1.0 PURPOSE

1.1. This document establishes MSHA's Standard Test Procedure (STP) for the Determination of Effect of Evaporation on the Flammability of Hydraulic Fluids: 30 CFR, Section 35.22.

1.2. The purpose of the test is to determine the effect of evaporation on the reduction of fire resistance of a hydraulic fluid.

2.0 SCOPE

2.1. This document applies to all applications for MSHA approval of Fire-resistant Hydraulic Fluids (FRHF) and audits involving MSHA approved FRHFs. The following types of hydraulic fluid are required to meet the evaporation test of 30 CFR, Section 35.22:

a. Water-glycols,
b. Synthetic fluids including phosphate-ester, phosphate ester base and halogenated hydrocarbon base fluids,
c. Water in oil emulsions,

2.2. **Note**: The evaporation test is waived for high water emulsions (also known as 95/5 fluids) because the percent of water lost by evaporation would reduce the fluid in the hydraulic system to a level that it could not operate (see CDS Document APOL5006: Policy Concerning Flammability and Physical Testing of Hydraulic Fluids Submitted for MSHA Approval Under 30 CFR, Part 35).

3.0 REFERENCES

3.1. This document supersedes CDS document ASTP4015 (dated: April 1980).

3.2. 30 CFR, Part 35, Subpart A & B

4.0 DEFINITIONS

4.1. Permissible – as applied to hydraulic fluids, means that the fluid conforms to the requirements and a certificate of approval has been issued.

4.2. Certificate of Approval – means a formal letter issued by MSHA stating the fluid has met the requirements as defined in 30 CFR, Part 35 and authorizing the use of an official identifying marking so indicating.

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

4.4. Applicant – means an individual, partnership, company, corporation, association, or other organization that manufacturers, compounds, refines, or otherwise produces a fire-resistant hydraulic fluid or a concentration and seeks a certificate of approval.

4.5. Concentrate – means a substance in concentrated form that might not be fire-resistant in its original state but when mixed with water or other vehicle in accordance with instructions from the applicant will constitute a fire-resistant hydraulic fluid.

4.6. Emulsion - A mixture of oil and water in which water is the continuous phase, and having a water content as high as 95% by volume.

4.7. Invert Emulsion – A mixture of oil and water in which oil is the continuous phase, and usually having a water content between 40% and 45% by volume.

4.8. Glycol – A mixture of water and a dihydric alcohol such as ethylene glycol.

4.9. Synthetic – A mixture of chemical compounds, containing no water.

5.0 TEST EQUIPMENT

5.1. Oven – Evaporation of the candidate hydraulic fluid will be made in a gravity convection oven operated and maintained at a temperature of 150° ±2°F (65 ±1°C). Air currents will not be mechanical or otherwise induced within the oven (see Figure 1).

5.2. Petri Dishes – Standard laboratory heat resistant glass petri dishes approximately 0.5 inches (12.7 mm) deep and 3.5 inches (90 mm) in diameter fitted with matching lid covers will be used to contain the fluid samples for oven evaporation and testing. Note: Lid covers will be used to cover the dishes after their removal from the oven.

5.3. Wicks – An ordinary smoker's pipe cleaner (U.S. Tobacco Co. Dill's or equivalent) will be used in the test procedure. The pipe cleaner's base wire thickness will be 0.03 – 0.04 inch (0.75 – 1.0 mm) and have a combustible content of 0.015 – 0.025 gram per inch.

5.4. Drainage Rack – to hold the fluid soaked pipe cleaner wicks during the 2-minute drain period (see Figure 2).

5.5. Balance – capable of reading to 0.01 grams used to weigh the petri dish and fluid before and after the prescribed oven time.

5.6. Electric Timer – or stopwatch capable of at least 0.2 second interval measurement.

5.7. Wick Cycling Apparatus – The cycling device used for testing will be capable of cycling wick samples in a horizontal plane (through a 90° arc) into a flame ignition source at the rate of 25 plus/minus 2-cycles per minute. Note: an automobile windshield wiper mechanism or other device capable of producing the specified cycling rate may be used for testing (see Figure 3).

5.8. Ignition Source – A Bunsen burner with an orifice of 0.35 inches and with an ID x H dimension of 0.35 inches x approximately 6 inches (8.9 mm x 152.4 mm) fired with methane gas (96.1 ± 1% methane) will be used as the ignition source for the test. The burner will be capable of producing an overall blue flame without forming a sharp inner cone.

5.9. Flowmeter – Gas flow to the Bunsen burner will be monitored by a flowmeter calibrated for methane gas delivery over a range of 0.04 – 0.07 cubic feet per minute (1133 – 1982 cubic cm per minute) at STP.

6.0 TEST SAMPLES

See Section 7.2 of this procedure.

7.0 PROCEDURES

7.1. General Test Description

7.1.1. The purpose of the test is to determine the effect of evaporation on the reduction of fire resistance of a hydraulic fluid. The test data obtained is used (along with data obtained under 30 CFR, Section 35.20 and 35.21) as a basis for approval or rejection of the product for use in underground mines.

7.1.2. Three (3) 30-milliliter samples of the fluid are placed in open petri dishes. One sample is tested and used "as received" (before evaporation), the

second sample is placed in an oven at 150°F for 2-hours and the third sample is placed in an oven at 150°F for 4-hours. After the 2 and 4-hour evaporation phase, each sample is removed from the oven and weighted to determine the percent weight of fluid lost due to evaporation. After cooling to room temperature, place a lid on the petri dish.

7.1.3. When conducting the ignition test, five (5) 3-inch lengths of pipe cleaner are submerged in each of the petri dishes for 2-minutes, removed, permitted to drain at least 2-minutes, and then subjected to tests on an electrically operated cycling device over a stationary Bunsen burner flame. In order for the fluid to be considered fire-resistant, the soaked wicks must pass over the stationary flame without igniting (before attaining a self-sustaining flame) the following number of cycles (see Figure 4).

a. 24 cycles for the "as received" fluid,
b. 18 cycles for the 2-hour evaporation fluid,
c. 12 cycles for the 4-hour evaporation fluid.

7.2. **Sample Preparation**

7.2.1. Prior to beginning the test the investigator should complete the appropriate information on the Wick Evaporation Test Sheets #1 and 2 (see Figures 5 & 6).

7.2.2. Prepare a total of 15 wicks for testing the candidate fluid (each 3 inches long (7.5 cm). In addition, prepare three petri dishes with 30 ml of fluid in each. Set one petri dish aside for tests on the fluid in its "as received" state and place the other two dishes (uncovered) into the oven operating and maintained at 150° ±2°F (65 ±1°C).

7.2.3. After 2-hours, remove one of the dishes from the oven and weigh it to determine the percent weight of fluid lost due to evaporation. After cooling to room temperature, place a lid on the petri dish.

7.2.3.1. Document your results on the Wick Evaporation Test Sheet #1 (see Figure 5).

7.2.4. After 4-hours, remove the remaining dish from the oven and repeat the above procedures.

7.2.4.1. Document your results on the Fluid Evaporation Test Sheet. #1 (see Figure 5).

7.2.5. A total of 5 wicks will be allotted for testing on each of the fluid samples (i.e. "as received", 2-hour and 4-hour).

7.2.6. Use tweezers to place the wicks into each of the petri dishes containing the test fluid and allow each wick to soak separately in the fluid sample for at least 2-minutes. Note: To ensure complete wetting, use tweezers to move the wicks around in the test fluid.

7.2.7. After soaking for 2-minutes, remove the wick from the petri dish and place it on the wick drainage rack for at least 2-minutes but no longer than 2.5 minutes before testing.

7.3. **Testing Preparations**

7.3.1. All testing will be conducted within a draft free fume hood capable of exhausting smoke and fumes produced during testing.

7.3.2. With a spare wick mounted in the wick holder (see Figure 3) ensure that the vertical distance from the wick to the burner top is 3.0 ± 0.125 inches (7.6 ± 0.3 cm).

7.3.3. Turn on and monitor the wick cycling device to ensure that:

a. the cycling rate is 25 ±2 cycles per minute,
b. that the midpoint of a cycle ends with the wick directly over the middle of the burner and
c. that the wick holder arm has a cycling radius of 4 ± 1/8 inch.

7.3.4. Turn on and adjust the methane gas flow to the Bunsen burner to 0.05 cubic feet per minute (1416 cubic cm per minute). Note: the burner flame will be blue with no appreciable inner cone and be approximately 4-inches (10 cm) in height.

7.3.5. At the start of the test, the wick holder arm will be located at the extreme end of a cycle (i.e. the greatest distance away from the burner flame). Mount a fluid soaked wick sample into the holder arm (using tweezers) and ensure that a 2 ± 1 inch (5 ± 0.2 cm) length of stem extends horizontally from the holder end.

7.4. **Testing**

7.4.1. Start the cycling device and record the number of times that the wick cycles into the burner flame until a self sustaining flame is observed on the wick. Note: a self sustaining flame is defined as one in which the wick becomes ignited and travels while flaming to the extreme end of a cycle (away from the burner) and is still flaming on its return and reentry into the burner flame.

7.4.1.1. A total of 5 tests will be performed on each of the three samples of fluid (i.e. "as received" fluid, 2-hour evaporated fluid and 4-hour evaporated fluid).

7.4.1.2. The average values for 5 test sets on each of the three samples will be taken as the test results.

7.4.2. Record the "Pass" or "Fail" tests results on the Wick Evaporation Test Sheet #2 (see Figure 6).

7.5. **MAINTENANCE**

7.5.1. After test completion, all equipment (wick cycling apparatus, petri dishes etc.) should be cleaned.

7.6. **TEST MODIFICATIONS**

7.6.1. 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 TEST DATA

8.1.1. In order for the candidate fluid to meet the flammability requirements of the wick test, the three samples must meet or exceed the following minimum number of cycles for the (i.e. "as received" fluid – 24 cycles, 2-hour evaporated fluid – 18 cycles, and 4-hour evaporated fluid – 12 cycles).

8.1.2. Test results are summarized in MSHA's approval and audit documentation files of fire-resistant hydraulic fluids.

9.0 PASS/FAIL CRITERIA

See Section 8.0 of this document.

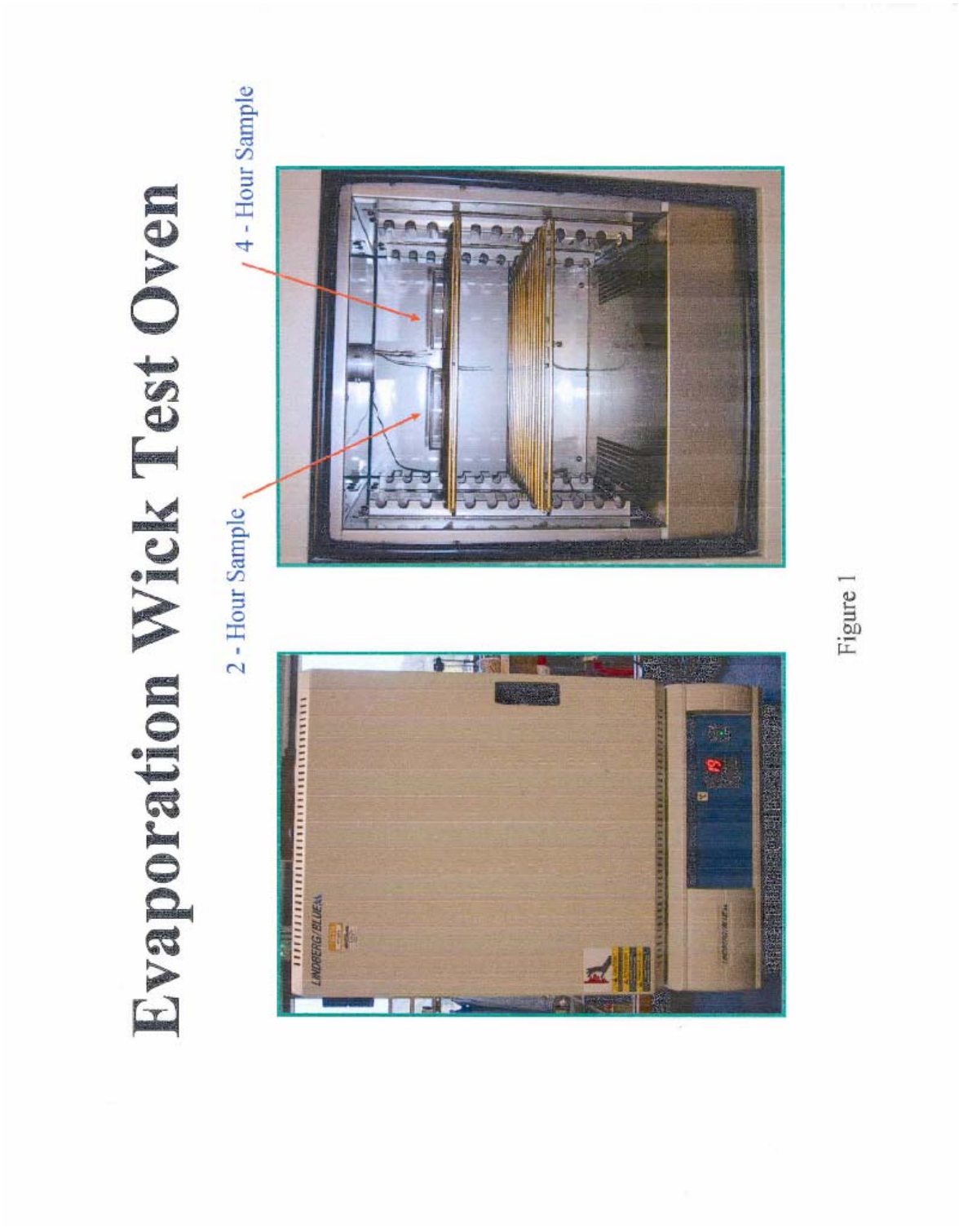

Figure 1

Evaporation Wick Drainage Rack

Figure 2

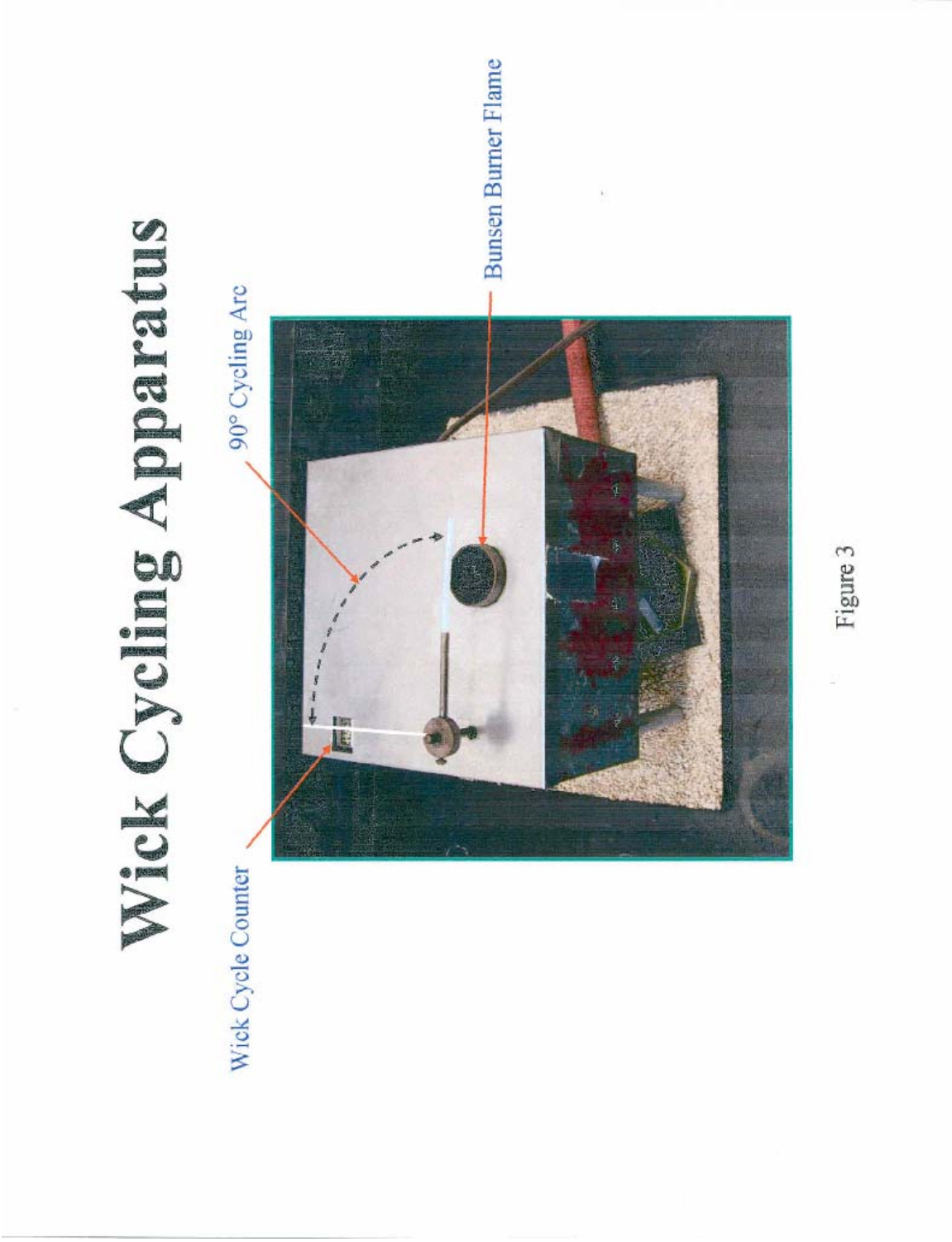
Wick Cycling Apparatus
Bunsen Burner Flame
90° Cycling Arc
Wick Cycle Counter

Figure 3

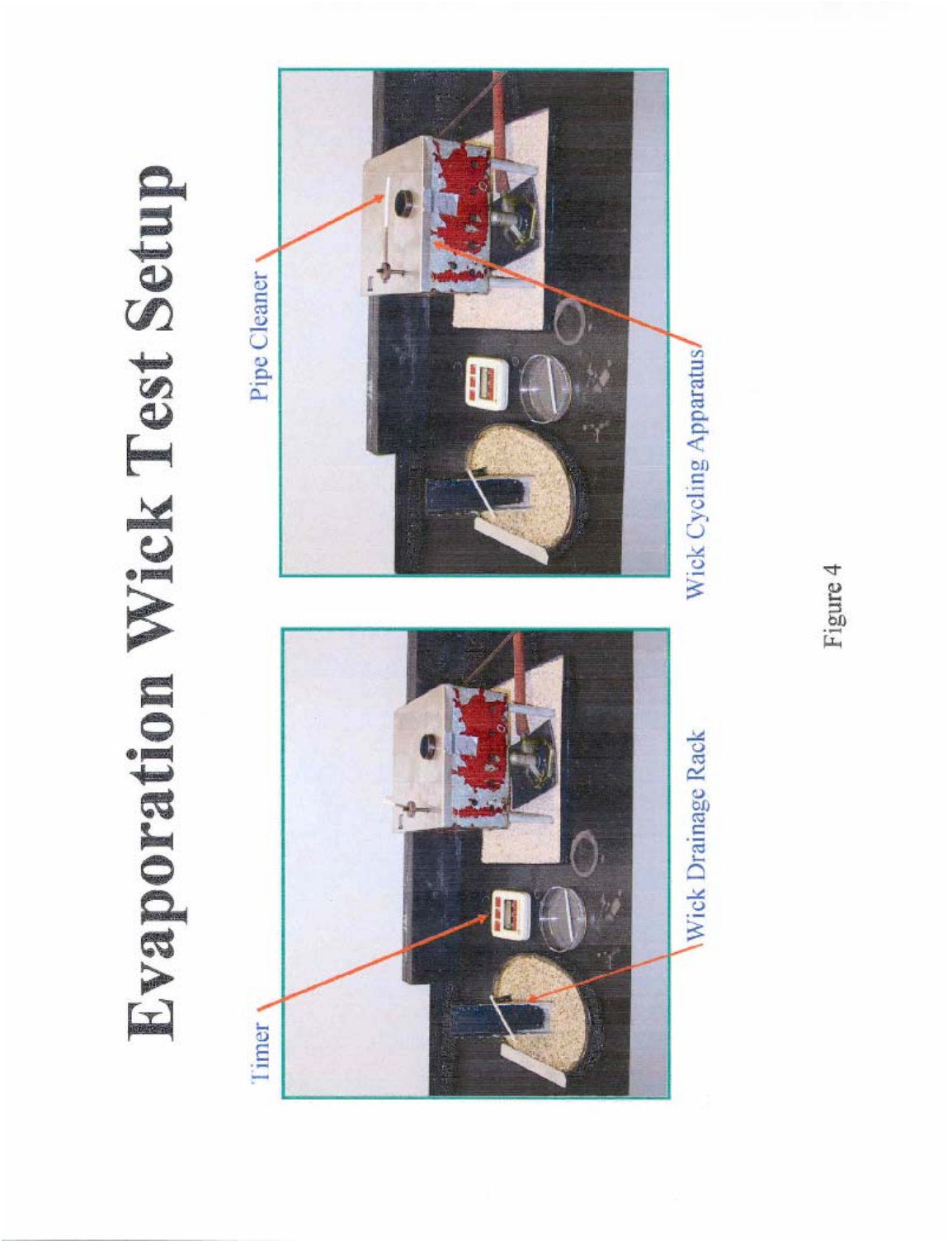
Evaporation Wick Test Setup
Pipe Cleaner
Wick Cycling Apparatus
Timer
Wick Drainage Rack

Figure 4

Wick Evaporation Test Sheet #1

Effect of Evaporation on Flammability Test: 30 CFR, Part 35, Section 35.22		
PAR No.		
Company:		
Trade Name:		
Hydraulic Fluid Type:		
Tested By:		
Date:		
As Received Sample (Before Evaporation)	**Sample after 2 hour evaporation**	**Sample after 4 hour evaporation**
A. Dish wt. grams	A. Dish wt. grams	A. Dish wt. grams
B. Fluid wt. grams	B. Fluid wt. grams	B. Fluid wt. grams
C. Dish & fluid wt. grams	C. Dish & fluid wt. grams	C. Dish & fluid wt. grams
D. Post evap. wt. (dish & fluid) grams	D. Post evap. wt. (dish & fluid) grams	D. Post evap. wt. (dish & fluid) grams
E. Fluid loss grams	E. Fluid loss grams	E. Fluid loss grams
F. % fluid lost ($^{E}/_{B}$) %	F. % fluid lost ($^{E}/_{B}$) %	F. % fluid lost ($^{E}/_{B}$) %
Conditions:	Conditions:	Conditions:

Figure 5

Wick Evaporation Test Sheet #2

Effect of Evaporation on Flammability Test: 30 CFR, Part 35, Section 35.22		
PAR No.		
Company:		
Trade Name:		
Hydraulic Fluid Type:		
Tested By:		
Date:		
As Received Sample (Before Evaporation)	**Sample after 2 hour evaporation**	**Sample after 4 hour evaporation**
Test (1): cycles	Test (1): cycles	Test (1): cycles
Test (2): cycles	Test (2): cycles	Test (2): cycles
Test (3): cycles	Test (3): cycles	Test (3): cycles
Test (4): cycles	Test (4): cycles	Test (4): cycles
Test (5): cycles	Test (5): cycles	Test (5): cycles
Average No. cycles	Average No. cycles	Average No. cycles
Average required to pass: 24	Average required to pass: 18	Average required to pass: 12
Comments:	Comments:	Comments:

Figure 6