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TESTING OF AAD FOR RESERVE PARACHUTE CANOPIES

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Abstract: *The purpose of the AAD (Automatic Activation Device) is to initiate the opening of the reserve container to save the skydiver. The AAD functions by severing the reserve container closing-loop thereby releasing the flaps of the reserve container. Operating principle of AAD is an electronic automatic activation device, operating on the principle of pressure reading. The primary means for detecting the altitude and fall rate is a pressure sensor. The altitude is calculated based on the difference between two atmospheric pressures. The AAD is an electronic device and as such may not always work properly even when installed and used properly. Testing of these devices functionality and its manual quality was a mandatory task before such an important part of a parachute assembly become part of the equipment of the Serbian airborne forces.*

Keywords: *AAD. parachute, reserve, testing.*

1. INTRODUCTION

Intention of an AAD producers is to provide users with maximum comfort and safety when using the automatic activation device. All efforts are directed to the cutter reliability when cutting the reserve parachute closing loop when its activation criteria are met. Although the device will work properly, it does not guarantee the functionality of the other parts of the parachute kit. The device itself does not exclude the possibility of severe injury or even death. The device is only one of the ways to increase the likelihood of resolving a critical situation the user may find himself in when skydiving.

The basis for safe jumps are quality training, appropriate health condition, mental abilities, quality equipment for performing jumps from authorized manufacturers and familiarization with the procedures of dealing with an emergency.

Only when these conditions are met, the automatic activation device may help to increase the likelihood of resolving an emergency, if such occurs. The AAD is an electronic device and as such may not always work properly even when installed and used properly.

Testing of these devices functionality and its manual quality was a mandatory task before such an important part of a parachute assembly become part of the equipment of the Serbian airborne forces.

2. OPERATING PRINCIPLE

The AAD is an electronic automatic activation device, operating on the principle of pressure reading. The primary means for detecting the altitude and fall rate is a pressure sensor. The altitude is calculated based on the difference between two atmospheric pressures. The pressure at current altitude and pressure on landing location “GROUND ZERO”. The pressure on the landing location is measured and set after switching on the device during calibration.

This pressure is automatically adjusted by a change in barometric pressure during the day without the need for user intervention. The information collected is evaluated by means of a microprocessor and ingenious software and it is converted to real fall rate and altitude. The device is activated only in the case the preset criteria are met; the criteria differ depending on the set profiles.

The AAD device is capable of meeting the preset criteria of fall rate in combination with altitude above the landing location, cut the reserve parachute closing loop by means of the cutter and thus initiate the deployment sequence.

3. CONSTRUCTION

The AAD is designed to best meet the requirements for durability and correct operation in all situations. It works with minimum power consumption, which allows it to maintain sufficient capacity of the energy source for its entire service life without having to replace the battery. It is built inside a minimum-size cover and thus gives the skydiver the possibility to open the reserve parachute without using the manual handle.

The consists of a processing unit with the battery, processor, electronic circuits and a pressure sensor, figure 1. The processing unit is connected to the control unit by means of a cable; the control unit contains a multifunction display and control button, Figure 2. The cutter connected in the processing unit body via a connector as a removable part of the device, Figure 3. The cutter is made of stainless steel and cuts the reserve parachute closing loop, if necessary, the principle of work is given on the Figure4. Before a complete installation, user must read the Manual provided by the container manufacturer carefully, Figure 5.

Figure 1. Procesing unit with battery

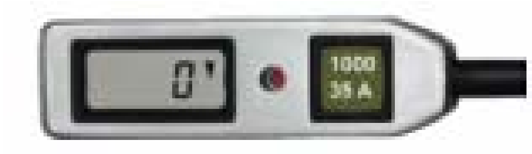

Figure 2. Control unit with display

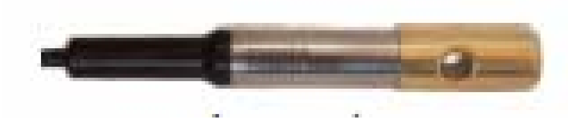

Figure 3. Cutter

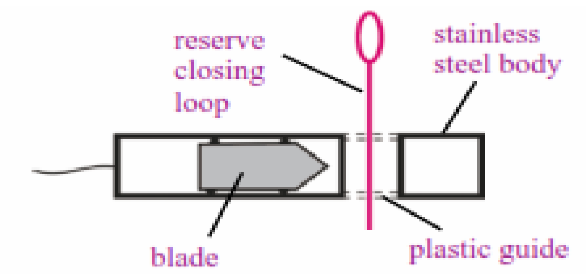

Figure 4. Cutter, principle of work

Figure 5. AAD on position in a container

Technical data of the AAD:

- Length, width, height of the processing unit (85 x 43 x 32 mm)
- Length, width, height of the control unit (65 x 18 x 6.5 mm)
- Length, diameter of the release unit (43 x 8.0 mm)
- Cable length of the control unit (1200 mm)
- Cable length of the release unit (500 mm)
- Volume (150 cm³)
- Weight (210 grams)
- Storing temperature (+ 71° to - 50° centigrade)
- Storing pressure 200 to 1075 hPa
- Working temperature (+ 63° to - 32° centigrade)
- Maximum allowable humidity up to 99,9 % rel. humidity
- Waterproof up to 15 minutes down to a depth of 15 feet (up to 24 hours down to a depth of 5 feet)
- Altitude adjustment range according 200 to 1075 hPa
- Operating range above sea level - 1600 feet to + 65500 feet
- Functioning period 14 hours
- Power supply lifetime warranty
- Maintenance 4 and 8 years from date of manufacture
- Total lifetime 12.5 years from date of manufacture

3. FLYING MODE

The AAD may be switched on in several modes. The mode is selected when the device is switched on and remains active until it is switched off again - the selection is not permanent.

The various modes are used to distinguish the type of jump and they determine the device behavior. First, basic mode is used most often - when the skydiver performs the jump at an airport (dropzone) and the aircraft take-off point and the landing location are thus the same - they are at the same elevation.

Second mode must be always used when the take-off and landing locations are at different elevations. This type of mode allows user to enter the elevation difference between the aircraft take-off point and the landing location during the switch on sequence.

If the device is switched on in first or basic mode, the current profile is shown on the display. If the device is switched on in the second or offset mode, the display shows "offset", the first letter of the profile, the entered elevation difference between the aircraft take-off point and the landing location, and the units icon [1].

When the button is depressed, the full description of the current profile is displayed.

List of modes:

– First or basic mode is used when the skydiver takes-off and lands at the same place, Figure6.

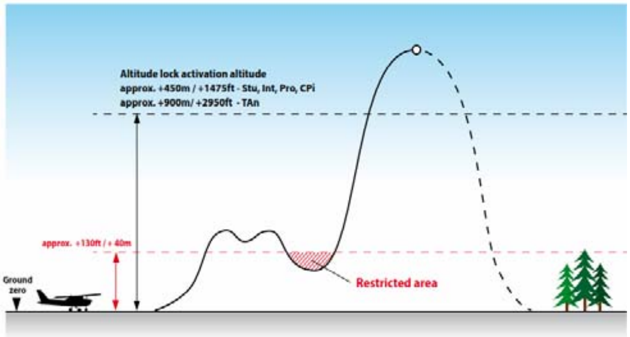

Figure 6. First or basic mode. Flight profile

– Second or offset mode

It is designed for situations when the landing location is higher (elevation) than the elevation at which the device was switched on, Figure7.

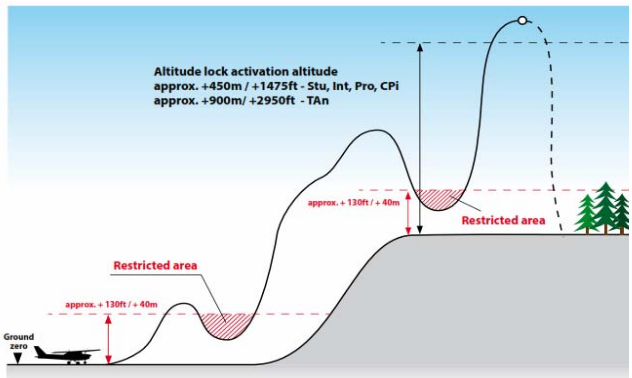

Figure 7. Second or offset mode. Flight profile

– Third mode is designed for situations when the landing location is lower (elevation) than the elevation at which the device was switched on, Figure8.

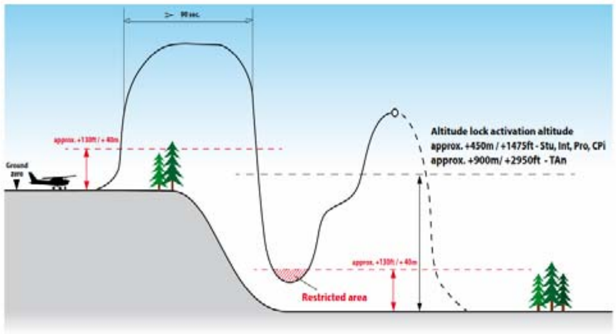

Figure 8. Third mode, Flight profile

– Interesting and important thing is that the AAD requires the plane to immediately climb above Ground Zero for a correct detection of start-up and remain above this altitude until the skydivers jump off. In the next phase of the flight it is necessary to exceed the Altitude lock according to the preset device profile (approx. 450 m/ 1 475 ft - approx. 900 m / 2 950 ft - Tan) to unlock the device. [2], [3], [4]

4. TESTING

According to the current regulations in Serbian army the verification test was carried out with the aim of:
a) To evaluate:

– Functionality of the device in laboratory conditions, considering the purpose,

– modernity and perspective of applied technical and technological solutions

– whether the product meets the manufacturer's declared characteristics,

– ease of handling and maintenance.

b) To give a conclusion on the usability of the product, considering its capabilities and declared characteristics by the manufacturer.

4.1. Laboratory testing

As a part of laboratory tests, the following was realized:

– Checking the correctness of work and

– Testing of functional characteristics.

According to the operating instructions, the control part of the device is correct if it successfully implements the self-checking. During the specified procedure, data on the control unit should be displayed the serial number and the date of production, the current atmospheric pressure value and the date of the following service inspection (depending on the operating mode). During this check, it is necessary that the cable with the cutter is also connected.

The testing of functional characteristics was performed in order to check the declared characteristics of the device in controlled conditions, through the simulation of the pressure change and its gradient in vacuum chamber. Tests were performed in vacuum chamber at VZ „Moma Stanojlović", Figure10.

In the choosen operational mode, a declared feature is to activate cutter on specified height (457 m), when vertical speed exceed 35 m/s, and the height of the dropping was H=1740 m.

After analyzation of the obtained results, recorded with the camera to:

– The AAD did activate the cutter when vertical speed was w = 40,7 m/s, based on the activation signal, performed its function, and cut the steel wire which was set to the proper position, Figure9.

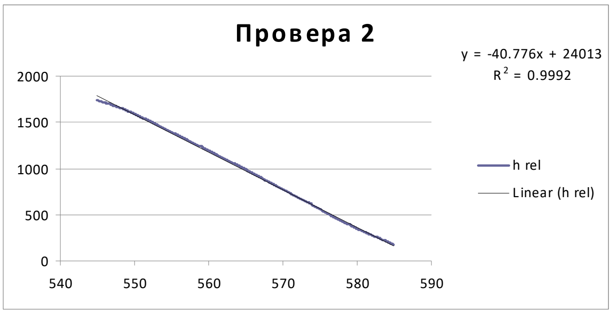

Figure 9. Flight profile of „free fall”

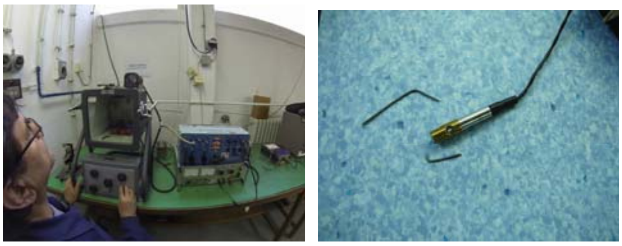

Figure 10. Vacuum chamber and activated cutter

4.2 Real condition testing

After testing the AAD in laboratory conditions, next step was a functional test of the complete parachute in real conditions, by dropping parachute dummies and realisation of parachute jumps done by experienced paratroopers.

According to the test plan and program, the functional correctness of the parachute was checked after exposure of complete parachute to extreme environmental temperature values (-40°C to +93.3°C) for 16 hours.

Functionality was confirmed in 6 drops of the parachute dummies at maximum declared load under the canopies of the main and reserve parachutes.

One of the points of testing the parachute was to check the functionality of the reserve parachute in case when parachute was activated by AAD.

Table 1. Test data for test kit number 1 and test kit number 2.

Test date	25.01.2022.	11.03.2022.
Parachute kit	1	2
Main parachute Type	10	20
Reserve parachute Type	11	22
Automatic activation device	111	222
Selected automate mode	1035	1035
Automate work area height	=(30-405) m	=(30-405) m
Automate work velocity	w>35 m/s	w>35 m/s
Declared „arming” height	765 m	765 m
Place of start position	a. Batajnica	a. Kovin
Elevation of start position	86 m	78 m
Temperature (°C)	-8 °C	-4 °C
Presure (mbar)	1025 mbar	1022 mbar
Wind (m/s)	no wind	wind 4 m/s
Place of dropping	a. Kovin	a. Kovin
Aircraft	Mi-17	Mi-17
Max.height in flight	870 m (QFE)	900 m (QFE)
Height of dropping	600 m (QFE)	600 m (QFE)
Free fall time	11,1 s	11,4 s

On that occasion it was noticed that there is a software problem which one was not observed during the laboratory functionality check of the AAD device. As a result of the existence of problems in the software, an additional dropping of the parachute dummy was realized, Figure 11 and Figure 12. But result was the same, nothing was activated and the dummies were fall all the way to the ground. Measuring equipment were totally destroyed, Figure13.

Figure 11. First fail dropp with dummy

The test was terminated, the manufacturer was informed about noticed problem, which turned out to be caused by a software flaw in the definition of the flight profile in a choosen operational mod of AAD.

Figure 12. Second fail dropp with dummy

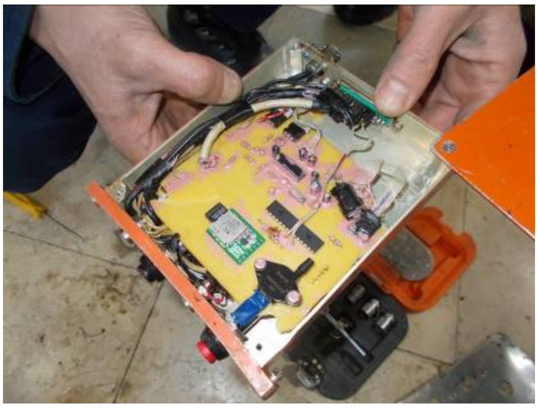

Figure 13. Destruction of measurement equipment

Since the AAD is a device whose functionality directly affects the saving of the user's life a software error is not acceptable. Due to the complexity of the software it is not possible to determine whether it is the only one established, so the AAD was rejected by the Serbian army.

A software error is very difficult to detect, especially with such devices like AAD, where an accidentally selected flight profile during deploying led to the deactivation of the device. In our case AAD based on the collected data, concluded that the jump was canceled and blocked the operation of cutter.

Very similar tests are carried out in other by numerous institutions dealing with quality assessment of technical products, like Vojenski technicki ustav s.p, odštepny zavod VTULaPVBO Praha, Czech republic or AirTEC GmbH Bad Vunenberg, Germany, the PIA AAD Design and testing report format when the manufacturer releases the folowing test report about his own product. According to test program the full examination volume includes tests according to the stated standards [5]:

- MIL-STD-810E Environmental Test Methods
- MIL-STD-45662A Calibration System Requirements
- RTCA/DO-160C Environmental Conditions and Test Procedures
- MIL-STD 331B Procedure C1 for Temp. and Humidity test
- RTCA/DO-178B Software considerations in Airborne Systems and Equipment Certifications
- MIL-STD-461D Requirements of the control of electromagnetic interference, emissions and susceptibility
- MIL-STD-331B Appendix F electrostatic discharge.

5. CONCLUSION

The AAD is an electronic automatic activation device, operating on the principle of pressure reading. All efforts are directed to the cutter reliability when cutting the reserve parachute closing loop when its activation criteria are met. Although the device will work properly, it does not guarantee the functionality of the other parts of the parachute kit.

Similar tests are carried out in other worldwide institutions dealing with quality assessment of technical products. What they have in common is the use of similar or even the same standards and the evaluation of the fulfillment of the requirements specified in those standards.

Submitting the results of internal tests or tests by third parties leads to a more reliable assessment of the quality of the technical products.

Serious manufacturers of technical products are thus encouraged to test their products in recognized institutions dealing with the quality assessment of technical products.

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[5] www.sskinc.com. Philosophy of reliability