Title/Subject: Standard Test Procedure for the Determining Viscosity of a Hydraulic Fluid in Saybolt Universal Seconds		
CDS No.: ASTP5005	Page No. 1 of 10	
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Signature/Initial: Kenneth Sproul, Chief, QA&MTD		

STANDARD TEST PROCEDURE FOR DETERMINING VISCOSITY OF A HYDRAULIC FLUID IN SAYBOLT UNIVERSAL SECONDS

1.0 Purpose:

This document establishes MSHA's Standard Test Procedure (STP) for the Determining the Viscosity of a Hydraulic Fluid in Saybolt Universal Seconds.

2.0 Scope:

This document applies to MSHA approved fire-resistant hydraulic fluids (FRHFs), audits of MSHA approved FRHFs, and accident investigations involving MSHA approved FRHFs.

3.0 REFERENCE:

3.1 This document supersedes CDS document ASTP4009 (dated: January 1985).

3.2 30 CFR, Part 35, Subpart A

3.3 The Brookfield Digital Viscometer Operating Instructions (Model DV-I^{+}) filed in the Quality Assurance and Materials Testing Division's (QA&MTD) Instruction & Operation Manuals file cabinet.

3.4 Brookfield publication "More Solutions to Sticky Problems".

3.3 Standard Application Procedure for MSHA Approval of Fire-Resistant Hydraulic Fluids According to the Code of Federal Regulations, Title 30, Part 35 (ASAP5003)

3.4 ASTM Viscosity Tables for Kinematic Viscosity Conversions and Viscosity Index Calculations (STP 43 C)

3.5 ASTM Standard Method for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity (ASTM 2161)

3.6 Viscosity Test Report (see Appendix 1)

3.7 Brookfield Factor Finder (Brookfield Model LV & Spindle Number)

3.8 ASTM Standard Viscosity Temperature Charts for Liquid Petroleum Products (D 341) Chart A: Saybolt Universal Viscosity (see Appendix 2)

4.0 Definitions:

4.1 Fire-resistant hydraulic fluid - means a fluid of such chemical composition and physical characteristics that it will resist the propagation of flame.

4.2 Viscosity - A property of fluids and slurries that indicates their resistance to flow, defined as the ratio of shear stress to shear rate giving the traditional unit of dyne-sec/cm^2 Poise.

4.3 Centipoise – A unit of measurement for viscosity equivalent to one-hundredth of a “poise” and symbolized by “cP”.

5.0 Background:

5.1 The manufacturer of a hydraulic fluid submitted for MSHA Approval must provide the viscosity of candidate fluid at 100°F, 150°F, and 175°F. The QA&MTD verifies the manufacturer’s viscosity values by taking the average of 5 readings at each of these temperatures.

5.2 Viscosity determinations are performed on a Brookfield DV-I$^+$ Viscometer with speed settings ranging from 0 to 100 RPM (See: the DV-I$^+$ Operating Instructions) and a set of four (4) #302 stainless steel spindles. The DV-I$^+$ viscometer has a minimum range of 15 cP and a maximum range of 2,000,000.

5.2 The DV-I$^+$ viscometer is used in conjunction with a Brookfield EX 200 constant temperature bath and a RTD temperature probe that is connected to the rear panel of the DV-I$^+$ viscometer. The RTD temperature probe is attached to the LV guard-leg that is immersed in the fluid to be tested.

5.3 The EX 200 bath is filled with a solution of distilled water mixed with approximately 1 gallon of glycol to prevent rust and provide pump lubrication. Review the specifications for the viscometer and constant temperature bath located in the QA&MTD's Instruction & Operation Manuals file cabinet.

5.4 The DV-I$^+$ Viscometer and Brookfield EX 200 constant temperature bath are to be set up according to the manufacturer's instructions. Note: the viscometer instruction manual requires the use of a 600cc Griffin beaker to make viscosity measurements.

6.0 Test Procedures:

6.1 Read the Brookfield Digital Viscometer Model DV-I$^+$ Operating Instructions.

6.2 Thoroughly mix the fluid to be tested. The fluid should be at room temperature for at least 24 hours before pouring it into the Griffin beaker.

6.3 Mount the guard-leg on the DV-I$^+$ Viscometer. Attach the spindle to the lower shaft. Lift the shaft slightly, holding it firmly with one hand while screwing the spindle on with the other (note: left-hand thread). Avoid putting side thrust on the shaft. Spindles #1 and 2 are generally used because of the range of viscosities that are usually found in hydraulic fluids.

6.4 Pour the fluid to be tested into the beaker to the proper height and place the beaker in the bath. Set the desired temperature on the dial and turn the unit on. Note: when determining viscosities at temperatures near or below room temperature, the cooling water described in the instruction manual should be attached and used.

6.5 Insert and center the spindle in the test material until the fluid's level is at the immersion groove in the spindle's shaft. Care must be taken when placing the spindle in the fluid to insure: (1) that no air bubbles are trapped underneath the spindle, (2) that the fluid height comes to the notch on the spindle, and (3) the fluid is free of air bubbles.

6.6 Enter the "two" digit Spindle Code Number and desired speed setting into the key pad of the DV-I^+ and turn the motor on. Allow time for the indicated reading to stabilize before recording the viscosity measurement. The time required for stabilization will depend on the speed at which the viscometer is running and the characteristics of the sample fluid. For maximum accuracy, readings below 10% should be avoided.

6.7 When the fluid has stabilized at the desired temperature, record the % torque and viscosity (cP) on the Viscosity Test Report. The average of five readings is used to determine the final value.

6.7.1 Centipoises are then converted to centistokes (cSt) using the following equation:

$$\text{Kinematic viscosity in Centistokes} = \frac{\text{Centipoises}}{\text{Specific gravity (at temperature)}}$$

6.3.2 Centistokes are then converted into the viscosity in Saybolt Universal Seconds (SUS) using the ASTM Viscosity Tables (STP 43C); see Example 1.

6.8 Centistokes may also be converted to SUS at temperatures other than 100°F using the following equation (ASTM 2161); see Example 2.

$$SUS_T = cSt\ [1 + 0.000061(t - 100°F)] \times 4.6324$$

$$\text{Where 4.6324 is a constant for } \frac{\text{SUS } 100°F}{\text{cSt } 100°F}$$

6.9 When determining the viscosity of a fluid at various temperatures, one of the temperatures should be 100°F since it is a common reference value for many oils and fluids. It is also a temperature that may be conveniently converted to Saybolt Universal Seconds from the centistoke value by using the ASTM Viscosity Tables for Kinematic Viscosity Conversions and Viscosity Index Calculations (ASTM 2161).

6.10 The viscosity should also be determined at room temperature and at 150°F. The 150°F temperature is used because it is the spray temperature for the temperature-pressure spray-ignition test described in 30 CFR 35.21. It is also the oven temperature used in the wick test to determine the effect of evaporation on flammability of hydraulic fluids described in 30 CFR 35.22.

6.11 These three temperatures, when converted to SUS may be plotted on an ASTM Standard Viscosity Temperature Chart (D 341), extrapolated, and compared graphically to submitted data at similar or other temperatures.

6.12 Since a great deal of information is available on viscosity, the users should familiarize themselves with the principles involved in viscosity determinations by reading the Brookfield publication “More Solutions to Sticky Problems”.

6.13 The DV-I$^+$ viscometer should be calibrated periodically by running a viscosity determination using Brookfield Viscosity Standards traceable to the National Institute of Standards Technology (NIST). The instrument may also be calibrated and certified to NIST standards by sending it to Brookfield Engineering Support at the following address: 11 Commerce Boulevard, Middleboro, MA 02346.

7.0 TEST MODIFICATIONS:

7.1 Since all possible materials, products, compositions, physical properties, and applicable methods cannot be foreseen, MSHA reserves the right to modify the above test procedures.

8.0 RESPONSIBILITY:

8.1 The QA&MTD is responsible for the maintenance and operation of the LVT viscometer. Test results are incorporated into MSHA approval documentation and/or other investigative documents.

9.0 NOTIFICATION:

9.1 The QA&MTD will notify all appropriate Approval and Certification Center personnel.

10.0 DISTRIBUTION:

10.1 This document will be distributed to all appropriate Approval and Certification Center personnel.

11.0 RESULTS:

11.1 Test results are summarized in MSHA's approval and audit documentation files of Fire-Resistant Hydraulic Fluids. Accident and other investigations requiring viscosity determinations of products other than hydraulic fluids will also summarize test results where appropriate.

12.0 REVIEW:

12.1 This document will be reviewed at least once every three years.

13.0 AUTHORITY:

13.1 30 CFR, Part 35, Subpart A

PAR (or MSRS): _____ **VISCOSITY TEST REPORT** File No.: _____

Company: _____ Data Sheet No. _____

Date: _____ STP No.: **ASTP 5005** Standard Test Procedure for Determining Viscosity of a Hydraulic Fluid in a Saybolt Universal Seconds

Test Sheet: _____ of _____ Tester: _____

Test Results: _____ Ambient Temperature: _____ deg F at _____

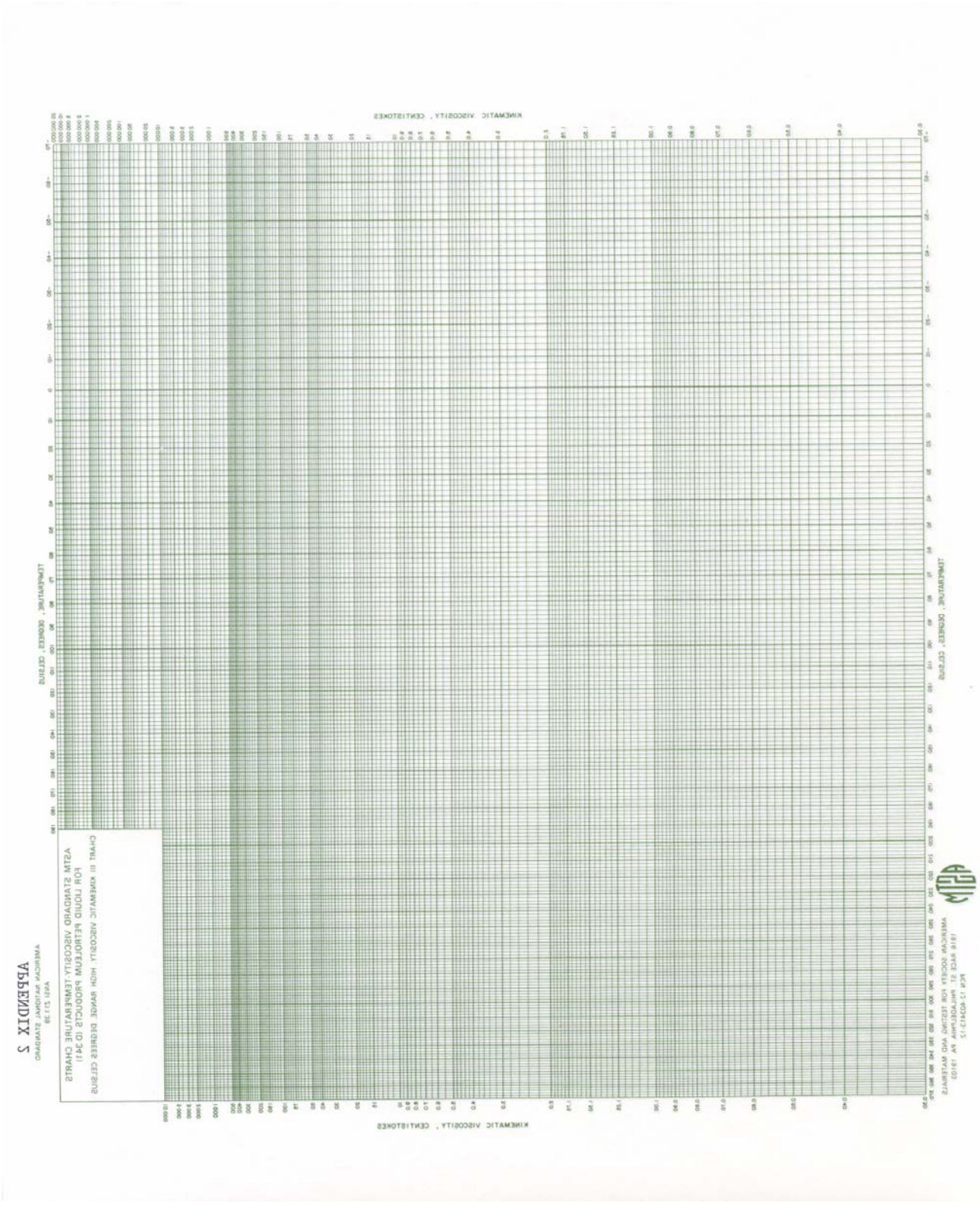
Test Information: Inches Hg

SAMPLE	MODEL	SPINDLE	RPM	% TORQUE	FACTOR	VISCOSITY CPS.	TEMP. Deg. C	TIME	NOTES

COMMENTS & CONCLUSIONS:

Appendix 1

Appendix 2


APPENDIX 2
ASTM STANDARD VISCOSITY TEMPERATURE CHARTS
FOR LIQUID PETROLEUM PRODUCTS (SI)
CHART III KINEMATIC VISCOSITY, HIGH RANGE, DEGREES CELSIUS
KINEMATIC VISCOSITY, CENTISTOKES
TEMPERATURE, DEGREES CELSIUS

Example #1: Determine SUS by using ASTM tables

PAR (or MSRS):

VISCOSITY TEST REPORT

File No.:

Company: **Century Lubricants**

Data Sheet No. 1

Date: 1-Jun-04

STP No.: **ASTP 5005** Standard Test Procedure for Determining Viscosity of a Hydraulic Fluid in a Saybolt Universal Seconds

Test Sheet: _____ of _____

Tester:

Test Results:

Ambient Temperature: deg F at

Inches Hg

Test Information: Viscosity Determination on Century Lubricants "ABC" Hydraulic Fluid. Hydraulic Fluid Type - Invert Emulsion, QA&MTD Inventory Can # 155, Manufacturer's Batch #4899. Tested on a Brookfield DV-I+ Viscometer and a Brookfield EX 200 Temp. Bath.

SAMPLE	MODEL	SPINDLE	RPM	% TORQUE	FACTOR	VISCOSITY CPS.	TEMP. Deg. C	TIME	NOTES
4899	DV-I+	#1	30	98.7	2	197.4	21.7	9:05	Avg. = 197.4 cP
				98.7		197.4	21.7	9.06	21.7°C = 71°F, SG = .9298
				98.7		197.4	21.7	9.07	197.4/.9298 = 212 cST
				98.7		197.4	21.7	9.08	212 cST = 982 SUS
				98.7		197.4	21.7	9.09	
4899	DV-I+	#1	30	50.6	2	101.2	37.7	9:50	Avg. = 101.2 cP
				50.7		101.4	37.8	9.51	37.8°C = 100°F, SG = .9197
				50.6		101.2	37.8	9.52	101.2/.9197 = 110 cST
				50.6		101.2	37.8	9.53	110 cST = 510 SUS
				50.5		101	37.9	9.54	
4899	DV-I+	#1	12	19.5	5	97.5	37.9	10:15	Avg. = 98.0 cP
				19.6		98	37.8	10:16	37.8°C = 100°F, SG = .9197
				19.6		98	37.8	10:17	98/.9197 = 106.5 cST
				19.5		97.5	37.8	10:18	106.5 cST = 494 SUS
				19.6		98	37.8	10:19	
4899	DV-I+	#1	60	41	1	41	65.5	11:02	Avg. = 40.9 cP
				40.8		40.8	65.5	11:03	65.6°C = 150°F, SG = .9024
				40.9		40.9	65.6	11:04	40.9/.9024= 45.3cST
				41.1		41.1	65.6	11:05	45.3cST = 211 SUS
				40.7		40.7	65.6	11:06	

COMMENTS & CONCLUSIONS:

Example 1

Example #2: Determine SUS by using the equation

PAR (or MSRS):

VISCOSITY TEST REPORT

File No.:

Company: **Century Lubricants**

Data Sheet No. 1

Date: 1-Jun-04

STP No.: ASTP 5005 Standard Test Procedure for Determining Viscosity of a Hydraulic Fluid in a Saybolt Universal Seconds

Test Sheet: _____ of _____

Tester:

Test Results:

Ambient Temperature: deg F at

Inches Hg

Test Information: Viscosity Determination on Century Lubricants "ABC" Hydraulic Fluid. Hydraulic Fluid Type - Invert Emulsion, QA&MTD Inventory Can # 155, Manufacturer's Batch #4899. Tested on a Brookfield DV-I+ Viscometer and a Brookfield EX 200 Temp. Bath.

SAMPLE	MODEL	SPINDLE	RPM	% TORQUE	FACTOR	VISCOSITY CPS.	TEMP. Deg. C	TIME	NOTES
4899	DV-I+	#1	30	98.7	2	197.4	21.7	9:05	Avg. = 197.4 cP
				98.7		197.4	21.7	9.06	21.7°C = 71°F, SG = .9298
				98.7		197.4	21.7	9.07	197.4/.9298 = 212 cST
				98.7		197.4	21.7	9.08	SUS = 212[1 + .00006(71 - 100°F)] x 4.6324
				98.7		197.4	21.7	9.09	SUS = 980
4899	DV-I+	#1	30	50.6	2	101.2	37.7	9:50	Avg. = 101.2 cP
				50.7		101.4	37.8	9.51	37.8°C = 100°F, SG = .9197
				50.6		101.2	37.8	9.52	101.2/.9197 = 110 cST
				50.6		101.2	37.8	9.53	SUS = 110[1 + .00006(71 - 100°F)] x 4.6324
				50.5		101	37.9	9.54	SUS = 510
4899	DV-I+	#1	12	19.5	5	97.5	37.9	10:15	Avg. = 98.0 cP
				19.6		98	37.8	10:16	37.8°C = 100°F, SG = .9197
				19.6		98	37.8	10:17	98/.9197 = 106.5 cST
				19.5		97.5	37.8	10:18	SUS = 106.5[1 + .00006(71 - 100°F)] x 4.6324
				19.6		98	37.8	10:19	SUS = 493
4899	DV-I+	#1	60	41	1	41	65.5	11:02	Avg. = 40.9 cP
				40.8		40.8	65.5	11:03	65.6°C = 150°F, SG = .9024
				40.9		40.9	65.6	11:04	40.9/.9024= 45.3cST
				41.1		41.1	65.6	11:05	SUS = 45.3[1 + .00006(71 - 100°F)] x 4.6324
				40.7		40.7	65.6	11:06	SUS = 211

COMMENTS & CONCLUSIONS:

Example 2

Document Information Form

CDS No. ASTP5005 (RCO Assigns)

___ Enter (Original)
_X_ Supersede CDS No. ASTP4009 (dated: 1/1/85)
___ Revise CDS No.

Title: Standard Test Procedure for Determining Viscosity of a Hydraulic Fluid in Saybolt Universal Seconds

Category: _XX_ A (PAR related) __N__ (Not PAR related)

Type: _STP_ (POL, SAP, SOP, STP, LEG, INF, CRI)

Sponsoring Division/Center Chief:Ken Sproul

Division/Center Contact: Donald Peiffer

Document is For:

___ External Distribution
_XX Internal Use Only

List of 30 CFR References:

Part	Section(s)
35	Subpart A

Key Words: Viscosity, Saybolt, Centipoises, Viscometer, Centistokes
(75 Characters)

Follow-Up Review Date: 9/01/07

Concurrence:

Technical Review By: _____ Committee Representative

Administrative Review By: _____Committee Chairperson

Division Chief Concurrence (Initials)

	Yes	No
AED	___	___
ESD	___	___
M&ESD	___	___
QA&MTD	___	___

Authorized By:_____ _____
Name A&CC Chief or Designate Date