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Advisory Circular

Subject: SMOKE DETECTION, PENETRATION, AND EVACUATION TESTS AND RELATED FLIGHT MANUAL EMERGENCY PROCEDURES
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1. PURPOSE. This advisory circular (AC) provides guidelines for the conduct of certification tests relating to smoke detection, penetration, and evacuation, and to evaluate related Airplane Flight Manual (AFM) procedures. These guidelines may be used to reduce the degree of subjective judgment needed in conducting tests and evaluating test results. While this AC is not mandatory, it offers a method of demonstrating compliance with the applicable airworthiness requirements.

2. RELATED FEDERAL AVIATION REGULATION (FAR) SECTIONS. The related sections are §§ 25.831, 25.855, 25.857, 25.858, 25.1301, 25.1309, 25.1359, 25.1585(a) and 121.308 of the FAR.

3. BACKGROUND. The development of standardized test procedures was initiated in 1975 to eliminate subjective evaluations of the smoke detection, penetration and evacuation procedures used in demonstrating compliance with the applicable sections of Part 25. Though the flammability characteristics of the interior cabin materials have been reduced since that time, these materials may emit potentially lethal smoke and toxic gases when they are exposed to sufficient heat or are involved in the combustion process. Due to these concerns, and a National Transportation Safety Board (NTSB) recommendation, these guidelines have been developed.

4. SUBJECTS AND DEFINITIONS. For purposes of this AC, the following are applicable:

a. Smoke. Smoke consists of aerosols (e.g., carbon particles), gases, fumes and vapors that are the result of pyrolysis or the combustion process.

b. Smoke Classification. It is difficult to classify smoke and standardize smoke test procedures because smoke characteristics and composition vary with the materials and processes that create smoke. Visual perception of objects, when viewed through smoke, varies with the wavelength of light used to illuminate the smoke or to measure smoke density. For these reasons, the wavelength of light used to establish transmissibility and smoke type should be selected to standardize the smoke test result if precise and repeatable results are desired.

c. Vapors or Fogs. Protection from vapors or fogs created by atomized fluids leaking from glycol or hydraulic systems are beyond the scope of this AC; however, prudent design practices, e.g., shrouding and drains, should be used to reduce exposure to these substances.

d. Buoyancy and Stratification. Buoyancy and stratification of smoke vary with the substance from which the smoke is generated and the environmental conditions in which it is generated. A smoke generator that uses tobacco as the fuel will produce smoke that is more buoyant (initially) than the cooler smoke produced from a theatrical type smoke generator. Although stratification can occur with either type of smoke, theatrical type smoke generators will generally fill a compartment from the floor up. Theatrical type smoke is buoyant enough that some mixing will take place from the natural turbulence in the compartment even though the smoke distribution may not be uniform. On the other hand, the more buoyant smoke from a tobacco type generator remains more stratified. During one test with tobacco smoke, it was observed that the smoke did not reach the floor for the duration of the test. This is one of the reasons the theatrical type smoke is recommended for smoke penetration tests. The less buoyant theatrical type smoke may not be useful for detection tests because it may not adequately represent the buoyant properties of smoke that may be generated from the typical smoke sources found in the compartments being tested.

e. Smoke Sources and Duration (Continuous Smoke Source).

(1) Reasonably probable sources of smoke include fires caused by cigarettes, incendiary or explosive devices, cargo fires, and failures of electrical and pneumatic equipment. Fluid leaks or spills, e.g., hydraulic, glycol, etc., in combination with heat or ignition sources may also produce hazardous quantities of smoke.

(2) Incidents of fire or smoke that cannot be extinguished continue to occur. Smoke and fire procedures should, therefore, be formulated considering that the fire or smoke exposure may be continuous. Smoke from fires in cargo or equipment located in inaccessible locations should be considered to be continuous, in particular. Continuous smoke from equipment bays, equipment cooling systems, the cockpit, and cargo compartments should be considered reasonably probable because these compartments have so many potential sources of smoke or have a history of fire or smoke occurrences.

(3) Failures that cause fire and smoke should be included in the failure assessment conducted under §§ 25.831, 25.1309 and 25.1359. It should be determined, for each failure condition considered for this assessment, whether smoke detectors and specific fire or smoke procedures are warranted and whether the failure or secondary effects should be prevented through the use of isolation, containment, extinguishers, etc. The likelihood of a continuous exposure to smoke may be based on a failure evaluation which would include the sources of failure, contributing materials, failure preventative measures and smoke control or containment means. The adequacy of the smoke control and the containment means should be verified by smoke tests.

f. Smoke Toxicity.

(1) A failure condition may create smoke at a continuous or variable rate and may occur at any time during a flight. Because the composition of the smoke would vary with the available oxygen, heat produced, and the type of materials pyrolized or consumed, the exposure duration and concentrations are unpredictable. Furthermore, human tolerance to typical airplane fire toxicants has not been adequately defined. For these reasons, a failure evaluation using a qualitative approach and smoke toxicity limits used to define a hazardous quantity of smoke is not practical. The practical approach is to prevent exposure to the smoke.

(2) Measuring concentrations of toxic or hazardous gases, such as carbon monoxide (CO), carbon dioxide (CO_2) and extinguishing agents is beyond the scope of this AC.

g. Material Flammability Characteristics. The flammability characteristics of interior cabin materials, electric wire insulation and hydraulic fluids have been improved; however, these materials will still emit smoke and combustion gases when exposed to sufficient heat or burned. Hydraulic fluids are considered flammable fluids, and glycol mixtures may also be flammable fluids depending on the concentration of water mixed with the glycol. The use of less flammable materials does not preclude the need to consider these materials as sources of smoke.

h. Airplane Modifications. Airplane modifications that may require smoke tests include the alteration of, addition to or removal of, pneumatic systems (bleed air, air conditioning, pressurization, ducting and distribution, equipment cooling, etc.), baggage or cargo compartments, interiors, interior seals, cockpit panels, etc. Each modification must be evaluated on its own merit. The assessment should consider all modifications, including those behind or between panels or between panels and the fuselage skin.

5. AIRPLANE FLIGHT MANUAL (AFM) FIRE AND SMOKE PROCEDURES.

a. Section 25.1585(a) specifies that emergency procedures for airplane fires must be furnished in the AFM. These procedures generally require the flightcrew to communicate the emergency, don protective breathing equipment, shut off ventilation to cargo compartments and recirculation systems, or increase the ventilation to occupied areas, or to use a combination of these procedures. Operational procedures also generally require flight attendants to communicate the nature and status of the emergency, don protective breathing equipment, attempt to extinguish the fire and perform other related emergency functions. Emergency procedures should be evaluated during the design review and smoke tests to determine that the optimum procedures have been selected.

b. Section 25.831 allows the use of depressurization within safe limits to evacuate smoke from the cockpit. Depressurization reduces the density of smoke by evacuation and may increase the ventilation air flow. This procedure is not, however, a final solution and should be considered only an interim means to control a fire until further action can be taken. The degree of depressurization used as a procedure for smoke evacuation should not result in automatic deployment of passenger oxygen masks. Decompression, whether intentional or the result of a fire related failure, may activate certain types of smoke detectors. Unless a detector that is not effected by decompression is installed, the emergency procedures and methods of distinguishing between these two conditions should be formulated and furnished in the AFM.

c. The AFM fire and smoke emergency procedures should include instructions for the flightcrew to immediately proceed to the nearest suitable airport when fire or smoke is detected. If it can be visually verified that the fire has been extinguished and a damage assessment indicates it is safe to do so, the flight may be continued. This verification and assessment should be accomplished by a flight crewmembers' observation of the fire or smoke source and not by reliance on observations of smoke or detectors. Flightcrews may be misled into thinking a fire is extinguished or under control when it is not. For example, diminishing smoke due to smoke evacuation procedures, fire detector failure or saturation, fire related containment or ventilation failures, or the use of extinguishing systems may cause loss of the detector warning or cause diminishing smoke even though the fire may not be extinguished.

d. Fire control in Class C cargo or baggage compartments is usually maintained by staggered discharge of multiple built-in extinguisher bottles. If an explosion occurs in the cargo or baggage compartment, the liner should be assumed to be ruptured. The smoke detector should, in turn, be considered unreliable due to possible damage or ventilation changes caused by loss of the integrity of the liner. Due to the possible loss of fire containment and detection capability following an explosion, the recommended procedure should be to discharge the extinguisher bottles as a precautionary measure if visual inspection of cargo or baggage compartments is not possible and to land at the nearest suitable airport.

6. SMOKE TESTS.

a. Test methods. There are three smoke tests associated with the certification process; smoke detector tests, smoke penetration tests and smoke evacuation tests. Either the visual observation method or the instrumented method may be used to conduct these tests.

(1) The Visual Observation Method. The visual observation method uses the subjective judgment of an FAA observer to make determinations as to the adequacy of the smoke tests and test results.

(2) The Instrumented Method.

(i) The instrumented method uses photosensitive instruments to measure light transmissibility through smoke. These measurements are compared to acceptable criteria in lieu of using an FAA observer's judgment. Judgment has not been completely eliminated, however, because the acceptability of the tests must still be determined.

(ii) The source light for measuring transmissibility should be a laser of wavelength 632.8 nanometers. The use of a longer wavelength is better for measuring particle density and is not affected as much by light scatter or reflection and ambient light as a light source of shorter wavelength.

(iii) Theatrical smoke, which is a cool white smoke, should be used for the penetration and evacuation tests. Theatrical smoke may not represent the darker smoke associated with burning fuel or synthetic materials; however, it is less objectionable and is buoyant enough for penetration test purposes. The use of theatrical smoke may not provide realistic detection times if detectors are mounted in the ceiling.

(iv) The instrumented method provides acceptable standards to measure the transmissibility of light through smoke. This method should eliminate the need for any subjective judgment in evaluating the test results. In the event a different smoke type is used or a light source with a different wavelength is used, it will be necessary to establish new transmissibility values.

b. Airplane Flight Test Conditions. Except as noted for the lavatory smoke detector tests, the test conditions should be selected as follows:

(1) Flight Tests. The configuration of the cabin air conditioning and pressurization systems should represent any normal operating condition and any other conditions in which the airplane may be dispatched. The test conditions should represent the flight conditions that are the most critical with respect to smoke detection, penetration and evacuation. These would include tests conducted during climb, cruise, descent, or approach flight conditions under maximum and minimum pressure differentials and under maximum and minimum ventilation flow rates.

(2) Ground Lavatory Smoke Detector Test. The airplane should be operated to simulate the ventilation airflow of the various dispatchable ventilation and pressurization configurations (one air conditioning pack, two air conditioning packs, etc.) for the cruise condition. Some airplanes may be designed with a lavatory vent that may be either closed or open on the ground. For such airplanes, a flight test should be conducted or the lavatory vent system should be temporarily reconfigured to simulate the flight condition.

c. Smoke Flight Testing Hazards. Conducting smoke tests can be hazardous because they are designed to simulate hazardous conditions. Caution is therefore warranted. A test site and time should be selected with the concurrence of Air Traffic Control. Air Traffic Control should also be informed of the type of test and that the test airplane may be operating under restricted cockpit visibility. This will facilitate, if necessary, the routing of other air traffic away from the test airplane.

d. Test Limitations.

(1) The tests described have been developed primarily for large cargo or baggage compartments, equipment bays, equipment cooling systems, galleys and lavatories that are accessible in flight. Modifications of the test procedures or equipment may be needed to validate a test procedure for compartments or cooling systems which are not accessible in flight. The effect that the smoke generator itself has on the test should be considered for small compartments or cooling systems.

(2) The results of these tests are valid only if the airplane is maintained in the condition and configuration that was tested, i.e., the integrity of the compartment, including any seals and liners, is maintained, and the ventilation systems and extinguishing systems are in working order. It is assumed for test purposes, unless a failure condition is being simulated, that a fire would not damage or destroy the integrity of the ventilation system or the compartment.

7. SMOKE DETECTOR INSTALLATION TESTS.

a. Background.

(1) The purpose of a smoke or fire detector is to provide a warning before the situation escalates to an uncontrollable or uncontainable condition. The detection must be as early as possible to assure that the methods or procedures used to contain or control a fire or smoke are effective. In this regard, the fire must be detected early enough to prevent damage to the wiring or equipment that is necessary for safe flight and penetration of liners, shrouds or tubing carrying flammable fluids. The fire must be detected at temperatures significantly below that at which the structural integrity of the airplane is substantially decreased.

(2) A smoldering fire producing a small amount of smoke in conjunction with a one minute detection time was selected as a fire or failure condition that could be detected early enough to assure that the fire and smoke procedures would be effective. Subjective judgment, considering the failure, size of compartment, materials contained in the compartment, and the containment methods and procedures, is needed to assess the significance of a small amount of smoke.

(3) Theatrical type smoke generators produce smoke at rates necessary for smoke penetration tests but in excess of those necessary for detection tests. These smoke generators are capable of simulating smoke from a vigorous fire which may be capable of destroying an airplane, a fire that should be detected long before it reaches that level of hazard. The cool smoke produced by a theatrical smoke generator may be unacceptable for ceiling mounted detectors because of its lack of buoyancy. Furthermore, smoke particles generated from typical materials found in cargo compartments will be filtered (particles stick to the inside walls of the tubes) in long smoke detector tubing runs. Theatrical smoke does not demonstrate any significant sticking effect. For these reasons, theatrical type smoke generators should not be used for detection tests.

b. Objective. The smoke detection test is designed to demonstrate that the smoke detector installation will detect a smoldering fire producing a small amount of smoke.

c. Limitations. Typical smoke detectors have inherent limitations. For example, they may cease to operate due to internal failures, fire related damage or smoke saturation. Certain smoke detectors may also provide a fire warning when decompression occurs. Due to these inherent limitations, it should not be assumed that a fire is out, when the indication ceases.

d. Test Equipment. The smoke generating equipment used for detector tests should simulate a smoldering fire which produces only a small amount of smoke. Materials that represent the fuel for the probable source of smoke may be burned in a container that is covered with a metal screen. For safety, a fire extinguisher and a metal container lid should be provided. A Beekeeper type smoke generator may be used when some restraint is placed on the quantity of smoke being generated. A pipe or cigar may be a suitable source of smoke for a closet or lavatory size compartment.

e. Test Procedure.

(1) The smoke should be generated at a location that is critical with respect to the detector's area of coverage. For the lavatory smoke detection test, the smoke source should be located at the most probable source, e.g., the trash receptacle.

(2) The smoke generator should produce only a small amount of smoke in order to simulate a smoldering fire.

(3) The smoke detection should occur within one minute after the start of smoke generation.

(4) The method of smoke generation and the time to detect the smoke should be recorded. Pictures are useful means of recording the test and test apparatus.

8. SMOKE PENETRATION TESTS.

a. Background.

(1) The purpose of smoke penetration tests is to demonstrate that smoke will not enter occupied areas of the airplane from cargo or baggage compartments, equipment bays, or equipment cooling systems containing large quantities of smoke. The definition of a "large quantity" of smoke is associated with the rate of smoke generation and the volume it must fill. A large quantity is achieved when the compartment is filled and kept filled by continuously generating smoke.

(2) Except as noted in paragraph e(1)(v) below, any penetration of smoke into occupied compartments from cargo compartments, equipment bays or equipment cooling systems during the tests is unacceptable because the toxicity of the smoke is unpredictable and in an actual situation, the smoke exposure might continue or increase to a hazardous level before a landing can be made. The smoke concentrations and exposure time in an actual fire or smoke situation might be well beyond those demonstrated during the limited duration of the smoke penetration tests. Generally, any smoke penetration during the tests demonstrates that the smoke containment means or control methods are unacceptable.

(3) Generally, the theatrical type generators produce smoke at an adequate rate for smoke penetration tests. Certain models of this type generator may not be adequate, however, for some of the larger cargo compartments. It may, therefore, be necessary to move the generator around the compartment, conduct several tests or use multiple generators.

b. Objective. The objective of this test is to demonstrate that a large quantity of smoke generated in a cargo or baggage compartment will not penetrate into any occupied compartment. This test also demonstrates that a large quantity of smoke generated in equipment bays or cooling systems will not penetrate into the passenger cabin, and if any smoke penetrates into the cockpit, it can be readily removed using the AFM emergency fire and smoke procedures.

c. Limitations. Successful completion of the smoke penetration tests does not relieve the requirement to conduct carbon dioxide, carbon monoxide, and extinguisher tests in complying with §§ 25.831(c), 25.851 and 25.855.

d. Equipment.

(1) The Visual Observation Method.

(i) A smoke generator that has the capability to fill the compartment being tested with smoke and keep it filled for the duration of the test should be selected. To save flight test time, it should be verified on the ground that the generator can continuously produce large quantities of smoke in the compartment being tested. The criteria of paragraph 8e(1)(iii) should be met with the airplane pressurization and ventilation systems operated to approximate the airflow for the test condition being simulated.

(ii) The smoke generator should not produce smoke that is noxious, corrosive, or toxic and should be capable of immediate shutdown if a hazardous condition develops. Portable protective breathing equipment, with spare bottles, should be provided for test personnel.

(2) The Instrumented Method.

(i) The Smoke Generator. The same equipment as specified in paragraph 8d(1) should be used.

(ii) Light Transmissibility Measuring Device. The light transmissibility should be measured through smoke along a three foot light path using a calibrated photoelectric cell and a laser that produces light with a wavelength of 632.8 nanometers. The light path may be folded provided each path through the smoke is no less than 18 inches. The calibration of the light transmissibility measuring device should be checked by using "Wratten" filters as outlined in National Bureau of Standards Information Report (NBSIR) 77, dated June 1977, (reference paragraph 11b) or any other acceptable calibration procedure.

e. Test Procedure.

(1) The Visual Observation Method.

(i) The smoke generator(s) should be placed to generate smoke in the Class B, C, D, or E cargo or baggage compartment, the equipment cooling system or the equipment compartment in the position most likely to result in penetration of smoke into occupied areas of the airplane. All compartment lights should be on.

(ii) Large quantities of smoke should be generated continuously. The AFM fire and smoke emergency procedures should be initiated no less than 30 seconds after detection.

(iii) The smoke should be generated continuously at a constant rate for at least 5 minutes after detection for compartments or equipment cooling systems containing smoke detectors. For those compartments that do not contain smoke detectors, e.g., Class D cargo or baggage compartments, smoke should be generated for 5 minutes. The compartment should be filled with smoke at the end of the 5 minute period. In this regard, the compartment is considered filled with smoke when an FAA observer, from anywhere in the compartment, cannot see his/her hand when it is held approximately 18 inches in front of his/her face unless the hand is silhouetted by a window or interior light.

(iv) Smoke generation should be continued for an additional 15 minutes if the criteria of paragraph 8e(1)(iii) are not achieved or unless it is apparent (e.g., from results of previous tests within the compartment) at any point in time after an additional 5 minutes that further smoke generation will not produce penetration in occupied areas.

(v) The FAA observer in the occupied compartment should verify that smoke does not penetrate occupied compartments. Except as noted below, the formation of a light haze indicates that the ventilation requirements of § 25.831(b) are not being met.

(A) Wisps of smoke that enter and immediately exit at the occupied compartment boundaries are acceptable as long as a light haze or stratified haze does not form. If this condition (i.e., wisps of smoke at the compartment boundary) occurs, the test procedure or paragraph 8e(1)(iv) should be followed.

(B) Crewmembers must be able to extinguish fires in Class B cargo or baggage compartments. This means that the crewmember must pass through the cargo or baggage compartment smoke barrier or access door at least once. The crewmember entering or exiting the compartment may disturb the normal airflow and cause some smoke to enter the passenger or flightcrew compartment. This is acceptable if the smoke that enters the passenger or flightcrew compartment is dissipated rapidly.

(C) Open or closed loop equipment cooling systems and equipment bays may interface with the cockpit systems. When penetration tests are conducted in the equipment bay or in the cooling system, a small amount of smoke may penetrate the cockpit. That smoke should dissipate quickly when the AFM smoke and fire procedures are used.

(vi) If the smoke generator(s) do not completely fill and keep the cargo or baggage compartment filled with smoke, additional tests should be conducted with the generator(s) relocated as necessary to provide adequate coverage.

(vii) Section 25.855(e)(3) requires that smoke should not be detected in any adjacent compartment. Smoke penetration tests are conducted in partial compliance with § 25.855(e)(3) (the last paragraph). Full compliance is shown when all smoke tests and extinguisher tests are completed successfully. The same criteria would apply when smoke detectors or extinguishing systems are installed in equipment bays or cooling systems to comply with § 25.831(c) or § 25.1309(c).

(2) The Instrumented Method. The procedures used for this method are the same as those shown in paragraph 8e(1) for the visual observation method except that the following are substituted for paragraph 8e(1)(v):

(i) Light transmissibility readings should be taken in the occupied area at seated head height level (4 feet above the floor) and at least 18 inches from the partition between the occupied compartment and the compartment in which the smoke is being generated.

(ii) If visible smoke is present in the occupied compartment, the reading should be taken at a number of points between the armrest and standing head height level (6 feet above the floor), and at least 18 inches away from the partition between the occupied compartment and the compartment in which the smoke is being generated.

(iii) The transmissibility level in any occupied compartment should not be less at any time during the test than it was before the start of the smoke tests, i.e., zero plus any prevailing atmospheric reduction in transmissibility.

(iv) The exceptions in paragraph 8e(1)(v) are also applicable to instrumented tests.

9. SMOKE EVACUATION TESTS.

a. Background.

(1) Cockpit smoke evacuation tests verify that smoke, from sources within the cockpit, can be readily evacuated in accordance with § 25.831(d). Typical commercial transport airplanes are capable of evacuating dense cockpit smoke within approximately a minute and a half after the AFM fire and smoke emergency procedures are initiated. Three minutes is the maximum acceptable time to evacuate smoke from any transport category airplanes.

(2) The ventilation of main deck lavatories or galleys may not be isolated from that of the passenger compartments. As smoke evacuation tests are not required for the passenger compartments, they are not required for such lavatories and galleys.

(3) Many galleys and lavatories currently being installed on large transport airplanes are designed with independent exhaust systems. The primary function of these exhaust systems is to ventilate and remove odors from these facilities; however, they also remove locally generated smoke. Smoke tests are useful as a means to verify that such exhaust systems are functioning properly in accordance with § 25.1301.

b. Objective. The objective of the in-flight smoke evacuation test is to demonstrate that the AFM emergency fire and smoke procedures provide means to clear the cockpit of dense smoke at an acceptable rate. This test should also demonstrate that the flightcrew can use the procedures without introducing any additional hazard.

c. Test Equipment. The same equipment as used in smoke penetration tests may be used in smoke evacuation tests (see paragraph 8d(1)).

d. Limitations.

(1) Some airplane designs have automatic cockpit or instrument light dimming features to reduce light intensity for night flight. Smoke may cause the automatic dimming feature to function, thus making instrument visibility more difficult. A manual means to override the dimming control should be provided for each dimming circuit. There should be a procedure that specifies that the light or instrument intensity be turned up, as necessary, when smoke is present in the cockpit.

(2) If it is determined that the autoflight systems must be used during the smoke evacuation tests, then their use should be incorporated into the AFM emergency procedures. An alternative should also be developed because a failed autoflight system could be the cause of the smoke in the cockpit. In this regard, there may also be phases of flight, e.g., takeoff, landing or decompression in which the use of the autoflight system may be prohibited when smoke is in the cockpit.

e. Test Procedures. The smoke evacuation tests should be conducted with smoke generated within the compartments as follows:

(1) Cockpit.

(i) The cockpit door or curtain, if installed, should be closed for the test. The crew should don protective breathing equipment as soon as the smoke is evident.

(ii) When the cockpit instruments are obscured (standard dial indicator numbers or letters become indiscernible), smoke generation should be terminated, and the appropriate AFM fire and smoke procedures should be initiated. The smoke should be reduced within three minutes such that any residual smoke (haze) does not distract the flightcrew nor interfere with operations under Instrument Flight Rules (IFR) or Visual Flight Rules (VFR).

(2) Galleys With a Dedicated Exhaust System. If a galley door or curtain is provided, it should be closed, and enough smoke should be generated to verify that smoke dissipation or smoke flow is toward the galley exhaust system. Airplane flight manual galley fire and smoke procedures should be demonstrated at this time.

(3) Lavatories With a Dedicated Exhaust System. The lavatory door or curtain should be closed, and enough smoke should be generated to verify that smoked dissipation or flow is toward the lavatory exhaust system. Airplane flight manual fire and smoke procedures should be demonstrated at this time.

10. <u>SMOKE TEST EQUIPMENT</u>.

a. <u>Typical Smoke Generation Equipment for Detection Testing</u>.

(1) Generators. An appropriate generator should be selected, e.g.:

(a) A metal container with a metal cover screen and lid;
(b) A pipe or cigar;
(c) A Woodsman Bee Smoker; or
(d) Any other acceptable device.

(2) Fuel. Representative materials should be selected, e.g.:

(a) Plastics;
(b) Rags;
(c) Tobacco;
(d) Burlap;
(e) Paper; or
(f) Any other acceptable representative material, etc.

b. <u>Typical Smoke Generation Equipment for Penetration and Evacuation Tests</u>.

(1) Generators, e.g.:

(a) Cloudmaker Model 11-48 (B, D);

(b) Farnum Barn Fogger;
(c) Pepper Fog;
(d) Cloud Nine (Superseded by Maxi-Mist);
(e) Maxi-Mist;
(f) Mini-Mist (Suitable for small compartments); or
(g) Any other acceptable device.

(2) Fuels. Use the fuel recommended by the smoke generator manufacturer, e.g.:

(a) Silicon Oil;
(b) Paraffin Oil;
(c) Mineral Oil; or
(d) Propolene Glycol or water solutions of propolene glycol or glycol.

c. Test Equipment for the Instrumented Method for Penetration Tests.

(1) Light Source. Helium Neon Laser Tube outputting light at a wavelength of 632.8 nanometers, Manufactured by CW Radiation Co., A Division of Aerotech, 101 Zeta Drive, Pittsburgh, PA 15238.

(2) Photo (Light) Detector. Model UDT 161. Manufactured by United Detector Technology, 3939 Landmark Street, Culver City, CA 90232.

(3) Smoke Generator. Cloudmaker 11-48. Supplied by Testing Machines, Inc., 400 Bayview Ave., Amityville, NY 11701.

(4) Fuel. Paraffin Oil or Mineral Oil.

11. REFERENCES.

a. "Fire Detector Response in Airplane Application" by Steve J. Wiersma and Robert G. McKee of the Fire Research Department, SRI International, Menlo Park, California. This article was published in the August/September, 1978 issue of Aviation and was based on a SRI International report by N.J. Alvares and R.G. McKee titled, "The response of Smoke Detectors to Pyrolysis and Combustion Products from Airplane Interior Materials," prepared for NASA under contract NAS2-8538. Reference was also made in this article to "Fire Detection Devices," Aviation Engineering and Maintenance, November/December, 1977.

b. National Bureau of Standards Information Report NBSIR-77 titled "Instruction Manual for NBS Photometric Smoke Measurement System" by Richard W. Bukowski, from the Center for Fire Research, Institute for Applied Technology, National Bureau of Standards, Washington, D.C. 20234.

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