wt	NA
BRITISH STANDARD (100cc) CUP	2%	99.925gr	NA
CUP WITH TARE WEIGHT	0.2G	Cup Wt	NA
BRITISH Standard (50cc) CUP	2%	49.963gr	NA
CUP WITH TARE WEIGHT	0.1G	Cup Wt	NA
WET FILM THICKNESS GAGE	**Mils**	**Mils**	**Mils**
MODEL C, 0 - 2 MILS	0.2	.5, 1, 1.5	0.1
MODEL C, 0 - 4 MILS	0.2	1, 2, 3	0.2
MODEL C, 2 - 12 MILS	0.4	4, 7, 10	0.5
MODEL C, 10 - 30 MILS	0.5	15, 20, 25	1.0
MODEL C, 20 - 60 MILS	0.5	30, 40, 50	2.0

WET FILM THICKNESS GAGE	MILS	MICRONS	MILS	MICRONS	MILS	MICRONS
MODEL IC 0 - 1 MILS / 0 - 25 MICRONS	0.1	2.5	.25,.5,.75	5,13,20	.05	1.0
MODEL IC 0 - 2 MILS / 0 - 50 MICRONS	0.2	5.0	.5,1,7.5	10,26,40	0.1	2.0
MODEL IC 0 - 4 MILS / 0 - 100 MICRONS	0.2	5.0	1,2,3	20,52,80	0.2	4.0
MODEL IC 2 - 12 MILS / 50 - 300 MICRONS	0.4	10	4,7,10	100,180,250	0.5	10
MODEL IC 10 - 30 MILS / 250 - 750 MICRONS	0.5	13	15,20,25	380,500,640	1.0	20
MODEL IC 20 - 60 MILS / 500 - 1500 MICRONS	0.5	13	30,40,50	760,1000,1280	2.0	40

WET FILM THICKNESS GAGE	MILS	MILS	MILS
MODEL CC 2-6 MILS	0.2	3,4,5	0.2
MODEL CC 4-8 MILS	0.2	5,6,7	0.2
GUARDED RING TENSIONED THICKNESS STANDARD	**MILS**	**MILS**	
GRTTS. 1.0 MIL NOMINAL	0.1	1	NA
GRTTS, 2.0 MIL NOMINAL	0.1	2	NA
GRTTS, 5.0 MIL NOMINAL	0.1	5	NA
UNIVERSAL APPLICATOR, ADJUSTABLE BLADE TYPE	**MILS**	**MILS**	**MILS**
2" BLADE, 0 - 50 MILS	1.0	0,25,50	1.0
4" BLADE, 0 - 50 MILS	1.0	0,25,50	1.0
6" BLADE, 0 - 50 MILS	1.0	0,25,50	1.0
8" BLADE, 0 - 50 MILS	1.0	0,25,50	1.0
10" BLADE, 0 - 50 MILS	1.0	0,25,50	1.0
12" BLADE, 0 - 50 MILS	1.0	0,25,50	1.0
2" BLADE, 0 - 10 MILS	0.5	0,5,10	0.2
4" BLADE, 0 - 10 MILS	0.5	0,5,10	0.2
6" BLADE, 0 - 10 MILS	0.5	0,5,10	0.2
8" BLADE, 0 - 10 MILS	0.5	0,5,10	0.2
10" BLADE, 0 - 10 MILS	0.5	0,5,10	0.2
12" BLADE, 0 - 10 MILS	0.5	0,5,10	0.2
PERMEABILITY CUP	**MM**	**MM**	
STANDARD DIAMETER	.05	56.4	NA
STANDARD HEIGHT	.05	10	NA
P-A-T BLADES	**MM**	**MM**	
1.0MM - 6 TEETH	.05	1.0	NA
1.0MM - 11 TEETH	.05	1.0	NA
1.5MM - 11 TEETH	.05	1.5	NA
2.0MM - 6 TEETH	.05	2.0	NA
3.0MM - 6 TEETH	.05	3.0	NA
5.0MM - 5 TEETH	.05	5.0	NA
	INCH	**INCH**	
3/32 - 4 TEETH	.002	3/32	NA

NOTES: (1) Prices quoted are FOB, Pompano Beach, Florida. Prices are subject to change without notice (2) Customer Service can provide certification prices for instruments not listed.

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 dyneseconds 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 substance. 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.

Figure 1. Standard Ford viscosity cup.

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

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 viscosjty. 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 sensitive 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.

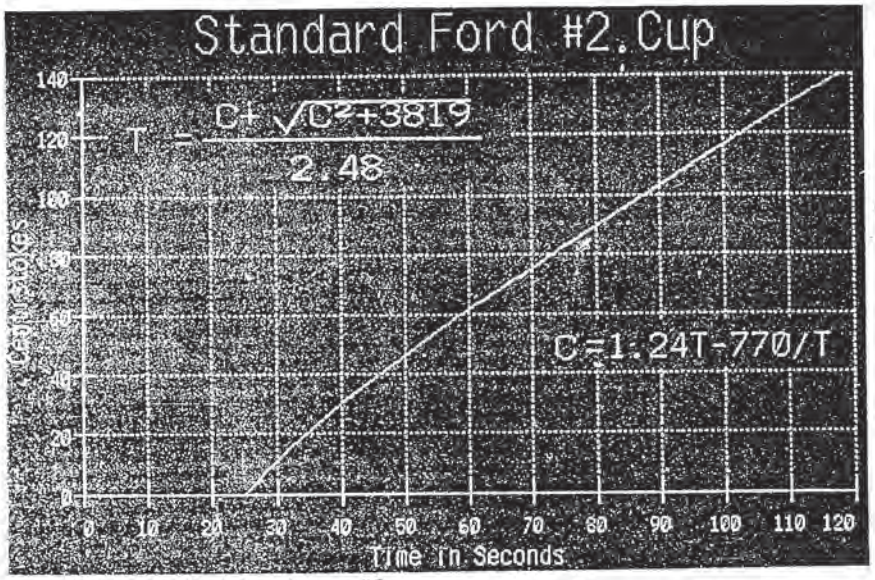

Figure 2. Standard Ford viscosity cup #2.

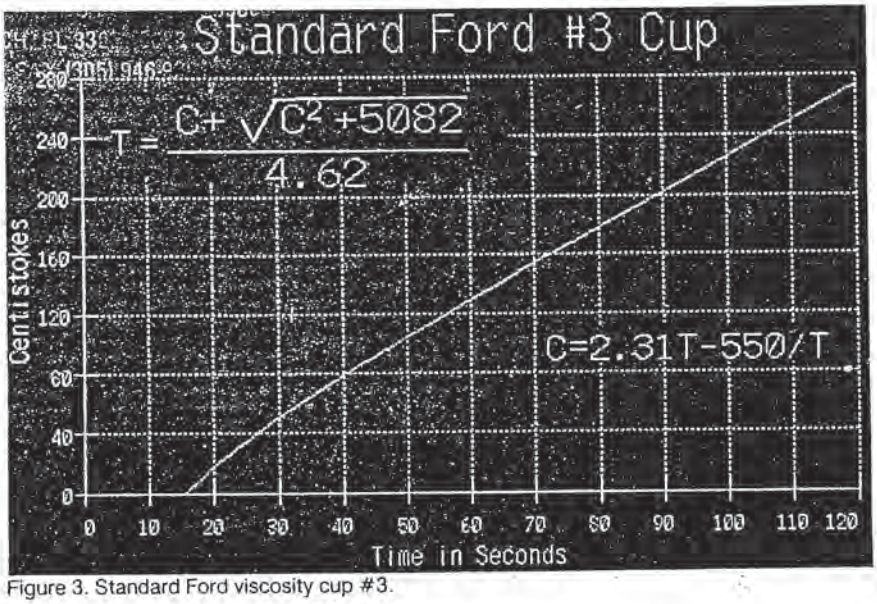

Figure 3. Standard Ford viscosity cup #3.

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 Commitee 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.

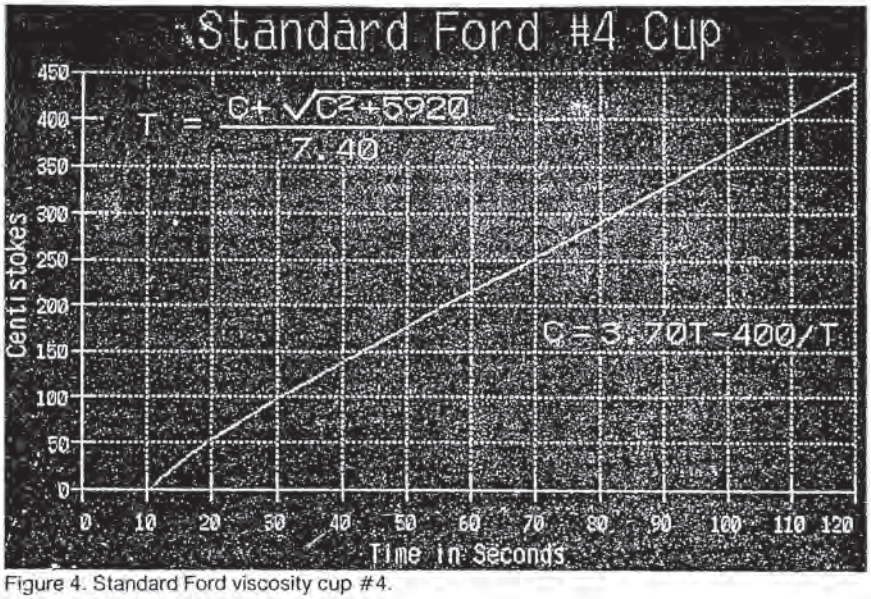

Figure 4. Standard Ford viscosity cup #4.

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. ■