Vigil®

AAD Design and Testing Report Format

According to PIA Technical Standards 120 2.01

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1. Objective

To define the testing procedures relevant to our A.A.D., according to the existing AAD Design and Testing Report Format, PIA Technical Standards 120 2.01.

The objective of these tests is to prove the functionality and the reliability of the Vigil.

This file also documents all tests carried out in regards to temperature, humidity, vibration and electromagnetic interferences.
All test methods and equipment used for these tests are described.

All live tests are documented to prove that the device functions properly.

2. Reference documents/Testing

All climate and environmental tests are performed by Weiss Technik Belgium (ISO 9001 certified) or with Weiss Technik equipment.
All calibrations of test cabinets are made according to strict regulations and procedures.
The Vigil has been tested by Weiss Technik and own laboratory on Coldness, Heat, Light (UV) and Vacuum.
Humidity: RTCA/DO-160C, section 6, category B - standard.
Temperature: RTCA/DO-160C, cat. B2
Shock resistance: RTCA/DO-160C:

The EMC Testing has been performed by Laboratory De Nayer, section EMC, accredited by Beltest for EMC-immunity and EMC-emission under registration number 053-T.
The Vigil has been tested on:
EN 61000-4-3 (1996): Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 3: Radiated, radio-frequency electromagnetic field immunity test.
And ENV502040 (1995): Radiated electromagnetic field from digital telephones - immunity test.

3. General description of the product

3.1. Specific usage modes of the device

This product has been designed so that one AAD fulfils all the different requirements for sport and military skydiving:

3.1. Specific usage modes of the device

- **PRO** Mode: for expert skydivers
- **STUDENT** Mode: for student skydivers
- **TANDEM** Mode: for tandem skydives

Other modes are under development (e.g. military, extreme) and will be marketed in the near future

The Vigil, in **PRO** mode, is suitable for the following:

- *Style*
- *Accuracy*
- *Formation skydiving*
- *Canopy Formation Skydiving*
- *Freestyle / Freefly*
- *Skysurf*
- *Freefall*
- *Freefall Instructors*

The Vigil, in **STUDENT** mode, is suitable for the following

- *Static line*
- *AFF*
- *Wingsuit*

The Vigil, in **TANDEM** mode, is suitable for:

- *Tandem jumps only*

3.2. Principles of operation

AAD nv/sa has developed today's most advanced and sophisticated activation device.
The Vigil is equipped with a very precise air pressure sensor and is managed by three micro controllers.
Each time the Vigil is turned on, it calibrates itself to the current ground elevation.
The Vigil is now ready for use and is in a stand-by status (recalibrating itself every 32 sec).
During take off the Vigil will go to an active status (64 calculations per sec.) above 150 ft or 46 m in a time of max. 32 sec. Vigil's active status will be confirmed by three short flashing of the green led.
Each mode «Pro», «Student» or «Tandem» has its own factory-set activation altitude and speed.
During your aircraft ascent, the Vigil's red LED will briefly flash three times when it passes through its pre-set activation altitude. While in freefall it determines the remaining freefall time before reaching the activation altitude.

The Vigil is not influenced by the skydiver's body position in freefall (belly down, belly up). Even while spinning, the Vigil correctly calculates the balance of remaining freefall time.
The system's main micro controller takes an altitude reading 64 times a second to arrive at eight altitude averages. It then calculates the remaining freefall time and determines whether or not the pre-set activation altitude has been reached and the cutter will or will not be activated.

This system is designed to automatically open the reserve parachute by calculating the freefall time necessary to reach the pre-programmed activation altitude. Activation will commence at the pre-programmed altitude if the parachutist is falling at a speed greater than the speed pre-determined by the device's functioning mode – Pro, Student or Tandem.

If the parachutist crosses the pre-set activation altitude and speed, the electronic unit commands the pyrotechnic cutter to sever the reserve container loop, thus allowing the reserve parachute to deploy.

The Vigil signals that it has reset itself to ground elevation by flashing the red LED located on the control unit.

3.3. Technical data

Main box: Compact, rounded corners, integrated connectors, industrial quality, and attractive look. The rugged, aluminium alloy box is composed of two distinct halves:

- One half consists of the main electronic printed circuit board.
- The other half is the base for the power pack, which contains a sealed-in battery, a "Pulse-plus" element, and two bronze air filters to protect against intruders, such as dust and humidity.

Electronics: The heart of the system. It includes the printed circuit board, which consists of multiple SMD components (Surface Mount Devices) and micro controllers that have very low power consumption.
Two covers in µ copper protect the printed circuit board in two ways: mechanical protection and electromagnetic shielding (effective protection against electromagnetic waves produced by radio communications, transponders, mobile phones, and radar).

Power Pack: The battery was designed especially for the Vigil. It supplies power to electronics over a long period of time and, even at the end of its life, can immediately supply the necessary current needed to fire the cutter (1A - 3,6V).

Remote Control: Stainless steel, design fulfils the aesthetic, technical and mechanical aspects required by the skydiving market.
The dimensions are designed to make it compatible with the equipment currently on the market. It is the only visible part of the AAD after installation.
Plexi: Amplifying lens, protection of the LCD display, and a window to view the flashing of the red and green LEDs. The LEDs allow information to be uploaded and downloaded through the bi-directional infrared port.

LCD: Alphanumeric LCD display equipped with 96 x 26 pixels.

Cutter: pyrotechnic knife with circular blade. Circular bladed knife insures the mechanical and thermal cutting of the loop.

Connecting wire:

- Two Kevlar strands are designed to resist forces of 50 kg.
- Flexible wiring protected with an electrostatic shielding braid (covers 91%).
- The outer sheath is very rugged with a high-tech look (Polyurethane).
- U.V. resistant. U.V. tests carried out by *Weiss Technik*. See annex A.

Connections:

- Connectors are resistant to traction and lateral forces.
- Positive locking system secures cables to the box (patent pending).
- Gold plated contacts.

3.4. Restrictions and Limitations

The standard Vigil was not designed for water jumps. An adapted version is under development.
The Vigil must be turned on at ground level (This will be the zero reference altitude). Never turn the Vigil Multimode on in the plane.
Attention: If there is a great change in atmospheric pressure (more than 10 mbar); it is recommended that you shut down and restart your Vigil to guarantee optimal precision.
It is impossible to enter a negative altitude correction of more than 500m or 1500ft under sea level. The LCD will indicate «Invalid» and the unit will not switch on.
When the user decides to ride down with the aircraft in lieu of jumping, the pilot must be advised of the status of your Vigil to limit his descent rate in function of the programmed mode 20m/sec for Student and 35m/sec for Pro and Tandem (this is especially important for Vigils programmed in Student mode).
To avoid Vigil coming back to the stand-by status, the plane may not fly more than 100 sec in a zone of 150 Ft/46m above or under takeoff level! (in all modes, with or without altitude correction).
It is not recommended to put a switched ON Vigil in a closed boot (trunck) of a driving vehicle due to possible air pressure variation.
However, there is no inconvenient to travel in an open vehicle at the drop zone altitude.

3.5. Means to prevent pre-mature or untimely firing of the AAD

Each time the Vigil is started up, it automatically carries out a self-test on the three principal set of elements: the power pack, the cutter, and the controllers.

The following messages appear on the display at the start-up:

- BAT OK (Power pack is functioning properly)
- CUT OK (Cutter is functioning properly)
- CTL OK (Electronics are functioning properly)

If the Vigil detects an error in one of these units during the start up, one of the following messages will be displayed:

- «Bat Low» Low Battery, the Vigil is still operational but it is imperative to replace the power pack as soon as possible

- «Bat Rpl» The power pack must be replaced, the Vigil will not switch on.
- «Cut Err» Malfunction of the cutter, and the Vigil will not switch on.
- «Ctrl Err» There is a discrepancy in one of the electronic circuits.

The Vigil will shut down automatically if it detects a problem.

The appearance of one of these messages (with the exception of «Bat Low») puts an end to the start up procedure and the Vigil will switch itself off and needs to be inspected by a recognized dealer.
If the «Bat Low» or «Bat Rpl» messages appear, the user needs to replace the power pack.
If the «Cut Err» message appears, the user needs to replace the cutter.
A new cutter is supplied free of charge in exchange for a completed and accepted Life Saving Report. This form is available at http://www.vigil.aero/ on the download page.
We recommend that all Vigil parts be replaced by a certified rigger. Some country's regulations require a certified rigger to do such replacements. You must adhere to your country's rules in this situation. The user may not have authorization to replace the power pack or cutter.
If the «Ctrl Err» message appears there may be a failure in the electronic circuits. You need to send the Vigil back to your distributor for a complete check up. The Vigil is guaranteed to be free from material and workmanship defects for one year.

4. Testing

4.1 General overview of the testing program

- Data acquisition
- Computer Simulation
- Pressure Chamber testing
- Live skydives with altitude correction
- Live skydives NO GO testing
- Dummy testing from 420, 500, 600, 800, 1000, 1200 en 1500 meters in Pro, Student **&** Tandem modes
- Lab Climate **&** environmental Testing
- Lab Quality Control Testing:

4.2. Altitude measurement subsystem

4.2.1 Computer simulation

To develop the Vigil many computer simulated tests were performed.
The pressure variations were accurately measured and their values were scrupulously compared with suitable mathematic algorithms.
This was to decrease the influence of the pressure fluctuations in different freefall positions.
These algorithms are used to determine the balance of freefall time before activation. This data was checked during many test jumps by comparing them between the data of the Vigil and those of calibrated test equipment.

This real data was used in computer simulations to check and validate our mathematical algorithms.

4.3 Release subsystem

4.3.2 Test in pressure chamber

Four pressure chambers were used for this:

- FXC Corporation 711-07 146-1
- Willot 'Tube' test chamber with 3 pre-settings
- Weiss Technik VT 505 EK-P (400°C)
- Custom build Weiss Technik Vacuum project (see picture):
    - Temperature range : -30 to +80°C
    - Internal Volume + of 1m³
    - Internal Dimensions : Ø 1,12m
    - External Dimensions : H x L x L (1800 x 1500 x 1300mm)
      Heating : 18 kW power
    - Electric specs : 380V (3/N/PE - 3x16A - 50/60Hz)
    - Temperature sensor : Pt100
    - Pressure control : PID
    - Temperature protection: Pt100, adjustable

    - Vacuum measurement : Pirrane principle
    - Vacuum pump power : vacuum flange
    - All simulations were realised with own custom hardware and software.
    - All the Vigils are repeatedly tested in this chamber.

    - In this decompression chamber more than one hundred Vigils can be tested and calibrated at the same time

All Vigils are subjected to simulations that accurately replicate jumps in all three modes: PRO, STUDENT and TANDEM.
These simulations include, but are not limited to, the following situations: cutter activating, cutter not activating, high and low altitude jumps.
These simulations played a role in the development of the Vigil as a precision life saving device.

All simulated tests and live jumps are documented.

4.3.3 Drop testing and live testing

Over 5000 jumps were carried out to validate the simulated results and to aid the development of the Vigil.
These jumps have permitted us to check that the units would activate the cutter as intended when the unit's specifications were met and when there were not met.
Different airports were used in testing the Vigil's functions.
Test jumps were done with skydivers carrying weighted vests equipped with eight to 20 test Vigil units.

Test jumps utilizing different freefall body positions were logged. (Belly down, belly up, spinning, tumbling, wing suit, freefly, skysurf, high wing loading under an open canopy)

Expert skydivers performed test jumps.

Drop-test dummies performed the high- and low-altitude drop tests. Tests jumps were done with the dummies positioned belly up and belly down (with stabilizer) and were performed in all programmable modes (PRO, STUDENT and TANDEM).

More than 50 test jumps with drop-test dummies were logged. These dummies were equipped with an average of 5 Vigils each, as a data logger.

The jumps were spread out over an entire jump season so tests were performed in various temperatures and weather conditions.

All test jumps are documented; some are available on video (see appendix).

4.3.4 EMC (shielding) testing

Testing performed by the independent Laboratories De Nayer Report number: E0306001 Edition number: 01 Date of Edition: 10/06/2003

Tested standards:
- IN 61000-4-3: Test of electromagnetic compatibility. Test of immunity to the electromagnetic fields of radio frequencies (up to 90 V/m).
- ENV 502 04: Test of electromagnetic compatibility. Immunity test to the electromagnetic fields generated by handheld telephones (up to 90 V/m).

The Vigil is not affected by cellular phone radiation.

See test report Annex B.

4.3.5 Release of the reserve

The principal function of the Vigil is to release the reserve parachute in the event that the parachutist fails to activate the main or reserve parachute.
The pyrotechnic cutter slices the reserve container loop, which releases the reserve parachute.
The outer dimensions of the Vigil cutter are exactly the same as the industry standard.
The cutter is made of stainless steel.
The Vigil cutter is:
- Diameter of 9mm
- Does not produce any excessive heat or smoke

- Does not require any maintenance
- Has a shelf life of 20 years

As reported on 22/02/03, the Belgian Ministry of Economic Affairs, Administration of Quality and Safety, Service of the Explosives does not consider the cutter P/N 9582006 as being hazardous material for air transport (see Appendix C).
The DOT (U.S. Department of Transportation) has classified the Vigil cutter "not regulated as an explosive, 0000 "(see Appendix D)

4.4. Detailed System Test

4.4.1. Installation and functionality

AAD nv/sa guarantees that its device satisfied the following seven installation criteria:

- The equipment functions as described in the Vigil User's Manual
- The Vigil functions according to the programmed characteristics
- AAD nv/sa checks the reliability of the product and of its components
- AAD nv/sa will not endanger the life of its users
- The Vigil avoids all possible interferences between it and the main parachute
- Installation is compatible with the industry standard
- Qualified riggers can install the Vigil in any one-pin rig

AAD nv/sa developed and manufactured the Vigil to be compatible with modern, sport and military parachute systems as a whole.

4.4.2. Drop testing (with dummies and skydivers)

Over 50 drop tests were achieved with an average of 5 Vigils on each dummy. These drops are video, data loggers and black box documented.

- Drop testing of dummies equipped with an on-board video camera, data loggers, Pro-Track data loggers, and with ground-to-air video
- Drop testing with dummies at a low altitude (420m - see sample graphic, Appendix E - Graphic to test the Vigil in a "cut-away" situation. Vigil #282, jump #54).
- Drop testing with dummies at different altitudes (500, 600, 800, 1000, 1200 **&** 1500 m)

These tests allowed to understand the Vigil's behaviour in any given freefall position, its speed, the altitude of opening, and to check the opening altitude according to the freefall time and the falling speed.

4.43. Live Jumps

Over 150 devices logged more than 5000 jumps in freefall. Between 8 and 20 Vigils were positioned in each test jumpers' vest.

The objectives of these tests were:

- To gather the greatest amount of data possible in multiple forms of skydiving/parachuting
- To compare live tests with the mathematical algorithms
- To conduct "Go/No-Go" testing (to confirm that the cutter will fire only when necessary)

List of principal locations where test jumps were made:

- Maubeuge (FRA)
- Schaffen, Belgian Airborne Training School (BEL)
- Spa (BEL)
- Pribram (CZE)
- Empuria Brava (ESP)
- Wallerfangen (GER)
- Gap (FRA)
- Deland, FL (USA)

4.5. Environmental Testing

4.5.1. Shock

The shock resistance of the Vigil was tested according to the standard RTCA/DO-160C.

4.5.2. Vibration

The Vigil was subjected to various vibration tests (between 10 and 60Hz), with an average amplitude of 8mm. The Vigil was not affected by the vibrations.

4.5.3. Humidity

The Vigil was mounted in a reserve parachute container (standard set-up).
It was tested according to the RTCA/DO-160C, section 6, category B - standard.
The Vigil functioned correctly in:

- Non-condensed humidity
- At 98% humidity

Humidity test on the Vigil box:
The box was not affected by a relative humidity of 98%.

For water and dirt resistance, the box is equipped with two bronze filters.
These filters ensure protection against the intrusion of dust and moisture.

4.5.4. Seawater/salt spray

Salt spray does not affect the functionality of the Vigil.

4.5.5. Temperature

The Vigil was subjected to temperature tests in accordance with the standard RTCA/DO-160C, cat. B2.
The Vigil functioned correctly between temperatures from 30°C to +50°C.

4.5.7. EMI/EMS/ESD

The Vigil was tested at high frequencies of radiation (between 30 and 500 MHz) for a maximum radiation of a little less 25µV/m.
The latter concurs with all the international requirements (CE, FCC)

For any passive sensitivity, the Vigil was exposed to frequencies between 30 and 900 MHz (see Report De Naeyer, Annex B)
CE testing with a maximum level of radiation of 90V/m was performed.
The test showed that the Vigil is not affected by the parachutist's airport environment (Radar, Transponder, Radio).

4.5.8. Aging Tests

If used in accordance with the user's manual, The Vigil has been designed for 20 years of use. It will do a complete check of each parameter every time you switch it on. If a parameter is out of tolerance, this will be indicated on the LCD display screen and the unit will not switch on.
In this case, the Vigil must be returned to your official dealer for inspection.

5. Human interface

5.1. Activation/deactivation

The Vigil is activated automatically as soon as the plane reached a height of 46m/150Ft above the ground.
Thereafter, the red LED located on the display flashes three times to signal that it is armed.

- In PRO 840 feet - 256m
- STUDENT 1040 feet - 317 m
- TANDEM 2040 feet - 622 m

5.2. Calibration

Every 32 seconds, the Vigil checks the air pressure.
The Vigil thus adapts to any change of pressure in a span of 3mbars.

5.3. Parameter changes

The user has the possibility of adjusting the device to compensate for a difference in altitude between the elevation of takeoff and that of landing (called correction of altitude B).
This correction is limited in altitude from + 2000 m to - 2000m
or + 6000 ft to – 6000 ft

6. Marking / Labelling

The Vigil is labelled:

1. Main box: self-adhesive hologram (quality control + number, ex: C540)
Engravings: "Vigil by AAD nv/sa – EC **&** US Pat. Pending + CE Logo (EMC compatibility)
2. Remote control: self-adhesive hologram (Label quality control + number)
3. The cutter: self-adhesive hologram (Label quality control + number) Date of manufacture (shelf life of the cutter is 20 years) + P/N 9582006
4. Electronics: self-adhesive hologram on the inside, on the PCB (quality control + number, ex: C540)
5. The electronics are marked with a Date of Manufacturing label (D.O.M.)
6. The Power Pack is marked with a D.O.M. label in order to track its age so replacement can be performed within four years

7. Documents

- User's Manual (see Appendix F) of the Vigil is available in the following languages:
  - English
  - French
  - German, Spanish and Russian will be available shortly in print version

  (Other languages are available online: www.vigil.aero)
- A Quick User's Manual in English
- A registration card permits the owners to be traced
- A Test Certificate proves that each Vigil has been tested
- An X-Ray Card
- A US Department Of Transportation
- A Belgian Certificate of Transportation

Each Vigil is checked and all tests are documented. Therefore, the unit is certified to be in working order at the time of shipping.

8. Maintenance

8.1. Field Maintenance & installation

Riggers can install the Vigil under their own authority. The instructions of the harness/container manufacturer must be followed at all times.
The battery's life span is ±4 years or 700 jumps. When the «Bat Low» or «Bat Rpl» message appears, whichever comes first, the battery needs to be replaced. Depending on the country's aviation rules and regulations, a skydiver or a rigger can perform this replacement.

8.2. Maintenance of the manufacturer

The Vigil does not require any maintenance

9. Quality Control Procedures/Systems and Methodology

9.1. Purchased parts/components

- All parts and components manufactured for the Vigil meet industry standards: Automotive or High-reliability specifications.
- All sub assemblies are checked at the Vigil factory.
- The quality control procedure guarantees that all products are of the highest standards.

9.2. Production

- AAD nv/sa created a system of quality control during the creation of its prototype models.
- The quality control system is fully operational.
- All the data related to control of our products is logged.
- This information is used to establish and update the database for evaluation purposes and for future evaluation of the products.

9.3. Final Test

- All the Vigil AADs are subjected to six simulations of tests (two in each mode, with and without activation of the cutter).
- During the development and the manufacturing of the Vigil, the company AAD nv/sa performed EMI tests.
- Different people closely inspect 100% of the production.

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Note: All technical products are prone to technical failures. These critical periods of failure generally appear when the product has just left the factory and when the product has reached its estimated lifespan

Thus, these final tests on the Vigil are carried out before the units are shipped.

10. Appendices

10.1. German Manual
10.2. PowerPoint presentation