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MILITARY SPECIFICATION

FIRE AND OVERHEAT WARNING SYSTEMS, CONTINUOUS, AIRCRAFT: TEST AND INSTALLATION OF

This specification has been approved by the Department of the Air Force and by the Naval Air Systems Command.

1. SCOPE

1.1 Scope. This specification describes the requirements for the design, manufacture, testing and installation of continuous type fire and overheat warning systems for use in aircraft. These systems employ continuous lengths of heat-sensing elements connected to a monitoring device.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

TT-S-735	Standard Test Fluids; Hydrocarbon

Military

MIL-P-116	Preservation, Methods of
MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for
MIL-E-5400	Electronic Equipment, Aircraft, General Specification for
MIL-D-6055	Drums, Metal, Reusable, Shipping and Storage (Cap. from 88 to 510 Cubic Inches)
MIL-R-6106	Relay, Electric, Aerospace, General Specification for
MIL-I-6181	Interference Control Requirements, Aircraft Equipment
MIL-E-7080	Electric Equipment, Piloted Aircraft, Installation and Selection of, General Specification for
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

FSC 6340

MIL-P-7936	Parts and Equipment, Aeronautical, Preparation for Delivery
MIL-I-8700	Installation and Test of Electronic Equipment in Aircraft, General Specification for
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant, Aircraft
MIL-C-26482	Connectors, Electric, Circular, Miniature, Quick Disconnect

STANDARDS

Military

MIL-STD-130	Identification Marking of US Military Property
MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-411	Aircrew Station Visual Signals
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MS25231	Lamp, Incandescent, Single Contact, Miniature Bayonet Base, T-3-1/4 Bulb
MS33586	Metals , Definition of Dissimilar

(When requesting any of the applicable documents, refer to both title and number. All requests should be made via the cognizant Government inspector. Copies of this specification and other unclassified specifications and drawings required by contractors in connection with specific procurement functions should be obtained upon application to the Commanding Officer, Naval Supply Depot (Code CDS), 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120. All other documents should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Preproduction testing. This specification makes provision for preproduction testing (see 4.3).

3.2 Components. The fire warning system shall consist of lengths of sensing elements, connectors, flexible connections, clamps, interconnecting wiring, relays, control unit, warning signals and test switches, as required.

3.2.1 Nomenclature. The term "control unit" as used in this specification shall include any device used to monitor the sensing element circuit and to actuate a warning device on the instrument panel. The term "sensing element" shall include any heat sensor used in the fire warning system. The term "system" shall refer to the fire warning system.

3.3 Design objective. Items of this specification which are identified as "design objectives" are intended as guides. Approval by the procuring activity is not required for deviations from such objectives. The contractor shall furnish evidence to the procuring activity or the Government inspector that due consideration has been given to meeting these objectives.

3.4 Materials and parts.

3.4.1 Metals. Metals shall be of a corrosion resisting type, or shall be protected to withstand aircraft fuels, lubricating oils, salt spray, prolonged high humidity and atmospheric conditions for the life of the equipment when in storage and in service use. Dissimilar metals, as defined in MS33586, shall not be used in intimate contact with each other.

3.4.1.1 Magnesium. The use of magnesium and its alloys shall be avoided if practicable, and its use where necessary shall be subject to approval by the procuring activity.

3.4.2 Nonmetals. All nonmetals shall be moisture- and flame-resistant to the extent practicable commensurate with other aircraft design requirements, shall not support fungus growth, and shall not be adversely affected by weathering, aircraft fluids and temperature extremes encountered during operation or storage of the aircraft.

3.4.3 Selection of materials and parts. Specifications and standards for necessary materials and parts, processes and equipment which are not specifically designated herein shall be selected in accordance with the order of precedence set forth in MIL-STD-143. AN or MIL standard parts shall be used wherever they are suitable for the purpose.

3.4.3.1 Materials. Materials shall conform to the applicable specifications as set forth in MIL-E-5400.

3.4.4 Interchangeability. All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in manufacturers' part numbers shall be governed by the drawing number requirements of MIL-D-1000.

3.4.5 Weight. Weight shall be kept to a minimum consistent with other requirements of this specification.

3.5 System design requirements.

3.5.1 Fire response. The system shall indicate a fire within 5 seconds after any 6-inch portion of the entire sensing element arrangement is exposed to a 2,000° F flame of the flame test burner illustrated on figure 1. The systems shall maintain the fire signal for the duration of the fire and shall automatically clear the signal in not more than 30 seconds following extinguishment of the fire. As a design objective, the system should also be capable of indicating a fire within 5 seconds after any 6-inch portion of the entire sensing element arrangement is exposed to a 1,500° F flame.

3.5.1.1 Automatic repeatability. The system shall be capable of signalling three consecutive fires without requiring manual resetting.

3.5.2 Loop circuit. Detachable sensing elements shall be connected to the control unit in a continuous loop circuit such that a single break in the sensing element loop will not cause the system to become inoperative. If one or more breaks occur, those portions of the sensing element circuit that remain connected to the control unit shall retain the ability to detect and signal a fire.

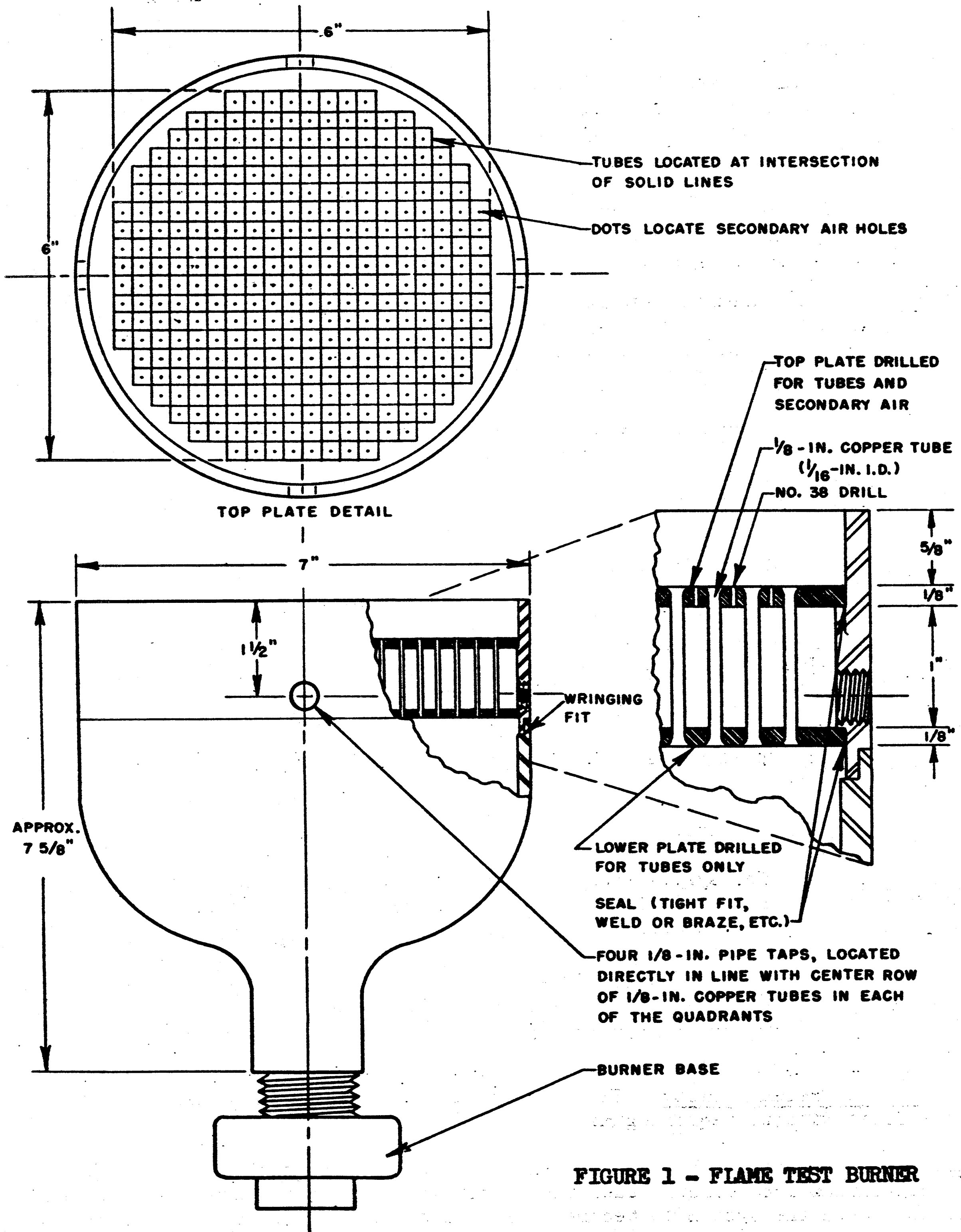

FIGURE 1 - FLAME TEST BURNER

3.5.3 Abnormal flight conditions. The system shall be capable of continuing operation during abnormal flight attitudes, rapidly changing altitudes, extremes of temperature, contaminating atmospheres, accelerations and other conditions which may be encountered during take-off, flight, landing or servicing the aircraft. As a design objective, the system should also be capable of detecting and signalling a fire when a fault such as a ground or short occurs in the sensing element circuit.

3.5.4 Prevention of false warnings. The design and installation of the system shall be such as to prevent the occurrence of false warnings resulting from flight operations, damage to the components of the system, loose connections or inadequate maintenance.

3.5.4.1 Flight conditions. A false warning shall not occur as a result of abnormal flight conditions as described in 3.5.3, nor from any bending or mechanical abuse of of the sensing elements.

3.5.4.2 Break in sensing element. A false warning shall not occur as a result of one or more breaks in the sensing element circuit.

3.5.4.3 Short or ground condition. A false warning shall not occur as a result of any normally ungrounded conductor accidently making a continuous or intermittent contact with any other conductor or with a grounded portion of the airplane.

3.5.4.4 Moisture accumulation. A false warning shall not occur as a result of an accumulation of saline moisture in any connector of the sensing element circuit. As a design objective, the range of sensing element circuit resistance in which a fire alarm may be signalled should not include resistance values that could be produced by any concentration of moisture in the end connectors.

3.5.4.5 Voltage variations. A false warning shall not result from transient voltage conditions, as specified in MIL-STD-704, or from any intermittent voltage between 0 and 124 volts for ac powered systems, or between 0 and 29 volts for dc powered systems.

3.5.5 Alarm temperature setting. Systems designed to respond to specific temperature levels shall be adjusted to signal an alarm at a temperature 150° F to 250° F above maximum operating ambient conditions integrated along the sensing element in each compartment. For systems operating on a rate-of-rise principle, the rate of temperature rise required to signal a fire alarm shall be at least 100 percent greater than the maximum rate of temperature rise occurring during normal engine starting and acceleration.

3.5.5.1 Response limits. Unless otherwise approved by the procuring activity, the system shall be adjusted not to signal a fire alarm at temperatures under 500° F in engine spaces. The temperature required to alarm the system, when applied to any 4- inch section of sensing element, shall not exceed 1,000° F. For overheat systems, trigger temperatures lower than 500° F may be used.

3.5.6 Alarm adjustment. Alarm temperature adjustments shall be secured with a locking device and sealed with tamper-proof seals. Externally mounted adjusting units shall be protected against mechanical damage.

3.5.7 Fire warning signal. The system, when actuating, shall display a legend-type warning signal showing the wore "FIRE" in bold red lettering at least one-half inch in height. The signal shall conform to MIL-STD-411 and shall be located in the direct view of the pilot and copilot.

3.5.7.1 Additional warning signal. In those aircraft where a crew member other than the pilot or copilot is responsible for the fire emergency procedure, the fire warning signal shall be located in the direct view of that crew member, and a master warning signal shall be provided for the pilot and copilot.

3.5.7.2 Lamps. Where light signals are used for fire warning, each signal shall include two MS25231-313 lamps or two other MS or AN lamps of equivalent wattage. During the fire indication, the lamps shall be operated at rated current.

3.5.7.3 Zone indication. Where more than one fire warning signal is provided, each signal shall indicate the specific engine or compartment in which the fire occurs, and shall be marked in accordance with table I of MIL-STD-411. The fire warning signals shall differentiate between fires in different zones of the same power plant when the crew's emergency procedure differs depending upon the zone involved. Warning signals marked to indicate an engine fire shall not be used to signal unrelated conditions, such as rocket pack fires, generator overheat or bearing overheat, which could produce misinterpretation of the actual emergency that exists.

3.5.8 Overheat actuation. Where overheat warning is provided and the emergency procedure for overheat differs from that for a fire condition, the warning system shall provide a distinct overheat signal. This signal shall be in accordance with the requirements of MIL-STD-411 applicable to warning signals.

3.5.9 Alarm verification. Crew members shall not be required to operate a test switch to verify an alarm.

3.5.10 Fire extinguishing installation. In those aircraft where a fire extinguishing system is installed, the fire warning light shall be incorporated in the fire emergency control handle serving the zone or area associated with the particular fire warning light. The fire warning light shall conform to the requirements of 3.5.7 through 3.5.7.3.

3.5.11 Dimming. Warning light dimming shall not be provided in the fire warning system.

3.5.12 Integrity test provisions. A test switch shall be provided in the immediate vicinity of each related warning signal. Actuation of the test switch shall cause the appropriate warning signal or signals to be energized as confirmation of the operational readiness of the system and the continuity of the sensing element circuit. Any discontinuity existing in the sensing element circuit shall prevent indication of the warning signal when the test switch is actuated. Further, the test signal shall not occur if any fault exists in the system that would prevent a warning signal in the event of a fire or overheat.

3.5.13 Power requirements. The system shall comply with applicable requirements of MIL-STD-704 and shall give specified performance as stated therein. Nominal input power shall be 28 volts dc or 115 volts, 400 cycles per second, single phase. When operating at standby, the system shall not draw more than 10 volt-amperes if operated on ac, nor more than 0.5 amperes if operated on dc exclusive of test circuit requirements.

3.5.14 Abnormal voltage protection. The system shall be capable of accepting input voltages below 102 volts ac or 17 volts dc, as applicable, without being damaged, and shall automatically resume operation when the input voltage returns within operating limits. If transistors are used in the system, protection shall be incorporated to prevent damage by 200 volts rms voltage transients of 50 milliseconds duration, and by 56 volts dc voltage transients of 50 milliseconds duration.

3.5.15 Electromagnetic interference. The system shall comply with the electromagnetic interference requirements of MIL-I-6181.

3.5.16 Design operating life. The system shall have a reliable operating life of at least 1,000 hours without requiring removal for bench servicing. As a reliability objective, less than five failures per 100 service installations shall occur per year.

3.5.16.1 Total operating life. The system shall have a minimum total operating life of 10,000 hours with reasonable servicing and replacement of parts.

3.6 Component design.

3.6.1 Control unit design. The control unit shall be a leakproof metal container and shall be hermetically sealed. The cover shall be securely attached by mechanical means other than solder. Internal wiring shall be in accordance with MIL-E-5400.

3.6.2 Sensing element. Sensing elements shall be enclosed in a fireproof metallic covering. Detachable sensing elements shall be provided with suitable end fittings to permit connection into continuous lengths. Sensing elements shall be hermetically sealed or shall be made environment-proof by other suitable means.

3.6.2.1 Sensing element lengths. Detachable sensing elements shall be furnished only in 36, 60, 120 and 180 inch lengths, with a tolerance of plus or minus one-half inch. Not more than two different lengths of sensing elements shall be used in an installation.

3.6.3 Fire-resistance. Sensing elements and other components installed in fire zones shall be capable of withstanding a temperature of 2,000° F for a period of 5 minutes without impairing the fire detection capability. External finishes on the sensing element surface need not be capable of withstanding this fire-resistance test.

3.6.4 Bend radius. The sensing element shall be capable of being bent completely around a one-inch radius without becoming mechanically or functionally damaged.

3.6.5 Connectors. Connectors used to connect sensing elements may be of a non-standard type provided they meet the performance requirements of this specification. Connectors not in the sensing element circuit shall conform to the applicable performance requirements of MIL-C-26482.

3.6.6 Support clamps. The sensors shall be securely supported by clamps in a manner that permits removal or loosening of the sensing elements without requiring removal or loosening of the clamps from the mounting surface. Mounting provisions shall be such as to prevent inadvertent rotation of the clamp. Sensor connectors shall be clamped independent of the sensor. Grommets, if used as inserts in the support clamps, shall be fire resistant and suitable for use with engine oils, jet fuels, and hydraulic fluids.

3.6.7 Relays. Relays, other than those enclosed in the control unit, shall be in accordance with MIL-R-6106.

3.6.8 Identification of product. The control unit shall be marked for identification in accordance with MIL-STD-130. Sensing elements furnished as detachable items shall be identified by part number and manufacturer's designation permanently stamped or etched on an end fitting.

3.7 Installation requirements.

3.7.1 Zones requiring fire detection. Sensing elements shall be routed to monitor the following zones and in such other areas as may be determined by the aircraft contractor to be fire or overheat zones:

- (a) Power sections and accessory sections of reciprocating engine compartments.
- (b) Compressor, burner, tailpipe (if necessary) and afterburner compartments of turbine engine installations.
- (c) The accessory section of turbine engines, if flammable fluid system components and sources of ignition are both present.
- (d) Engine compartments of rocket engine installations.
- (e) Auxiliary power plant compartments if not normally occupied.
- (f) Compartments containing electrical or electronic equipment in the vicinity of combustibles where such compartments are not normally occupied.
- (g) Bleed air ducting when in combination with fuel and ignition source.
- (h) Auxiliary heater systems located in unoccupied areas.

3.7.2 Temperature survey. A temperature survey shall be conducted analytically to determine the maximum temperatures occurring at proposed locations of the sensing elements during each of the aircraft operating conditions listed in 4.6.38. Results of this analysis shall be used to determine the required temperature characteristics of individual sensing elements.

3.7.3 Accessibility. Components shall be located to facilitate repair, replacement and test, preferably without the use of special tools or the movement of other parts in the airplane. Connection points shall be readily accessible for required checks of the sensing element resistance values.

3.7.4 Sensing element installation details.

3.7.4.1 Location of sensing elements. Sensing elements shall be located as close as practicable to sources of combustibles, such as fuel strainers, and ignition sources, such as electrical equipment, where the proximity of these combustibles and ignition sources constitutes a possible source of fire. The selected locations shall also comply with the following requirements:

- (a) Sensing elements shall be placed in the path of the most probable flame travel, including all air exits from potential fire zones and "dead" airspaces, so that fire can be detected under both flight and ground conditions.
- (b) Sensing elements shall be within the airflow path to be monitored and shall not be shielded, insofar as practicable, by ribs, formers, tubing or other obstructions.

(c) Sensing elements shall be located to monitor regions where flammable fluids may drain, drip or accumulate.
(d) Where airflow reversal may occur, such as the forward portion of turbine engines, fire detection shall be provided at all air inlets and outlets connected to areas containing combustible material or fluids.
(e) Sensing elements shall be located out of the path of normal exhaust gas discharge.
(f) Sensing elements shall not be mounted in any manner which interferes with ready repair or replacement of an engine.
(g) Sensing elements located in the lower portion of turbine engine compartments shall, where practicable, be routed longitudinally for maximum fire detection.
(h) Sensing elements and connectors shall be readily accessible to connect circuit measuring devices during maintenance of the system.
(i) Unless specifically authorized by the preparing activity, sensing elements in engine compartments shall be mounted on the airframe. Consideration will be given to mounting sensing elements on the engine where (1) such method of installation can be shown to provide markedly superior flame detection properties or (2) the engine enclosure consists mainly of hinged or removable sections.

3.7.4.2 Support clamp spacing. The spacing between support clamps shall not exceed 8 inches. The first support clamp from each end of the sensing element shall be located not more than 4 inches from the connector, with sufficient sensing element curvature to provide flexibility for relative structural motion. Clamps shall be positioned to prevent chafing of the sensing elements on adjacent portions of the airplane.

3.7.4.3 Mounting clearance. Sensing elements shall be positioned as close as practicable to the mounting surface to minimize the possibility of being damaged during maintenance of adjacent equipment. Direct contact of the sensing element to the aircraft skin or to structural members shall be avoided. Adequate clearance shall be provided to prevent sensing elements from vibrating against other objects.

3.7.4.4 Points having relative motion. The routing of sensing elements between two adjacent points of support which have different relative motions shall be avoided whenever practicable. Where necessary to route the sensing element loop between two such points, a flexible connector suitable for the ambient temperature condition shall be used. Flexible connectors installed in potential fire zones shall comply with the requirements of 3.6.3. Sensing elements shall not be mounted on flexible tubing or other non-rigid components subject to appreciable movement during aircraft operation. Flexible connections across hinge lines for all doors, panels and dive brakes shall be designed and installed to prevent pinching.

3.7.4.5 Bends. Bends in the sensing element shall have a radius not less than 1 inch. In addition to the clamps required by 3.7.4.2, the sensing element shall be supported by a clamp at or near the center of each bend, where practicable. The section of sensing element between the end connector and the first clamp shall be straight, where practicable.

3.7.4.6 Removable airframe sections. Insofar as practicable, sensing elements shall not be mounted on or supported by cowl panels, access doors or other airframe sections that are removed or opened during maintenance of the aircraft. Where such mounting or support is necessary, suitable quick disconnects shall be used or free access shall be provided to disconnect the sensing elements. Removable airframe sections shall not be supported by the fire detection wiring when the section is removed or opened for aircraft servicing or inspection.

3.7.4.7 Guards. Guards shall be provided where necessary to prevent mechanical damage to the sensing elements during engine removal or installation. The number and size of the guards shall be kept to a practicable minimum to prevent reduction in fire detection sensitivity.

3.7.4.8 Connector location. Connectors and end fittings shall be located and positioned to prevent the entry and accumulation of moisture or other contaminants.

3.7.4.9 Safety wiring. All connectors and end fittings shall be secured by safety wire or by a suitable locking means.

3.7.5 Electrical requirements. Except as modified herein, installation of electrical and electronic components of the fire warning system shall be in accordance with the applicable requirements of MIL-E-7080 and MIL-I-8700, respectively.

3.7.5.1 Circuit breaker. A separate circuit breaker shall be provided for the exclusive use of each fire warning system. The electrical power shall be supplied from the essential bus. Testing circuits need not comply with the foregoing requirements provided that failure of the testing circuit will not impair ability of the system to detect and signal a fire.

3.7.5.2 Wiring. The installation of wiring of the fire warning system shall be in accordance with MIL-W-5088, except that all wire used within a potential fire or overheat zone shall be in accordance with MIL-W-25038. The alternative use of interconnecting wire in fire zones is permitted if such wiring is suitably protected to withstand a 2,000° F enveloping flame for a period of at least 5 minutes without impairing the fire detection capabilities.

3.8 Submittal of data. Prior to the initial installation of the fire warning system, and after any changes to an engine or nacelle that may affect the operation of the fire warning system, the airplane contractor shall submit to the procuring activity for review and concurrence the design data listed below. The contractor shall also specifically indicate any proposed deviations from this specification.

- (a) Calculated operating and maximum temperatures for zones or sections in which sensing elements will be located, and the alarm temperature settings for those zones.
- (b) Location of warning system control units, warning signals and test switches.
- (c) The estimated maximum temperature to which the control units will be subjected.
- (d) A schematic diagram showing electrical circuitry, including the test circuit and warning lights, but not including the internal circuitry of the control unit.
- (e) A sketch of the sensing element configuration in relation to engines, firewalls, shrouding and adjacent bulkheads.
- (f) Estimated weight of the system.

3.9 Workmanship. The workmanship shall be sufficient of quality to insure safety, proper operation, and service life. All fasteners shall be tight and adequately secured. Details of workmanship shall be subject to inspection and approval of the procuring activity.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection responsibility. The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examinations and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specifications where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of tests. The inspection and testing of fire warning systems shall be classified as follows:

(a) Preproduction tests (4.3)
(b) Quality conformance tests (4.4)

4.3 Preproduction tests. Preproduction tests shall be required for each new design of a fire warning installation and shall consist of all tests specified under "Test methods." The tests shall be conducted in the sequence listed under 4.6, unless the procuring activity has approved an alternate test sequence.

4.3.1 Preproduction test samples. The preproduction test sample shall consist of (a) a complete fire warning system duplicating the configuration to be installed in the airplane and (b) a calibration test assembly as described in 4.5.3.

4.3.1.1 Failure of test sample. If damage to any component occurs during the preproduction test to render the component inoperative, that component shall be replaced, and all prior testing that depended upon satisfactory operation of the component shall be repeated. A false alarm signal occurring during any of the tests shall disqualify the components from further testing. Repeat tests following a false alarm signal will be authorized only if the supplier presents satisfactory evidence to the Government inspector that the cause of failure has been suitably remedied.

4.3.2 Test reports. Unless otherwise specified, the preproduction tests shall be conducted at the airframe contractor's plant or at the vendor's plant, under supervision of the Government inspector. The contractor shall furnish a test report, in duplicate, showing results of all tests performed and indicating the test results associated with each applicable paragraph under 4.6. The report shall include a listing of all components tested, showing nomenclature and part numbers. The test report shall be forwarded for approval by the procuring activity.

4.3.2.1 Alteration after tests. If any alteration is made in material, adjustment or construction after approval of the test, the supplier shall immediately notify the procuring activity, outlining points of difference and similarity between the approved and the altered component or installation. Supplementary tests will be required at the option of the procuring activity.

4.3.3 Waiver of preproduction tests. Preproduction tests for fire warning systems will not be mandatory on subsequent contracts for the same airplane series, provided the system installation and components have not been changed. In conducting preproduction tests, it is not intended that any tests be performed if compliance with the requirements of this specification can be shown by previously conducted tests. However, the procuring activity shall have the right to require the performance of any of the tests at any time it is considered necessary to determine compliance of the installation to this specification. Preproduction tests shall not apply to the procurement of components as spares or supply replacement items.

4.4 Quality conformance tests. Quality conformance tests shall consist of the following:

(a) Individual tests (4.4.1)
(b) Sampling tests (4.4.2)

4.4.1 Individual tests.

4.4.1.1 Component individual tests. Each component submitted for acceptance under contract shall be subjected to the tests of 4.6.1 through 4.6.6, as applicable.

4.4.1.2 Installation individual tests. Each installation of a fire or overheat warning system in an airplane shall be subjected to the tests of 4.6.8, 4.6.9 and 4.6.10.

4.4.2 Sampling tests. Completely assembled sensing elements representing at least 10 percent of the total length of elements manufactured from each batch of core material shall be selected at random for calibration tests in accordance with 4.6.7. The element lengths shall be tested individually.

4.4.2.1 Rejection of samples. If any one sensing element selected as a sample fails the test of 4.6.7, an additional 10 percent sample shall be selected and tested in accordance with 4.6.7. If two or more sensing elements of the first sample group fail the test of 4.6.7, or if any one sensing element of the second sample group fails the test, all sensing elements manufactured from that batch of core material shall be subjected to the test of 4.6.7.

4.5 Test conditions.

4.5.1 Ambient conditions. Unless otherwise specified, all tests shall be conducted at ambient temperature and pressure, both of which shall be recorded.

4.5.1.1 Flame test ambient temperature. Flame tests shall be conducted at room temperature, except that a higher starting ambient temperature may be used if the sensing element being tested will be installed in a location where the ambient temperature will not, under continuous operating conditions, decrease below this value.

4.5.2 Supply voltage. Unless otherwise specified, the system shall be operated at rated input conditions during the tests.

4.5.3 Environmental test procedure. Environmental tests shall be conducted using a "calibration test assembly." For systems using detachable sensing elements, the calibration test assembly shall consist of two 60-inch lengths of sensing elements joined together with one end only connected to the control unit through flexible interconnecting wiring. For systems using a nondetachable sensing element, the calibration test assembly shall consist of a sensing element length of 120 inches or longer, with one end only connected to the control unit. The sensing element length shall be completely inserted in a heat source such as an accurately calibrated forced air oven or an accurately calibrated salt bath. In conducting the specified calibration tests, the temperature of the heat source shall be raised to the specified starting temperature and then increased at a rate not exceeding 4° F per minute. Unless otherwise specified, the control unit shall be at room temperature during the environmental tests, except that control units intended to be operated in engine spaces shall be subjected to the same heat as the sensing element test section.

4.5.4 Flame test conditions. Response of the fire warning system to controlled flame conditions shall be demonstrated under 4.6.24 through 4.6.32 on an operating mock-up of the complete system installation. The mock-up shall consist of the exact configuration of components intended to be used in the actual installation in the airplane. The mock-up may be assembled on a flat surface for convenience, and the clamps may be omitted. The mock-up shall be adjusted to the alarm temperature setting that will be used in the airplane installation. Where the airplane installation includes two or more fire warning systems of substantially equal configuration, only one system shall be mocked up. Flame tests shall be conducted in accordance with 4.5.4.1 through 4.5.4.3.

4.5.4.1 Flame test burner. Flame tests shall be performed using a flame test burner constructed in accordance with figure 1. The burner shall use bottled gas rated at 2,500 BTU per cubic foot, and the air shall be adjusted to produce a uniform,steady flame with no yellow tips appearing above the blue flames. For tests at 2,000° F, the burner shall be adjusted to consume 65,000 BTU per hour. For tests at 1,500° F, the burner shall be adjusted to consume 30,000 BTU per hour. The allowable variation in flame temperature for either test temperature shall be plus or minus 50° F.

4.5.4.2 Flame temperature measurement. All flame temperatures shall be measured by using an 18 gauge wire thermocouple. The thermocouple bead shall be at the center of the flame and the two wires leading to the bead shall be parallel and shall extend for a distance of 3 inches horizontally into the flame. The vertical distance between the flame and the thermocouple shall be the same as that between the flame and the test article.

4.5.4.3 Flame application. Unless otherwise specified, the flame shall be 2,000° F and shall be applied to a 6-inch long portion of sensing element most remote from the control unit. Where the sensing element circuit includes individual elements of differing response characteristics, the specified flame tests shall be accomplished on the most remote element of each type, measured from the control unit. The portion of sensing element not subjected to the test flame shall be at room temperature or at the ambient temperature permitted by 4.5.1.1. The sensing element portion to be tested shall be mounted in a fixture that permits rapid immersion and removal from the flame, and holds the sensing element in a fixed position in the flame. An accurate timing device shall be provided to measure automatically the elapsed time of response and reset. A manual resetting means shall not be used to clear the alarm in any test under this specification.

4.6 Test methods.

4.6.1 Examination of product. Each component shall be examined to determine conformance with this specification with respect to materials, workmanship, size, length, and marking.

4.6.2 Component resistance. The electrical circuits of each detachable sensing element and each connector shall be tested to determine that the resistance is within the manufacturer's design limits.

4.6.3 Control unit calibration. Each control unit shall be tested to determine that its respond and reset points are within the manufacturer's specified values. Systems using non-detachable sensing elements shall be subjected to a comparable resistance test.

4.6.4 Control unit high potential test. Each control unit shall be subjected to one of the following tests, as applicable, and breakdown of insulation as a result of the test shall constitute failure.

(a) A sinusoidal voltage at a commercial frequency shall be applied between all electrical circuits connected together and the metallic case for a period of 5 seconds. The RMS value of the applied voltage shall be either 5 times the maximum operating voltage or 500 volts, whichever is lower.

(b) For control units operated with a permanent internal ground connection, a sinusoidal voltage at a commercial frequency shall be applied between each electrical circuit and the metal case for a period of 5 seconds. The RMS value of the voltage applied shall be 1.25 times the maximum circuit operating voltage obtainable between the test points. DC circuits shall be tested by application of 1.25 times the maximum dc operating voltage.

4.6.5 Sensing element insulation test. Each length of detachable sensing element shall be immersed in tap water for a period of 5 minutes with a vacuum equal to 28 inches of mercury applied to the air above the water. The element shall then be removed from the water and the insulation resistance shall be measured by applying a voltage of 150 volts between the inner conductor and the shell. The reduction in insulation resistance shall not exceed 25 percent of the value obtained in 4.6.2. External surfaces of the sensing element may be dried before measuring the final resistance.

4.6.6 Connector high potential test. Each connector and flexible connection shall be subjected to 500 volts RMS at a commercial frequency for at least one minute, applied between the pin or socket contact and the shell or body. The leakage current shall not exceed 2 milliamperes.

4.6.7 Sensing element calibration tests. The sensing element temperature-resistance calibration shall be tested to determine that it is within the values shown on the manufacturer's specification. For this test, the sample sensing element shall be inserted in an accurately calibrated forced air oven or immersed in an accurately calibrated salt bath. Sensing elements shall be tested throughout the entire temperature operating range shown on the manufacturer's specification. Sensing elements having fixed alarm points shall be tested to verify respond and reset values shown on the manufacturer's specification. For warning systems that do not operate on the change-of-resistance principle, the manufacturer shall substitute a calibration test equivalent to the foregoing temperature-resistance calibration.

4.6.8 Examination of installation. Each warning system installation shall be examined to determine compliance with the installation and operating requirements specified herein.

4.6.9 Resistance. The resistance of each installed sensing element circuit shall be checked to verify that it complies with the specified value.

4.6.10 Continuity. Each installed warning system shall be checked for continuity of the circuits as evidenced by actuation of the fire or overheat warning signals when the system integrity check is made.

4.6.11 Calibration at nominal alarm setting. The calibration test assembly shall be adjusted to alarm at a temperature between 500° F and 1,000° F as selected by the manufacturer. The sensing element shall be subjected to heat as specified in 4.5.3. The starting temperature of the heat source shall be at least 75° F below the pre-set alarm temperature. The temperature at which the system alarms shall be within plus or minus 6 percent of the preset alarm temperature, and shall be designated as the "reference alarm temperature."

4.6.12 Repeat calibration tests. The calibration test of 4.6.11 shall be repeated following the environmental tests of 4.6.14, 4.6.15, and 4.6.21. The alarm temperature setting used in 4.6.11 shall be retained. The temperature at which the system alarms following each of the environmental tests of 4.6.14, 4.6.15, and 4.6.21 shall not vary more than 6 percent from the reference alarm temperature of 4.6.11.

4.6.13 Overheat calibration. Where overheat detection is provided, the test of 4.5.3 shall be repeated for overheat detection. The response temperature shall be designated by the manufacturer. The starting temperature of the heat source shall be 50° F below the specified response temperature. The temperature at which the system responds to overheat shall be within plus or minus 6 percent of the specified response temperature.

4.6.14 High temperature. The calibration test assembly shall be subjected to the high temperature test of MIL-E-5272, Procedure II. The calibration test of 4.6.12 shall be performed while the control unit is kept at the high temperature.

4.6.15 Low temperature. The calibration test assembly shall be subjected to the low temperature test of MIL-E-5272, Procedure I. The calibration test of 4.6.12 shall then be performed while the control unit is kept at -65° F.

4.6.16 High altitude and rate of climb. The calibration test assembly shall be installed in an altitude chamber at ambient temperature and operated at standby. The pressure shall be varied from normal atmospheric pressure to an altitude pressure equivalent to 100,000 feet, at a rate of not less than 20,000 feet per minute. The calibration test assembly shall then be maintained at the 100,000-foot altitude pressure for 48 hours. Alarm and clear resistance values of the control unit shall be noted at the beginning and end of the 48-hour period while the calibration test assembly is maintained at the 100,000-foot altitude pressure. The alarm and clear resistance values noted shall be within the limits specified by the manufacturer. The pressure shall then be increased to sea level conditions. The sealed portions of the calibration test assembly shall not leak as a result of exposure to this pressure. The resistance to leakage shall be demonstrated by subjecting the sealed portions of the calibration assembly to the immersion test described in MIL-E-5272, Procedure I. There shall be no evidence of leakage.

4.6.17 Rain. The calibration test assembly shall be subjected to the rain test of MIL-E-5272, Procedure II. The rain test shall not be required for components that have been subjected to the immersion test of 4.6.16.

4.6.18 Humidity. The calibration test assembly shall be subjected to the humidity test of MIL-E-5272, Procedure I, except that 5 cycles shall be performed.

4.6.19 Vibration. The calibration test assembly shall be subjected to the vibration test of MIL-E-5272, Procedure XII, except that a value of plus or minus 15g shall be substituted for the plus or minus 10g acceleration. One half of each resonant and cycling period shall be conducted at room temperature. The other half of the periods shall be conducted at the maximum operating ambient temperature to which the system will be subjected in the airplane installation. During this test, the sensing elements shall be supported by mounting clamps spaced approximately 8 inches apart.

4.6.19.1 Acoustical noise test. Sensing elements, clamps, and all other connectors normally located in the engine nacelle or other high noise level areas shall be subjected to sound pressure levels of 150 db for a period of 30 minutes.

4.6.20 Salt spray test. The calibration test assembly shall be subjected to the salt spray test of MIL-E-5272, Procedure I, for a period of 50 hours.

4.6.21 Fuel and oil immersion test. The sensing element length, including one exposed end fitting, shall be completely immersed in test fluid conforming to TT-S-735, type III, followed by complete immersion in oil conforming to MIL-L-7808. Each immersion shall be at room temperature for a period of not less than 15 minutes. Following each immersion, the specimen may be allowed to drain for one minute. No cleaning other than the drainage specified above shall be accomplished. The calibration test of 4.6.12 shall be performed following the second immersion.

4.6.22 Disassembly and inspection. At the completion of the tests of 4.6.14 through 4.6.21, each component of the calibration test assembly shall be disassembled to the extent practicable and shall be inspected. Any evidence of major deterioration, corrosion or excessive wear shall be cause for rejection.

4.6.23 Radio interference test. The fire warning system shall be tested to determine conformance with the requirements of MIL-I-6181.

4.6.24 Power variation tests. Flame tests in accordance with 4.5.4 shall be performed under the various input power conditions specified in MIL-STD-704. In each case, an alarm shall occur in not more than 5 seconds after exposure to flame, and shall clear in not more than 30 seconds after removal of the flame.

4.6.25 Response time with 1,500° F flame. Flame tests shall be conducted in accordance with 4.5.4 using a flame temperature of 1,500° F. An alarm shall occur in not more than 10 seconds after flame application.

4.6.26 Reset test. The flame test of 4.5.4 shall be applied for a period of at least one minute. The flame shall then be removed. Within 5 seconds after the alarm has cleared, the flame shall be re-applied and an alarm shall occur in not more than 5 seconds.

4.6.27 Partial extinguishment test. The flame test of 4.5.4 shall be applied for a period of 30 seconds. The test flame shall then be masked so as to reduce its effective area of contact by approximately 50 percent. The alarm signal shall not clear. After an additional 30 seconds, the flame shall be removed entirely and the alarm signal shall then clear in not more than 30 seconds.

4.6.28 Repeated response and clearance time. The flame test of 4.5.4 shall be applied for two periods of at least one minute each. The sensing element shall be cooled to room temperature, or to the alternate temperature permitted by 4.5.1.1, after each exposure to flame. The flame shall then be applied a third time to the same portion previously heated. An alarm signal shall occur in not more than 5 seconds after each exposure to flame. During cooling of the sensing element after each exposure to flame, the alarm shall clear in not more than 30 seconds after the flame has been removed. Artificial means of cooling the sensing element shall not be used. During the tests of this paragraph, the sensing element section subjected to the flame shall be vibrated at an acceleration of 10g at a frequency of 30 cycles per second. The vibration required under this paragraph may be produced by a mechanical means such as an 1,800 rpm motor driving an eccentric arm or cam.

4.6.29 Discontinuity in sensing element circuit. The system shall be operated at standby and the integrity test switch shall be actuated. The warning light shall illuminate immediately to indicate system continuity. The test switch shall then be released. The sensing element loop shall then be opened by disconnecting two connected sections. No alarm shall occur. The test switch shall then be actuated and the warning lights shall not illuminate. The test switch shall then be released. A 6-inch section of one sensing element portion shall be subjected to a 2,000° F flame in accordance with 4.5.4. A 6-inch section on the other side of the discontinuity shall then be similarly tested. An alarm shall occur in each case in not more than 5 seconds after application of the flame. In systems that do not use detachable sensing elements, the sensing element circuit shall be opened by a suitable method, with the flame applied between the break and the control unit.

4.6.30 Sensing element flame-proof test. The flame test of 4.5.4 shall be applied for a period of at least 5 minutes. After the alarm signal occurs, it shall not clear during the remainder of the 5-minute period. The flame shall then be removed and the sensing elements allowed to cool to room temperature or to the ambient temperature permitted by 4.5.1.1. After the alarm signal has cleared, the above flame shall again be applied to the same portion of sensing element and an alarm shall occur in not more than 10 seconds. For systems using detachable sensing elements, the above flame tests shall be applied at a connection point of two sensing elements and shall include the end fittings and 3 inches of elements on each side.

4.6.31 Bending test. A portion of sensing element shall be bent completely around a mandrel of one inch radius while connected to the control unit operating at standby. An alarm shall not occur during any part of the bending operation. Following this operation, a 6-inch portion of the sensing element, including the bent portion, shall be subjected to a 2,000° F flame. An alarm shall occur in not more than 5 seconds. The portion of sensing element not subjected to flame shall be at room temperature or at the ambient temperature permitted by 4.5.1.1.

4.6.32 Connector flame-proof test. The test of 4.6.30 shall be conducted for each type of bulkhead connector and mounting connector to be furnished with the fire warning system. The connector shall be attached between two sensing elements for this test.

4.6.33 Grounded sensing element test. With the system operating at standby, the integrity test shall be performed and the warning signal shall actuate. The integrity test switch shall be released. A ground connection shall then be applied to the internal conductor of the sensing element circuit and an alarm shall not occur. The test of 4.6.33.1 or 4.6.33.2, as applicable, shall then be performed. The test of this paragraph shall be repeated for the second internal conductor if the sensing elements contain two conductors that are normally ungrounded.

4.6.33.1 Activated system.- For systems that continue to function when the sensing element conductor becomes grounded, the following test shall apply. The integrity test shall be made with the system still grounded and the warning signal shall be actuated. The flame test of 4.5.4 shall be performed with the sensing element circuit grounded and an alarm shall occur in not more than 5 seconds after exposure to flame.

4.6.33.2 Deactivated system. For systems that are incapable of signalling a warning with a grounded sensing element circuit, the following test shall apply. The integrity test shall be made with the sensing element circuit still grounded, and the warning signal shall not actuate

4.6.34 Salt water immersion test. With the system operating at standby, the sensing element loop shall be disconnected at a convenient point or the internal conductor shall be exposed by other means. The open end fitting or exposed conductor shall be completely immersed in a 5 percent solution (by weight) of salt water for not less than 10 seconds and an alarm shall not occur. The end fitting shall be removed from the salt solution, and excess solution may be shaken off. Within one minute after removal from the salt solution, the test switch shall be actuated and the warning signal shall actuate to verify system operation.

4.6.35 Support clamp. A sensing element support clamp shall be subjected to a temperature of 2,000° F for a period of at least 5 minutes. The temperature shall be supplied by an oven or by a completely enveloping flame in accordance with 4.5.4.1 and 4.5.4.2. After cooling, the clamp shall be examined to determine that it remains capable of retaining the sensing element.

4.6.36 Temperature rise tests. The fire warning system installation in engine compartments shall be subjected to the temperature rise tests of 4.6.36.1 and 4.6.36.2 to demonstrate that no alarm occurs under these conditions. The test may be performed on a simulated installation, at the contractor's option, or during flight tests. The rate of temperature rise and the duration values shall be as defined by the airframe contractor's detail specification for the specific airplane.

4.6.36.1 False alarm due to local temperature rise. The sensing element installation shall be subjected to various combinations of rate of temperature rise and duration of these rates of rise. An alarm shall be signalled only when the alarm setting is exceeded. The test shall be conducted under actual or simulated conditions of local overheating.

4.6.36.2 False alarm due to general temperature rise. The test of 4.6.36.1 shall be repeated except that the rates of rise and durations as specified in the contractor's detail specification for general temperature rise throughout the engine compartment shall be used. No alarm shall be signalled when the sensing element installation is exposed to any combinations of these rates of rise and durations. The test shall be conducted under actual or simulated conditions of general temperature rise throughout the engine compartment.

4.6.37 Flight demonstration. The tests of 4.6.37.1 and 4.6.37.2 shall be accomplished during the flight demonstration of the complete airplane prior to acceptance as a service model.

4.6.37.1 False warning. The following tests shall be performed to demonstrate that the system will not produce false alarms under various flight operating conditions, with any combination of atmospheric conditions that may be encountered. The system integrity check shall be made to verify system operation prior to each test.

(a) Engine start.
(b) Quick warm-up to maximum allowable temperature (cooling flaps closed, if permissible).
(c) Ground runup to full power.
(d) Take-off.
(e) Military power climb from take-off (and maximum thrust).
(f) Level flight at full military power (and maximum thrust) at service ceiling and at the altitude providing maximum heating of the engine compartment.
(g) Propeller feathering, if applicable.
(h) Engine restart during flight at minimum allowable airspeed (if permissible).
(i) Landing roll with maximum allowable reversed-thrust operation.
(j) Dive from service ceiling under conditions simultaneously resulting in both maximum increase in ambient air temperature and airplane speed. The change should be accomplished in minimum practicable time, starting from low speed conditions.
(k) Missed approach or go-around after low-power approach.
(l) Hovering.
(m) Vertical take-off.
(n) Transition.

4.6.37.2 Temperature determination. Actual ambient temperatures of the engine spaces monitored by the fire warning system shall be obtained during flight tests, ground operations and following engine shutdown. Appreciable deviations from the ambient temperatures calculated under the temperature survey of 3.7.2 shall require revision of the system alarm setting.

4.7 Engineering inspection. The fire warning system installation of one of the first complete experimental or production aircraft will be subject to inspection by engineering representatives of the procuring activity for conformance with the requirements of this specification. It is expected that this inspection will be conducted at the contractor's plant concurrently with similar engineering inspections of other systems of the aircraft.

4.8 Satisfactory performance. Failure of any component being tested to meet the requirements of any specified test,or occurrence of a false alarm during any test, shall constitute failure of the component.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging.

5.1.1 Level A. When this level is specified, components of fire warning systems shall be preserved and packaged in accordance with MIL-P-7936. Unit packaging shall be in accordance with MIL-P-116. Control units, including those with non-detachable sensing elements, shall be packaged under Method IId in a container conforming to MIL-D-6055. Other components shall be packaged in accordance with Method III.

5.1.1.1 Non-mixing of components. Unless otherwise specified, interior packages shall contain items of only one part number.

5.1.2 Level C. When this level is specified, the components shall be preserved and packaged in accordance with standard commercial practice.

5.2 Packing.

5.2.1 Levels A and B. When level A or level B is specified, packaged items shall be packed for overseas or domestic shipment, respectively, in accordance with MIL-P-7936.

5.2.2 Level C. When this level is specified, components shall be prepared for shipment to comply with the latest standard commercial regulations.

5.3 Marking. Marking of interior and exterior containers shall be in accordance with MIL-P-7936.

6. NOTES

6.1 Intended use. Fire warning systems covered by this specification are intended for use in engine spaces, baggage compartments and other normally unoccupied compartments in which a potential fire hazard exists.

6.2 Ordering data. Requisitions, contracts and orders should refer to the title, number and date of this specification and should state the levels of packaging and packing desired.

6.3 Definitions.

6.3.1 Procuring activity. For purpose of this specification, the term "procuring activity" is defined as the Government activity that is procuring the aircraft involved.

Custodians:
Navy - AS
Air Force - 11

Reviewer activities:
Navy - AS
Air Force - 11, 82

Preparing activity:
Navy - AS