SAE Aerospace — An SAE International Group	AEROSPACE STANDARD	AS4273	REV. A
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(R) Fire Testing of Fluid Handling Components for Aircraft Engines and Aircraft Engine Installations

RATIONALE

This SAE Aerospace Standard (AS) presents an improved fire test procedure sequence and changes to meet the new FAA requirements specified in AC 33.17 and AC 20-135.

1. SCOPE

This document establishes requirements, test procedures, and acceptance criteria for the fire testing of fluid handling components and materials used in aircraft fluid systems. It is applicable to fluid handling components other than those prescribed by AS1055 (e.g., hoses, tube assemblies, coils, and fittings).

It also is applicable to materials, wiring, and components such as reservoirs, valves, gearboxes, pumps, filter assemblies, accumulators, fluid-cooled electrical/electronic components, in-flight fluid system instrumentation, hydromechanical controls, actuators, heat exchangers, and manifolds. These components may be used in fuel, lubrication, hydraulic, or pneumatic systems.

1.1 Classifications

Component assemblies shall be classified according to fire test duration. The test methods described herein shall be applicable to each classification.

1.1.1 Fire Resistant

The capability of a material or component to perform those functions intended under the heat and other conditions likely to occur at the particular location during a fire and to withstand a 2000 °F flame (±150 °F) for 5 minutes minimum.

1.1.2 Fireproof

The capability of a material or component to withstand a 2000 °F flame (±150 °F) for 15 minutes minimum, while still performing those functions intended to be performed in case of fire.

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1.2 Applicability Guidelines

All flammable fluid conveying components that are located in a designated fire zone shall be at least fire resistant. All flammable fluid tanks and their associated shutoff valves located in a fire zone shall be fireproof. Components which convey flammable fluids can be evaluated to a fire resistant standard provided the supply of flammable fluid is stopped by a shutoff feature. Engine fuel system components can be considered to have a shutoff feature if the fuel flow would be shutoff with engine shutdown. Engine oil system components must consider that oil flow may continue after engine shutdown because of windmilling causing continued rotation of the oil pump. It should be noted that historically most oil system components have been evaluated to a fireproof standard. Other flammable fluid conveying components such as hydraulic and thrust augmentation systems should be evaluated in a similar manner.

Components adjacent to fire zones may be required to be fire resistant or fire proof (see AC20-135 Appendix 1).

1.3 Components Protected by Nonintegral Shields

Components to be fire tested that are protected from direct flame impingement by a nonintegral fireproof device such as a shield, box, baffle, etc., must employ this device in the fire test. The device must be positioned per the installation and the instrumentation that measures the flame temperature during the test be within 0.25 inches (6.36 mm) from the device. The burner is positioned as defined in 4.7, and the component must be positioned in its actual relationship to the device.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws, regulations, and associated FAA policy and guidance material unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS1055 Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings, and Similar System Components

AS8028 Power Plant Fire Detection for Instruments, Thermal and Flame Contact Types

AIR1377 Fire Test Equipment for Flexible Hose and Tube Assemblies

2.2 ANSI Publications

Available from ANSI, 25 West 43rd Street, new York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 2685 Aircraft-Environmental Condition and Test Procedures for Airborne Equipment-Resistance to Fire in Designated Zones

2.3 Federal Standards

Title 14 of the Code of Federal Regulations, Aeronautics and Space, Parts 23, 25, 27, 29, and 33 regarding flammable fluid-carrying components and compliance

FAA Powerplant Engineering Report No. 3A, Standard Fire Test Apparatus and Procedure, Revised March 1978.

FAA Report No. FAA-RD-76-213 Re-evaluation of Burner Characteristics for Fire Resistance Tests, January 1977

FAA Advisory Circular No. 20-135 Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria, dated February 6, 1990

FAA Advisory Circular No. 33.17-1 Fire Prevention, dated June 28 2002

FAA Aircraft Material Fire Test Handbook, Report No. DOT/FAA/CT-89/15, Sept. 1990

3. QUALIFICATION

Qualification or certification normally requires detailed test plans to be submitted to the purchaser and/or cognizant agency for approval prior to test. The test schedule must be coordinated with the appropriate agency to allow witnessing of the test unless witnessing is waived.

For FAA applications, conformity of the test specimen per FAA procedures and an FAA approved test plan will be required.

Components qualified or certified to this document shall be products which have passed the fire test requirements listed or which comply with the similarity criteria described herein.

Test report(s) proving qualification of products to this document shall be furnished by the supplier to the purchaser and to agencies designated by the purchaser.

Components that have been qualified to this document do not require retest to be qualified at lower pressures, lower fluid temperatures, and/or higher fluid flow rates unless those changes are more critical. Identical components with higher pressures, higher fluid temperatures, and/or lower flow rates or other significant changes shall be evaluated for retest.

Qualification by similarity to a component previously qualified by test under similar conditions shall include analyses to quantify the effects of any operating differences and physical differences from the original test parameters and test article. Factors to be considered shall include but not be limited to materials, construction, structural loading, installations, sealing of shafts and parting surfaces, flow rates and distribution for cooling, surface area exposed to the flame, and fluid pressure/temperature.

4. TEST PROCEDURE

4.1 Test Purpose

The tests prescribed herein are intended to verify that the test specimen will demonstrate compliance with fire resistance or fireproof requirements as defined in this document.

4.2 Test Requirements

Component operating conditions maintained during the fire test shall represent realistic worst case flight conditions with regard to fire-resistance/fireproof capability. Engine-related components and associated lines and fittings shall be conveying fluids at the minimum flow rate for flight operation, corresponding pressure, and the highest fluid temperature encountered over the normal flight envelope.

NOTE: For high-pressure hydraulic and pneumatic systems and other systems, the low flow condition may not be worst case; analysis to determine worst case may be required.

Flammable fluid tanks (i.e., oil tanks) shall be tested with a minimum flight idle fluid flow rate and maximum flight fluid temperature and system pressure for 5 minutes, and then immediately followed by a 10 minute engine shutdown fluid flow or windmill fluid flow depending on engine type and design. The fluid level shall be at the “minimum dispatch fluid level.” Any gulping volume shall be removed for the 5 minute low flow portion of the test and returned to the tank at the start of the 10 minute shutdown flow portion of the test. For an oil system, "gulping" refers to the volume of oil typically evacuated from the main oil tank and retained within the oil system during normal engine operation. This "gulping" is generally evidenced by a decrease in oil tank quantity while the engine is operating normally, with the gulping volume retained within the engine sumps. The gulped oil is scavenged back to the oil tank after the engine is shutdown.

Rotational speeds and other applicable parameters shall also correspond to the selected defined and accepted flight condition.

For nonengine related components, requirements shall be established based on the operating envelope with consideration of loading, fluid pressures, and temperatures at the minimum sustained flow rate. All components shall be supplied with test fluid conforming to the primary fluid specified for the system in which the component is used. An explosive condition can conceivably be created by fuel leaks. A substitute test fluid may be used in place of the primary fuel if approved by the purchaser, and any leakage of the fluid meets the requirements of 4.3(a.3).

4.3 Success Criteria Guidelines

These guidelines represent success criteria that have provided satisfactory results for evaluating the flame resistance of fluid handling components for aircraft and aircraft engines. For more detailed certification guidelines (see FAA AC20-135 and AC33.17).

a. Fire Test Pass/Fail Criteria: In general, the following fire test criteria have been applied to the test article and accepted:

   1. Maintain the ability to perform those functions intended to be provided in the case of fire, including fuel shut off when so commanded.

   2. No leakage of hazardous quantities of flammable fluids, vapors or other materials. In general no leakage should occur. Small drips or weeps may be acceptable if a safety assessment of the installation shows the resulting leakage would not cause or contribute to a hazardous condition.

   3. No support of a sustained fire (e.g., rapid self-extinguishing and no re-ignition) by the constituent material of the article being tested or by flammable fluid leaking from the test article.

   4. No burn through of firewalls.

   5. No other hazardous conditions should result.

   NOTE: Hazardous Quantity: An amount of flammable fluid which could sustain a fire of sufficient severity and duration so as to significantly increase the overall fire hazard or result in a hazardous condition.

b. Additional Fire Test Pass/Fail Criteria: Firewall isolation valves and their controls shall be capable of closing off the supply of flammable fluid after 5 minutes of fire testing. If the valve is in the fire zone, the valve shall be exposed to flame for an additional 10 minutes after being closed. During additional 10 minute exposure the valve shall remain closed. The valve shall continue to perform its intended function of shutting off the supply of flammable fluid to the fire zone at the end of the test.

4.4 Instrumentation

Instrumentation with corresponding accuracies, recording devices, and equipment calibration requirements shall be used to measure and record all necessary test parameters. These shall include but not be limited to the following:

a. Fluid flow rate

b. Fluid temperature

c. Fluid pressure

d. Burner orientation

e. Burner calibration water flow rate[1]

f. Burner calibration water temperature in[1]

[1] Or calorimeter readout.

g. Burner calibration water temperature out[1]

h. Burner flame temperature

i. Component drive speed (if required)

j. Air velocity (if airflow simulation used)

k. Loading (if required)

l. Surface temperature (if required)

m. Vibration instrumentation (if required)

n. Test article functional outputs (e.g., FMU fuel metering valve position or shutoff valve position)

4.4.1 Calibration

Descriptions of test equipment to be used for each fire test shall be included in the detailed test plan and test report. The next required calibration dates shall be recorded on the equipment list for each item of test equipment. The burner shall be calibrated prior to each test. The burner temperature and intensity requirements are covered in 4.6.

Calibration of the flame heat flux density may be accomplished with either a water tube or a calorimeter.

The procedures for both methods are covered by this document and can be found in 4.9. Figures 3 and 4 show the flame heat flux density calibration.

If a water tube is used to calibrate the heat flux density, the burner shall input the minimum required heat flux density into a 15 inch (381 mm) exposed length of 0.5 inch OD x 0.032 inch wall (13 mm x 0.8 mm) copper tubing with a water flow rate of 500 lb (227 kg)/hour ± 5% reference AS1055 and AIR1377. There shall be no backup plate behind the copper tube.

4.5 Environmental Conditions

The environmental conditions for all tests, unless otherwise specified, shall be as follows:

a. Ambient temperature: 40 to 110 °F (4.4 to 43 °C)

b. Ambient pressure: Local barometric

4.6 Flame Temperature and Intensity

4.6.1 Flame Temperature

The flame shall have a temperature of 2000 °F ± 150 °F (1093 °C ± 83 °C) as measured per 4.7 while maintaining the flame intensity required per 4.6.2. Figure 1 and 3 show arrangement for calibration of the test flame with typical traverse burner. Figure 2 shows a horizontal flame path. In either case, the calibration shall be accomplished in the same plane/orientation as will be used for the test specimen.

A minimum of three calibration thermocouples shall be used. The thermocouples shall be located 4 inches ± 1/4 inch (102 mm ± 6 mm) from the end of the burner on liquid fuel burners and 3 inches ± 1/4 inch (75 mm ± 6 mm) for gas burners. The thermocouples should be bare junction 1/16 to 1/8 inch metal sheathed, ceramic packed chromel-alumel thermocouples with nominal 22 to 30 AWG (American Wire Gage) size conductors, or equivalent. The three thermocouples shall be located on a horizontal line with one on the centerline of the burner discharge nozzle and with the other two located on either side, halfway between the center thermocouple and the longest edge of the burner.

4.6.2 Flame Intensity

To standardize the British thermal units output of the flame, British thermal units measuring equipment shall be used. The burner shall provide a heat flux density of at least 9.3 Btu/ft²/s (10.56 W/cm^2) [calorimeter] or 4500 Btu/h (1320 W) [heat input to the water tube]. The heat intensity calibration device shall be located 4 inches ± 1/4 inch (102 mm ± 6 mm) from the end of the burner on liquid fuel burners and 3 inches ± 1/4 inch for gas burners

4.7 Test Setup

Figures 1 and 2 show the arrangement for test component mounting, and burner traverse capability. Refer to Figures 3 and 4 for calibration of burner flame heat flux density.

4.7.1 Test Cell Airflow

Any exhaust fan used shall be located far enough from the test article that airflow at the test article is minimized.

Air velocity simulation over the test specimen shall not be used unless the air velocity is well defined. If airflow is simulated, re-evaluation of installation airflow assumptions will be necessary when new installations are specified for an already qualified component. Any limitation on the airflow should be stated in the engine installation instructions. Any limitations on the airflow should be noted in the Qualification/Certification Report.

4.7.2 Test Burner

Guidance on acceptable burner types and configurations can be found in FAA Advisory Circular No. 20-135. The basic burner requirements are that the flame should produce a 2000 °F ± 150 °F temperature and engulf or provide representative impingement coverage, dependent on specimen size. In addition, the burner should provide a heat flux density of at least 9.3 Btu/ft²/s, to the calorimeter or 4500 Btu/h (1320 W) heat input to the water tube. Depending on the specific application, the following burners have been used:

1. The type specified in FAA Powerplant Engineering Report No. 3A. This burner has been used to test flammable fluid-carrying components, cowling, composite materials, firewall materials, fuel and hydraulic hoses, and other similar applications.

2. SAE 401 Burner (standard). This burner has been used for testing fire detectors, associated electrical wiring, and similar applications and is specified in various Technical Standard Orders (TSO) and military standards. AS401 that covered this burner has been superseded by AS8028.

   NOTE: This burner should not be used for powerplant installation fire testing in accordance with this document.

3. SAE 401 Burner adjusted to increase the output to at least 9.3 Btu/ft²/s heat flux density. This adjusted burner has been used to test firewall materials, composite materials, cowling, electrical wiring, fuel flowmeters, firewall fittings, and other components.

4. Propane and oxy-acetylene torch-standard and diverging nozzles. The propane or oxy-acetylene burner has been used for wiring, flow meters, firewall penetrations, and other “small” component type applications, where the heat flux density will not inherently affect the results of the test.

   Detail information on the above burners can be found in FAA Powerplant Engineering Report No. 3A, IS0 2685, AIR1377, and AS8028.

The burner shall be set up so that it can be moved from the calibration position to the same relative position on the test specimen without shutting off the burner. An optional test setup is one where the test specimen is moved to the burner after calibration.

4.7.3 Burner Position

The burner shall be positioned so that the distance to the closest flame impingement surface of the component is equal to the distance where the requirements of 4.6 are met.

4.7.3.1 Flame Path

The test flame generally should be applied to the test article feature(s) that is determined by analysis and/or test to be critical with respect to surviving the effects of the fire. More than one test may be required based on the number of susceptible areas identified by the criticality analysis. For this approach, determination of the flame impingement location should consider, as a minimum, the following potential factors: materials; part features (such as elastomer seals); local torching effects; vibration; internal fluid level/pressure/flow rate; surface coatings; fire protection features; etc. Other factors not listed may apply.

Alternatively, the test plan may consider all potential sources of fire in the intended installation when determining test flame impingement location requirements. The intent is to identify locations or features, which cannot be directly impinged by fire, and choosing the most critical from those locations which can be directly impinged. If the applicant chooses this installation analysis approach, it should be based on the actual intended installation, and should consider, as a minimum, the factors noted above, plus the following potential installation specific factors: cowling and nacelle structure, undercowl airflow, aircraft engine build up (EBU) hardware, etc. Other factors not listed may apply.

Such installation analyses should avoid simple generalities, such as “the most likely flame direction is vertical assuming fuel collects at the bottom of the cowl,” and most properly should be coordinated with the installer before the test plan is submitted. If the alternative potential sources and installations effects are used, these installation assumption effects must be reported in the component/engine installation instructions and may require re-test for a different installation. In other words, if credit is taken for an aspect of the installation (i.e., shielding or potential flame source), that provides an advantage, it should be reported in the fire test so that it can be accounted for when the component is used in a different installation. Lastly, due consideration should be given to fire protection features such as fire shields, fire protective coatings, or other methods, so as not to discourage or invalidate their use.

4.7.3.2 Flame Temperature Measurement

The thermocouple used for monitoring flame temperature during the test shall be located in a plane normal to the flame path, at the center of the flame, and 0.25 inches (6.4 mm) from the surface of the test specimen closest to the flame. This measurement can assist in explaining temperature shift which may occur during the fire test.

If a significant temperature shift is observed from the calibration level, determine if the thermocouple is contacting the test article. It may not be possible to move the thermocouple once the test has commenced so record the temperature shift and continue testing using the shifted value.

The shift may be explained by a post-test verification of the burner flame and should the temperature recover to the approximate pre-test level as the original calibration, the temperature shift is explained and understood.

If the thermocouple is not touching the test article, the shift is due to test article temperature radiation or flame flow changes. This shift also can be explained by rechecking the temperature calibration, and as previously stated, if the temperature recovers to original level, an explanation is available to verify flame stability.

4.7.4 Component Orientation

The orientation of the test specimen in the test setup shall be as it is mounted on the engine or airframe (level flight attitude). Gearbox-mounted components shall be mounted to a gearbox or simulated gearbox during the fire test. Active gearbox drive for higher horsepower accessories is not required if representative seals, internal pressure, and flow can be realistically simulated within the accessory.

4.7.5 Protection of Support Equipment

Facility hardware that is not part of the component to be tested, but is necessary to adapt the component for test (e.g., fuel lines, electrical harnesses, flexible shafts) may be shielded from the flame provided the shielding does not shield the component from the flame. Support equipment must not create a nonrepresentative heat sink.

4.7.6 Supplemental Component Shielding

Components that are designed to include heat shields, blankets, coatings, and etc. shall be tested with these installed per the component manufacturer's specifications. Thin shields, coatings and/or composites vulnerable to vibration during a fire event shall be subjected to vibration inputs during the fire test. The unit under test shall be vibrated at an amplitude of 0.4 mm (0.8 mm total displacement) at the non-resonant frequency closest to 50 Hz. Thin stainless steel shields are not considered vulnerable to vibration during the test and therefore are not required to be vibrated during the fire test.

4.8 Fire Test Data Recording and Monitoring

4.8.1 Data Recording

Steady state data shall be recorded for all pertinent parameters (e.g., air/hydraulic oil/lube oil/fuel flow rates, pressures, and temperatures, electrical inputs and outputs, rotating component speed, flame temperature, and structural loading/vibration if applicable).

Data shall be recorded at fixed intervals of 1 minute, maximum, for fire-resistant (5-minute duration) tests and for fireproof (15 minute) tests. Still photographs, black-and-white, or colored, of the installed test specimen before, during, and after testing are recommended.

4.8.2 Video Recording

It is recommended that a color video recorder be used to document the flame and flame-impingement phenomenon on the specimen.

4.9 Flame Calibration

4.9.1 Water Tube Method Precalibration Preparations

The following preparations are necessary prior to making a measurement.

a. Water should be supplied at a temperature not lower than 50 °F (10 °C) and not higher than 70 °F (21.1 °C).

b. The water flow rate should be adjusted to 500 lb (227 kg) per hour ±5%, which is approximately equal to 1 gallon (3.8 L) per minute. Use actual lb/h to obtain Btu increase.

c. The external surface of the copper tubing should be cleaned with fine steel wool before each test. The tubing bore should be inspected for corrosion periodically and scale accumulation should be removed. A .45 caliber pistol cleaning brush attached to a suitable extension may be used to accomplish this.

    NOTE: The heat transfer tube should not be in the flame during burner adjustment and flame temperature calibration. This will avoid radiation effects of the thermocouples and undesired soot buildup on the heat transfer tube.

d. With the water flowing through the device, the heat transfer tube should be centered in the flame per 4.7. A 2 to 5-minute warm-up period should be allowed to obtain stable conditions before temperature measurements are recorded. After the warm-up period, the temperatures indicated by the inlet and outlet thermometers are recorded every 1/2 minute during a 3 minute period. The average difference in temperature (°F) of the inlet and outlet water multiplied by the rate of the water flow [(ACTUAL READING) lb per hour)] equals the rate of Btu increase of the water flowing through the device.

4.9.2 Calorimeter Method (can be used with any acceptable burner)

Calorimeter:

The calorimeter will be a total heat flux, foil type Gardon Gage of an appropriate range such as 0 to 15 Btu/ft^2/s (0 to 17 W/cm^2), accurate to ±3% of the indicated reading. The sensor emissivity should be no less than 0.94.

NOTE: Cleaning of the sensor surface is not permitted. Any type of cleaning solution is likely to affect the surface coating and thus the integrity of the calibration. For minor soot buildup, use compressed air to blow the surface clean. If compressed air is not sufficient to remove accumulated debris, the calibration has more than likely already been compromised.

Calorimeter Setup:

Figure 4 shows the arrangement for calibration of the burner heat flux density using a calorimeter. The calorimeter will be mounted in a 6 x 12 ± 1/8 inch (152 x 305 ± 3 mm) x 3/4 inch (19 mm) min thick insulating block that is attached to a steel angle bracket for placement in the test stand during burner calibration. The insulating block will be monitored for deterioration and replaced when necessary. The mounting will be shimmed as necessary to ensure that the calorimeter face is parallel to the exit plane of the test burner cone.

NOTE: Because of their thermal gradient requirement, calorimeters do not function well if they are not mounted. Without mounting, there is no way to dissipate absorbed heat and the calorimeter will quickly come to a uniform or near uniform temperature.

4.10 Fire Test Sequence

The burner flame shall be calibrated for temperature and heat flux density before each fire test.

The specimen shall be operated during the fire test with all input and output parameters set to the levels established by the requirements of 4.2.

1. Turn on any airflow simulation fans or test room ventilation fans that will be used during testing.

2. Turn on the burner and allow it to run for 5 minutes to ensure steady state conditions have been achieved.

3. Conduct calibration for flame temperature and heat flux density.

4. After calibration the burner conditions shall be maintained constant and immediately moved to the test specimen.

5. Conduct fire test per time requirements (see 1.1, 4.2, and 4.3, as applicable). Record temperatures per 4.8.1.

6. Conduct post test calibration for flame temperature immediately after completion of test without shutting off the burner.

7. Shut off burner when all items above accomplished.

5. COMPONENT IDENTIFICATION

Assemblies shall be permanently and legibly identified (e.g., Manufacturer, Serial Number, Part Number).

6. POST TEST HARDWARE DISPOSITION

Hardware that has been exposed to fire testing shall never be used on a vehicle that is to be flown. The test specimen(s) shall be stored as directed by the customer/purchaser.

7. TEST PLAN

A detailed test plan shall be prepared and submitted to the customer and/or agency. The test plan shall include, as a minimum, the following items:

a. Definition of test specimen (describe part operation and include sketches)

b. Conformity of test specimen (P/N & S/N)

c. Procedure

d. Description of test equipment, test burner, test location

e. Chronology of events, test procedures (including calibration)

f. Pass/fail criteria

g. Specification requirements for fire test (e.g., applicable FARs)

h. Operating characteristics justification

i. Burner orientation justification

j. Data recording requirements

k. The test plan should include or reference the criticality analysis and/or test required in 4.7.3.1 to determine flame path and installation effects.

8. TEST REPORTING

The following information is suggested for inclusion in the report.

a. Summary/objective, procedure, results (including calibration)

b. Description of specimen, description of test procedures, description of test equipment, test location, chronology of events, (specific component) test procedures, test specimen operating criteria, results, analyses, (detailed) conclusions and recommendations, certification (those who conducted test article conformity, witnessed the tests and/or monitored the data)

c. Specification requirements for fire test (excerpts from customer/purchaser's specification document

d. Appendices/fire test plan, Aerospace Standard(s), component test data (including witness log sheets, and pre and post test inspection records), photographs (before and after test)

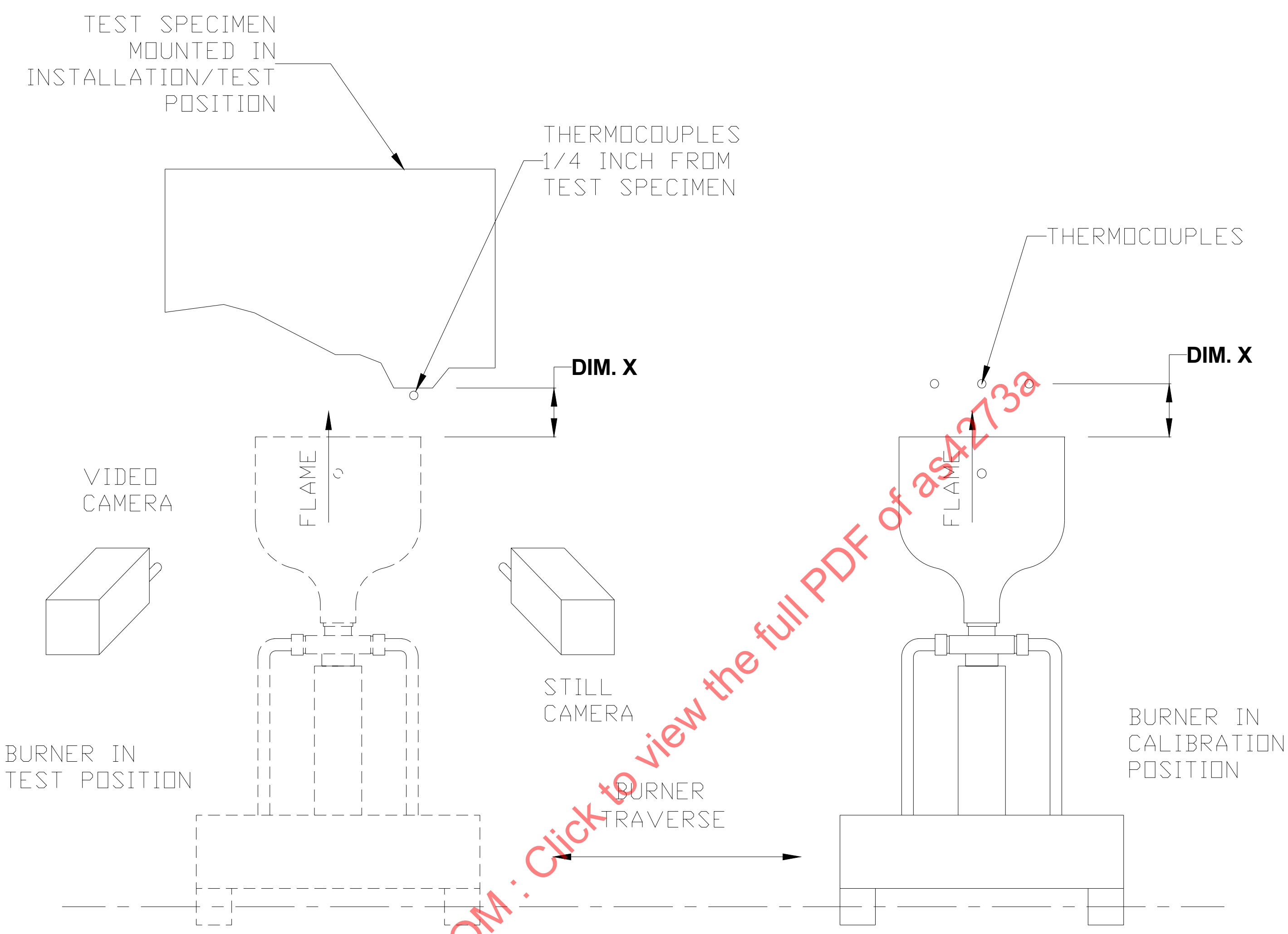
e. The test report should include or reference the criticality analysis and/or test required in 4.7.3.1 to determine flame path and installation effects.

f. If installation effects are used, they should be defined and justified and included in the installation instructions.

9. NOTES

9.1 The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document.

PREPARED BY SAE COMMITTEE AE-5, AEROSPACE FUEL, OIL, AND OXIDIZER SYSTEMS



DIM X= 4±1/4 INCHES (102MM ± 6MM) FOR THE LIQUID FUEL BURNER
AND 3±1/4 INCHES (75MM ± 6MM) FOR THE GAS BURNER

NOTE: VERTICAL FLAME SHOWN FOR SCHEMATIC REASONS. SEE 4.7.3.1 FOR REQUIRED DIRECTION

FIGURE 1 - TYPICAL TRAVERSE BURNER ARRANGEMENT