EQUIPMENT TESTING FOR ENVIRONMENTAL EFFECTS TO ENSURE SAFE TRANSPORT

Bozhidar Dzhudzhev, Nikolay Pantileev, Vladimir Kamenov

Abstract: The report presents the capabilities of Environmental Testing Laboratory, part of Bulgarian Institute of Metrology, for testing of equipment used in the automotive, shipbuilding and aviation industry and the impact of the environment on the transportation of equipment. The standards according to which tests were performed in the test laboratory, the created vibrations and the non-compliance criteria are given. Test results of different equipment are shown.

Key words: testing laboratory, transport, vibration, temperature.

1. Introduction

There is a lasting tendency to increase safety requirements for the equipment, assemblies and components used in the automotive, ship and aviation industries. Any equipment or component to be fitted to a vehicle must undergo tests carried out in accordance with certain standards. In practice, virtually every manufacturer has developed its test procedure that meets the requirements of the standards and often significantly exceeds them. All products must be tested for environmental impacts. Some of these tests include vibration and climate testing, which are the core activity of the Environmental Testing Laboratory.

The laboratory was established in 2013 and is part of the Bulgarian Institute of Metrology (BIM). It has modern technical equipment for testing and measurement giving opportunity for vibration (sinusoidal, accidental and impact) and climatic tests (cold, heat, humid, temperature, temperature and humidity) of electromechanical and mechanical products and components. The laboratory has a management system according to BDS EN ISO / IEC 17025 [1].

The report describes the technical capabilities of the test laboratory and the methods under which it operates. Various types of tests for the automotive, ship and aviation industry done in the laboratory are presented.

2. Technical equipment and test methods in Environmental Testing laboratory

The activities of the laboratory are related to vibration and climate testing.

2.1. Vibration test

The vibration test is performed by a test system (Table 1, Fig. 1) consisting of the following components.

Table 1 Test system

Component	Type	Manifacturer
Electrodynamic exciter	TV 56 263/LS-340	TIRA Gmbh
Power amplifier	A1 02 1 010	TIRA Gmbh
Controller	VibPilot24	m+p international
Accelerometer – 4 pieces	4315 B	Bruel&Kjaer
Software for management and analysis of measurement information	VibControl	m+p international

The test system of Fig. 1 creates, at any moment of time, linear vibrations in only one direction. A three-pronged test is possible if:

- the test object is rotated on the electrodynamic exciter,

- the Z-test is carried out in the vertical position of the electrodynamic exciter. For directions X and Y, the exciter is rotated at an angle of 90 degrees with respect to the Z direction and a movable table is attached to it. The test item shall be placed on the test bench in one direction and rotated 90 ° to the vertical for the other direction. The moving table allows to place objects with a mass up to 100 kg.

The vibrations that the test system can create are sinusoidal, random and shock with the following technical parameters:

Amplitude up to 50.8 mm, acceleration to 75 g (151 g for shock), frequency range 0 Hz to 3

Fig.1 Vibration test system

kHz, maximum force 6300 N (12600 for shock), maximum test mass 150 kg.

The vibration test system is managed by Vib-Control software. There is an easy-to-use user interface that sets the test parameters and monitors the measurement information obtained from the accelerometers.

2.2 Climatic test

The climatic test shall be carried out in a climatic chamber for temperature / humidity testing Walk-in Climatic Chamber, type TCZ 6005 S(m), manifacturer TIRA Gmbh (fig.2).

Fig. 2 Climatic chamber for temperature/humidity tests TCZ 6005 S(m

Table 2 Basic standards and methods

Standard	Method
I. CLIMATIC TESTS	
BDS EN 60068-2-1:2007 Environmental testing - Part 2-1: Tests - Test A: Cold (IEC 60068-2-1:2007)	**т. 5.2 - Ab**: Cold for non heat-dissipating specimens with gradual change of temperature **т. 5.3 - Ad:** Cold for heat-dissipating specimens with gradual change of temperature that are powered after initial temperature stabilization **т. 5.4 - Ae**: Cold for heat-dissipating specimens with gradual change of temperature that are required to be powered throughout the test
BDS EN 60068-2-2:2008 Environmental testing - Part 2-2: Tests - Test B: Dry heat (IEC 60068-2-2:2007)	**т. 5.2 - Bb**: Dry heat for non heat-dissipating specimens with gradual change of temperature **т. 5.3 - Bd**: Dry heat for heat-dissipating specimens with gradual change of temperature that are not powered during the conditioning period **т. 5.4 - Be**: Dry heat for heat-dissipating specimens with gradual change of temperature that are required to be powered throughout the test
BDS EN 60068-2-14:2009 Environmental testing -- Part 2-14: Tests - Test N: Change of temperature (IEC 60068-2-14:2009)	**т. 8 - Nb:** Change of temperature with specified rate of change
BDS EN 60068-2-30:2006 Environmental testing – Part 2-30: Tests – Test Db and guidance: Damp heat, cyclic (12+12 hour cycle) (IEC 60068-2-30:2005)	**Db:** Damp heat, cyclic
***BDS EN 60068-2-38:2009** Environmental testing -- Part 2-38: Tests - Test Z/AD: Composite temperature/humidity cyclic test (IEC 60068-2-38:2009)	**Z/AD:** Composite temperature/humidity cyclic test
***BDS EN 60068-2-67:2003** Environmental testing -- Part 2: Tests - Test Cy: Damp heat, steady state, accelerated test primarily intended for components (IEC 60068-2-67:1995)	**Cy:** Damp heat, steady state, accelerated test primarily intended for components
БДС EN 60068-2-78:2013 Environmental testing -- Part 2-78: Tests - Test Cab: Damp heat, steady state (IEC 60068-2-78:2012)	**Cab:** Damp heat, steady state
II. VIBRATION TESTS	
BDS EN 60068-2-6:2008 Environmental testing -- Part 2-6: Tests - Test Fc: Vibration (sinusoidal) (IEC 60068-2-6:2007)	**Fc:** Vibration (sinusoidal)
BDS EN 60068-2-27:2009 Environmental testing -- Part 2-27: Tests - Test Ea and guidance: Shock (IEC 60068-2-27:2008)	**Ea:** Shock
БДС EN 60068-2-64:2008 Environmental testing -- Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance (IEC 60068-2-64:2008)	**Fh:** Vibration, broadband random
* standards not used for environmental transport testing	

The climatic chamber has the following technical characteristics:

- temperature range from – 60 oC to 100 oC,
- volume 2010/1610/2010 mm (length/width/height),
- rate for heating and cooling 1 °C/min,
- humidity range from 10 % RH to 95 % RH

The chamber is managed by specialized software WinKratos, which sets, monitors and records the test parameters.

2.3 Test methods

The testing laboratory works with the basic standards and methods given it table 2.

3. Environmental testing of equipment

3.1 Environmental testing of equipment for the industry

Testing of equipment and components used in vehicles with environmental impact shall be carried out in accordance with ISO 16750-1 [2], MIL-STD-202G [3] and MIL-STD-810G [4] or other compatible standards.

In the laboratory random vibration tests of alternators, according to SAE J1455 [5], which refers to MIL-STD-202G [3] and MIL-STD-810G [4] in the frequency range 20 Hz to 2 kHz in direction Z (Figure 3) are done.

Fig. 3 shows the type of vibration to which the alternator is subjected. Yellow and red lines are boundaries. Passing the yellow lines will activate an alarm that indicates that the set and generated vibrations are different, but the test may continue. Passing the red lines will stop the test.

It can be seen that during the test, the generated vibration (Fig. 3) passes the yellow border at several points, after further studies it is found that this is due to resonance phenomena in the fastener connecting the housing and the alternator stator package.

The test is successful if there are no functional and mechanical failures during and after the test.

The environmental impact test of equipment and components for ships shall be conducted in accordance with BDS EN 300 019-1-0 V2.1.2 [6], DNV STD CERT 2.4 [7], MIL-STD-810G [4] or other compatible standards.

An antenna test for ships in accordance with MIL-STD-810G [4] has been carried out in Environmental Testing Laboratory. The tests are performed on sinusoidal vibrations in the frequency range from 4 Hz to 33 Hz (Figure 4). Measuring accelerometers shall be attached to the test object at points specified by the manufacturer to monitor the presence of resonance phenomena during the test. It can be seen (фиг.5) that there is resonance at 16 Hz. According to the standard at this frequency, an additional sinusoidal vibration test must be carried

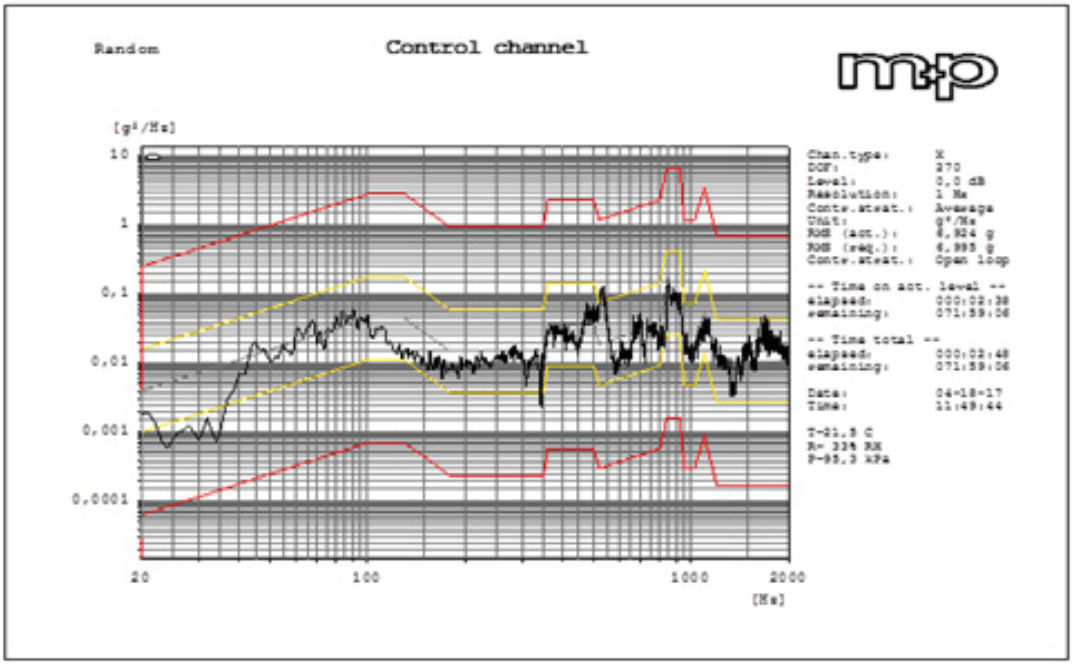

Fig.3. Random vibrations for alternator tests

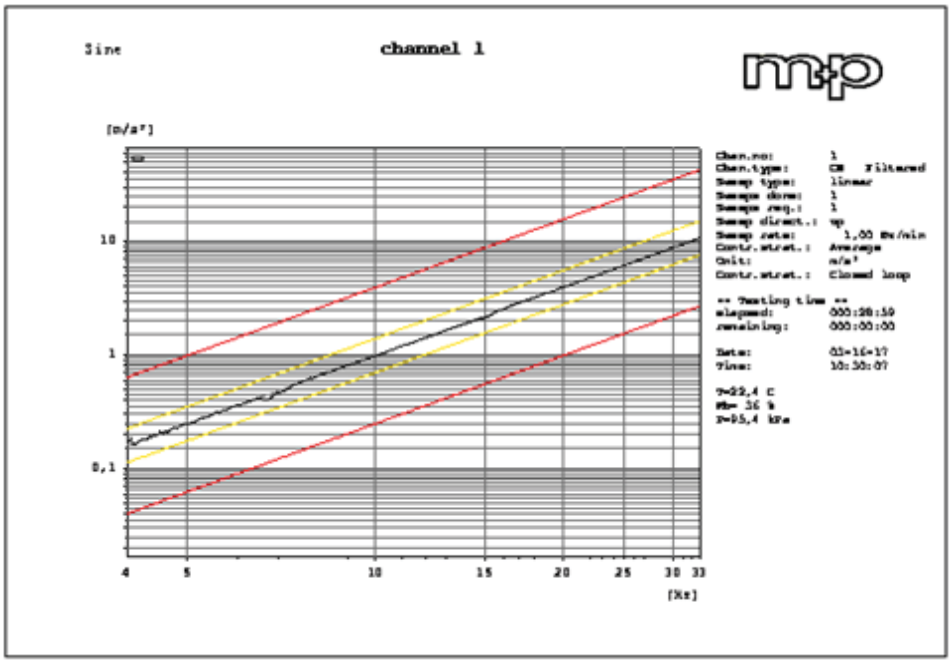

Fig. 4. Vibration measured form control accelerometer

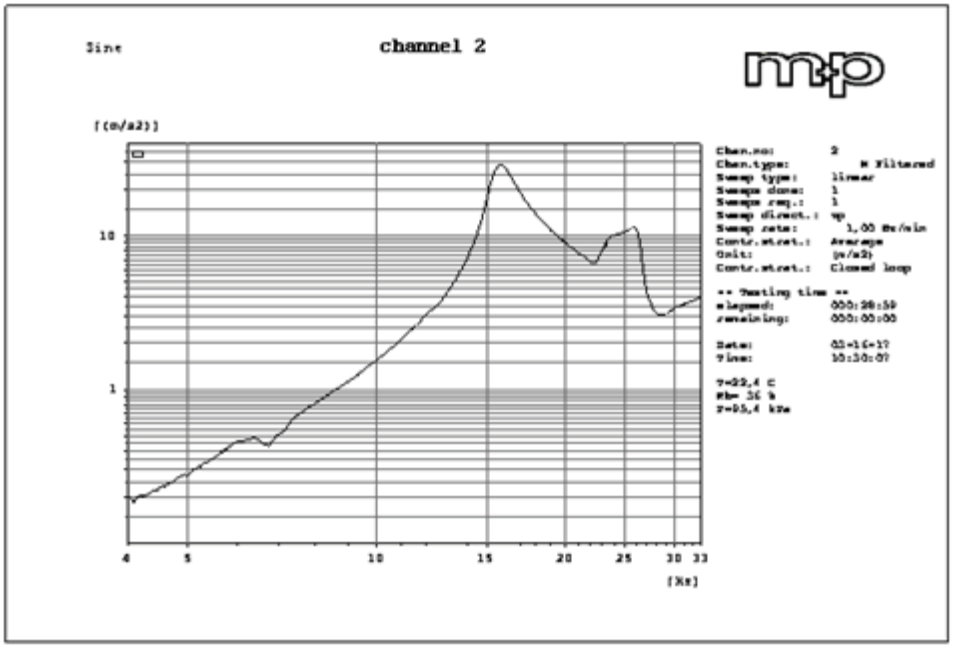

Fig. 5. Vibrations measured form measuring accelerometer

out for 2 hours.

At the end of the test, mechanical damage and test equipment functionality shall be checked

Environmental testing of equipment and components for aviation is performed in accordance with RTCA standards DO-160G [8], MIL-STD-810G [4] or other compatible standards. The standards describe the impacts and test parameters according to the location of the installation.

The laboratory tested antennas for airplanes according to MIL-STD-810G [4]. The test object is subjected to random vibrations in the frequency range 15 Hz to 2 kHz, the type of which is shown in Figure 6. A deviation of the vibration created by the set vibration is observed in the approximately 1500 Hz range. This deviation is due to resonance in the test object.

The test has a duration of 4 hours for each direction and is successful if the object is not mechanically damaged and remains operational during the test.

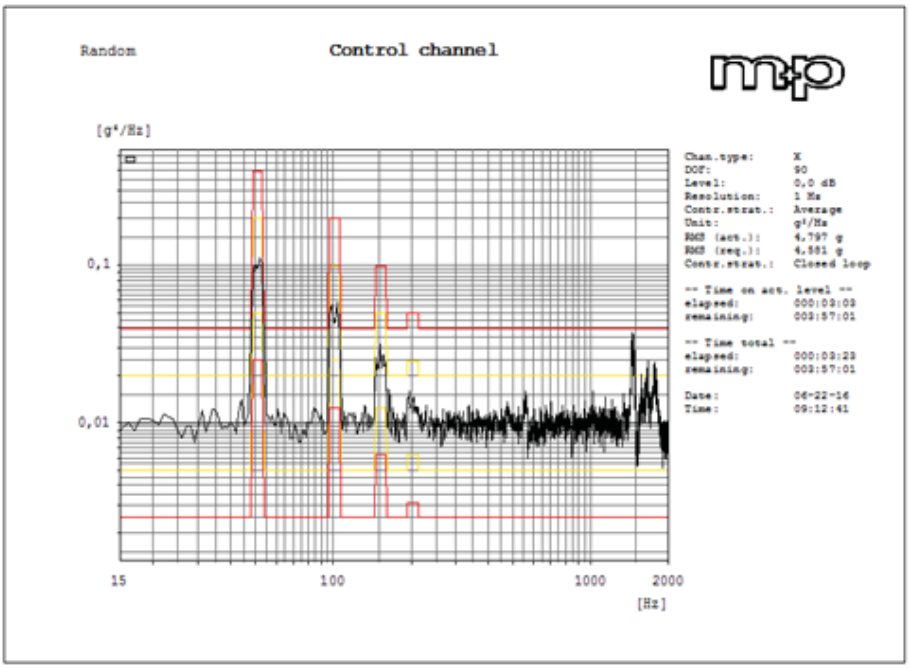

Fig.6. Random test vibrations for antennas

3.4. Testing of equipment for environmental impact during transport

During transportation, the products are subjected to vibrations and climatic impacts. Manufacturers must ensure that these impacts do not damage their production. This is achieved by tests performed according to standards RTCA DO-160G [8], MIL-STD-810G [4], BDS EN 60721-3-2 [9] and all standards in Table 2.

During these tests the objects are completely packaged in the way they will be transported. At the end of the test, the product is unpacked and inspected for mechanical damage or loss of functionality.

Fig. 7 shows the test setup for vibration testing I / O modules during transport in X direction, and fig. 8 the applied impact on the test object. After testing in each direction, the object is subtracted and a mechanical damage and functionality test are done.

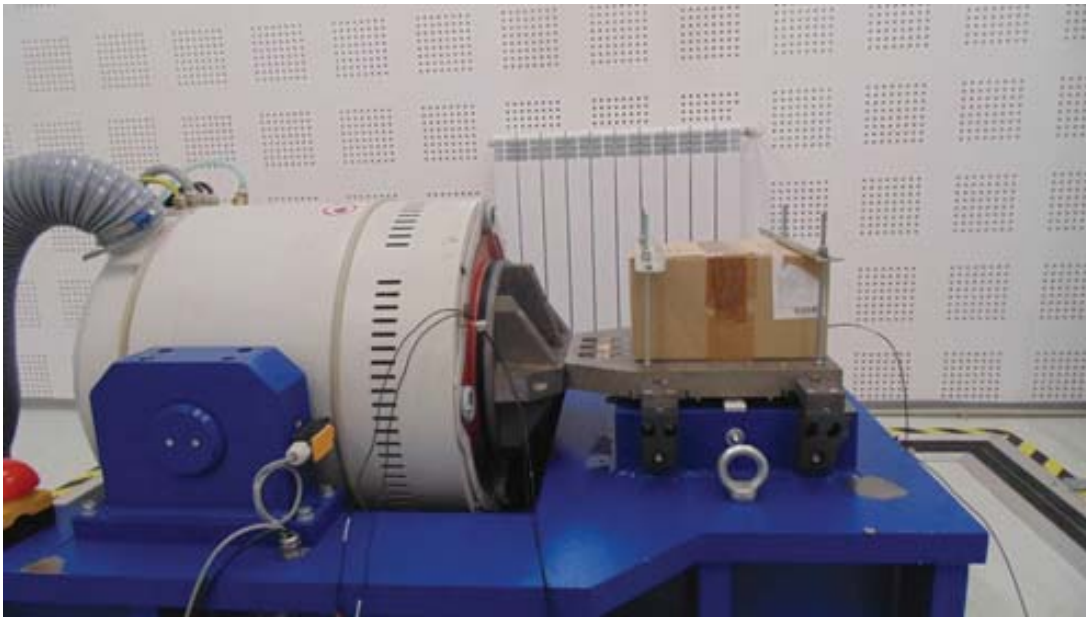

Fig. 7. Experimental setup for transport vibration tests for X-axis

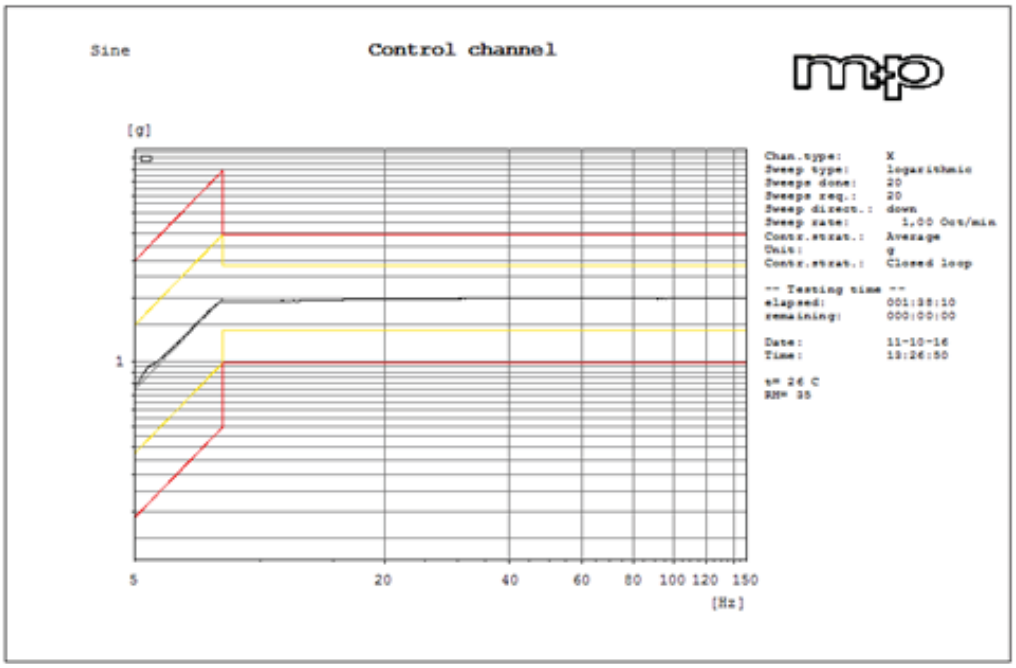

Fig. 8. Transport vibration tests of I/O modules

4. Conclusion

The Testing Laboratory "BOC" has modern technical equipment for testing and measuring vibrations and climatic effects, enabling testing according to a large number of standards.

The laboratory has experience in testing environmental equipment in various areas of transport and allows manufacturers to experience their production of vibration and climatic effects during transport.

In the future, the testing laboratory may extend its testing activities by creating conditions for testing:

- salt mist according to BDS EN 60068-2-11 [10],
- water according to BDS EN 60068-2-18 [11],
- dust and sand according to BDS EN 60068-2-68 [12].

5. References

[1] BDS EN ISO/IEC 17025:2006 General requirements for the competence of testing and calibrating laboratories

[2] ISO 16750-1:2006(en) Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General

[3] MIL-STD-202G:2002 Test method standard electronic and electrical component parts

[4] MIL-STD-810G:2008 w/Change 1 Environmental engineering considerations and laboratory tests

[5] SAE J1455:2011 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

[6] BDS EN 300 019-1-0 V2.1.2:2010 Environmental engineering (EE); Environmental conditions and environmental tests for telecommunication equipment; Part 1-0: Classification of environmental conditions; Introduction (EN 300 019-1-0 V2.1.2 (2003-09))

[7] DNV STD CERT 2.4:2006 Environmental test specification for instrumentation and automation equipment

[8] RTCA DO-160G:2014 Environmental Conditions and Test Procedures for Airborne Equipment

[9] BDS EN 60721-3-2:2003 Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation (IEC 60721-3-2:1997)

[10] BDS EN 60068-2-11:2003 Environmental testing Part 2-11Tests Ka: Salt mist (IEC 60068-2-11:1981)

[11] BDS EN 60068-2-18:2003 Environmental testing Part 2-18 Test R and guidance: Water (IEC 60068-2-18:2000)

[12] BDS EN 60068-2-68:2003 Environmental testing Part 2-68 Tests – Test L: Dust and sand (IEC 60068-2-68:1994)

Information about the Authors:

Bozhidar Dzhudzhev,

1. PhD specialty „Electrical Measurement Systems“ (2015), Faculty of Automatics, TU-Sofia, senior assistant proffesor

Address: Technical University-Sofia
1000, 8 Kl. Ohridski Blvd.
Web addres: *http://www.tu-sofia.bg/*
e-mail: b.djudjev@tu-sofia.bg

2. Head of Environmental Testing Laboratory, Directorate ISIUS, BIM, Chief Specialist

Address: Sofia, quarter “Poligona“, 2 “Prof. P. Mutafchiev“ str.,
Web addres: *http://www.bim.government.bg/,*
e-mail: cvlab@abv.bg

Nikolay Pantileev, PhD, Associate Professor, Director of the Directorate ISIUS, BIM

Address: Sofia 1000, "G. M. Dimitrov" 52 str.,
Web addres: *http://www.bim.government.bg/,*
e-mail: emclab@abv.bg

Vladimir Kamenov,

1. PhD specialty „Applied Mechanics“, Faculty of Mechanical Engineering, TU-Sofia, senior assistant proffesor

Address: Technical University-Sofia
1000, 8 Kl. Ohridski Blvd.
Web addres: *http://www.tu-sofia.bg/*
e-mail: vkamenov@tu-sofia.bg

2. Testator in Environmental Testing Laboratory, Directorate ISIUS, BIM, Chief Specialist

Address: Sofia, quarter “Poligona“, 2 “Prof. P. Mutafchiev“ str.,
Web addres: *http://www.bim.government.bg/,*
e-mail: cvlab@abv.bg