Federal Aviation Administration

Memorandum

Date: December 18, 2007

To: Manager, Small Airplane Directorate, ACE-100

From: Manager, Project Support Branch, ACE-112

Prepared by: Albert J. Mercado, Project Officer, ACE-112

Subject: Review and Concurrence, Equivalent Level of Safety (ELOS) Finding for Balony Kubicek BB Balloon IGNIS burner, FAA Project Number TC0248CE-B, Regulatory Ref: 14 CFR § 31.47(d), Amendment 31-7, ACE-07-13

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 § 31.47 (d), Amendment 31-7 for the Balony Kubicek BB Balloon IGNIS burner.

Background

The U.S. type certification project for the Balony Kubicek BB Balloon is being conducted as a 14 CFR § 21.29, validation project 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 Civil Aviation Inspectorate (CAI) of the Czech Republic For Design Approval, Airworthiness Certification, Continued Airworthiness, and Mutual Cooperation and Technical Assistance.*

Balony Kubicek spol. s r.o. is an independent company in Brno, Czech Republic specializing in the design and manufacture of hot-air balloons and airships. The Balony Kubicek BB Balloon models are hot air balloons comprised of conventional envelopes of various volumes and basket and burner combinations.

Section 31.47 was revised by Amendment No. 31-7 in 1996 to amend the certification test requirements for burners used on manned free balloons. Before Amendment 31-7, the burner certification requirement resembled the testing requirement for airplane engines. Airplane engines are operated continuously at high percentage powers, while balloon burners are operated on an intermittent basis to maintain level or buoyant flight. The burner requirement called for maximum fuel flow burning over the majority of the test time. The requirement did not reflect

the fact that a burner is continually turned on and off every few seconds, or that a minimum heat output condition is much more critical than a maximum heat output condition. The challenging test conditions for a burner are short blasts to maximize the thermal shock and operation on vapor, which can result in the burner coils glowing red.

Certification testing should simulate flight conditions and the critical concern is not the duration of operation, but the number of mechanical and thermal cycles, § 31.47 (d) changed the balloon burner requirements to include testing of mechanical and thermal cycles, and testing of operation on vapor. Section 31.47(d) focuses on the testing of critical functions experienced during flight. The intent of § 31.47(d), Amendment 31-7, is to increase safety by requiring more realistic tests and to cut the fuel costs to balloon manufacturers seeking certification.

The applicant proposes 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.

The Federal Aviation Administration (FAA) also recognizes that a similar ELOS was granted during the previous European Aviation Safety Aviation (EASA) certification of the BB Balloon with the IGNIS burner. This ELOS is noted in the balloon certification basis (EASA CRI E-01, issue 2, dated 15 February 2007: FAR §31.47(d) endurance test for IGNIS burner) of EASA Type Certification Data Sheet (TCDS) EASA.BA.003 Issue 6, dated 2 August 2007.

This request was coordinated within the FAA by Issue Paper (IP) P-1.

Applicable regulation(s)

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

Regulation(s) requiring an ELOS finding

The applicable regulation is 14 CFR § 31.47 (d), Amendment 31-7, which states:

> Section 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.
>
> (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 of compensating design features or alternative Methods of Compliance (MoC) which allow the granting of the ELOS (including design changes, limitations or equipment need for equivalency)

The alternative method of compliance proposed by Balony Kubicek is provided below.

The existing procedure of proof of compliance according to § 31.47(d) is purely empirical in view of a prediction of safe operation. It supposes that a burner manufactured, assembled and maintained in a specified manner will be capable of safe operation providing it satisfies the required testing (40 hours of ground and in-flight cyclic operation).

This described method doesn't 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) has 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 this a hot-air balloon burner is operated in a cyclic manner and the most critical regime of its function in view to the heat load is an operation with minimum fuel pressure (or during the feeding by a vapour phase) on a minimum heat production when a significant heating and rapid cooling of the construction occurs, or while heating by a whisper burner when the vaporising coil isn't cooled by a flowing fuel. So a number and a manner of absorbed heating cycles are critical instead of the duration of heating.

However, cycles described in § 31.47 (d) represent quite well a real operation of the burner according to an experience of manufacturers and users.

The recent proof of compliance of a hot-air balloon burner is extremely costly and time-consuming and it doesn't describe the detailed distribution of critical places of the burner.

On the other hand the proposed proof of compliance using operation cycles described in § 31.47(d) Amendment 31-7 provides a detailed description of burner operation modes, significant time and money spared and a lower environmental impact while conserving at least the same level of safety.

The test will be conducted in two parts. In both of them each element of the system must be installed and tested to simulate actual balloon installation and use.

- Firstly, the resistance of control mechanisms and fittings against mechanical wear will be proved by performing more operation cycles than required in §31.47 (d).
- Secondly, the detailed distribution of thermal conditions on characteristic parts of the new burner will be obtained by thermography.
- The measurements will be performed by comparing the function of a new burner with another type of burner which had been safely operated during a long period of time.

Detailed description of proof:

A) Cyclic test of fittings and control parts

Main flight valve wear test program:

i. 2250 cycles at the maximum fuel pressure for which approval is sought, with a burn time for each 2.5 to 3 seconds. (One cycle means opening and turning off the flight valve.)

ii. 3000 cycles at an intermediate fuel pressure, with a burn time for each 2.5 to 3 seconds. An intermediate fuel pressure is 40 to 60 percent of the range between the maximum fuel pressures referenced above. (One cycle means opening and turning off the flight valve.)

iii. 2250 cycles at the minimum fuel pressure for which approval is sought, with a burn time for each 2.5 to 3 seconds. (One cycle means opening and turning off the flight valve.)

Secondary or emergency system of burner (whisper burner) test programme:

iv. 2000 cycles at an intermediate fuel pressure (see A) ii, with a burn time for each 2.5 to 3 seconds. (One cycle means opening and turning off the flight valve.)

B) Checking of thermal conditions on the vaporizing coil by a thermography:

At least 8 measurements with an evaluation have to be performed. Burn cycles according to § 31.47 (d) (1) and (2), Amendment 31-7. The temperature has to be read on the vaporizing coil on at least three different places. Evaluation of results means a comparison of the obtained values with the limiting values of the used material and with the chosen reference burner.

i. **Sequence 1:** heating until the stabilization of temperatures.
Perform this test to find out the distribution of temperatures and a thermal response of the burner. Continuous burn time at least 2 minutes.

ii. **Sequence 2:** cooling down after the heating.
Sequence 2 follows after sequence 1 without interruption. Perform this test to find out the distribution of temperatures and thermal response of the burner after turning off the fuel valve, while the pilot burner is still in function.

The places for reading of temperatures will be chosen by a person responsible for the test and based on the thermography results.

iii. **Sequence 3:** 8 cycles of heating and cooling down (until the stabilization of temperatures) at the maximum fuel pressure.
The fuel pressure 0.9 to 1.2 MPa (according to § 31.47 (d) (1) (i)). Burn time 5 seconds in each one minute cycle and a final cooling down for 180 seconds approximately until the temperature stabilizes.

iv. **Sequence 4:** 8 cycles of heating and cooling down (until the stabilization of temperatures) at an intermediate fuel pressure.
The fuel pressure has to be 0.5 to 0.6 MPa (according to § 31.47 (d) (1) (ii)). Burn time 5 seconds in each one minute cycle and a final cooling down for 180 seconds approximately until the temperature stabilizes.

v. **Sequence 5:** 8 cycles of heating and cooling down (until the stabilization of temperatures) at the minimum fuel pressure.
The fuel pressure has to be 0.3 to 0.4 MPa (according to § 31.47 (d) (1) (iii)). Burn time 5 seconds in each one minute cycle and a final cooling down for 180 seconds approximately until the temperature stabilizes.

vi. **Sequence 6:** 8 cycles of heating and cooling down (until the stabilization of temperatures); whisper burner
Fuel pressure 0.5 MPa. Burn time 60 seconds in each five minute cycle and a final cooling down for 7 minutes approximately until the temperature stabilizes.
Corresponds to § 31.47 (d) (2).

vii. **Sequence 7:** Operation on vapor; at least three cycles of heating and cooling down.
Perform the test on the main flight valve fed by a vapor phase, fuel pressure 0.3 to 0.4 MPa. Burn time 30 seconds in each one minute cycle and a final cooling down for 10 minutes approximately until the temperature stabilizes.
Corresponds to § 31.47 (d) (iv).

The test must also include at least five flameouts (including the pilot valve) and restarts of the burner.

C) Flight tests

i. Fifteen hours of normal flight operation.

The result of the test is satisfactory if:

- the values of temperature and of temperature gradients obtained by the thermography are equal or lower than limiting values for the tested material and equal or lower than the values measured on the reference burner;

- the burner is free of damage after the test

- no dangerous damage or wear is found during disassembling and crack detection after the test.

Explanation of how design features or alternative Methods of Compliance (MoC) provide an equivalent level of safety to the level of safety intended by the regulation

The intent of § 31.47(d) Amendment 31-7 is to increase safety by requiring more realistic tests and to cut the fuel costs to balloon manufacturers seeking certification.

Balony Kubicek contends that the methods described in § 31.47(d) do not represent 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).

The alternative method of compliance proposed by the Balony Kubicek must demonstrate that the proposed testing procedures provide an equivalent level of safety to § 31.47(d), Amendment 31-7. The proposal compares thermography measurements between the IGNIS burner with a similar certificated burner. Balony Kubicek must show that the use of thermography comparisons with burners with extensive service history is equivalent to the testing required in § 31.47(d), Amendment 31-7. Additionally, the reliability of the technique must be shown to provide equivalent results from a metallurgical perspective, and the specific service history of the comparison burners must show the validity of the comparison.

FAA approval and documentation of the ELOS finding:

The alternate method of compliance requested by Balony Kubicek and concurred with the EASA CAA CZ for the IGNIS burner 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 and 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 that 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):

Concurred by:

__*William J. Timberlake*_____	_*12-17-07*___
Manager, Project Support Branch, ACE-112	Date
_*Pat Mullen* _____	_*12-18-07*___
for Manager, Standards Office, ACE-110	Date
_*John Colomy*_____	_*12-18-07*__
for Manager, Small Airplane Directorate, ACE-100	Date