Recommended Practice for the Operation, Maintenance and Testing of Firebox Flame Arrestors

API RECOMMENDED PRACTICE 12N
SECOND EDITION, NOVEMBER 1, 1994

REAFFIRMED: APRIL 2008

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Exploration and Production Department

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FOREWORD

The bar notations identify parts of this standard that have been changed from the previous API edition.

This standard shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

Recommended Practice for the Operation, Maintenance and Testing of Firebox Flame Arrestors

1 Scope

1.1 This recommended practice should be considered in the installation, maintenance and testing of firebox flame arrestors installed on the air intake of oilfield production equipment. Flame arrestors are commonly used on indirect heaters, emulsion treaters, glycol reconcentrators and other equipment used to heat fluids in production operations. These flame arrestors are designed to prevent flashback through the arrestor in the event that combustible fluids in the atmosphere should be drawn into the heater through the air intake and come in contact with the main burner or pilot flames.

1.2 This recommended practice is limited to gas fired, natural draft burner systems with continuously burning pilots. Flame arrestors for oil fired burners or burner systems using forced draft or induced draft are outside the coverage of this recommended practice. Also excluded from coverage of this recommended practice are burner systems in which a spark produced by the system could cause an internal explosion such as with a spark ignition device.

1.3 Equipment known as line arrestors, tank arrestors, spark arrestors, or stack arrestors are outside the coverage of this recommended practice.

1.4 Some of the recommended practices for field testing after installation may not be applicable to equipment located in confined areas. The user may modify these recommended practices as required to satisfy his own specific needs.

2 Definitions

2.1 access opening: An opening which allows communication to the interior of the flame arrestor housing making the mixer, pilot, burner, etc., accessible. This opening is normally closed by a flat plug or plate 3" to 4" in diameter, securely attached to the housing and tightly sealed against the opening.

2.2 breeching: An extension of the firetube outside of the vessel which is being heated. The arrestor breeching serves as the attachment for the flame arrestor and surrounds the mechanical devices such as mixer, igniter, etc.

2.3 mixer, pilot, burner: Mechanical devices located in the arrestor housing and breeching which mix the fuel and air and control burning and flame position.

2.4 combustion: The chemical reaction of rapid oxidation which is accompanied by the emission of light and heat—the flame. Combustion begins when the temperature of the ignitable substance reaches its apparent ignition temperature. This process will be self-sustaining as long as the heat released in combustion maintains the temperature within the flammable range of the ignitable substance.

2.5 firebox: The firebox is also called the firetube. It is the enclosure where the fuel is burned, and is submerged in the fluid to be heated. The most common configuration is one or more U-tubes. The fire is propagated in one end and exhausts into a stack on the other end.

2.6 flame arrestor: A device which prevents the propagation of flame from an enclosed area which contains the burner. If the area outside the enclosure were to contain an ignitable mixture, flashback would thus be prevented. The flame arrestor must be able to accomplish this without stopping the communication of air between the two areas.

2.7 flame arrestor element (flame cell): A device which is mounted in a housing that serves as the combustion air intake. Its function is to prevent propagation of the flame from the firebox to the outside atmosphere. Sustained exposure to direct flame impingement may render the element inoperative.

2.8 flame arrestor housing: An enclosure which contains the flame arrestor element and may contain mechanical devices such as mixer, air controller, etc. It bolts to the breeching.

2.9 manufacturer: The assembler or supplier of complete flame arrestor units.

2.10 stack: A vertical pipe on the exhaust end of the firetube which exhausts the products of combustion and creates draft through the firetube.

2.11 user: The owner or operator of the vessel containing the flame arrestor.

2.12 vessel: An enclosure containing fluid that is being heated.

3 Theory

3.1 Flame arrestor elements used on oilfield production equipment are designed to extinguish a flame caused by the ignition of combustible gas or vapor which has entered the firebox from the atmosphere surrounding the unit and has come in contact with the pilot or main burner flame, and thus prevent passage of the flame to the atmosphere. The flame arrestor is designed to remove heat faster than the heat may be generated by the combustion process. By maintaining a temperature lower than the ignition temperature of the ignitable substance, combustion is extinguished.

3.2 When a flammable mixture burns in a tubular enclosure, some of the heat of combustion is absorbed by the sur-

rounding walls. If the enclosure is of sufficiently small diameter, enough heat will be absorbed to prevent propagation of the flame. Therefore, the smaller the tube and the greater the coefficient of heat conductivity of the material from which the tube is made, the greater will be the dissipation of heat from the system. Aluminum is often used to form the element due to its corrosion resistance and heat transfer properties, although other materials such as stainless steel may be used. It is acknowledged that designs other than banks of parallel tubular enclosures could conceivably be used for arrestor elements. Placement of the element within the housing may be in either the horizontal or the vertical plane and is a matter of design choice.

3.3 The previous discussion points out the need to properly space the arrestor away from the flame. Should the distance be too short, the cooling effect of the arrestor may be offset by the heat of the flame. This might render the arrestor inoperative even if the element were intact and undistorted.

4 Operation

4.1 Proper operation is of critical importance in ensuring that the benefits of a properly designed firebox flame arrestor are realized.

4.2 The area immediately surrounding the firebox flame arrestor should be readily accessible and free of obstacles, such as piping or vessels, which would prevent unrestricted movement of personnel in the event of an emergency. The immediate area should be free of potential hazards such as relief valve outlets, instruments bleeding combustibles, or open drains, and should have adequate ventilation.

4.3 Before any firebox flame arrestor is put into operation, a visual inspection should be made to ensure that all fittings, gaskets, and bolts are in place. Personnel knowledgeable with gas firing accessories should confirm that there are adequate valves, regulators, and accessories for proper operation, and that these are installed correctly. According to the manufacturer's recommendation the proper location of the air/gas mixer, burner tip and pilot assembly should be verified. All automatic controls and devices should be inspected and actuated periodically to be sure they are operational and that they are properly set.

4.4 The burner should be put into operation according to the following recommended steps:

a. Make sure the atmosphere is suitable for open flame. The use of a portable combustible gas indicator is recommended.
b. Close all gas supply valves for the main burner and pilot.
c. Drain fuel gas scrubbers if so equipped.
d. Check for an adequate fluid level above the firetube. Ensure that the firebox and stack are clear and free of foreign debris.
e. Open the lighting port of the firebox. Do not stand directly in front of the firetube or the lighting port. Stand to the side, and up-wind, if possible, of the lighting port and end plate of the firetube. Under no circumstances should an individual crawl underneath a heater to light a pilot.
f. Determine if combustible gas is present. If a combustible gas indicator is available, check for combustibles in the pilot area and also down the firetube. If combustibles are indicated, recheck positive closing on the valves, wait for the firetube to ventilate, and retest for combustible gases. If a portable combustible gas indicator is not available, then adequate purge time, with all gas supply valves closed, must be allowed before trying to light the burner system. When a satisfactory gas check has been secured, proceed to light the pilot.
g. The torch should be premeasured to reach precisely to the pilot. Light the torch using diesel fuel or kerosene. The torch should be of such material that debris will not be left in the firebox after lighting.
CAUTION: Do not use gasoline or any other volatile fuel.

Pass the torch in front of the opening to check for possible flashback. (If flashback occurs, start over at Step a.) Insert the torch, placing it next to the pilot.

Leave the torch in position and slowly open the pilot valve until the pilot ignition is heard.
CAUTION: If the pilot does not light in a reasonable period of time, close the pilot valve and begin at Step f.

Remove the torch and extinguish.
CAUTION: Do not place the torch on the ground as hydrocarbons may be present.

4.5 The flame should be centered in the firetube. The burner should be regulated for continuous firing when possible. The air/gas mixture should be set to provide proper burning quality and to prevent hazardous firetube carbon deposits. This may require that the system be shut down, adjusted, and re-lit several times if the adjustments cannot be made without opening the arrestor housing.

5 Maintenance and Inspection

5.1 To maintain proper operation, the flame arrestor should be installed in a sturdy housing which is normally bolted to the firebox entrance. A gasket should be placed between the firebox entrance and the housing to ensure a proper seal. The housing is designed to hold the flame arrestor element, gas lines, mixer, pilot, and other accessories required for burner operation. Inspection, maintenance, and care of this equipment helps ensure that the equipment operates as intended.

5.2 A flame arrestor element is designed to form air paths of carefully controlled size, configuration and length. Anything which changes the size, configuration or length of the air passages may affect arrestor performance. Any air path from the exterior into the firetube which does not pass di-

rectly through the arrestor can similarly represent an impediment to proper operation of the unit. Visual inspection for unplugged holes or loose mounting flanges, which can cause a flash through, should be performed each time the equipment is approached. In addition, flame arrestor units require more detailed periodic inspection. Frequently observed defects are noted in the following paragraphs.

a. The seal between the flame arrestor and the firetube must be airtight. Similarly, any seam on the firetube such as the point where the stack joins the tube must be free of cracks or holes which allow a flame to escape.
b. Burners must be installed in such manner that there is no possibility of air bypassing the flame arrestor. Inspection ports (sight glasses) and access openings must be airtight when the unit is in service. Access closures must be securely fixed and sight glasses must be free of chips or cracks which might loosen, resulting in hazardous conditions.
c. The flame cell itself should be inspected for defects, deformation or heat damage. Any visible distortion or deformation is cause for immediate testing prior to returning the unit to service as described in the testing procedure or alternatively, replacement of the element and retesting.
d. Restrictions in the air passages can cause a flame arrestor to malfunction. Accumulations of dust, dirt, salt, corrosion products or other contaminants must be removed from the element periodically for proper functioning of the unit.
e. An arrestor should be inspected upon initial receipt and at any time the arrestor's performance is suspect. Site conditions and operational load will dictate the care and maintenance schedule required for the firebox flame arrestor and its components. Inspection frequency should generally not exceed one year in mild service. More frequent inspection is desirable in severe service such as in very dusty areas. If any defect or suspected defect is identified, testing of the unit is recommended.

6 Testing

6.1 Testing is recommended to ensure that two requirements of a flame arrestor are satisfied. The first is that the unit is properly designed and built. The second is that the arrestor is properly installed and remains in operating condition. The first requirement should be satisfied by the manufacturer. The second requirement should be met by the user after the flame arrestor has been properly installed and prior to its actual use, and repeated on a periodic basis to ensure operability of the flame arrestor. The frequency of these subsequent tests must be determined by the user based on the type of conditions to which the unit is subjected. Considering what is required of the flame arrestor, the need for periodic testing to ensure proper operability cannot be overemphasized.

6.2 Field testing is the responsibility of the user and should be conducted as described in paragraph 6.7. Manufacturers have the responsibility to conduct a program of testing as described in paragraph 6.7 which will assure that each material specification, air passage configuration, diameter and thickness of flame cell or element normally available is tested for flashback in each normally available housing type and size. It is recognized that a variety of burner configurations may exist for a given flame cell. It is the responsibility of the manufacturer to control the quality of each arrestor it manufactures to ensure that proper thickness, pore size, and configuration are maintained. Adequate quality control measures with periodic testing according to paragraph 6.7 should assure compliance of all arrestors, making routine testing of each complete arrestor assembly unnecessary. It is the option of the user to request any specific completed assembly be tested in the manner described below in paragraph 6.7 prior to delivery from the manufacturer.

6.3 The most severe test conditions exist when the atmosphere is completely calm. Unless such conditions do exist, appropriate shielding material should be available to create such conditions in front of the arrestor being tested.

6.4 Because of the nature of the tests, the following precautions are recommended in performing the tests in the field.

a. During the test the area around the unit being tested will contain ignitable mixtures. No potential sources of ignition should be present within the vicinity of the test location. All equipment in the area of the unit being tested should have all sources of ignition extinguished.
b. If the above condition cannot be fulfilled, the flame arrestor should be removed from the vessel and tested at a remote location. The disadvantage of this procedure is the fact that neither the breeching nor the accessory components of the firing system can be checked during such a test.
c. With the burner operating normally, the unit should be thoroughly checked to make sure that all holes are properly plugged, mounting flanges are tight and there are no other visible flash-through possibilities.
d. An adequate fire extinguisher should be available in the test area during the test. Personnel should be properly trained in the use of fire extinguishers and should wear fire retardant clothing and goggles or face shields.
e. If a stack damper is present, it should be placed in a fully open position.

6.5 The following equipment and materials should be used in performing the flame arrestor tests:

a. A 3/8" or 1/4" open-ended pipe at least ten feet long should be used to direct the ignitable mixture at the arrestor. This test pipe should be flexibly connected to the source of the gas so the ignitable mixture can be sprayed over the full area

of the arrestor (Figure No. 1).

b. Vapor from bottled liquefied petroleum gas with a minimum pressure of 20 psi should be used. The valves or regulators should be of sufficient size to give adequate flow through the 3/8" or 1/4" pipes. A regulator on the LPG system normally supplied with the small portable bottle often has an orifice too small to give the desired gas flow, so exclusion of the regulator on the LPG bottle is suggested.

c. The flame arrestor has to be flooded quickly with the ignitable mixture before the mixture reaches the pilot. To accomplish this, a quick opening valve of ball type or stop cock type should be used. Refer to Figure 1.

6.6 As pointed out earlier, actual field testing is the only way of ensuring that the flame arrestor has been installed in such manner as to promote proper operation. The user performs the test procedure as an onstream test which allows the flame arrestor to be tested under operating conditions. The manufacturer uses the test procedure to ensure that the flame arrestor is designed, manufactured and assembled properly. Testing by the manufacturer gives no assurance that the flame arrestor will be properly installed on the unit to be protected, nor are the breeching and accessory components of the firing system checked during the test. The flame arrestor will be considered properly tested provided the following procedures are followed by both manufacturer and user.

6.7 Test Procedure:

CAUTION: No person should attempt to test a flame arrestor while alone.

a. This procedure is not intended to test the ability to prevent flashback through the arrestor in the event that combustible gas builds up in the firebox and is subsequently ignited.

b. With the burner firing, the open end of the test pipe is placed in front of the arrestor so that the gas is drawn into the arrestor element (Figure No. 2). The valve is opened and a small amount of gas is instantaneously injected into the element resulting in ignition inside the firebox. The procedure is repeated with a minimum of 10 and preferably 20 of the test injections made at different points of the element.

c. After each ignition in the firetube, a check should be made to make sure that the pilot light and burner have not been extinguished. If the pilot and burners should be extinguished, fuel gas should immediately be shut off and provisions of Section 4.4 for relighting should be followed.

d. If the flame is propagated through the arrestor element at any point of the test, failure has occurred and the element should be replaced. Attempts should not be made to repair old elements after failure.

e. Additional instructions for users testing in the field: After the element is tested, other components of the gas burning system should be tested by directing small amounts of gas on them. These components would include breeching of the firetube in all places where the flame arrestor is attached; welding around the flame arrestor casing and around the firetube breeching; all the attaching flanges, plugs and connections. Testing of welding is desirable since ignition could take place through small holes in the welding. The testing of the breeching and the flame arrestor casing should be done when the heater is being fired at near full load conditions so that hot flue gases are present in the firetube and breeching.

6.8 If flashback is observed after any injection, the arrestor element or flame cell should be considered unserviceable. It should be replaced with a new element and retested.

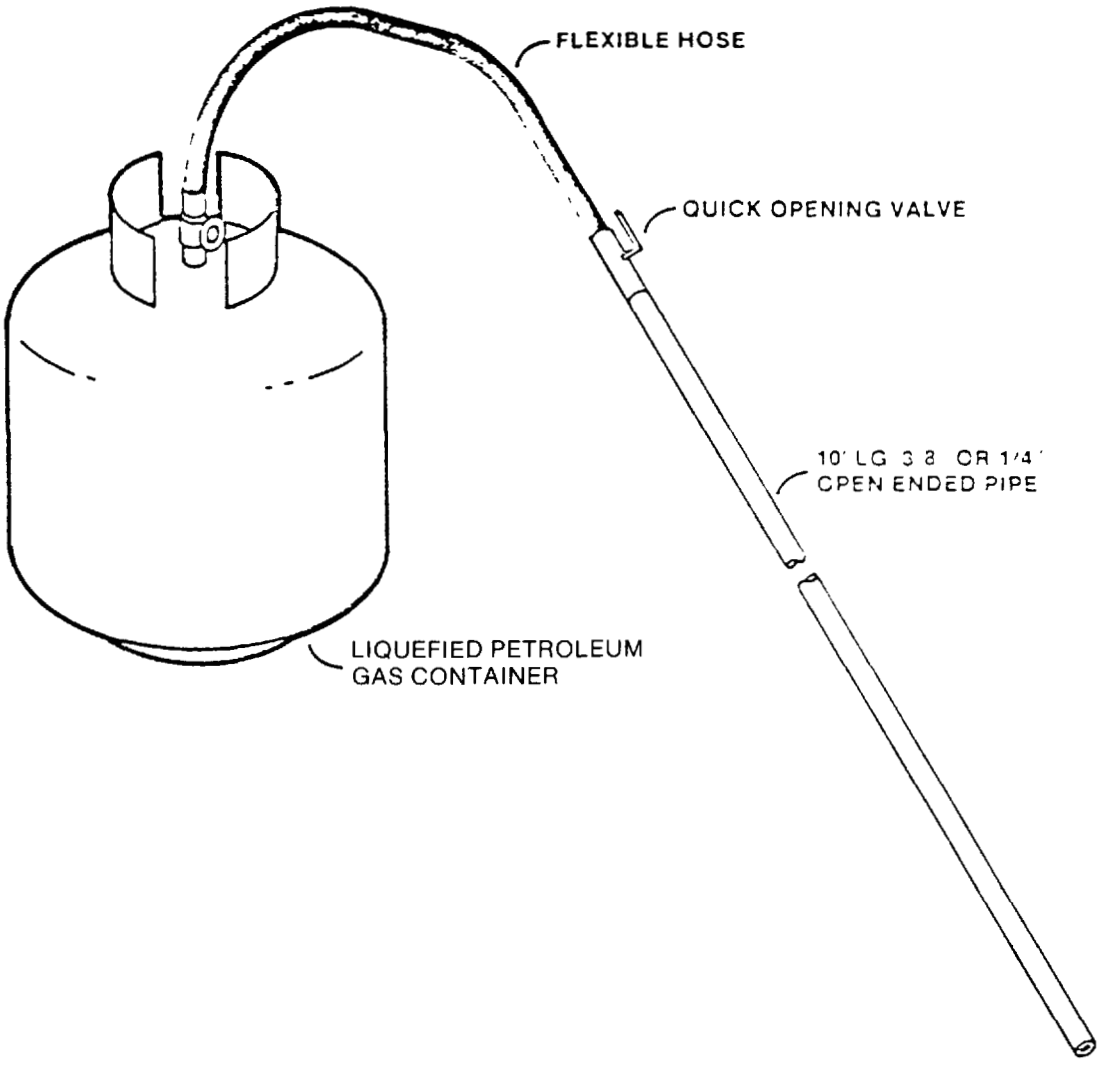

Figure 1—Equipment for Testing

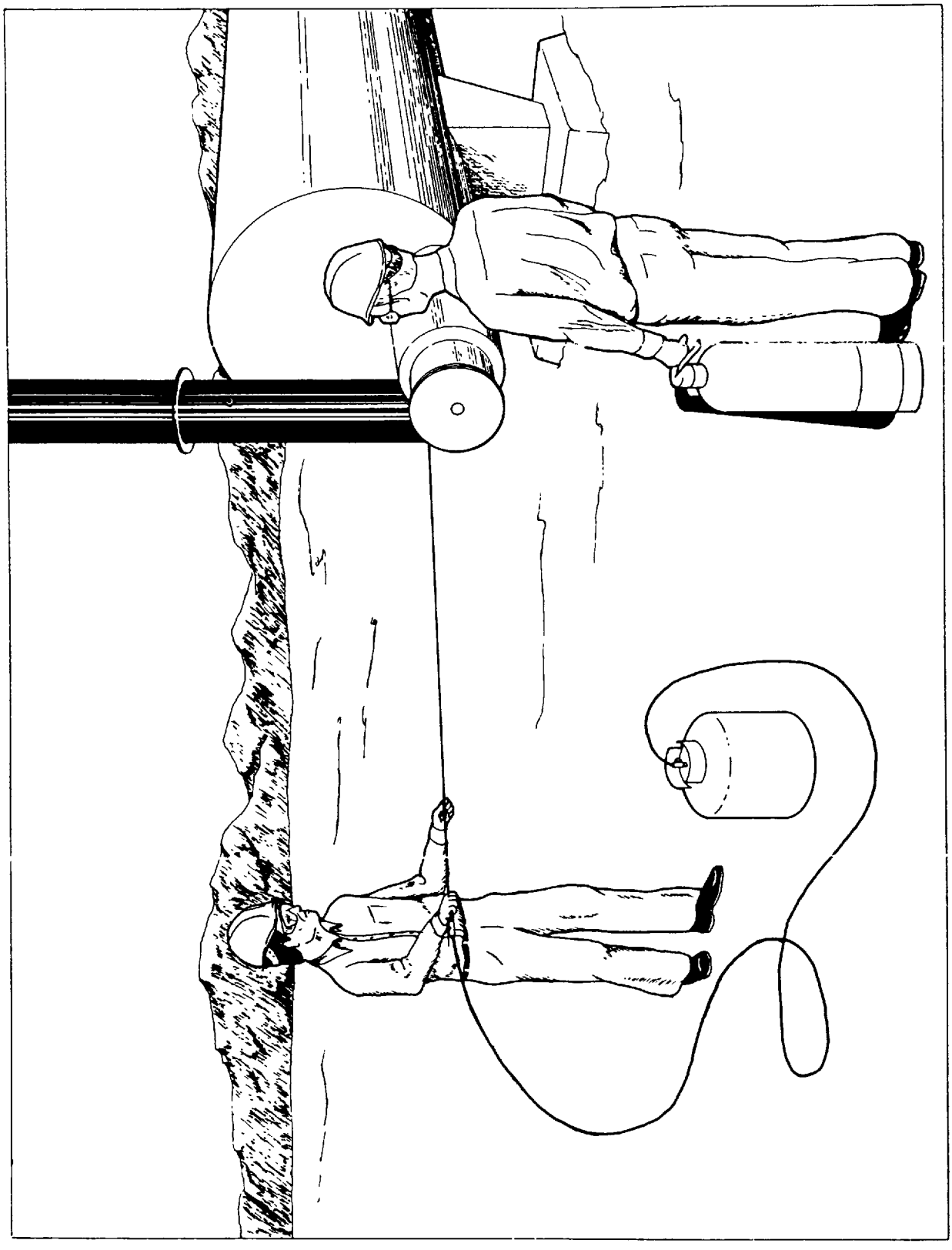

Figure 2—Testing Flame Arrestor Element

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