



U.S. Department
of Transportation
**Federal Aviation
Administration**

Memorandum

Subject: **ACTION:** Equivalent Level of Safety, SIAI
Marchetti S211A, 14 CFR Part 23, § 23.1182;
Nacelle Areas Behind Firewalls; Finding No.
ACE-95-10

Date:

APR 06 1995

From: Manager, Standards Office, ACE-110

Reply to
Attn. of:

To: Manager, Small Airplane Directorate, ACE-100

This memorandum is to document concurrence with an equivalent level of safety to the fireproof requirements of 14 CFR Part 23, § 23.1182.

BACKGROUND:

The SIAI Marchetti S211A is a two-place, acrobatic, single-engine jet airplane that is a slightly modified version of the S211 military trainer. The S211A complies with the § 23.1191 fireproof requirements. However, there are flight control rods on the side opposite of the engine that will not meet the criteria of § 23.1182; therefore, SIAI Marchetti has proposed that their crew escape system offers an Equivalent Level of Safety (ELOS) to this regulation. SIAI Marchetti was requested at the preliminary FAA S211A Type Certification Board meeting, February 8, 1994, to provide a recommended fire containment interval sufficient to allow the flightcrew member reasonable time to assess the situation and act consistent with crew and ground inhabitants safety. The S211A is equipped with existing Martin Baker MK 10 ejection seats. This seat is used in more than 10 types of existing military jets throughout the world.

APPLICABLE REGULATIONS:

Section 23.1182; Nacelle areas behind firewalls.

Components, lines, and fittings, except those subject to the provisions of § 23.1351(e), located behind the engine compartment firewall must be constructed of such materials and located at such distances from the firewall that they will not suffer damage sufficient to endanger the airplane if a

portion of the engine side of the firewall is subjected to a flame temperature of not less than 2,000° F for 15 minutes.

APPLICANT'S POSITION:

The S211A aircraft utilizes a Titanium sheet material, 0.016 inch thick, to comply with the § 23.1191 fireproof requirements. However, there are flight control rods on the side opposite of the engine that will not meet the criteria of § 23.1182; therefore, SIAI Marchetti has proposed an Equivalent Level of Safety (ELOS) to this regulation.

The S211A aircraft has a crew ejection seat system. SIAI engineering has provided a fire containment interval sufficient to allow the flightcrew member reasonable time to ascertain the situation and determine/apply a course of action consistent with crew and ground inhabitants safely. The approach utilized to develop this interval was similar to that normally employed for control system failures; through the establishment of event phased time increments:

1. Fire Initiation to Cue Time
2. Recognition Time
3. Decision/Reaction Time
4. Ejection Sequence Time

DISCUSSION:

A. The development of flightcrew member ejection time requirements of 42.5 seconds is as follows:

1. Fire Initiation to Cue Time - 5 Seconds

On the S211A, a redundant Fire Detection System provides both Visual and Aural Warnings to the cockpit. The maximum response time for this system, designed and qualified in accordance with MIL-F-7872 and TSO-C11D is five seconds. The time for the FIRE Lamps to light and the Aural Warning to sound is negligible.

2. Recognition Time - 5 Seconds

The development of this interval includes the pilot awareness of the warning (a second), a one-second allowance for a potential instinctive reaction to RESET the warning (however, this warning cannot be reset), and three seconds for a Visual Survey of the aft fuselage (via the rear-view mirrors) for

potential confirmation of a fire. The S211A redundant warning system, however, provides a positive indication of a fire and the flightcrew member should initiate preparations for ejection.

3. Decision/Reaction Time - 22 Seconds

The longest of the intervals, the time allowances include initially Retarding the Throttle to Idle (one second) and three seconds to maneuver the aircraft (assumed from the worst case condition of inverted flight at low speed and altitude) to an erect, wings-level attitude suitable for ejection. If the Fire Visual/Aural Warnings remain on, or fail the Press-to-Test Check, cut off the fuel supply to the engine via the Manual Fuel Shut-Off Valve (one second). An allowance of 17 seconds is then provided to perform a 180 degree turn, at low altitude and low load factor, to establish aircraft heading/attitude for ejection.

4. Ejection Sequence Time - 10.5 Seconds

A time interval of two seconds is provided for direct preparation for ejection including the coordination with a potential second flightcrew member. This allowance is over and above the preparation that will be on-going once the decision has been made to eject in Step 3. A further allowance of eight seconds is included for final communications with Ground Controllers relative to the emergency situation and the eject decision. Actual ejection time, to clear the vehicle itself, is 0.5 seconds (0.25 seconds per crew member).

The above sequence of events and corresponding intervals were validated, to the extent possible, using flight crew members in a ground simulation of an engine fire emergency. The overall required containment time of 42.5 seconds is considered conservative since the timed events were developed in a serial process whereas in an actual situation many activities are performed in parallel, particularly if there are two flightcrew members on board.

B. Development of the S211A fire containment capability time interval is as follows:

The second part of the development of the subject Equivalent Level of Safety for the S211A aircraft was the establishment of the Fire Containment Capability of the aircraft. Analysis of the S211A configuration in proximity to a potential Engine Compartment fire revealed that the most critical components were the Elevator Control Rods (located one inch above the Horizontal Titanium Firewall). Loss of this Primary Control function would

seriously impair the ability to maintain safe flight. The wiring for the electrically powered Longitudinal Trim System (Horizontal Stabilizer) is MIL-W-25038; qualified to withstand a temperature of 2,000° F for five minutes. The Directional Flight Control System is similar to the Elevator Control Configuration and the subsequent test analysis applies. However, the Rudder control is not essential for safe controlled flight.

To establish the subject capability, a Fire Test was performed, using the criteria of AC 20-135, to determine the temperature profile at the control rods as a function of time. The aircraft installation was simulated on a test stand, a heating source was provided by Burner capable of producing 4,500 BTU/hour (SAE ARP 1055A), and suitable instrumentation was in-place. With the surface of the Firewall heated up to approximately 2,000° F, the Control Rod surface temperatures attained approximately 932° F after almost four minutes of applied heating. While the subsequent Firewall temperatures were reduced slightly from the 2,000° F criteria, the significant stabilization period shown indicates that the Control Rod temperature would peak at about the 932 degree level. Comparing the material characteristics of the 2024 T42 Aluminum Control Rod (wall thickness of 1.2 mm) with the test temperature profile resulted in the following load retention characteristics:

1. Maintain 90% Rod Design Strength (Ultimate) Capability up to 45 seconds (to 200° C).
2. Maintain Maximum § 23.143 Transient Stick Force Capability (60 pounds) up to two minutes (to 430° C) with the Margin of Safety of 120% relative to Control Rod Yield Limits.
3. Reduced Stick Force Capability available beyond two minutes for some period of time.

The Required Fire Containment Interval of 42.5 seconds is well within the Fire Containment Capability of the aircraft providing a significant margin of safety of the flight crew. The above Fire Containment Capability results may be considered conservative for the S211A configuration and the scenario provided in the Required Fire Containment analysis. If the Fuel Shut-Off Valve is closed within 15 seconds of actual fire, less than 5.5 liters of fuel are available to sustain the fire. This is based on the highest fuel delivery rate (0.3 Liters per second) that can be achieved by the Auxiliary Fuel Pump prior to shut-off, plus less than one Liter of fuel, by volume, available in the lines. In addition, drain holes at the bottom of the nacelle should preclude combustion of this total volume. The overall effect is that the temperature at the Firewall will not likely achieve the 2,000 degree level.

