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MSHA Wick Test for Hydraulic Fluids: A Preliminary Evaluation

Center for Fire Research
National Engineering Laboratory
U.S. Department of Commerce
National Bureau of Standards
Washington, DC 20234

July 1981

Final Report

Sponsored in part by
U.S. Bureau of Mines
Pittsburgh, Pennsylvania 15213

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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MSHA WICK TEST FOR HYDRAULIC FLUIDS: A PRELIMINARY EVALUATION

Joseph J. Loftus

Abstract

This report is an evaluation and analysis of "The Test to Determine the Effect of Evaporation on the Flammability of Hydraulic Fluids (Wick Test)." The Wick Test is used by the Mine Safety and Health Administration (MSHA) to qualify hydraulic fluids for use in underground coal mines. This report includes a review of the test method's operating characteristics as well as a comparison of test results from the Wick Test with two alternative test procedures--a hot wire coil test and a sustained flame contact test. The evaluation program included currently used fluids such as invert emulsions, synthetics, and water glycols. The Wick Test studies showed that the test method was not well defined and that reproducibility was poor. The repeatability of the Wick Test could be improved by using a sustained flame contact.

Key words: Coal mines, hydraulic fluids; ignition; flammability; wick test.

1. INTRODUCTION

The Code of Federal Regulations, Schedule 30, Part 35, outlines three flammability test methods for hydraulic fluids. The Mine Safety and Health Administration (MSHA) employs these test methods to qualify hydraulic fluids as acceptable for use in underground coal mining operations for unattended equipment or for attended equipment lacking fire suppression systems. Acceptable fluids must meet all of the flammability requirements of the three test methods. These test methods are:

- Test to Determine the Effect of Evaporation on the Flammability of Hydraulic Fluids (Wick Test);

- Autogenous Ignition Temperature Test;

- Temperature-Pressure Spray Ignition Test.

In order to improve the operating characteristics of these tests, MSHA requested the Center for Fire Research at the National Bureau of Standards to conduct an evaluation of all three test methods. The following is a report on an evaluation and analysis of "The Test to Determine the Effect of Evaporation on the Flammability of Hydraulic Fluids (Wick Test)." This report includes a review of the test method's operating characteristics as well as a comparison of test results from the Wick Test with two alternative test procedures--one a hot wire coil test and the other a sustained flame contact test.

This report does not include an evaluation of whether the Wick Test is appropriate or necessary to provide fire safe hydraulic fluids for underground coal mines. Final recommendations concerning the need for the Wick Test will be deferred to a subsequent report detailing an overall fire test program for hydraulic fluids used in underground coal mines.

2. TEST MATERIALS

A total of 14 different hydraulic fluids were selected for test. The fluids were obtained from manufacturers who normally supply these materials to the underground coal mining industry and who report that the fluids are fire resistant under the Code of Federal Regulations, Schedule 30, Part 35; i.e., meet the requirements of all three test methods. Included were two water glycols, seven synthetics, and five invert emulsions. Water glycols consist of a water-glycol solution with at least 35 percent water, synthetics are fluids which contain organic esters; e.g., phosphates, or synthesized hydrocarbons, and invert emulsions are hydraulic fluids that consist of a water and oil emulsion in which the water content may vary from 40 to 95 percent. Table 1 lists the fluid types and the specific gravities measured for each of the test materials.

3. WICK TEST

The Wick Test is used by MSHA to determine the effect of evaporation on the flammability of hydraulic fluids. Detailed operating procedures are contained in the appendix to this report. Briefly, this test measures the fire resistance of hydraulic fluids by cycling fluid soaked wicks (i.e., pipe

Table 1. Test materials

Hydraulic Fluid Type	No.	Specific Gravity g/cu cm
Invert Emulsions	5	0.92
	7	0.94
	11	0.91
	13	0.93
	14	0.92
Water Glycols	1	1.08
	2	1.06
Synthetics	3	0.99
	4	1.14
	6	1.14
	8	1.20
	9	1.13
	10	1.15
	12	1.14

cleaner stems) into a bunsen burner flame. The number of cycles to ignition of the wick is counted. Fluids are tested at three different conditions--as received and after heating in an oven at 65°C for 2 and 4 hours, respectively. The Wick Test criteria specify that hydraulic fluid samples must resist ignition for a minimum number of cycles at all three test conditions. The minimum acceptable performance as listed in table 2 varies with sample conditioning, it is lowest for samples conditioned for 4 hours and highest for samples as received.

3.1 Bunsen Burner

The Code of Federal Regulations state that "a standard (bunsen or equivalent) laboratory burner" should be used as the ignition source in the Wick Test. Three general types of bunsen burners were found that meet this general description and these are described in table 3. The burners differ only in orifice size and the presence or absence of a flame arrestor.

Observations made by the Center for Fire Research at the MSHA laboratories showed that the bunsen burner used by MSHA had a barrel length of 14.8 cm (5.9 in) with an inside diameter of 1.3 cm (0.5 in). The burner had no flame arrestor and had an orifice plate of 1.93 mm (.076 in) aperture. These dimensions correspond to the artificial burner described in table 3.

The burner flame height was measured at approximately 15 cm (6 in) and the flame temperature at the Wick Test location showed a value of 835°C. It was noted that MSHA uses commercial grade methane (96 percent methane) for the Wick Test. [Note: The Wick Test does not specify the type of gas to be used for test but does call for a nonluminous flame of about 10 cm (4 in) in height.]

The Center for Fire Research conducted a study to determine the effects of variations in burner orifice size on flame temperature. For test, four methane gas flow rates ranging from 1274 to 1840 cc/min were used with three different burner types and flame temperatures were measured with a shielded type J (chromel alumel) thermocouple located in the flame at the Wick Test location. The results of these tests listed in table 4 show that there are almost negligible differences between the 1.02 and 0.79 mm orifices. The 1.93 mm orifice produced considerably higher flame temperatures for gas flow rates in the 1274 cc/min to 1652 cc/min range. At 1840 cc/min, the flame temperatures recorded for all three orifice plates were approximately the same, 789°C to 809°C. Table 4 also shows that, for the fixed thermocouple location, recorded temperatures decrease with increasing gas flow rates.

Table 2. MSHA wick test acceptance criteria

Sample Conditioning	Minimum Number of Cycles
As received	25
2 hrs. at 65°C	18
4 hrs. at 65°C	12

Table 3. Description of three types of bunsen burners meeting the general requirements of CFR schedule 30:35.22

Type	Orifice	Flame Arrestor
L.P. Gas	0.79 mm (.031 in)	Yes
Natural Gas	1.02 mm (.040 in)	Yes
Artificial Gas	1.93 mm (.076 in)	No

Table 4. Effect of orifice size on the flame temperature of a bunsen burner

Flow Rate (cc/min)	Flame Temperature (°C)		
	1.93 mm	1.02 mm	0.79 mm
1274	960	835	840
1463	928	837	828
1652	906	815	821
1840	790	789	809

The relationship between gas flow rate, ignition of a fluid soaked wick and flame temperature was determined in tests on one invert emulsion fluid (no. 5) exposed to a flame from the artificial gas burner. In these tests the rate of flow was monitored over a range of 1368 to 1841 cc/min. Table 5 indicates that there is no correlation between the number of cycles to ignition and the gas flow rate. The minimum number of cycles to ignition occurs at gas flows between 1463 to 1746 cc/min and within this range the actual gas flow rate was not critical.

3.2 Wick

The wicks (used for test), are described in the Code of Federal Regulations as being "ordinary, smoker's pipe cleaners (U.S. Tobacco Company, Dill's, or equivalent)." "Dill" pipe cleaner stems measure approximately 15 cm (6 in) in length and contain white cotton fibers with a base wire thickness of 0.8 to 0.9 mm. The wick's combustible content was determined by taking weights before and after burning all of the wicking material away from the wire stem. In this way, the combustible content was found to be 0.01 ± .004 g/cm.

3.3 Cycling Device

MSHA uses a windshield wiper mechanism for cycling fluid soaked wicks into the test burner flame. The cycling rate for test is specified at 25 cycles per minute.

CFR reproduced this test apparatus in the laboratory and made some elementary measurements; for example, dry wick samples ignited in less than four cycles and kerosene wicks in one cycle. The residence time for a wick in the burner flame was 0.12 sec/cycle and for a 25 cycle exposure it was estimated that a wick would spend a total of 3 seconds in the burner flame.

Table 6 compares CFR and MSHA Wick Test results on essentially the same types of hydraulic fluid materials. [Note: The MSHA test data is old data obtained by CFR in a survey of MSHA's records dating back a number of years.] The MSHA data shows lower cycle counts to ignition than does CFR for all but one of the fluids (no. 1 after 2 and 4 hours in the oven).

Synthetic fluids were not ignited in the NBS Wick Tests while MSHA's tests showed ignitions for similar type fluids within 21 to 26 cycles of the wick. Because of the discrepancy between results obtained in the two laboratories, especially for synthetic hydraulic fluids, the Center for Fire Research

Table 5. Relationship between gas flow rate, number of cycles to ignition and flame temperature for fluid (no. 5) and 1.93 mm orifice

Flow Rate (cc/min)	Number of Cycles to Ignition	Flame Temperature (°C)
1368	60	940*
1463	52	928
1538	50	915*
1652	50	906
1746	47	840*
1841	58	790
1925	62	740*

* Interpolated flame temperature

Table 6. Comparison of MSHA and NBS wick test data

	Number of Cycles to Ignition					
	0 time		2 hrs.		4 hrs.	
Fluid No.	MSHA*	NBS	MSHA*	NBS	MSHA*	NBS
7	37	55	36	47	34	41
13	36	66	30	75	35	60
4	26	N	23	N	23	N
9	23	N	22	N	21	N
12	26	N	23	N	22	N
1	50	92	34	14	16	10

* MSHA data obtained by the Center for Fire Research in a review of test results recorded over a period of time

conducted tests where the cycling rate of the wick was reduced to increase the actual time a wick spent in the burner flame. Table 7 summarizes the data obtained for tests on six synthetic fluids cycled at the rate of 15 cycles/min. The fluids were tested in their as-received state.

An examination of these data shows that ignition propensity increased when the cycling rate was decreased. However, even at this reduced rate, fluid nos. 4, 9, and 12 performed better (longer cycle counts) in tests using the Center for Fire Research's apparatus than the MSHA apparatus.

3.4 Sample Conditioning

Each hydraulic fluid must be evaluated under three different sets of conditions (1) at room temperature (20°C) in their "as received" state, (2) after 2 hours, and (3) after 4 hours of conditioning in a gravity convection oven operated at 65°C (150°F). Samples removed from the oven are allowed to return to room temperature before testing.

3.5 Wick Test Results

Table 8 lists the results of NBS Wick Tests on 14 different hydraulic fluids. The data indicate that the invert emulsion fluids easily met the Wick Test acceptance criteria outlined in table 2. While the two water glycol fluids performed very well in as-received tests, evaporations caused fluid no. 1 to fail the 2 hour oven conditioning tests and fluid no. 2 samples to fail after 4 hours conditioning.

Since evaporation of materials at 65°C (150°F) from fluid samples is the primary objective of oven-conditioning, weight loss measurements were made for the test fluids as a function of oven type. Two types of ovens in common use are: (1) a forced air circulating oven which uses a blower to move heated air through the oven chamber and out exhaust vents and (2) a nonforced air circulating or gravity convection oven which has no blower or exhaust vents.

Results of these evaporation experiments showed negligible weight losses for the invert emulsion and synthetic hydraulic fluids; however, water glycol fluids were found to lose approximately 40 weight percent after 4 hours in either oven at 65°C. Data for the water glycol fluids, table 9, shows small differences between forced air circulating and convective oven samples. Fluids (nos. 1 and 2) after 2 hours in the forced air circulating oven samples lost more weight (2.3 and 6.2 percent more, respectively) than samples conditioned in the convective oven. Weight loss differences between the two ovens

Table 7. Effect of reduced cycling rate on ignition of as received synthetic hydraulic fluids

	Number of Cycles to Ignition	
Fluid No.	15 cycles/min.	25 cycles/min.
4	50	N
6	32	N
8	40	N
9	41	N
10	52	N
12	84	N

N = Nonignition

Table 8. Wick test results on hydraulic fluids

Hydraulic Fluid Type	No.	Number of Cycles to Ignition* As Received	2 hrs.	4 hrs.
Invert Emulsions	5	52	52	44
	7	55	47	41
	11	47	35	30
	13	66	75	60
	14	38	47	45
Water Glycols	1	92	14	10
	2	79	29	7
Synthetics	3	N	N	N
	4	N	N	N
	6	N	N	N
	8	N	N	N
	9	N	N	N
	10	N	N	N
	12	N	N	N

N = Nonignition
* Average: for five tests

Table 9. Comparison of wick test results for water glycol samples conditioned in an air circulating oven and convective oven

	2 Hour Conditioning				4 Hour Conditioning			
	Air Circulating Oven		Convective Oven		Air Circulating Oven		Convective Oven	
Fluid Number	Cycles to* Ignition	% Weight Loss	Cycles to* Ignition	% Weight Loss	Cycles to* Ignition	% Weight Loss	Cycles to* Ignition	% Weight Loss
1	14	31.0	50	28.7	10	41.1	12	40.7
2	29	29.1	47	22.9	7	39.2	11	37.8

* Average: for three tests

decreased for samples conditioned for 4 hours in the ovens. These weight loss data showed that fluid no. 1 lost 0.4 percent more in the air circulating oven and no. 2 lost an additional 1.4 percent in the same oven.

Wick tests were also performed on water glycol samples conditioned in the two ovens. The data illustrated, table 9, show that the samples conditioned for 2 hours in the convective oven took longer to ignite (50 and 47 cycles) than samples conditioned for the same length of time in the forced air circulating oven (14 and 29 cycles). Comparable weight losses were obtained for samples from both ovens conditioned for 4 hours. The number of cycles to ignition was also comparable, but the forced air circulating oven samples were still lower, 7 and 10 cycles, than the convective oven samples, 12 and 11 cycles, for fluid nos. 1 and 2, respectively.

4. ALTERNATIVE TEST METHODS

Two alternative test methods were developed for the evaluation of the effects of evaporation on the flammability of hydraulic fluids. These tests were developed with the aim of improving on the repeatability and reproducibility of the existing Wick Test method (see section 4.3). One was a hot wire coil test that exposed fluid soaked wick samples to radiant and convective heat. The other test exposed wick samples to sustained flame contact. Both tests measured times (seconds) to ignition.

4.1 Hot Wire Coil Test

The hot wire coil test exposes fluid soaked wick samples [2.5 cm (1 in) in length] to radiant and convective heat from an electrically heated wire coil. The time (seconds) to ignition of the wick sample is recorded. The hot wire coil test apparatus is shown in figure 1.

The coil is made of 16 turns of 22-gage nichrome resistance wire (3,301 ohm/m) with a diameter of 8 mm. The coil ends are attached to the tops of 2.5 cm (1 in) high ceramic posts which are attached to a plywood base. The post centers are 5 cm apart. The top of the coil is flush with the top of the posts. A wick holder made of aluminum rods and a wood base supports the wick for test 4 mm above and central to the coil. The coil is powered by an AC autotransformer adjusted to approximately 13 ± 1 volt and is calibrated for test by using (kerosene) soaked wicks which ignited in 6.0 ± 0.2 seconds.

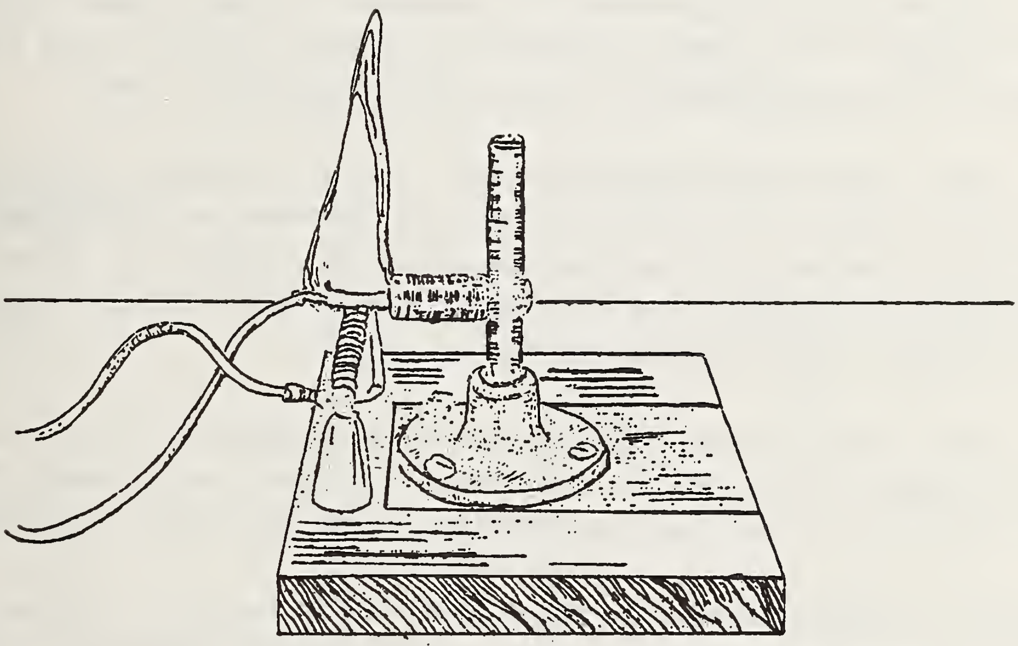

FIGURE 1.
HOT WIRE WICK TEST APPARATUS

Sample conditioning is the same as for the MSHA Wick Test. Table 10 lists the results of tests on 14 hydraulic fluids exposed to the hot wire coil. As previously noted, the synthetic fluids did not ignite. The invert emulsions increased their resistance to ignition after oven conditioning, while ignition resistance of the water glycols decreased. After 2 hours in the oven, the ignition times for the water glycols approached that of the kerosene wick samples.

4.2 Sustained Flame Contact Test

This test exposes fluid soaked wick samples to direct flame contact. The test uses the same fluid sample preparation, wicks, artificial gas burner, and methane gas (96 percent methane) as used for the MSHA Wick Test.

The burner flame height [10 cm (4 in)] is also similar. The bunsen burner is mounted on a pivot that allows for the easy movement of the burner from a 45 degree holding location to a vertical position (see figure 2). When in a vertical position the distance from the burner top to the test wick (which traverses the burner flame diameter) is 7.5 cm (3 in).

For test, a fluid soaked wick is mounted horizontally in the wick holder, the burner is moved to an upright position and a timer is started. The elapsed time from the start of the test to ignition of the test wick is recorded.

Results of sustained flame contact tests on 14 hydraulic fluids are listed in table 11. These data indicate that, for these test conditions, unconditioned synthetic fluids ignited in the shortest amount of time followed by invert emulsions and water glycols. After conditioning in an oven for 2 hours, invert emulsions produced slightly lower ignition times, while synthetics were not significantly affected. Water glycols, however, showed dramatic decreases in their ability to resist ignition from 25 and 29 seconds to 3 seconds.

4.3 Comparison of Test Methods

A comparison of test results obtained by the three different test methods (see table 12) shows that the sustained flame contact test was most severe on synthetic fluids when tested in their original state, while the MSHA wick and hot wire coil tests failed (with one exception) to produce ignitions for tests on the synthetic fluid materials.

All test methods ranked the water glycol fluids slightly more resistant to ignition than the invert emulsion fluid materials.

Table 10. Results for hot wire coil tests on 14 hydraulic fluids

Hydraulic Fluid Type	No.	Fluid Conditioning As Received	 2 hrs. @ 65°C	 4 hrs. @ 65°C
		(Time - Sec. to Ignition)*		
Invert Emulsions	5	30	34	42
	7	30	51	49
	11	29	50	55
	13	28	61	56
	14	43	60	63
Water Glycols	1	53	9	6
	2	50	7	9
Synthetics	3	N	N	N
	4	N	N	N
	6	N	N	N
	8	N	N	N
	9	N	N	N
	10	N	N	N
	12	N	N	N

N = Nonignition
* Average: for five tests

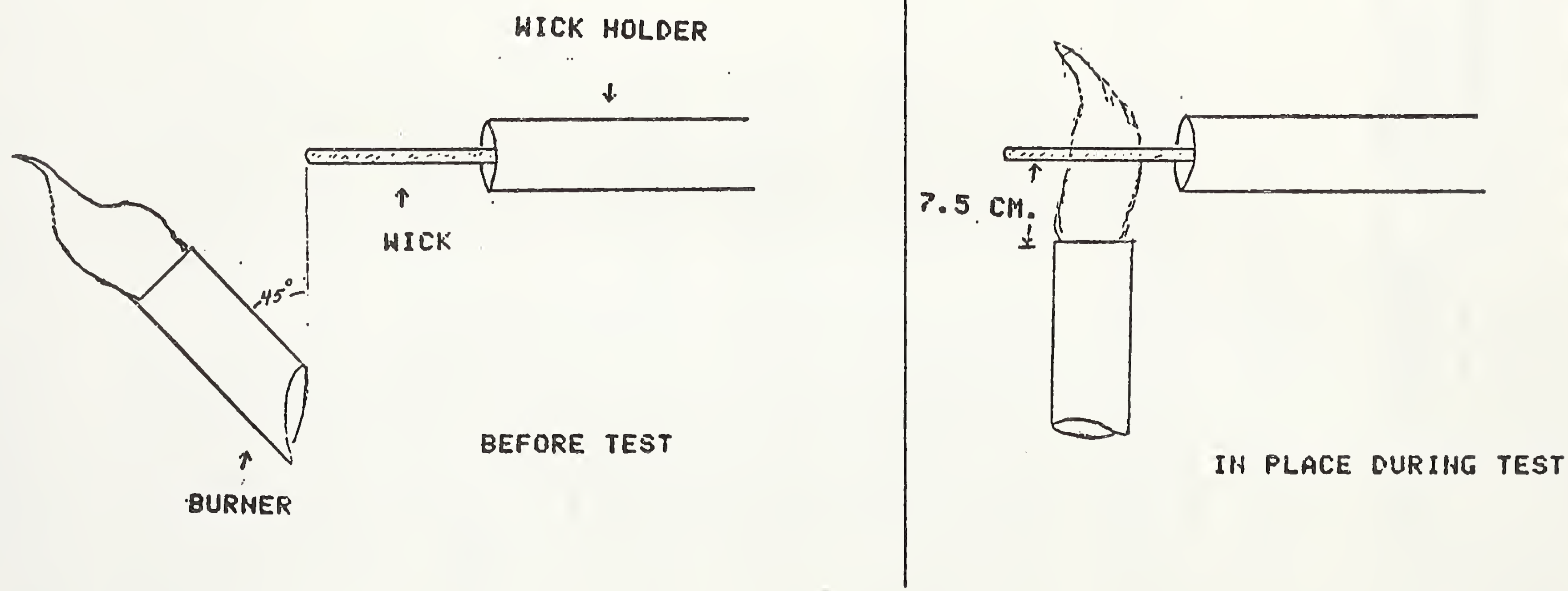

FIGURE 2.
SUSTAINED FLAME CONTACT TEST

Table 11. Results for sustained flame contact tests on 14 hydraulic fluids

Hydraulic Fluid Type	No.	Fluid Conditioning: 0-Time	2 hrs.	4 hrs.
		(Time - Sec. to Ignition)*		
Invert Emulsions	5	18	13	12
	7	20	17	17
	11	20	18	17
	13	18	17	17
	14	24	18	19
Water Glycols	1	25	3	3
	2	29	3	2
Synthetics	3	6	6	6
	4	8	7	6
	6	10	7	8
	8	8	9	10
	9	8	7	8
	10	10	6	5
	12	7	6	6

* Average: for five tests

Table 12. Results of tests on hydraulic fluids in "as received condition" by three different test procedures

Hydraulic Fluid Type	No.	Wick Test (Cycles)	Est. Sec.*	Hot Wire Coil Test (Time - Sec.)	Sustained Flame Contact Test (Time - Sec.)
Invert Emulsions	5	52	6	30	18
	7	55	7	30	20
	11	47	6	29	20
	13	66	8	28	18
	14	38	5	43	24
Water Glycols	1	92	11	53	25
	2	79	9	50	29
Synthetics	3	N		N	6
	4	N		N	8
	6	N		N	10
	8	N		N	8
	9	N		N	8
	10	N		N	10
	12	43	5	N	7

* Estimated total exposure time - (sec.) for wick in flame

Table 13 lists the results of tests for all three test methods when the fluids were tested subsequent to oven conditioning. An examination of these data shows that the water glycol fluids were the most susceptible to ignition by all of the test methods; however, the tests did not agree on the ranking of the synthetic and invert emulsion fluids.

Table 14 lists the average number of cycles or times to ignition along with the standard deviation for the invert emulsions and water glycol fluid materials.

A comparison of the variance, which is the square of the standard deviation, for the hot wire coil test to the Wick Test and the sustained flame contact test to the Wick Test shows that in 18 of 21 cases, the variability of the sustained flame contact test was less than the variability of the Wick Test while 13 of 21 cases demonstrated that the variability of the Wick Test was less than the hot wire coil test.

The greater variability of the test results in the Wick Test as compared to the sustained flame contact test was due to the random nature of drop formations. Early cycling of the wick through the bunsen burner flame causes the fluid to bubble on the wick. Droplets are formed from the bubbling fluid in a random manner and these fall from the wick during that part of the cycle when the wick is not in the burner flame. The wick re-enters the flame with less fluid material on it and with repeated cycles either more bubbles are formed or the wick ignites. The sustained flame contact test does not have this problem.

5. CONCLUSIONS

The Center for Fire Research conducted an evaluation of the Code of Federal Regulations, Schedule 30, Part 35, test (used by MSHA) to determine the effect of evaporation on the flammability of hydraulic fluids. Based on the results of its investigation the following conclusions are drawn.

- The test method does not clearly define the type of burner used in the test. The orifice size of the burner is not specified.

- The type of gas used in the test is not identified.

- No procedures are provided for monitoring the gas flow to the burner.

Table 13. Results of tests on hydraulic fluids conditioned for 2 hours and 4 hours in an oven at 65°C and tested by three different test procedures

Hydraulic Fluid Type	No.	Wick Test 2 hrs.	Wick Test 4 hrs.	Hot Wire Coil Test 2 hrs.	Hot Wire Coil Test 4 hrs.	Sustained Flame Contact 2 hrs.	Sustained Flame Contact 4 hrs.
		(Cycles to Ignition)		(Time - Sec. to Ignition)		(Time - Sec. to Ignition)	
Invert Emulsions	5	52	44	34	42	13	12
	7	47	41	51	49	17	17
	11	46	30	50	55	18	17
	13	75	60	61	56	17	17
	14	47	45	60	63	18	19
Water Glycols	1	14	10	9	6	3	3
	2	29	7	7	9	3	2
Synthetics	3	N	N	N	N	6	6
	4	N	N	N	N	7	6
	6	N	N	N	N	7	8
	8	N	N	N	N	9	10
	9	N	N	N	N	7	8
	10	N	N	N	N	6	5
	12	N	N	N	N	6	6

Table 14. Comparison of the standard deviation(s) for three different wick test procedures

Hydraulic Fluid No.	Wick Test (Oven) Time	Cycles*	S	Hot Wire Coil (Time) Sec.*	S	Sustained Flame Contact (Time) Sec.*	S
	0	52	2.59	30	7.05	18	0.84
5	2 hrs.	52	8.37	34	4.60	13	1.52
	4 hrs.	44	2.61	42	7.67	12	1.67
	0	55	2.35	30	2.99	20	1.92
7	2 hrs.	47	4.44	51	1.64	17	1.34
	4 hrs.	41	1.58	49	4.62	17	1.14
	0	46	9.34	29	3.79	20	1.30
11	2 hrs.	35	4.12	50	3.51	18	1.14
	4 hrs.	30	2.88	51	9.89	17	0.89
	0	66	5.98	28	2.99	18	0.50
13	2 hrs.	75	4.55	61	10.01	17	1.10
	4 hrs.	60	3.78	56	8.20	17	1.10
	0	38	4.98	42	5.50	24	2.00
14	2 hrs.	47	2.30	60	2.50	18	1.30
	4 hrs.	45	0.96	63	5.12	19	1.92
	0	92	5.13	53	2.06	25	4.09
1	2 hrs.	14	0.71	9	1.14	3	0.00
	4 hrs.	10	2.61	9	2.35	3	0.00
	0	79	3.13	50	3.30	29	5.22
2	2 hrs.	29	5.03	7	1.64	3	0.71
	4 hrs.	7	1.10	6	1.57	2	0.55

* Average for five tests each data cell

- The pipe cleaner stems (wicks) are not sufficiently described; e.g., the amount of combustible on the wick, etc.

- The distance of the wick to the top of the burner is not specified.

- The meaning of self-sustained flame is not clear (Note: A cycling wick will sometimes ignite but then go out before it re-enters the burner flame.). Some laboratories do not consider this an ignition.

- The repeatability of the Wick Test is hampered by the fact that fluid droplets tend to fall off the wicks in a random manner during test and thus fluid rich wicks would necessarily take more cycles to ignite. This may lead to a wide spread in the number of cycles to ignition for a single fluid material.

- Since repeatability of the test may be poor in one laboratory, it is likely that the reproducibility of the Wick Test between laboratories would also be less than adequate.

- The sustained flame contact test should be considered by MSHA as a replacement to the Wick Test. This test provides the following advantages: (1) the time the wick sample remains in the test flame is not variable as in the case of cycling wicks in the MSHA Wick Test, (2) the problem of fluid material falling or dropping off the wicks during test is eliminated, and (3) the sustained flame contact test was found repeatable for tests on hydraulic fluids in the laboratory and would most likely be found to produce reproducible test results between laboratories.

APPENDIX

MSHA Wick Test to Determine the Effect of Evporation on the Flammability of Hydraulic Fluids

(A) Test Apparatus

(1) Oven (gravity convection type) for conditioning fluid samples.

(2) Petri dishes 90 x 16 mm to contain samples for conditioning in the oven.

(3) Wicks--pipe cleaner stems (Dill or equivalent).

(4) Bunsen burner fired with methane gas (96 ± 1 percent methane).

(5) Cycling device (electrically operated windshield wiper mechanism or equivalent).

(B) Sample Preparation

A total of 15 wicks each 7.5 cm (3 in) long are required for test. Five wicks are soaked in original state fluid, five in fluid conditioned for 2 hours in an oven operated at a temperature of 65°C (150°F), and five in fluid conditioned for 4 hours at the same temperature. Each wick is soaked for at least 2 minutes and is allowed to drain for 1 minute before test.

(C) Test Procedure

The bunsen burner flame is ignited and adjusted to produce a 10 cm (4 in) high nonluminous flame.

A prepared wick sample is mounted in the sample holder positioned at the end of a 90 degree arc farthest away from the burner flame.

A test is started by cycling the wick sample into the burner flame (at the rate of 25 ± 2 cycles per minute) and making a count of the number of times the wick cycles into the burner flame without ignition. (Note: Ignition is defined here as sustained flaming on a wick traveling away from and back into the burner flame.)

Five tests are made for each fluid condition, i.e., original, 2 hour, and 4 hour oven conditioned samples.

(D) Test Criteria

A hydraulic fluid is classified as fire resistant by the MSHA Wick Test if the following conditions were met:

(1) Original state fluid must cycle at least 25 times without ignition.
(2) Two hour samples must cycle at least 18 times without ignition.
(3) Four hour samples must cycle at least 12 times without ignition.

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4. TITLE AND SUBTITLE

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5. AUTHOR(S)

Joseph J. Loftus

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

Final Report

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

U.S. Bureau of Mines
Pittsburgh, Pennsylvania 15213

and

Mine Safety and Health Administration
Triadelphia, West Virginia 26059

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

This report is an evaluation and analysis of "The Test to Determine the Effect of Evaporation on the Flammability of Hydraulic Fluids (Wick Test)." The Wick Test is used by the Mine Safety and Health Administration (MSHA) to qualify hydraulic fluids for use in underground coal mines. This report includes a review of the test method's operating characteristics as well as a comparison of test results from the Wick Test with two alternative test procedures--a hot wire coil test and a sustained flame contact test. The evaluation program included currently used fluids such as invert emulsions, synthetics, and water glycols. The Wick Test studies showed that the test method was not well defined and that reproducibility was poor.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

Coal mines; hydraulic fluids; ignition; flammability; wick test.

13. AVAILABILITY

[XX] Unlimited
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