



*VISCOSITY
CALCULATION
TOOLS*

VIS
DISK[®]

VERSION 2.0
for Windows[®]

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Requirements

The VISDISK program is a software application for Windows® requiring approximately 1 megabyte of hard disk space. The program will operate successfully from the Windows environment. To install VISDISK you need a:

- Personal computer (PC) with a Pentium or better processor.
- Windows®-compatible graphics adapter (card) and monitor supporting VGA or better (SVGA recommended).
- CD-ROM drive.
- Windows® XP® or later operating system. We recommend the use of a mouse for VISDISK operation.
- Windows®-supported printer.
- Minimum of several megabytes of available hard disk space.

Installation Procedure

Place your VISDISK installation CD in your computer's CD drive tray and return the tray to its closed position.

If the installation does not begin automatically, click the Windows® Start Bar and select the **Run** option to open the Run window. Then type **D:setup** in the **Open** field (if your disk drive is a drive other than D, replace the "D" with the appropriate drive letter) and click **OK**.

The software prompts you to enter the preferred drive and directory to install VISDISK. The default path for installation is:

```
C:\Program Files\CANNON Instrument\VISDISK.
```

Press the **Enter** key to accept the default installation path, or type in an alternate drive and directory path. The setup program installs the VISDISK files to the specified

drive and directory. The program also creates a VISDISK icon for the Windows® Desktop. At the conclusion of the installation, the VISDISK setup program confirms a successful installation.

Network Installation

CANNON recommends that network installation of the VISDISK program is completed by in-house computer network support staff or other qualified personnel to ensure that users have the necessary network rights for installation, and operations including read, write, copy and create.

VISDISK is NOT a shareware or multi-user program. An individual copy must be purchased and installed for each and every user.



VISDISK Overview

The VISDISK software is based on a series of computer programs originally written by Dr. Robert E. Manning of Cannon Instrument Company. These programs have been incorporated as a series of application modules in a single software release, VISDISK for Windows.

The VISDISK program brings computerized solutions to many difficult computational problems associated with kinematic viscosity determination. VISDISK also provides supporting data analysis capability for several equipment items manufactured by CANNON, including the PolyVISC, Cold-Cranking Simulator (CCS), Bending-Beam Rheometer, and the CANNON Mini-Rotary Viscometer (CMRV). VISDISK facilitates calculation/verification of kinematic viscosity by providing a data table for input, and then performing complex viscosity and density calculations. An interpolation component calculates viscosity at any specified temperature or temperature at a desired viscosity. Test data can also be used to generate a complete interpolation report at temperature increments specified by the user.

What's New in Version 2

The version 2 release of VISDISK has added a graphing capability and an NBS “best-fit” computation that analyzes multiple kinematic viscosity data points and selects the optimum viscosity curve for the sample data provided, as shown in Figure 1.

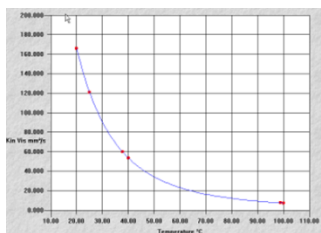


Figure 1: VISDISK Graph

Table Updates

SAE and ISO VG Lubricant Specifications tables have been updated, and future changes to the tables can be incorporated through an internet update procedure.

Probe Calculations

The version 2 VISDISK release permits data entry of temperature and resistance/voltage data associated with temperature probes used for the CANNON Bending-Beam Rheometer, the CCS, and the DSR. Probe calibration constants are then calculated by the VISDISK software.

Intrinsic Viscosity

An intrinsic viscosity calculation module provides intrinsic viscosity data, as well as graphing capability for dilute solution polymer data. The program also provides K values (Huggins and Kraemer), inherent viscosity, reduced viscosity, and results for Fickentscher, Solomon-Ciutta and Billmeyer equations.

The user interface has been harmonized with the simple and functional styling of the VISCPRO software used with the majority of CANNON automatic instruments.

Other Application Modules

In addition to calculation of kinematic viscosity and viscosity index, VISDISK:

- Performs oil blending calculations using the W.AWright Method and the Chart Blending Method
- Provides Cold-Cranking Simulator (CCS) and Mini- Rotary Viscometer (MRV) viscosity calculations
- Calculates conversions between centistokes and Saybolt or Krebs units
- Enables VI calculations from kinematic viscosity measurements at any two temperatures
- Generates kinematic viscosity interpolation reports, and displays SAE and ISO VG Lubricant Specifications tables
- Provides an interface for analysis of Cold-Cranking Simulator and Mini-Rotary Viscometer data

- Provides temperature probe constant calculations

For more information consult the section of this manual associated with the specific application.

Units of Measure

In VISDISK, viscosity calculations are measured in the units indicated. If values in other units are used, the calculations will be incorrect.



Introduction to Viscosity

Viscosity is defined as the resistance of a fluid to flow. Precise control of viscosity is essential in many different industries, including those producing oils, paints, inks, polymers, and liquid foods.

Shear Flow

Viscous flow can be thought of as the differential movement of a number of monomolecular layers of fluid between a stationary and a moving parallel plate. The moving plate transmits its motion to the adjacent monomolecular layer, which in turn transmits part of its motion to the next layer, and so on. The slippage between two successive layers results in a gradual decrease in velocity across the gap between the two plates. Flow of this type, where different portions of a fluid flow at different velocities, is called shear flow. Equation 1 and Figure 2 tie together the varying components of viscosity.

$$\eta = \frac{F/A}{V/h} = \frac{\text{shear stress}}{\text{velocity gradient}}$$

Equation 1: Shear Flow

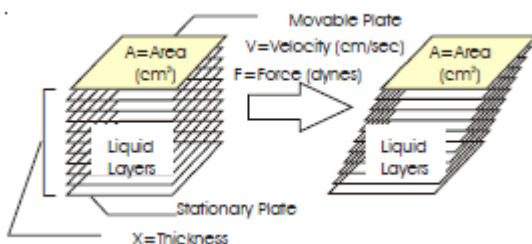


Figure 2: Shear Flow Diagram

In Equation 1 and Figure 2, η is viscosity, F is the force in the shearing direction, A is the area of the plate, V is the velocity of the moving plate, and h is the thickness of the fluid film.

Kinematic Viscosity

Kinematic viscosity is defined as a fluid's dynamic viscosity divided by its density (g/mL). Kinematic viscosity is readily determined by measuring the time required for a fixed volume of liquid to flow through a capillary under gravity.

The unit of kinematic viscosity is stokes or centistokes (cSt) in the cgs system of units, and meters squared per second (m^2/s) or mm^2/s in SI units. The unit of viscosity is the poise or centipoise (cP) in the cgs system of units, and pascal second (Pa·s) or mPa·s in SI units. The centipoise and millipascal second are numerically equal; the centistokes and mm^2/s are also numerically equal.

Viscosity Index (VI)

An oil's viscosity index (VI) is a measure of its sensitivity to changes in temperature. The viscosity index is based on an arbitrary selection of oils considered to have high and low variations in kinematic viscosity with temperature changes. The kinematic viscosity of a liquid having a high viscosity index changes relatively less with temperature. Conversely, a liquid with a low viscosity index exhibits a substantial decrease in kinematic viscosity as the temperature increases. For most applications in the automotive industry, engine oil with a VI value of less than 100 would be unsuitable.

Viscosity Conversions

Many different measures of kinematic viscosity have been used in the past. Conversions between these different systems involve calculations that are not always easy to carry out.

Examples of such conversions include Saybolt Universal Seconds (SUS) to centistokes, Saybolt Furol Seconds (SFS) to centistokes, and centistokes to Krebs units. The VISDISK program performs these complex calculations. The user simply enters the known value and VISDISK displays the resultant value for the alternative unit(s).



Windows Basics

The VISDISK program is a Windows-based application. Users familiar with the Windows interface will appreciate its intuitive and user-friendly features.

The following is intended as a guide for using VISDISK efficiently in the Windows environment.

Application: a software program containing coded data that can be executed to perform a function or functions.

Click: pressing and releasing one of the mouse buttons, generally the left mouse button.

Key Combinations: Some software functions may be executed by keystroke combinations. To execute a keystroke combination, press the first key in the combination and hold it down while pressing the second key. Then release both keys.

Double-click: pressing and releasing the mouse button twice in rapid succession.

Click and drag: pressing then holding down the mouse button while moving the mouse.

Drag and drop: pressing then holding down the mouse button while moving the mouse, then releasing it (usually to move or copy objects from one place to another).

Mouse pointer: the Windows pointer arrow which moves on-screen when the mouse moves.

Window: A bordered rectangle representing an application or process or a group of the same.

Folder: A window in which applications/files may be grouped, or an icon representing the same.

File: A unique data set/unit identified by a filename and represented by a name and/or icon.

Program group: A folder containing related application icons/links

Icon: a Windows graphic symbol representing an application, folder, or program group. Applications can be started and folders can be opened from the icon by double-clicking on the icon.

Minimizing/Maximizing windows: A window may be minimized (reduced to a single icon and/or a button on the Start Bar) by clicking the Minimize icon on the Title Bar. A window may be “maximized (expanded to fill the monitor screen) by clicking the Maximize icon on the Title Bar as shown in Figure 3.



Figure 3: Minimize/Maximize Icons

Moving windows: To move a window, click and drag on the window title bar.

Closing windows: To close a window, press the Escape key (Esc), or click the Done button, or click the Close icon on the Title Bar as shown in Figure 4.



Figure 4: Close Icon

Active window: The active window is the window which contains currently-available application options. If multiple windows are open, the active window will usually be highlighted with a different screen color to differentiate it from any inactive windows. To make any window the active window, simply click anywhere in the open window or use the Ctrl + Tab key combination to switch between all currently- open windows in a single application. You can use the Alt + Tab key combination to switch between multiple application windows.

VISDISK Window Options

VISDISK for Windows provides three convenient menu options for managing multiple application windows. These options are accessed from the Window menu item. To select an option, click Window from the menu choices; then click the desired option.

Cascade: The Cascade option presents each window in a cascading format from left to right across your monitor screen. The currently-active window will remain active (the window furthest to the right).

Tile Horizontally: The Tile Horizontally option presents each window in a tile format. The windows will be arranged to permit the widest possible view of the window contents. The exact configuration will depend upon the number of currently-open windows. The currently-active window will remain active (the window at the top).

Tile Vertically: The Tile Vertically option presents each window in a tile format. The windows will be arranged to permit the tallest possible view of the window contents. The exact configuration will depend upon the number of currently- open windows. The currently-active window will remain active (the window furthest to the left).

You can also make any currently-open window the “top-most” window by clicking the Window menu option and then clicking the window name as it is displayed in the Window submenu.

EXAMPLE: The windows in Figure 5 are currently displayed in Cascade format. Clicking the CCS Calculations menu option will bring that window to the forefront.

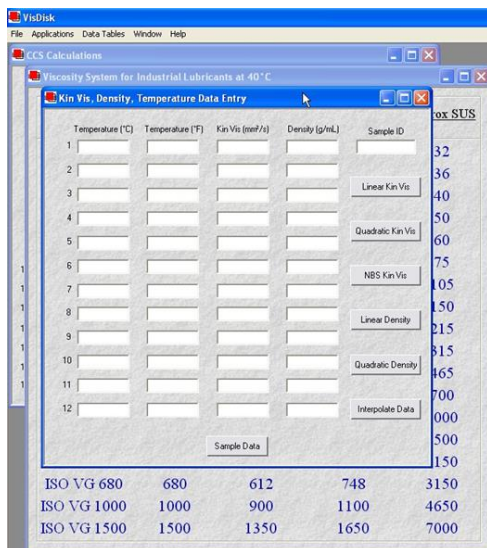


Figure 5: Cascade Format

A check mark in front of the menu Window listing indicates the currently-active window.

Title Bar: The bar at the top of each window. This typically displays the application title/description.

Menu names: The list of application commands which may be listed under the title bar. In the Windows primary window, those commands include FILE, OPTIONS, WINDOW and HELP.

Scroll Bar: This is the vertical bar that sometimes appears at the right side of a window. The presence of the scroll bar indicates that additional window content is hidden beyond the window borders. To scroll up or down to reveal this content, click on the arrows at the top and bottom of the scroll bar. The graphic rectangle on the scroll bar indicates the position of your cursor relative to the available window content. For more rapid scrolling, you may click on the scroll bar above or below the graphic square, click on the square and drag to a new location on the scroll bar, or use the Page Up or Page Down keys.

Menus: Text options usually displayed at the top of a window. Clicking a menu item will initiate an action or reveal a submenu.

Submenus: These application options are usually displayed as “drop-down” text lists accessed from a previous menu.

Buttons: Buttons, like windows, can be active or inactive. Buttons are activated with a mouse click.

Using the Keyboard with the Software Interface

Although Windows is designed as a mouse-driven application, Windows menus can be accessed from the keyboard. Each menu item includes a reference to a single character with an underline. View the underline by pressing the Alt key. Select the menu item by pressing the Alt key in combination with the underlined character. Then use the arrow keys to scroll the menu options associated with that item.

Some VISDISK windows have several text fields or buttons. You can access the fields/buttons in sequence by pressing the Tab key. To select the operation

performed by the button without using the mouse, just tab to the desired button and press the Enter key.

The VISDISK manual instructions assume a mouse-driven interface. To select a menu option, use your mouse to point to the menu item and click on it.

For additional information on using software applications designed for compatibility with the Windows operating system, with or without mouse support, consult your Windows reference manual.

Entering Data

To enter data, simply click in one of the data fields and type in your entry. Note that your mouse pointer becomes a bracket symbol in Windows® areas where data entry is permitted.

If entered data is invalid, VISDISK displays an error message. If you receive an error, recheck the input values and enter valid data in each field. Some fields require values that are higher or lower than previously-entered values. Refer to the chapter in this manual describing the specific application, and/or the onscreen prompts for more details.

After entering data, you must ENTER your data by pressing the TAB or ENTER keys for VISDISK to perform its calculation. To move from one data field to another data field, use the mouse, Tab key or the Enter key.

Erasing Data

To erase data, position the mouse pointer bracket to the left of the character(s) to be deleted and press the Delete key. Or, click and drag the bracket over a series of characters in a field to highlight them, and then type over the highlighted data to erase and replace it.



Using the VISDISK Software

To start the VISDISK program, double-click on the VISDISK icon. This opens the primary VISDISK window.

The primary VISDISK window has three basic elements:

Title Bar: The VISDISK title bar, which includes the application name and description (Viscosity Calculation Desktop) and the name of the current file (untitled until it is given a name and saved from the FILE menu).

Menu Bar: Directly underneath the Title bar are the menu choices: File, Applications, Data Tables, Window and Help.

VISDISK Status Bar: The status bar is at the bottom of the VISDISK window. Status messages indicate selections made from the VISDISK menu system. They also provide guidance for appropriate user actions.

VISDISK Menu Options

File: When the File menu option is selected, the drop-down menu provides four choices:

Open: Provides access to previously-saved data.

1. Click Open and then click to select the desired data file type (CCS viscosity, kinematic viscosity or CMRV cell constants).
2. Then use the Open window to navigate to the desired directory and select the desired data file.



Caution: Opening a preexisting file will overwrite any current data.

Save: Saves existing data to the file specified by the user.

3. Click Save and then click to select the desired data (CCS viscosity, kinematic viscosity or CMRV cell constants).
4. Use the Save window to navigate to the desired directory; then enter the desired file name in the File name field. VISDISK will assign a default extension of .CSV to the file name. If another extension is chosen, the filename will not display in the File/ Open window unless you change the Files of Type setting to All Files.

Print: Use this option to print information from any active window. Only information from the active window will print. To select another window for printing, click on the desired window to make it the active window.

Exit: Click Exit to leave and close the VISDISK software.

The active window may be hiding inactive windows. To move the active window, click and drag on the title bar. Or use the Window/Cascade or Tile functions to select multiple window display options.

Applications: The Applications menu option provides access to all of the VISDISK application modules via a dropdown submenu. For specific information on each application, please see the following chapters of this Software Manual.

Window: The Window menu option provides viewing choices for multiple windows (see previous chapter for additional information). Click the desired option to change the screen display. The Cascade and Tile options will display multiple windows in the chosen format. Or you can click on any specific window to make it the active window. A check mark indicates the currently-active window.

Help: VISDISK has complete application-driven help screens for all application modules and calculations. To access the main Help features from the primary window, including a help index and subject listing, click on Help and select your desired option from the choices. Or, press F1 from the specific application window or table. This context-sensitive help is available from the primary window and from most VISDISK application windows.



Blending: W.A. Wright Blending Method

W. Andrew Wright, was a research scientist at the Applied Research Department at Sun Oil Co. of Pennsylvania, and chairman of the ASTM Subcommittee D02.07 on Flow Properties for a number of years. He was responsible for the current dependence in the petroleum industry of kinematic viscosity measurements at the preferred temperatures of 40 and 100 degrees Celsius. The current Viscosity Index tables have been derived largely through his work.

Requirements

The W.A. Wright blending calculation requires that the kinematic viscosity of both component oils be known at two temperatures.

To access the W.A. Wright Blending Method calculation module, click [Applications](#), then go to [Blending](#), and then [W.A. Wright Blending Method](#). This opens the W.A. Wright Blending Method window.

1. For each of the two oils, input a higher kinematic viscosity and a lower kinematic viscosity.
2. Enter the corresponding temperatures at which the kinematic viscosities were determined.
3. Enter the desired kinematic viscosity and temperature for the target blend.
4. Then press the Tab or Enter key for the results. Refer to Figure 6.



Figure 6: Wright Method Calculations

VISDISK program calculates the volume fraction of each component required to provide the target kinematic viscosity at the target temperature.

If a blend cannot be created with the specifications requested, an error window is displayed. Close the error window and input new data to obtain the blend specification.

After a valid blend is calculated, the buttons at the bottom of the window are activated.

After a valid blend has been calculated, it is possible to calculate weight fractions for the blend.

To calculate and display the weight fractions for the target blend, click the **Weight Fraction** button to open the **Weight Fraction** window as shown in Figure 7.

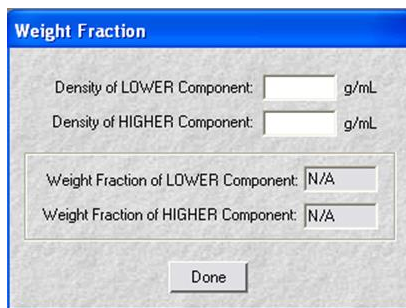


Figure 7: Weight Fraction Window

Factoring in Density


For some samples, blend component density is an important criterion in the calculation of blend percentages. To account for density differences in blend components, input the known density values for each component in the appropriate fields. Then press the Tab or Enter key to calculate the weight fraction for each component.

Recalculate and update the weight fraction multiple times if necessary. Simply re-enter the known density for each component in the appropriate field.

When calculations are complete, click **Done** to exit the **Weight Fraction** window.

Solve for Kinematic Viscosity (Kin Vis)

For some applications, it may be desirable to know the blend viscosity at additional temperatures. After entering valid data for calculation of a blend, click the **Solve for Kin Vis** button to open the temperature window. Input the desired temperature for the blend. After entering the temperature, press the Tab or Enter key. VISDISK automatically calculates the viscosity of the resultant blend as shown in Figure 8.



The image shows a software window titled "New Target Kin Vis Given Temperature". The window has a blue header bar. Below the header, there are two input fields. The first is labeled "New Target Temperature:" followed by a text box and "°C". The second is labeled "New Target Kin Vis:" followed by a text box containing "N/A" and "mm²/s". At the bottom center of the window is a button labeled "Done".

Figure 8: Kin Vis Window

Recalculate multiple times with different values if necessary. Simply re-enter the desired temperature for the blend in the appropriate field. The calculation is performed and the results immediately displayed.

When finished, click **Done** to exit the **Solve for Kin Vis** window.

Solve for Temperature

For some applications, it may be desirable to know the blend temperature required to obtain a particular kinematic viscosity. After entering valid data for calculation of a blend, click the **Solve for Temperature** button to open the KV window and input the desired viscosity for the blend. After entering kinematic viscosity, press the Tab or Enter key.

VISDISK automatically calculates the temperature necessary to produce the desired kinematic viscosity for the blend as shown in Figure 9.

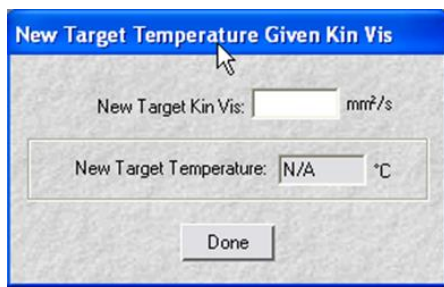


Figure 9: Solve for Temperature Window

Recalculate multiple times with different values if desired. Simply re-enter the desired kinematic viscosity for the blend in the appropriate field. The calculation is performed and the results immediately displayed.

When finished, click **Done** to exit the **Solve for Temperature** window.



Blending: ASTM D341 Chart Blending Method

The Chart Blending Method only requires that the kinematic viscosities of both blending oils be known at a common temperature. This earlier method of viscosity calculation is less accurate than the W.A. Wright Blending Method.

The original method was a graphical procedure based on the ASTM D341 (1943. *Kinematic Viscosity Chart between 0 and 100 degrees Fahrenheit*). The kinematic viscosity of the lower viscosity component was placed at the 0 line, while the kinematic viscosity of the higher viscosity component was placed at the 100 line. A straight line connecting these two points allowed reading of the approximate volume percent fraction of each component from the abscissa. The current Chart Blending Method provides an analytical alternative to the ASTM D341 graphical method.

These equations use the kinematic viscosity in centistokes (cSt) or millimeters squared per second (mm^2/s). If other viscosity units are used, the answers will be incorrect.

Procedure

1. To access the module, click [Applications](#), then [Blending](#), then select [Chart Blending Method](#). This opens the [Chart Blending Method](#) window as shown in Figure 10.

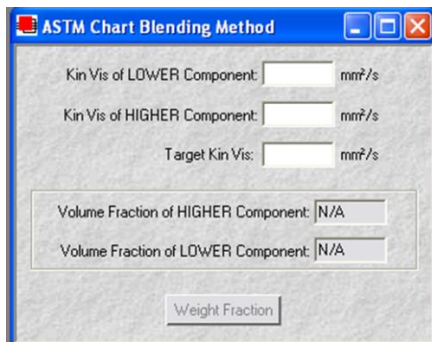


Figure 10: Chart Blending Method Window

2. Using the appropriate data entry fields, input the kinematic viscosity of the lower viscosity component. Do the same for the higher viscosity component. Press the Tab or Enter key to navigate from field to field.
3. Enter the target kinematic viscosity (mm^2/s) and temperature ($^{\circ}\text{C}$) of the desired blend. Press Tab or Enter when done. The volume fractions of the higher and lower components are then calculated and displayed.
4. To obtain the required weight fractions necessary to achieve the target blend, click on the **Weight Fraction** button from the **Chart Blending Method** window. Then enter the known density for both components.

VISDISK will calculate and display the weight fractions of the target blend, adjusted for differences in blend component density.

5. Click **Done** to exit the **Weight Fraction** window.



Cold-Cranking Simulator Calculations

The CCS Calculations VISDISK module determines calibration constants for the Cold-Cranking Simulator (CCS) from speed and viscosity data. The calibration procedure for this instrument is described in ASTM method D5293.

VISDISK calculates the CCS constants using your choice of the following three equations:

Shunt Resistor Equation is shown in Equation 2 (for older CCS models without the shunt resistor).

$$\eta = \frac{B0}{N} + B1 + B2 \times N$$

Equation 2: Shunt Resistor Equation

No Shunt Resistor Equations are shown in Equation 3 and Equation 4, which are currently used in all production CCS instruments manufactured by CANNON.

$$\eta = \frac{B0}{N} + B1$$

Equation 3: No Shunt Resistor Equation 1

$$\ln(\eta) = B0 + B1 \times \ln(N)$$

Equation 4: Shunt Resistor Equation 2

Procedure

1. Select **CCS Viscosity** from the **Applications** menu.
2. Enter the RPM speed in the first column.
3. Enter the known viscosity (mPa·s) of the standard in the second column.
4. Select the preferred equation by clicking the radio button corresponding to the desired formula.

5. When finished entering data, click **Analyze** to update calculated values.

VISDISK performs the calculation and updates the table with the calculated viscosity (cP). The percentage difference (**% diff.**) between the actual viscosity and the calculated viscosity is also displayed as an indicator of the correlation between the test and the calculated data. Refer to Figure 11.

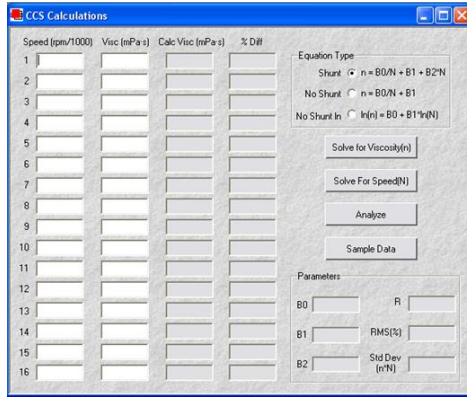


Figure 11: CCS Calculations

6. To interpolate (solve) for a particular viscosity or speed, click the desired button (**Solve for Viscosity** or **Solve for Speed**) and enter the known value. Then press the Tab or Enter key to calculate the solution. Refer to Figure 12.

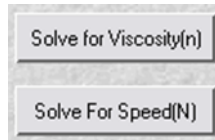


Figure 12: Solve for Viscosity or Speed

When using a linear equation for calculation, a minimum of two data points is required (at least three provide more accurate results). When using a quadratic equation, a minimum of three data points is required (at least four provide more accurate results). To insert “dummy” data in the CCS calculation table for practice purposes, click the **Sample Data** button to insert the dummy data in the appropriate fields. Click **Clear Data** to remove all current entries.

The early model Cold-Cranking Simulators had a viscosity range of approximately 700-13,000 mPa·s. Current models have extended range options to 27,000 mPa·s. The coefficients for the equation are also displayed.



Kinematic Viscosity/Density Calculations

The VISDISK software is able to calculate the constants for several empirical viscosity equations using kinematic viscosity data entered by the user. These equations may then be used to estimate the kinematic viscosity (cSt), viscosity (cPs), and the density of an oil at any temperature, and/or the temperature required to achieve a particular viscosity.

The data required for calculations/interpolations are the actual kinematic viscosities and densities of the sample, as measured at up to twelve different temperatures. This data can be obtained from a certified viscosity standard.

Several different empirical equations for calculating interpolated kinematic viscosities and/or temperatures may be selected directly from the **Data Entry** window. Each calculation has its own button option:

- ASTM (American Society for Testing and Materials) Linear Kin-Vis/Temperature Equation
- ASTM Quadratic Kin Vis/Temperature Equation
- NBS (National Bureau of Standards) Equation

After the constants of the selected equation are determined, user may perform viscosity, density and temperature interpolations with VISDISK. Density/temperature calculations may also be accomplished in VISDISK with either a linear or quadratic empirical equation.

To calculate the kinematic viscosity or density at any temperature, or the temperature at which a given KV or density value is attained, first complete the kinematic viscosity calculations (next section) and then follow the instructions for KV or density interpolation (see following sections).

Calculate Kinematic Viscosity

1. Select **Kin Vis, Density, Temperature** from the **Applications** menu. This opens the **Kin Vis, Density, Temperature Data Entry** window as shown in Figure 13.

	Temperature (°C)	Temperature (°F)	Kin Vis (mm ² /s)	Density (g/mL)	Sample ID
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
6	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
7	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
8	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
9	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
10	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
11	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
12	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Figure 13: Kin Vis, Density, Temperature Window

2. Enter available viscosity data in the appropriate data entry fields. The complete data set should include:
 - the temperature at which your sample was tested
 - the kinematic viscosity at that temperature (in cSt)
 - the density (g/ ml) at the test temperature(s)



Note: When entering a temperature value in °C or °F, the alternate temperature scale value for that data set is automatically calculated by VISDISK.

If you have no data, but are learning the program, you may click on the **Sample Data** button to insert demonstration data in the appropriate fields. Click the **Clear Data** button to remove all viscosity data from the **Data Entry** window.

- Click the appropriate button to select the desired equation to be used for calculation: **ASTM Linear Kin-Vis/ Temperature Equation**; **ASTM Quadratic Kin Vis/Temperature Equation** or the **NBS Equation**.



Note: At least two sets of data must be entered in order to use the Linear Equation or interpolation; at least three sets of data are required for the quadratic or NBS equations.

After an equation is selected, the equation window opens and the data displayed in the window includes the calculated calibration constants, the resultant calculated viscosity for each calibration standard, and the percent difference between the calculated and actual viscosity values for the standard. This data permits the user to assess the accuracy of the calibration.

The NBS calculation requires selection of a single data point for the calculation. When the NBS kin vis button is clicked, the **Choose a Data Line** window opens. User is then prompted to input the desired data point. If the default Data Line, **B**, is selected, VISDISK automatically performs an analysis of existing data to determine the “Best” point for the NBS calculation. Or, if preferred, the user may select a specific data point by entering the number of the data point into the **Choose a Data Line** window.

Graphing Capability

After kinematic viscosity data has been analyzed, VISDISK version 2 offers a graph display option for plotting the viscosity/temperature relationship.

To display the graph, click the **Graph** button from the analysis window. Refer to Figure 14.

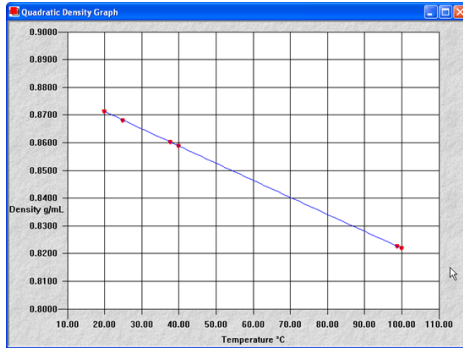


Figure 14: Graph of Quadratic Calculations for Kinematic Viscosity

Point-to-Point Interpolation

VISDISK can be used to create an interpolation table based solely on existing data points, as shown in Figure 15.

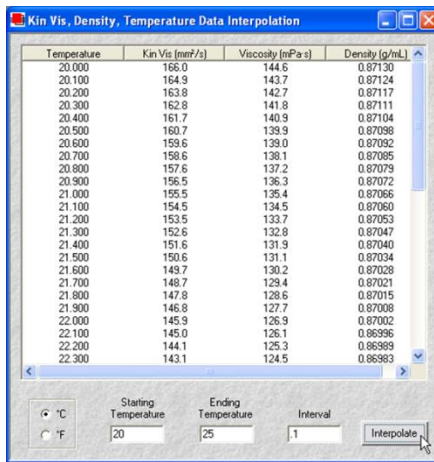


Figure 15: Point-to-Point Interpolation

To do this, click the **Interpolate Data** button from the **Kin Vis, Density, Temperature Data Entry** window after data entry is complete. Select the desired temperature scale (Fahrenheit or Celsius) by clicking the radio button corresponding to the desired scale (°C or °F). Then input the following information in the fields provided:

- Starting Temperature
- Ending Temperature
- Interval (the temperature increment to be used)

When data entry is complete, click the **Interpolate** button as shown in Figure 16. An interpolation table will be displayed using a simple “straight-line” calculation. User may need to use a scroll button to view all the data, depending upon the number of interpolations generated (the maximum number of interpolated points permitted is 1,000).

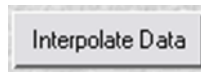


Figure 16: Interpolate Button

To print the interpolation table, make certain that the Interpolation window is the active window. Then click **File/Print**.

Temperature/KV Single-Point Interpolation Options

From each of the viscosity equation windows, VISDISK can use the existing data set to solve the equation for either the temperature required to achieve a given kinematic viscosity or the kinematic viscosity that would be obtained at a specified temperature.

After an equation window is opened, simply click the **Solve for Temp** or **Solve for KinVis** button to open the **Solve for Temperature/KinVis** window. Then type the desired value in the open field and press the Tab key; VISDISK will display the calculation results.

Click **Done** to exit the window.

Calculating Density/Temperature

To verify density measurements or make density/ temperature related calculations, click the button corresponding to the appropriate density equation button (**Linear Density** or **Quadratic Density**).

VISDISK opens a window displaying the equation and the measured and calculated viscosity for the current data set, as well as the percentage difference between the measured and calculated values. An analysis will provide the correlation coefficient (R) and root mean squared (RMS) values relating to the density data.

To view a graph of density values generated by the current data set, click the **Graph** button.

To solve (interpolate or extrapolate) for a particular temperature (**Temp**) or **Density**, click the **Solve for Temp** or **Solve for Density** button to open the **Solve for Temperature/ Density** window. Then type the desired value in the open field and press the Tab key; VISDISK will display the calculation results as shown in Figure 17.

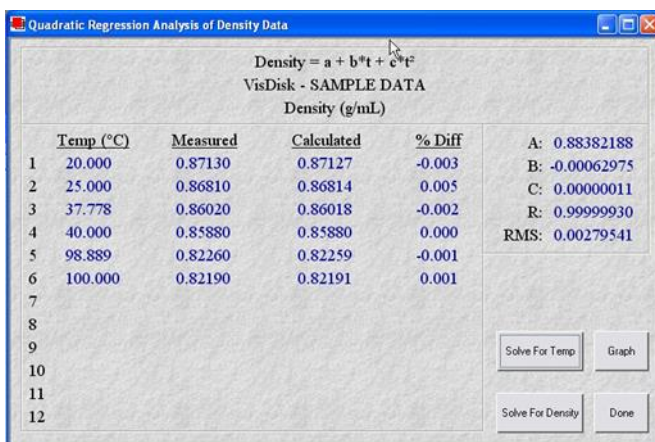


Figure 17: Quadratic Regression Analysis

Click **Done** to exit the window.

To print the results, make sure that the table window is active by clicking on it. Then select **Print** from the File menu or click on the print icon.



PolyVISC Intrinsic Viscosity

The PolyVISC Intrinsic Viscosity calculation module (named after the CANNON instrument that provides automated dilute solution polymer testing) provides intrinsic viscosity data when raw kinematic viscosity and concentration data is entered for the solvent and solutions.

The program also provides graphing capability for dilute solution polymer data, as well as values for K values (Huggins and Kraemer), inherent viscosity, reduced viscosity, and Fickentscher, Solomon-Ciutta and Billmeyer equations. Refer to Figure 18.

Sample ID	Concentration (g/dL)	Efflux Time (sec)	Density (g/mL)	C	E
1					
2					
3					
4					
5					
6					
7					
8					

Analyze Data Density Correction Energy Correction

Solvent Efflux Time (sec) Solvent Density (g/mL) C E

Figure 18: Polymer Intrinsic Viscosity Data Entry

Procedure

1. From the **Applications** menu, click **PolyVISC Intrinsic Viscosity**.
2. Enter the relevant solution data in the appropriate fields in the table provided. Make certain to include complete information for Sample ID, sample concentration (g/dL), and efflux time (seconds).

To more precisely complete the analysis using density or energy correction constants C and E, click the check box corresponding to the data to enable data entry. Then enter the appropriate data.

3. Input the Solvent Efflux time (pure solvent) in the **Solvent Efflux Time** field at the bottom of the window.
4. Click **Analyze Data** to complete the viscosity calculations and open an analysis window with complete intrinsic viscosity results in tabular and graphical formats.



Saybolt/Krebs Unit Conversions

Although the most accurate method for measuring kinematic viscosity is by using capillary viscometers where the unit of kinematic viscosity is expressed in centistokes (cSt), determinations are still made in other types of viscometers with viscosity units as Saybolt Universal Seconds (SUS), Saybolt Furol Seconds (SFS) and/or Krebs Units. Conversions between centistokes and Saybolt or Krebs units normally require the use of complicated equations or extensive tables.

The VISDISK program simplifies these conversions by performing all the necessary calculations. The user simply provides the original values. All VISDISK calculations for Saybolt conversions are based on formulas given in ASTM D2161. Krebs Units calculations are based on an equation developed by Dr. Robert Manning of CANNON Instrument Company.

Saybolt Furol Seconds (SFS) are units officially defined only for temperatures of 122 °F and 210 °F. VISDISK calculations at other temperatures are calculated or extrapolated and are not formally sanctioned by the ASTM method.

Procedure

1. Select SUS, SFS, and Krebs Units from the **Applications** menu. This opens the conversion window as shown in Figure 19.

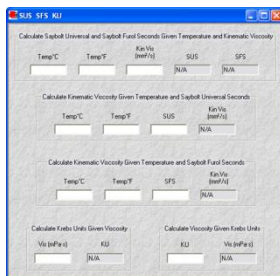


Figure 19: Conversion Window

2. Input the required data into the applicable field(s) and press the Tab or Enter key.

VISDISK performs the calculation and displays the conversion result in the indicated field.

To recalculate the conversion using different values, simply input the new values in the appropriate fields. Press the Tab or Enter key to continue with the new value(s). VISDISK automatically displays the recalculated conversion in the appropriate field.

To exit the Calculation window, click on **Done**.



Temperature Probe Calculations

BBR Temperature Probe

The BBR Temperature Probe module is designed to determine and/or verify the temperature probe constants used by the Bending-Beam Rheometer controlling software to maintain the desired test temperature. Refer to Figure 20.

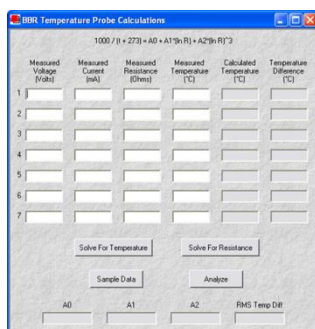


Figure 20: BBR Temperature Calculation Window

The module permits input of voltage values associated with the temperature probe at different temperatures. The BBR Temperature Probe module calculates the constants **A₀**, **A₁** and **A₂**. These calculated values can then be compared with the printed values on the calibration certificate accompanying the probe to verify the probe calibration.

Procedure

1. Click **Applications**; then **Temperature Probe**; then **BBR** to open the **BBR Temperature Probe Calculations** window as shown in Figure 20.
2. Enter the values for **Measured Voltage**, **Measured Current**, and **Measured Temperature**.



Note: Probe resistance is a calculated value based on Ohm’s Law.

3. Click the **Analyze** button to (re)calculate constants using the equation indicated at the top of the window. VISDISK also displays a calculated temperature given the probe electrical characteristics, as well as the difference between the calculated temperature and the input actual temperature from your temperature reference.
4. If desired, click the **Solve for Temperature** or **Solve for Resistance** buttons to open an interpolation/extrapolation window. Then, enter the value for the temperature or resistance and VISDISK automatically displays the associated temperature or resistance value.
5. Click **Done** to exit the **Solve For Temperature/Resistance** window.

CCS Thermistor Probe

The Cold-Cranking Simulator, models CCS-2100 and CCS-2100LT, contain a temperature probe consisting of a glass-encapsulated thermistor.

The CCS Model uses a 100-ohm thermistor and a 3000-ohm shunt resistor in parallel.

Although the temperature probe supplied with each instrument is already calibrated, recalibrate or check the probe after long use is advisable. The procedures below enable this.

Procedure

1. Select **Temperature Probes** from the **Applications** sub-menu and select the desired CCS instrument.
2. Enter the values for **Measured Resistance** and **Measured Temperature** in the appropriate fields. Then enter the shunt resistance in the indicated field.



Note: To insert “dummy” data in the **CCS Probe Calculations** window for practice purposes, click the **Sample Data** button to insert the

dummy data in the appropriate fields. Click **Clear Data** to remove all current entries.

3. Click the **Analyze** button to (re)calculate constants using the equation indicated at the top of the window. VISDISK also displays a calculated temperature given the probe electrical characteristics, as well as the difference between the calculated temperature and the input actual temperature from your temperature reference.
4. If desired, click the **Solve for Temperature** or **Solve for Resistance** buttons to open an interpolation/extrapolation window. Enter the value for the temperature or resistance and VISDISK automatically displays the associated temperature or resistance value.
5. Click **Done** to exit the **Solve for Temperature** or **Solve for Resistance** window.

DSR Temperature Probe

The DSR Temperature Probe Calculations module is designed to verify the function of the DSR probe as shown in Figure 21.

1000 / (t + 273) = A0 + A1*(ln R) + A2*(ln R)³

	Measured Resistance (Ohms)	Measured Temperature (°C)	Calculated Temperature (°C)	Temperature Difference (°C)
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
6	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
7	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

A0 A1 A2 RMS Temp Diff

Figure 21: DSR Temperature Probe Calculations Window

The DSR Temperature Probe module permits user input of resistance values associated with the temperature probe at different known temperatures. The DSR Temperature Probe module calculates the constants **A₀**, **A₁** and **A₂**. These calculated values can then be compared with the printed values on the calibration certificate accompanying the probe to verify the probe calibration.

There is also an interpolation option (**Solve for Temperature/Resistance**) for determining temperature given a specific resistance value, or resistance given a specific temperature value.

Procedure

1. Click **Applications**; then **Temperature Probe** and then **DSR** to open the **DSR Temperature Probe Calculations** window.
2. Enter the **Measured Resistance** and **Measured Temperature** values.
3. Click the **Analyze** button to (re)calculate constants using the equation indicated at the top of the window. VISDISK also displays a calculated temperature given the probe electrical characteristics, as well as the difference between the calculated temperature and the input of actual temperature from your temperature reference.
4. If desired, click the **Solve for Temperature** or **Solve for Resistance** buttons to open an interpolation/extrapolation window. Enter the value for the temperature or resistance and VISDISK automatically displays the associated temperature or resistance value.
5. Click **Done** to exit the **Solve for Temperature** or **Solve for Resistance** window.

Viscosity Index Calculations

The viscosity index (VI) of a fluid is a measure of its sensitivity to changes in temperature. Viscosity index is based on an arbitrary selection of oils considered to have high and low variations in viscosity with temperature changes. The higher the VI of a fluid, the less its kinematic viscosity varies with changes in temperature. Conversely, a fluid with a low viscosity index exhibits a substantial decrease in viscosity as the temperature increases. Refer to Figure 22.

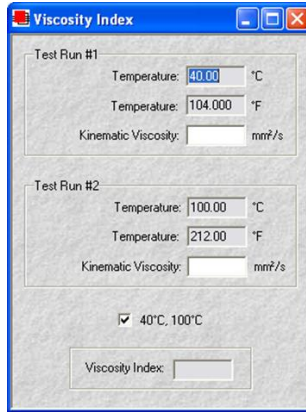


Figure 22: Viscosity Index Window

The viscosity index (VI) is calculated to one decimal place in VISDISK. The ASTM D2270 chart value is derived by rounding to the nearest whole number.

Procedure

1. Select **Viscosity Index** from the **Applications** menu.
2. Enter the temperature and viscosity data for the two tests (make certain to input temperature values in the field corresponding to the desired temperature scale of °C or °F).

VISDISK then displays the VI value.

Note: If you are entering viscosity data at 40 °C and 100 °C, you can skip the temperature data entry and just click the 40 °C, 100 °C temperature check box to automatically enter those temperature values every time the **Viscosity Index** window is opened.



To enter other values for temperatures, click the box again to uncheck the option. Then input the desired temperature and viscosity values.

Recalculating Viscosity Index

To recalculate the viscosity index using different temperatures or kinematic viscosity values, enter the new values into the appropriate fields and press the Tab or Enter

key. VISDISK automatically displays the recalculated VI value in the **Viscosity Index** field.

CANNON Mini-Rotary Viscometers

The CANNON Mini-Rotary Viscometer (CMRV) is used to measure the apparent viscosity and yield stress of engine oils over the temperature range of 0 °C to -35 °C. Before carrying out such measurements, a constant must be determined for each cell by calibrating it with a viscosity standard.

VISDISK allows the entry of cell constants. VISDISK uses these constants to calculate the **Apparent Viscosity** (in cP) of samples from the time required to complete three revolutions of the cell rotor. VISDISK also calculates **Yield Stress** (in pascals) from the weight added to the weight basket.

Procedure

1. Select **Mini-Rotary Viscometer** from the **Applications** submenu.
2. If you have already entered multiple sets of cell constants, choose the desired data by selecting the appropriate Instrument ID number from the drop-down **CMRV Instrument Number** window box.
3. If you have not yet entered data, click the **Add Instrument** button to create a new Instrument ID.



Note: You may retrieve previously-saved CMRV data sets by clicking **File** and then **Open**, selecting the **CMRV Cell Constants** option, and opening the desired CMRV data file.

4. Enter the calibration data (including **Cell Constants**, **Sample ID**, **Rotation Time** and **Weight**) for all viscometry cells. Enter and save as many sets of constants as desired. User must choose a new **CMRV Instrument Number** for each set. Refer to Figure 23.

CMRV Calculations						
CMRV Instrument Number		234	Add Instrument			
Cell Constant	Sample ID	Time for 3 Revs. (sec)	Weight (grams)	Apparent Visc. (mPa·s)	Yield Stress (pascals)	
1	2125	1	11.00	20.00	23380	42500.000
2	2046	2	10	20	20460	40920.000
3	1985	3	9.7	20	19250	39700.000
4	2203	4	9.5	20	20930	44060.000
5	2108	5	8.4	20	17710	42160.000
6	2117	6	7.3	20	15450	42340.000
7	2154	7	7.1	20	15290	43080.000
8	2121	8	5.9	20	12510	42420.000
9	2244	9	5.0	20	11220	44880.000

Figure 23: CMRV Calculations Window

- As you complete the data entry for each cell, the **Apparent Viscosity** and **Yield Stress** is automatically calculated by VISDISK and displayed in the appropriate fields.
- To save your data, click **File**; then **Save**; then select **CMRV Cell Constants**. Enter the desired file name for the data.
- To exit the **CMRV Calculations Window**, click the **Close** button.

The **Time for 3 Revs** is the time required for three complete consecutive revolutions of the rotor for a given cell when a load of a known mass is applied to the rotor thread. See the relevant ASTM method (ASTM D3829, D4684, D6821 and D6896) for more information.



Data Tables

VISDISK provides two useful tables for use in determination of viscosity values: the ISO VG Lubricant Specifications table and the SAE J300 Viscosity Grade table.

The ISO VG Lubricant Specifications Table

ASTM Standard D2422 provides an ISO viscosity grade (ISO VG) classification with twenty defined viscosity ranges, providing a uniform basis for the specification/classification of industrial fluid lubricants and the elimination of unjustified intermediate viscosity products. The reference temperature is 40 °C. This classification is not intended to be applied to lubricants identified with an SAE number which are used primarily for automotive equipment.

The ISO VG Lubricant Specifications table includes the following information shown in Table Data.

Table Data

- ISO VG Identification
- Mid-Point viscosity value (mm^2/s , cSt)
- Minimum kinematic viscosity (mm^2/s , cSt)
- Maximum kinematic viscosity (mm^2/s , cSt)

The VISDISK program also displays the approximate SUS value for each grade.

Procedure

Select **ISO VG Lubricant Specs** from the **Data Tables** menu. This opens the **ISO VG Lubricant Specifications** table.

SAE J300 Viscosity Grades for Engine Oils Table

VISDISK provides a table of SAE Viscosity Grades for Engine Oils.

SAE Classifications

In SAE J300, the Society of Automotive Engineers classifies engine oils according to their viscosity ranges. Low-temperature viscosities are measured using a Cold-Cranking Simulator and a Mini-Rotary Viscometer (both manufactured by CANNON Instrument Company). For those oils with numbers followed by W (for winter service), the SAE J300 table provides maximum acceptable viscosity values at specified temperatures.

For those oil grades without the W suffix, the SAE J300 table provides acceptable minimum and maximum viscosity values at 100 °C, as well as the minimum high-shear rate viscosity at 150 °C, as measured by the High-Temperature High-Shear viscometer (manufactured by Cannon Instrument Company).

Table Data

- SAE Viscosity Grade classification
- Maximum cranking viscosity (mPa·s) at specified temperatures in °C.
- Maximum borderline pumping viscosity (mPa·s) at specified temperatures in °C with no yield stress.
- Minimum and maximum low-shear rate kinematic viscosity (mm²/sec.) at 100 °C
- Minimum High-Shear-Rate viscosity at 150 °C

Procedure

Select [SAE J300 Lubricant Specs](#) from the [Applications](#) sub-menu. This opens the [SAE J300 Specifications](#) table.



References and Definitions

1. Standard Viscosity-Temperature Charts for Liquid Petroleum Products, Annual Book of ASTM Standards, Vol. 05.01.
2. Standard Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 °C and 100 °C, ASTM D2270, Annual Book of ASTM Standards, Vol. 05.02.
3. Standard Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity, ASTM D2161, Annual Book of ASTM Standards, Vol. 05.02.
4. Standard Classification of Industrial Fluid Lubricants by Viscosity System, ASTM D2422, Annual Book of ASTM Standards, Vol. 05.02.
5. SAE Standard SAE J300, Engine Oil Viscosity Classifications.
6. Standard Test Method for Apparent Viscosity of Engine Oils at Low Temperature Using the Cold-Cranking Simulator, ASTM D2602, Annual Book of ASTM Standards, Vol. 02.02.
7. Rein, S. W. Viscosity-I and Viscosity-II, Lubrication, Vol 64, 1978, 00. 1-17

Reprints of ASTM methods may be purchased from ASTM:

ASTM
100 Barr Harbor Drive
Conshohocken, PA 19428-2959

Phone: 610-832-9585

Fax: 610-832-9555

www.astm.org

8. NBS Equation (Kin Vis Density Calculations) was derived from an equation from R.C. Hardy, NBS, 1954.

Organizations

ASTM: American Society of Testing and Materials

NBS: National Bureau of Standards, now NIST (National Institute of Standards & Technology)

SAE: Society of Automotive Engineers

SAE J300 is an Engine Oil Viscosity Classification and SAE standard which defines the limits for a classification of engine lubricating oils in rheological terms. For the low temperatures classification, the temperature range is from -10 °C to -35 °C, and includes specifications for both pumpability and cranking considerations, and results in the SAE “W” grades 0W through 25W. The middle temperature range (100 °C) defines the non-“W” SAE grades 20 through 60.

There is also a high temperature high-shear rate specification for engine oil lubricants.



VIS DISK[®]

VISCOSITY
CALCULATION
TOOLS

VERSION 2.0
for Windows[®]

 **CANNON**
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