



Federal Aviation Administration

Memorandum

Date: August 1, 2008

From: Manager, Small Airplane Directorate, ACE-100

To: Ultramagic Balloon and ELOS File

Prepared by: Taylor Martin, Aerospace Engineer, ACE-112

Subject: Review and Concurrence, Equivalent Level of Safety (ELOS) Finding for Ultramagic Balloon MK-2, MK-2 Super and MK-10 Burners FAA Project Number CE0108tm, Regulatory Ref: 14 CFR § 31.47(d), Amendment 31-7, Finding No. ACE-08-15

This memorandum documents concurrence for the subject ELOS, we request your office review and concur with the proposed ELOS findings for an alternate method of compliance to the Burner requirements of 14 CFR Part 31, § 31.47 (d), Amendment 31-7 for the MK-2, MK-2 Super, and MK-10 burners.

BACKGROUND

The U.S. type certification project for the Ultramagic Balloons is being conducted as a 14 CFR Part 21, § 21.29, validation project. This project is in accordance with the *Interim Procedures for Working with the European Community on Airworthiness Certification and Continued Airworthiness* and the *Operating Procedures between the Federal Aviation Administration (FAA) and the Arrangement between the Governments of Spain and the United States of America and their parts*, which concluded on September 23, 1957, at Madrid, and, as amended, September 18 and October 13, 1978.

Ultramagic Balloons has been designing and manufacturing hot air balloons for over 25 years. During this time, the company has grown to become one of the largest hot air balloon manufacturers in the world. The type validation project of the H-31, M-42, M-56, M-77C, M-120, and N-425 balloons is one in a series of validation projects between the FAA, Spanish Direccion General de Aviacion Civil (DGAC) Aviation Authority, and EASA, which has had a lengthy history of balloon validation projects with the FAA.

The validation of these new balloon models and the type design changes of EASA project number P-EASA.CSV.BA.01002 will be done using FAA Order 8110.52 following type validation principles. This ELOS will close any documentation gaps associated with these Ultramagic burners, which were inadvertently omitted during the validation of previous model

balloons on this type certificate. This ELOS memo will serve as the equivalency for the burner requirements of 14 CFR Part 31, § 31.47 (d), Amendment 31-7, for the new model balloons (H-31, M-42, M-56, M-77C, M-120, and N-425). Although the FAA inadvertently missed issuing an ELOS when these burners were introduced during previous balloon model validations on this type certificate, this will show that these burners have a good service experience and did not introduce any unsafe conditions.

APPLICABLE REGULATIONS

The certification basis for the Ultramagic Balloon is 14 CFR Part 31, Amendment 31-7, April 24, 1996. Additional Special Conditions, ELOS, and Exemptions may be incorporated during this project.

REGULATIONS REQUIRING AN ELOS

The applicable regulation is 14 CFR Part 31, § 31.47 (d), Amendment 31-7. Section 31.47, paragraph (d) states:

(d) The burner system (including the burner unit, controls, fuel lines, fuel cells, regulators, control valves, and other related elements) must be substantiated by an endurance test of at least 40 hours. Each element of the system must be installed and tested to simulate actual balloon installation and use.

- (1) The test program for the main blast valve operation of the burner must include:
 - (i) Five hours at the maximum fuel pressure for which approval is sought, with a burn time for each one minute cycle of three to ten seconds. The burn time must be established so that each burner is subjected to the maximum thermal shock for temperature affected elements;
 - (ii) Seven and one-half hours at an intermediate fuel pressure, with a burn time for each one minute cycle of three to ten seconds. An intermediate fuel pressure is 40 to 60 percent of the range between the maximum fuel pressure referenced in paragraph (d)(1)(i) and minimum fuel pressure referenced in paragraph (d)(1)(iii);
 - (iii) Six hours and fifteen minutes at the minimum fuel pressure for which approval is sought, with a burn time for each one minute cycle of three to ten seconds;
 - (iv) Fifteen minutes of operation on vapor, with a burn time for each one minute cycle of at least 30 seconds; and
 - (v) Fifteen hours of normal flight operation.
- (2) The test program for the secondary or backup operation of the burner must include six hours of operation with a burn time for each five minute cycle of one minute at an intermediate fuel pressure.

DESCRIPTION AND EXPLANATION OF COMPENSATING DESIGN FEATURES:

The procedure of proof of compliance according to § 31.47(d), Amendment 31-2 has been met mainly by in-service experience and a prediction of safe operation. It assumed that a burner manufactured, assembled and maintained in a specified manner will be capable of safe operation providing it satisfies the required testing (50 hours of ground and in-flight cyclic operation).

Ultramagic thought, at that time of Amendment 31-2, that the described method did not fully represent the modes of the highest heat load and heat gradients on the burner. Even the discussion preceding to a modification of this methodology and reducing the required test time from 50 to 40 hours (§ 31.47(d), Amendment 31-7) supposed that the manner of operation of a hot-air balloon burner is different from an aircraft jet engine, which is typically operated on a high power rate without interruption.

Compared to the process above, a hot air balloon burner is operated in a cyclic manner and the most critical regime of its function in view of the heat load is an operation with minimum fuel pressure (or during the feeding by a vapor phase during inflation of the envelope) when a significant heating and rapid cooling of the construction occurs. So a number and a manner of absorbed heating cycles are critical instead of the duration of heating.

Cycles described in § 31.47(d), Amendment 31-7, represent quite well a real operation of the burner according to the experience of manufacturers and users.

However, to repeat the test procedure of § 31.47(d), Amendment 31-7, for the MK-2, MK-2 Super and MK-10 burners to show direct compliance would be a very expensive and time consuming process. The result would not justify the effort in the sense that reliability of older burner models would be shown, although these have proven to be reliable for a long time also under FAA TC B02CE.

Ultramagic agrees that the methods described in § 31.47(d), Amendment 31-7, represents the modes of the highest heat load and heat gradients on the burner. A hot-air balloon burner is operated in a cyclic manner and the most critical regime of its function with respect to heat load is an operation with minimum fuel pressure (or during the feeding by a vapor phase) on a minimum heat production when significant heating and rapid cooling of the construction occurs, or while heating by a whisper burner when the vaporizing coil is not cooled by a flowing fuel. A number and a manner of absorbed heating cycles are critical instead of the duration of heating as required in § 31.47(d), Amendment 31-2. Therefore, the burner families models MK-21, BMK-008 and BMK-050 showed direct compliance with § 31.47(d), Amendment 31-7.

Today this would also be possible for the MK-2, MK-2 Super, and MK-10 burners; however, it would impose a repeated test program to a family of burners that have shown a high level of safety by years and number of reliable operations. Also, these burners are already replaced by improved models (MK-21, BMK-008, and BMK-050) and are out of production.

The applicant proposes, therefore, a proof of compliance that will provide a detailed description of the burner operation modes, a significant reduction in time and resources expended, and a lower environmental impact while maintaining an equivalent level of safety to § 31.47(d), Amendment 31-7.

Ultramagic, therefore, proposes to demonstrate what has been done once under Amendment 31-2 and now under Amendment 31-7.

14 CFR Part 31, Amendment 31-7, reference for ELOS process	Alternative means of Compliance used	14 CFR Part 31, Amendment 31-2
<p>31.47(d) The burner system (including the burner unit, controls, fuel lines, fuel cells, regulators, control valves, and other related elements) must be substantiated by an endurance test of at least 40 hours. Each element of the system must be installed and tested to simulate actual balloon installation and use.</p>	<p>The burner system (including the burner unit, controls, fuel lines, fuel cells, regulators, control valves, and other related elements) underwent an endurance test of 10 hours.</p> <p>► 25 percent of time required</p>	<p>31.47(d) The heater system (including the burner unit, controls, fuel lines, fuel cells, regulators, control valves, and other related elements) must be substantiated by an endurance test of at least 50 hours. In making the test, each element of the system must be installed and tested so as to simulate the actual balloon installation.</p>
<p>(1) The test program for the main blast valve operation of the burner must include:</p>		<p>The test program must be conducted so that each 10-hour part of the test includes seven hours at maximum heat output of the heater and three hours divided into at least 10 equal increments between minimum and maximum heat output ranges.</p>
<p>(i) Five hours at the maximum fuel pressure for which approval is sought, with a burn time for each one minute cycle of three to ten seconds. The burn time must be established so that each burner is subjected to the maximum thermal shock for temperature affected elements;</p>	<p><u>required:</u> 1 minute ≈ 3 sec burn + 57 sec cooling <u>delivered (at 1,2 MPa/17.4 psi):</u> 1 minute ≈ 2x3 sec burn + 2x25 sec cooling plus one 2-minute continuous burn /hour ► more severe (frequent) test than required</p>	<p>Applicant's comment: 5 x 7 hours full power test</p>
<p>(ii) Seven and one-half hours at an intermediate fuel pressure, with a burn time for each one minute cycle of three to ten seconds. An intermediate fuel pressure is</p>	<p>This part of the test is performed literally by itself. During fuel consumption fuel pressure drops because the fuel cools down due to evaporation cooling. By</p>	<p>Applicant's comment: 5 x 3 hours low/medium pressure power test</p>

14 CFR Part 31, Amendment 31-7, reference for ELOS process	Alternative means of Compliance used	14 CFR Part 31, Amendment 31-2
40 to 60 percent of the range between the maximum fuel pressure referenced in paragraph (d)(1)(i) and minimum fuel pressure referenced in paragraph (d)(1)(iii);	feeding the burner from a fuel cell this part of the test scheme is fulfilled in a perfectly realistic manner.	
(iii) Six hours and fifteen minutes at the minimum fuel pressure for which approval is sought, with a burn time for each one minute cycle of three to ten seconds;	This part of the test was performed during flight test in winter time. The minimum fuel pressure for Ultramagic burners is 0.3 MPa (43.5 psi) and Propane has this pressure at -14 °C (6.8 °F).	Applicant's comment: (see (ii)) 5 x 3 hours low/medium pressure power test
(iv) Fifteen minutes of operation on vapor, with a burn time for each one minute cycle of at least 30 seconds; and	No test on rig performed.	Applicant's comment: not required by Amendment 31-2
(v) Fifteen hours of normal flight operation.	MK-2, MK-2S, and MK-10 burners were flight tested in the company owned balloon as follows: - MK-2 for ≈ 35 flight hours - MK-2S for ≈ 15 flight hours - MK-10 for ≈ 50 flight hours	
(2) The test program for the secondary or backup operation of the burner must include six hours of operation with a burn time for each five minute cycle of one minute at an intermediate fuel pressure.	No test on rig performed.	Applicant's comment: not required by Amendment 31-2

The alternative means of compliance, as accepted by the DGAC Spain, does not show direct compliance to Amendment 31-2 in terms of test duration. It was a common position of the European balloon industry that this test would consume a large amount of fuel and wreck the burner coil without delivering the intended results.

Amendment 31-7 compliance is still not directly achieved.

- The testing time is about 25 percent of what § 31.47(d) requires.
- The burner test on vapor is not available.
- Backup burner test is not available

Backup burner test § 31.47(d)(2)

The MK-2, MK-2 Super, and MK-10 models have no secondary or backup burners. If redundancy is necessary, a second burner of the same model is mounted to the load frame. The liquid, or silent burner, may serve as a backup; however, it is only used for silent operation near cattle or other sensitive animals. The liquid burner inherently has no heat problem as only liquid propane is ejected, ignited, and burns at a distance from its nozzle. Amendment 31-7 requires 72 minutes of testing, but the Ultramagic liquid burners only function tests were made as this was considered to be more reasonable to prove safe operation.

Backup burner test § 31.47(d)(1)(iv)

The MK-2, MK-2 Super, and MK-10 models did not undergo a test rig campaign for this. See service history.

Backup burner test § 31.47(d)

The MK-2, MK-2 Super and MK-10 models underwent 10 hours instead of a full 40-hour test rig campaign. However, a leak test was performed after the campaign. The burner system was successfully exposed to 3 MPa (435 psi) malfunction and leak test. No dangerous damage or wear is found during disassembling and crack detection after the test. As an alternative means of compliance, we considered the service history of the MK-2, MK-2 Super, and MK-10 models.

Service History	Years of Production	Total Number Produced	ADs	Remarks
MK-2	1985-1991	2 single 117 double 6 triple no quad	none	none known to be sold in the USA
MK-2 Super	1991-1992	no single 13 double 4 triple 1 quad	none	none known to be sold in the USA
MK-10	1992-2001	52 single 294 double 25 triple 15 quad	none	sold in the USA: 14 double 2 quad

Furthermore, flight testing was performed up to 6,000 m (19,650 feet) at -30 °C (32 °F).

In the pre-EASA times, (TC) approvals were granted by LBA Germany (LFHB), France (CTG 015) and United Kingdom (BCAR 31), for example. All of these codes derive from 14 CFR Part 31.

Overall, the most severe test is the everyday use by the customer. Some customers do not notify the manufacturer about their misuse of parts during operation, but the manufacturer learns about it based on which spare parts are ordered. Looking back over the years of operation in Europe and the USA we had no unusual service problems or Airworthiness Directives on our burner products.

Thus, we conclude that the MK-2, MK-2 Super, and MK-10 models have a good safety and reliability record and it has demonstrated an equivalent level of safety to § 31.47(d), Amendment 31-7.

Although the current validation project CE0108tm/P-EASA.CSV.BA.01002 covers only balloons models H-31, M-42, M-56, M-77C, M-120, and N-425, the above is also applicable to all balloon models already on the FAA TCDS B02CE, revision 5.

Ultramagic has requested an equivalent level of safety finding for the MK-2, MK-2 Super, and MK-10 burners as an alternative to literal compliance with Title 14 Code of Federal Regulations (14 CFR) Part 31, § 31.47(d), Amendment 31-7.

When MK-2, MK-2 Super, and MK-10 burner systems were developed, 14 CFR Part 31, Amendment 31-2, effective April 12, 1965, was in place. At that time, Ultramagic's position was that § 31.47(d) did not represent a suitable test method. They applied to DGAC Spain for acceptance of an alternative means of compliance, which was granted by DGAC Spain and this was termed "exemption" in the DGAC system.

FAA APPROVAL AND DOCUMENTATION OF THE ELOS FINDING:

The alternate method of compliance requested by Ultramagic and concurred with by the EASA/DGAC for the MK-2, MK-2 Super, and MK-10 burners is acceptable to the FAA. The applicant's method of compliance meets the intent of the burner requirements to increase safety by performing more realistic tests and reducing the fuel costs to balloon manufacturers seeking certification. It provides an equivalent level of safety to § 31.47(d), Amendment 31-7.

The FAA has approved the aforementioned equivalent level of safety finding in project issue paper P-1. This memorandum provides standardized documentation of the ELOS finding, which is non-proprietary and can be made available to the public. The Small Airplane Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number should be listed in the Type Certificate Data Sheet under the Certification Basis. Equivalent Level of Safety Findings have been made for the following regulation(s):

14 CFR Part 31, § 31.47(d), Amendment 31-7, Burners (documented in Small Airplane Directorate ELOS Memo, ELOS Finding No. ACE-08-15)]

CONCURRED BY:

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