Federal agency for state property management
JSC Research Center of Construction, Research Institute of Building Constructions

TECHNICAL REPORT

On the subject "**Conduction of dynamic tests of conduits system including pipes, fittings, containers, wells, and pump stations of trade mark "KRAH PIPES" (Estonia) with assessment of the opportunity of their application in the regions of Russian Federation with seismic intensity 7-9 magnitudes**".

The contract #200/24-8-12/ck 20.02.2012

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1. Introduction

The technical report is using the results of experimental researches of polyethylene conduit elements of trade mark “KRAH PIPES”, designed for outdoor sewerage, disposal of waste water and ventilation.

The tests were conducted on the stand which was specially designed by JSC Research Center of Construction, Research Institute of Building Constructions. The stand is made as a pendulum-type platform vibrator.

The purpose of the laboratory tests is estimation of workability and exploitative reliability of polyethylene pipe conduit elements in seismic regions of Russian Federation with 7÷9 degrees of intensity according to the MSK-64 scale.

The report is issued in accordance with the requirements of existing regulations. The terms and definitions from SNIP II-7-81* were used for describing methods and results of seismic stability experimental researches of polyethylene pipe conduit elements for outdoor sewerage, disposal of waste water and ventilation.

2. The tasks of conducted experimental researches

In accordance with Federal law #184-FS from 27.12.2002 " Law on Technical Regulation" new building products designed and produced for series manufacture and in case of changing products exploitative conditions are subjected to compulsory assessment and confirmation of compliance with safety requirements.

The important step in such experimental research concerning estimation of seismic stability is the tests on the special stands (platform vibrator) with the help of the special vibration machines.

The data of the results of the dynamic tests allow determining strength and exploitative characteristics of researched constructions under dynamic impact and also it is a basis for assessment of expandability of application area of testing structures taking into consideration the safety requirements, maintenance reliability and durability of the structures to be erected in seismic areas of Russian Federation.

Assessment of possibility of polyethylene conduit elements of trade mark "KRAH PIPES" application in seismic regions in Russia on the areas with 7÷9 degrees of intensity includes next steps:

1. Complex experimental research of polyethylene conduit elements system on the vibration platform with different stages of dynamic loading.
2. Making amendments concerning constructive solutions of polyethylene conduit elements and their connections in company standard or book of technical solutions (if this is required by the test results) and changes coordination with JSC Research Center of Construction, Research Institute of Building Constructions.

3. Constructive solution of polyethylene conduit. Field of application

The examples of polyethylene conduit elements of trade mark “KRAH PIPES”, designed for outdoor sewerage, disposal of waste water and ventilation were presented by Customer for conduction of dynamical tests. (fig. 3.1)

The polymer pipes “KRAH” made by ТУ 2248-001-30233670-2011 (specification of requirements) of ring cross-section are made by method of spiral winding of the melt profile. Pipes (fittings) are applied for drainage of gravity-flowing waste water with maximum temperature +60 ˙C and short-duration temperature +95 ˙C.

Pipes are made with the cross-sections of the different types “OP” (fig. 3.2), “SOP” (fig. 3.3), “PR” (fig. 3.4), “SPR” (fig. 3.5) and “VW” (monolithic wall); fittings are made of circular cross-section. General dimensions of the pipes depending on profile type and ensured ring stiffness are given in the tables 3.1÷3.5.

Welded Wells “KRAH” made by ТУ 4859-002-30233670-2011 (specification of requirements) for free-flow pipeline are made of double-layered goffered polyethylene pipes. Wells are divided into two types: showery wells (fig. 3.6) and trough wells (fig. 3.7). Dimensions of the shaft pipes of wells are given in the table 3.6.

The connections of the pipes and the fittings are made by next ways:

- Electrofusion method (fig. 3.8) - electrofusion welding of pipes with the help of embedded parts;
- Connection with the help of the rubber gasket (fig. 3.9);
- Connection with the help of the hand extruder (fig. 3.10, 3.11)

The elements of the pipe conduit system for dynamic tests and their geometrical dimensions are given in accordance with the existing engineering documentations [2, 3].

Table 3.1

Nominal internal diameter DN/ID	Nominal external diameter DN/OD	Profile types	Nominal ring stiffness, SN, kN/m^2	Diameter EF So* of pipe with el. welded connection, mm			Diameter EF Sp of pipe with el. welded connection, mm			Diameter RG So pipe with wrapper rings connection, mm			Diameter RG Sp pipe with wrapper rings connection, mm			Weight, kg/m
				Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		
					+	-		+	-		+	-		+	-	
800	896	PR34-001.14	2	849,6	2,5	2,5	848,0	3,2	3,2	849,6	2,5	2,5	834,6	5	3	25,68
1000	1096	PR42-002.28	2	1049,5	2,5	2,5	1047,9	4,8	4,8	1049,5	2,5	2,5	1034,5	5	3	39,16
1200	1320	PR54-004.39	2	1249,5	2,5	2,5	1247,8	4,8	4,8	1249,4	2,5	2,5	1234,4	5	3	55,81
1400	1524	PR54-005.66	2	1459,4	2,5	2,5	1457,1	4,8	4,8	1459,4	2,5	2,5	1444,4	5	3	77,22
1500	1642	PR65-007.22	2	1559,7	2,5	2,5	1557,4	4,8	4,8	1559,7	2,5	2,5	1544,7	5	3	81,5
1600	1746	PR65-008.25	2	1660	3,2	3,2	1657,7	4,8	4,8	1660	2,5	2,5	1645	5	3	91,41
1800	1966	PR75-011.95	2	1870,1	3,2	3,2	1867,8	4,8	4,8	1870,1	2,5	2,5	1855,1	5	3	115,18
2000	2170	PR75-016.25	2	2069,7	3,2	3,2	2067,4	4,8	4,8	2069,7	2,5	2,5	2054,7	5	3	158,65
2200	2404	OP65-022.23	2	2269,5	3,2	3,2	2265,7	4,8	4,8	2269,5	2,5	2,5	2254,5	5	3	204,31
2400	2650	OP75-031.25	2	2469,4	3,2	3,2	2465,6	4,8	4,8	2469,4	2,5	2,5	2454,4	5	3	230,81
3000	3282	OP75-054.16	2	3069,5	3,2	3,2	3065,6	4,8	4,8	3069,5	2,5	2,5	3054,5	5	3	362,33

Table 3.2

Nominal internal diameter DN/ID	Nominal external diameter DN/OD	Profile types	Nominal ring stiffness, SN, kN/m^2	Diameter EF So* of pipe with el. welded connection, mm			Diameter EF Sp of pipe with el. welded connection, mm			Diameter RG So pipe with wrapper rings connection, mm			Diameter RG Sp pipe with wrapper rings connection, mm			Weight, kg/m
				Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		
					+	-		+	-		+	-		+	-	
600	696	PR34-000.99	4	649,4	2,5	2,5	647,8	3,2	3,2	649,4	2,5	2,5	634,4	5	3	17,88
800	896	PR42-002.28	4	849,6	2,5	2,5	848,0	3,2	3,2	849,6	2,5	2,5	834,6	5	3	31,57
1000	1120	PR54-004.39	4	1049,5	2,5	2,5	1047,9	4,8	4,8	1049,5	2,5	2,5	1034,5	5	3	46,82
1200	1346	PR65-008.25	4	1249,4	2,5	2,5	1247,8	4,8	4,8	1249,4	2,5	2,5	1234,4	5	3	67,59
1400	1566	PR75-011.95	4	1459,7	2,5	2,5	1457,1	4,8	4,8	1459,4	2,5	2,5	1444,4	5	3	88,98
1500	1670	PR75-014.61	4	1559,7	2,5	2,5	1557,4	4,8	4,8	1559,7	2,5	2,5	1544,7	5	3	107,66
1600	1774	PR75-017.42	4	1660	3,2	3,2	1657,7	4,8	4,8	1660	2,5	2,5	1645	5	3	128,08
1800	1974	SPR75-026.22	4	1870,1	3,2	3,2	1867,8	4,8	4,8	1870,1	2,5	2,5	1855,1	5	3	157,93
2000	2180	SPR75-032.23	4	2069,7	3,2	3,2	2067,4	4,8	4,8	2069,7	2,5	2,5	2054,7	5	3	214,24
2200	2482	OP75-054.16	4	2269,5	3,2	3,2	2265,7	4,8	4,8	2269,5	2,5	2,5	2254,5	5	3	269,25
2400	2684	OP75-057.41	4	2469,4	3,2	3,2	2465,6	4,8	4,8	2469,4	2,5	2,5	2454,4	5	3	300,43
3000	3318	OP75-117.04	4	3069,5	3,2	3,2	3065,6	4,8	4,8	3069,5	2,5	2,5	3054,5	5	3	573,12

Table 3.3

Nominal internal diameter DN/ID	Nominal external diameter DN/OD	Profile types	Nominal ring stiffness, SN, kN/m^2	Diameter EF So* of pipe with el. welded connection, mm			Diameter EF Sp of pipe with el. welded connection, mm			Diameter RG So pipe with wrapper rings connection, mm			Diameter RG Sp pipe with wrapper rings connection, mm			Weight, kg/m
				Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		
					+	-		+	-		+	-		+	-	
600	696	PR42-001.64 (4/3/120)	6	649,4	2,5	2,5	647,8	3,2	3,2	649,4	2,5	2,5	634,4	5	3	
800	920	PR54-003.94 (5/3/140)	6	849,6	2,5	2,5	848,0	3,2	3,2	849,6	2,5	2,5	834,6	5	3	35,21
1000	1142	PR65-007.22	6	1049,5	2,5	2,5	1047,9	4,8	4,8	1049,5	2,5	2,5	1034,5	5	3	53,82
1200	1366	PR75-011.95	6	1249,4	2,5	2,5	1247,8	4,8	4,8	1249,4	2,5	2,5	1234,4	5	3	75,11
1400	1574	PR75-017.42	6	1459,7	2,5	2,5	1457,1	4,8	4,8	1459,4	2,5	2,5	1444,4	5	3	112,71
1500	1678	PR75-022.60	6	1559,7	2,5	2,5	1557,4	4,8	4,8	1559,7	2,5	2,5	1544,7	5	3	146,96
1600	1850	OP75-031.25	6	1660	3,2	3,2	1657,7	4,8	4,8	1660	2,5	2,5	1645	5	3	155,3
1800	2060	OP75-041.08	6	1870,1	3,2	3,2	1867,8	4,8	4,8	1870,1	2,5	2,5	1855,1	5	3	196,94
2000	2270	OP75-052.04	6	2069,7	3,2	3,2	2067,4	4,8	4,8	2069,7	2,5	2,5	2054,7	5	3	248,57
2200	2490	OP75-067-83	6	2269,5	3,2	3,2	2265,7	4,8	4,8	2269,5	2,5	2,5	2254,5	5	3	307,64
2400	2702	OP75-086.78	6	2469,4	3,2	3,2	2465,6	4,8	4,8	2469,4	2,5	2,5	2454,4	5	3	384,5
3000	3340	OP75-167.99	6	3069,5	3,2	3,2	3065,6	4,8	4,8	3069,5	2,5	2,5	3054,5	5	3	705,86

Table 3.4

Nominal internal diameter DN/ID	Nominal external diameter DN/OD	Profile types	Nominal ring stiffness, SN8, kN/m^2	Diameter EF So* of pipe with el. welded connection, mm			Diameter EF Sp of pipe with el. welded connection, mm			Diameter RG So pipe with wrapper rings connection, mm			Diameter RG Sp pipe with wrapper rings connection, mm			Weight, kg/m
				Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		
					+	-		+	-		+	-		+	-	
600	696	PR42-001.88	8	649,4	2,5	2,5	647,8	3,2	3,2	649,4	2,5	2,5	634,4	5	3	21,97
800	920	PR54-004.39	8	849,6	2,5	2,5	848,0	3,2	3,2	849,6	2,5	2,5	834,6	5	3	37,84
1000	1162	PR75-009.43	8	1049,5	2,5	2,5	1047,9	4,8	4,8	1049,5	2,5	2,5	1034,5	5	3	58,45
1200	1370	PR75-014.61	8	1249,4	2,5	2,5	1247,8	4,8	4,8	1249,4	2,5	2,5	1234,4	5	3	85,32
1400	1582	PR75-023.51	8	1459,7	2,5	2,5	1457,1	4,8	4,8	1459,4	2,5	2,5	1444,4	5	3	136,9
1500	1750	OP75-031.25	8	1559,7	2,5	2,5	1557,4	4,8	4,8	1559,7	2,5	2,5	1544,7	5	3	146,17
1600	1860	OP75-041.08	8	1660	3,2	3,2	1657,7	4,8	4,8	1660	2,5	2,5	1645	5	3	174,63
1800	2082	OP75-054.16	8	1870,1	3,2	3,2	1867,8	4,8	4,8	1870,1	2,5	2,5	1855,1	5	3	222,65
2000	2290	OP75-067.83	8	2069,7	3,2	3,2	2067,4	4,8	4,8	2069,7	2,5	2,5	2054,7	5	3	281,08
2200	2508	OP75-099-21	8	2269,5	3,2	3,2	2265,7	4,8	4,8	2269,5	2,5	2,5	2254,5	5	3	389,39
2400	2718	OP75-117.04	8	2469,4	3,2	3,2	2465,6	4,8	4,8	2469,4	2,5	2,5	2454,4	5	3	463,39
3000	3366	OP75-242.02	8	3069,5	3,2	3,2	3065,6	4,8	4,8	3069,5	2,5	2,5	3054,5	5	3	853,27

Table 3.5

Nominal internal diameter DN/ID	Nominal external diameter DN/OD	Profile types	Nominal ring stiffness, SN16, kN/m^2	Diameter EF So* of pipe with el. welded connection, mm			Diameter EF Sp of pipe with el. welded connection, mm			Diameter RG So pipe with wrapper rings connection, mm			Diameter RG Sp pipe with wrapper rings connection, mm			Weight, kg/m
				Nomina l	tolerance extremes		Nomin al	tolerance extremes		Nominal	tolerance extremes		Nominal	tolerance extremes		
					+	-		+	-		+	-		+	-	
600	720	PR54-004.39	16	649,4	2,5	2,5	647,8	3,2	3,2	649,4	2,5	2,5	634,4	5	3	28,86
800	946	PR65-009.19	16	849,6	2,5	2,5	848,0	3,2	3,2	849,6	2,5	2,5	834,6	5	3	50,59
1000	1174	PR75-017.42	16	1049,5	2,5	2,5	1047,9	4,8	4,8	1049,5	2,5	2,5	1034,5	5	3	80,55
1200	1450	OR75-031.25	16	1249,4	2,5	2,5	1247,8	4,8	4,8	1249,4	2,5	2,5	1234,4	5	3	117,22
1400	1668	OR75-049.01	16	1459,7	2,5	2,5	1457,1	4,8	4,8	1459,4	2,5	2,5	1444,4	5	3	178,16
1500	1784	OP75-060.53	16	1559,7	2,5	2,5	1557,4	4,8	4,8	1559,7	2,5	2,5	1544,7	5	3	203,57
1600	1892	OP75-071.43	16	1660	3,2	3,2	1657,7	4,8	4,8	1660	2,5	2,5	1645	5	3	240,36
1800	2110	OP75-108.32	16	1870,1	3,2	3,2	1867,8	4,8	4,8	1870,1	2,5	2,5	1855,1	5	3	354,95
2000	2328	OP75-141.38	16	2069,7	3,2	3,2	2067,4	4,8	4,8	2069,7	2,5	2,5	2054,7	5	3	450,79
2200	2538	SOP75-196-48	16	2269,5	3,2	3,2	2265,7	4,8	4,8	2269,5	2,5	2,5	2254,5	5	3	570,62
2400	2754	SOP75-252.87	16	2469,4	3,2	3,2	2465,6	4,8	4,8	2469,4	2,5	2,5	2454,4	5	3	686,31
3000	3420	SOP75-491.38	16	3069,5	3,2	3,2	3065,6	4,8	4,8	3069,5	2,5	2,5	3054,5	5	3	1212,28

Table 3.6

Nominal well diameter	Well height, H	
	Nominal value	Toleranceextremes
600	от 500 до 9000*	± 25
800	от 500 до 9000*	± 25
1000	от 500 до 9000*	± 25
1200	от 500 до 9000*	± 40
1400	от 500 до 9000*	± 45
1500	от 500 до 9000*	± 50
1600	от 500 до 9000*	± 55
1800	от 500 до 9000*	± 60
2000	от 500 до 9000*	± 65
2200	от 500 до 9000*	± 70
2400	от 500 до 9000*	± 75
3000	от 500 до 9000*	± 80

a.

b.

Figure 3.1

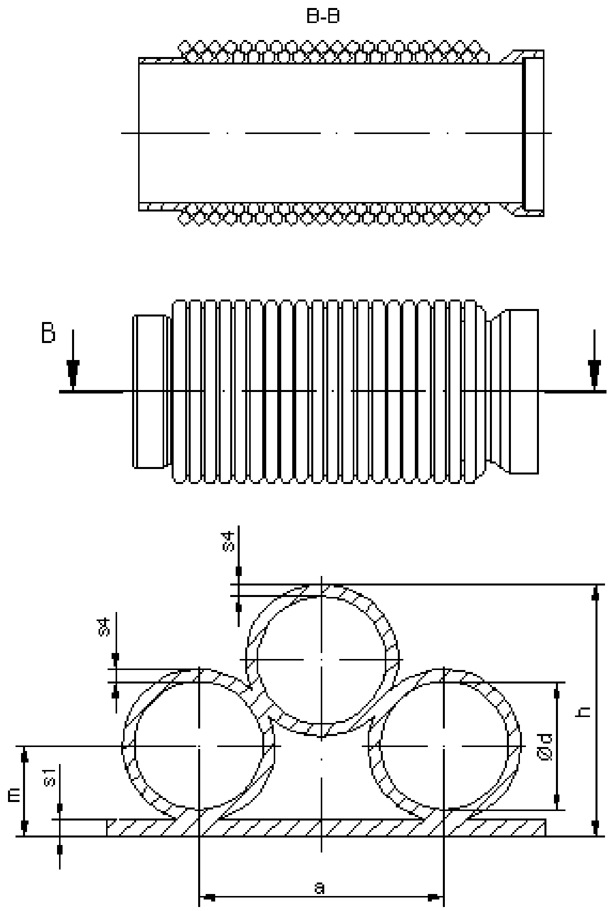


Figure 3.2

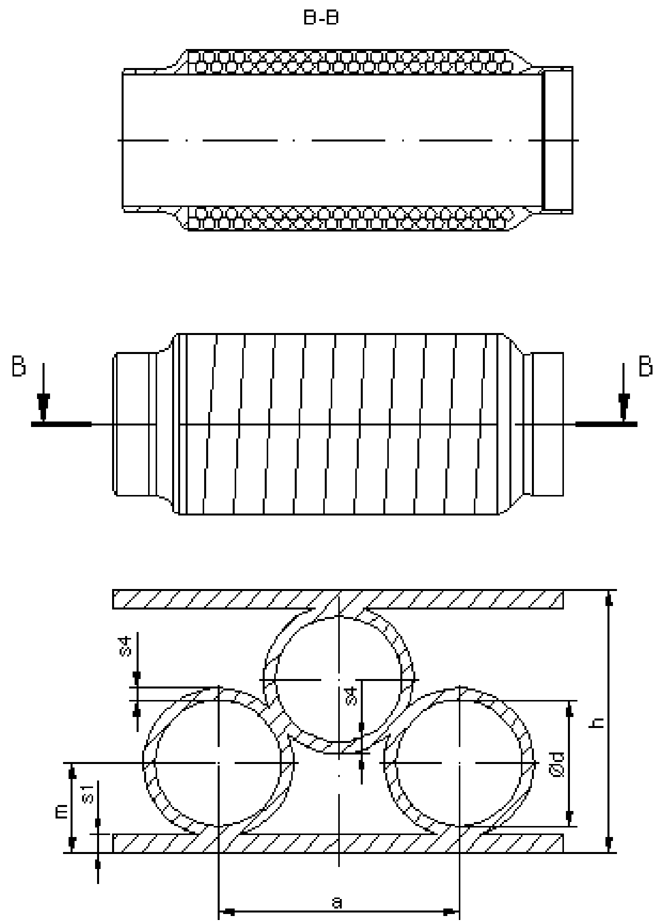


Figure 3.3

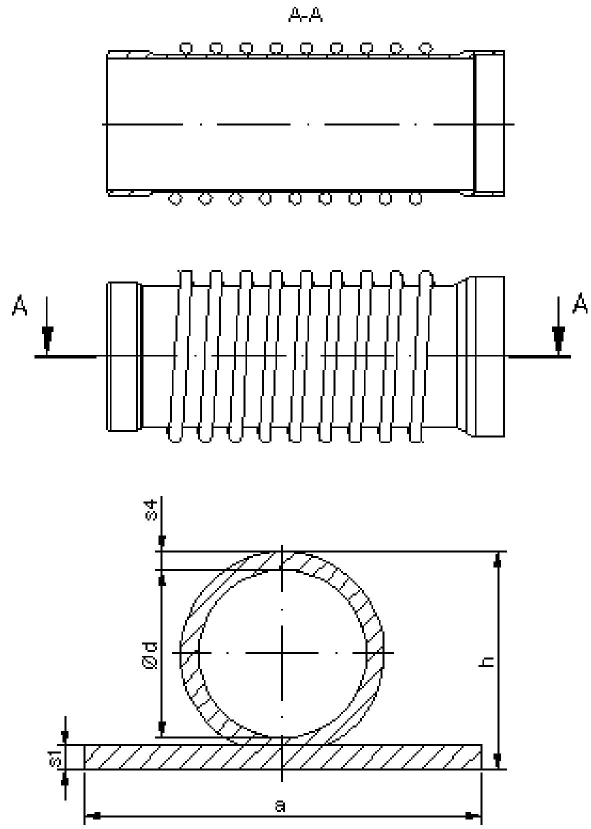


Figure 3.4

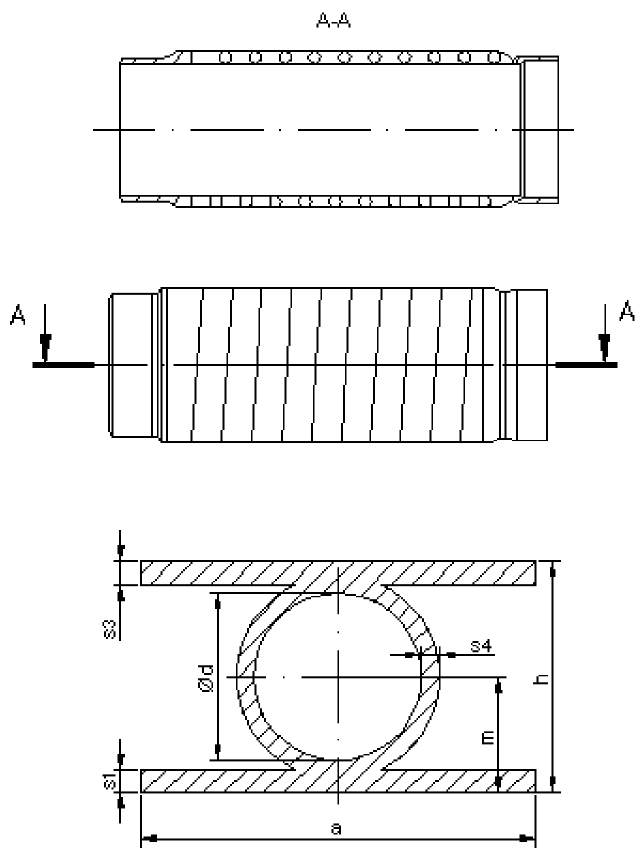


Figure 3.5

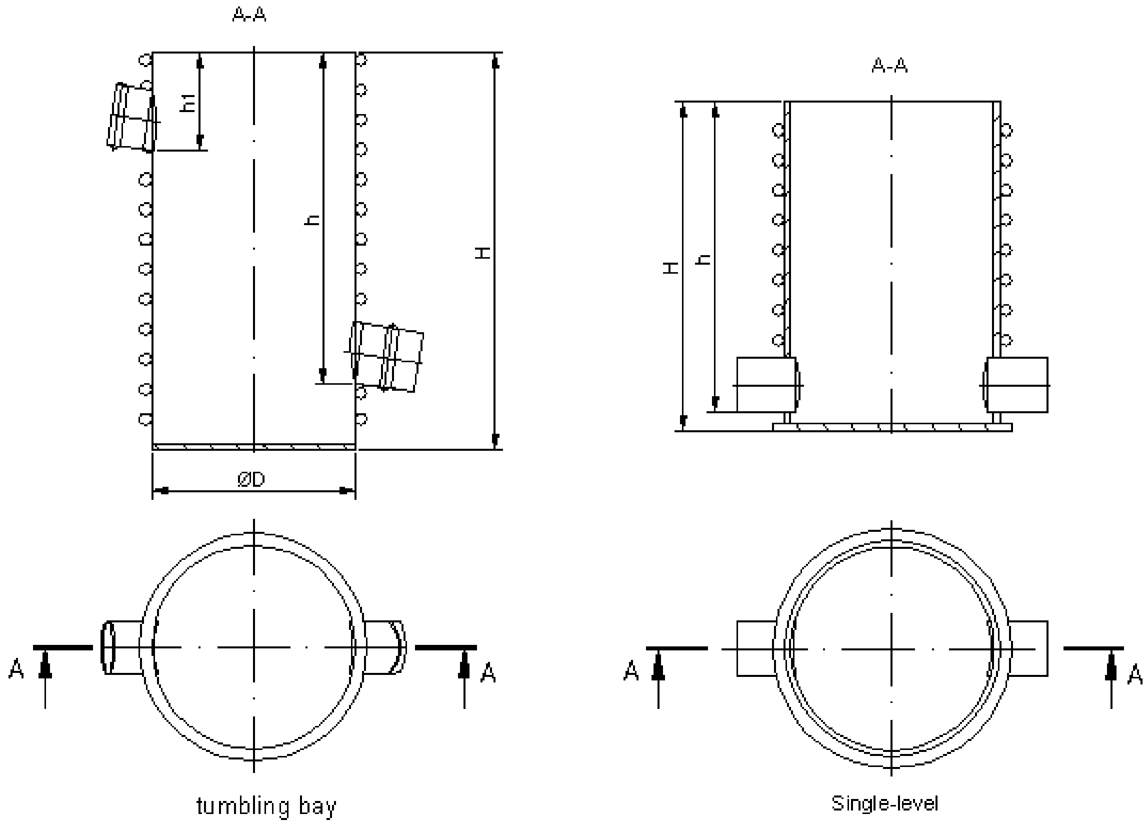
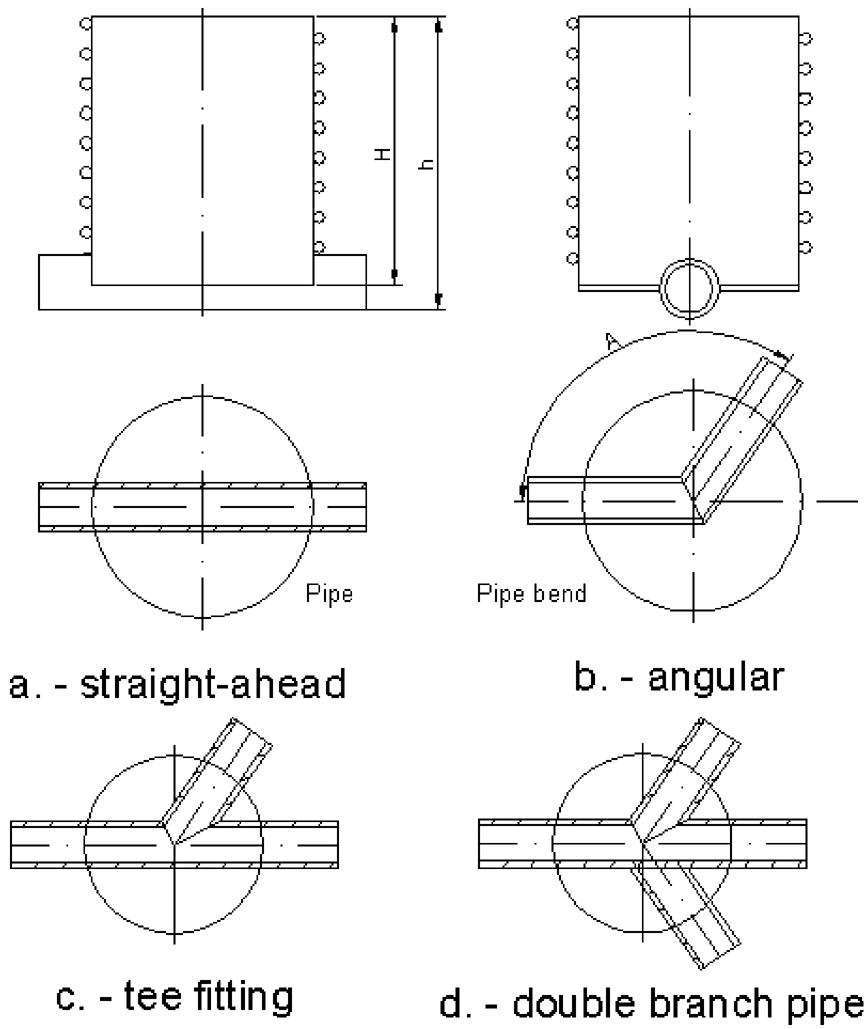


Figure 3.6



H
h
A
Pipe
Pipe bend
a. - straight-ahead
b. - angular
c. - tee fitting
d. - double branch pipe

Figure 3.7

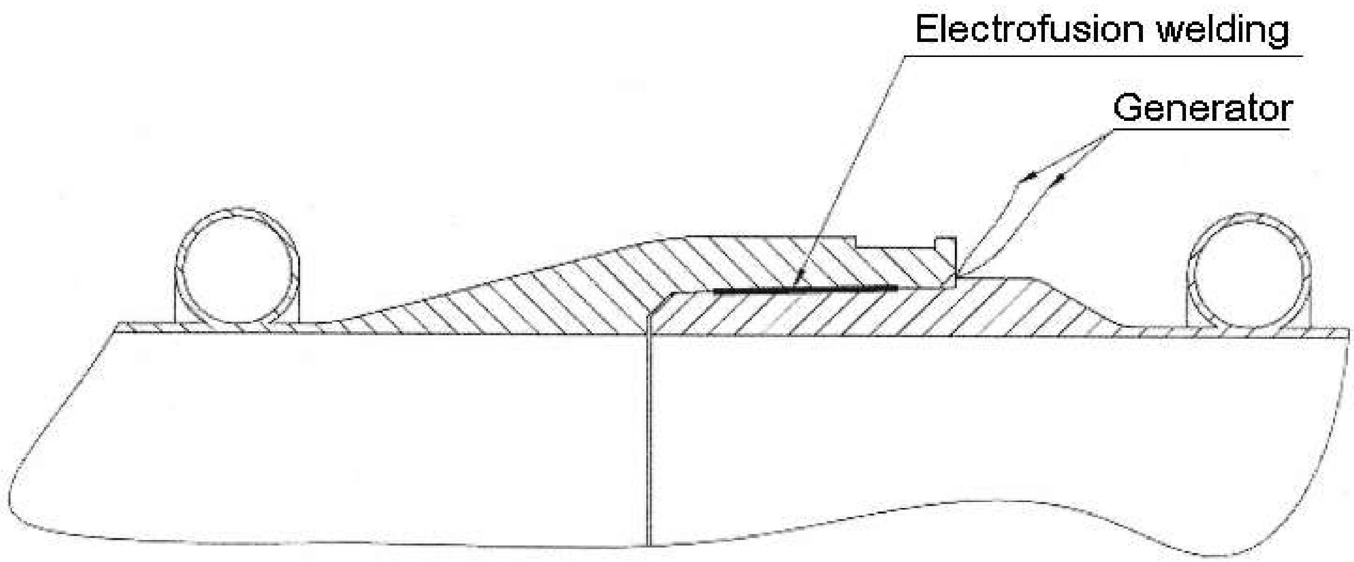


Figure 3.8

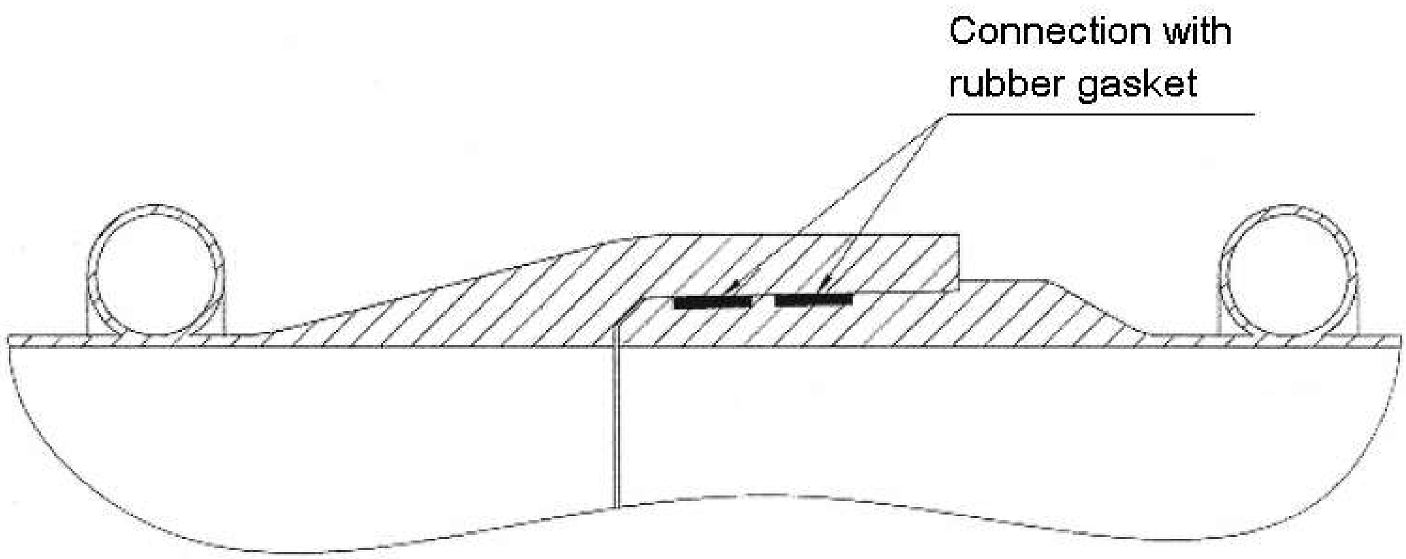


Figure 3.9

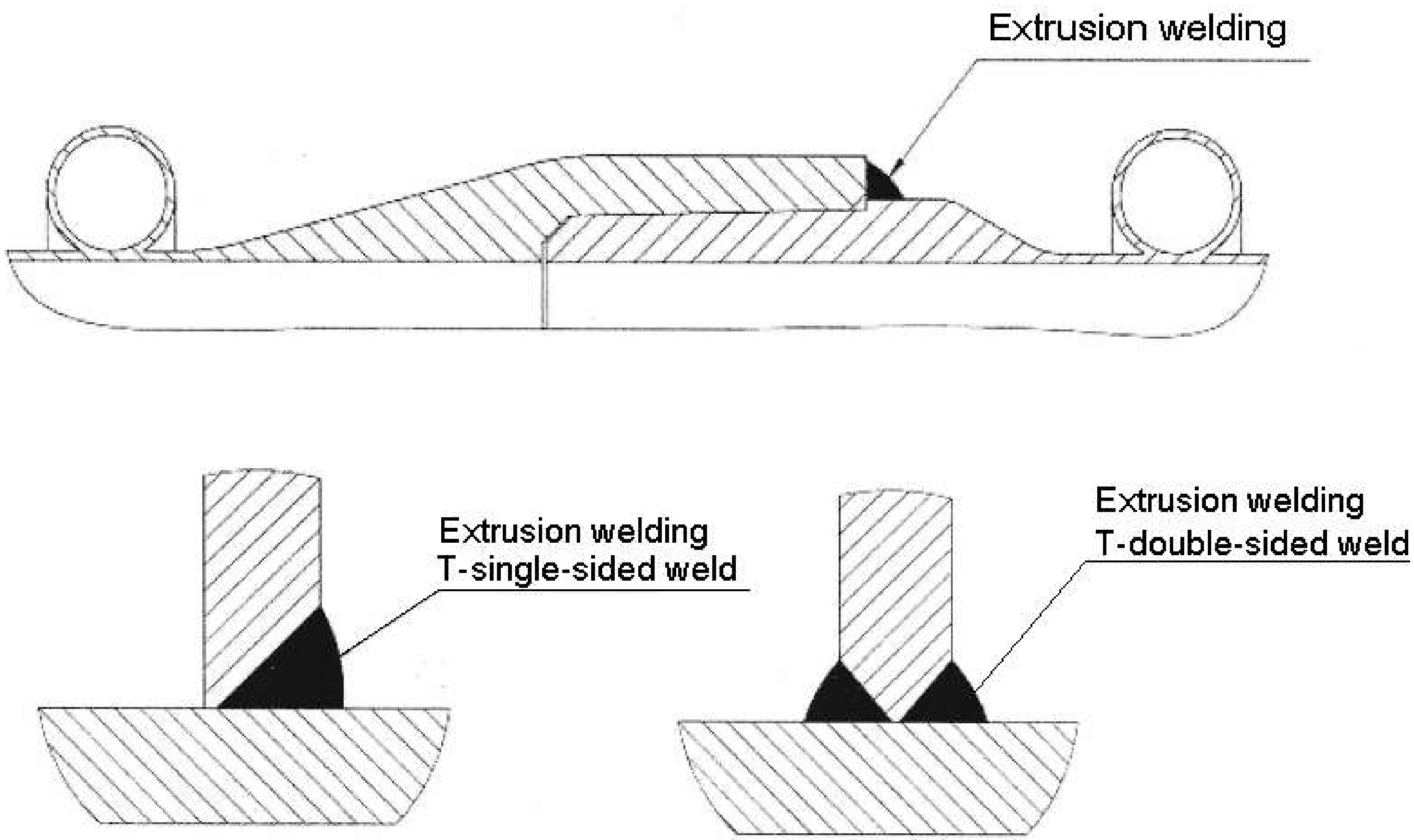

Extrusion welding
Extrusion welding
T-single-sided weld
Extrusion welding
T-double-sided weld

Figure 3.10

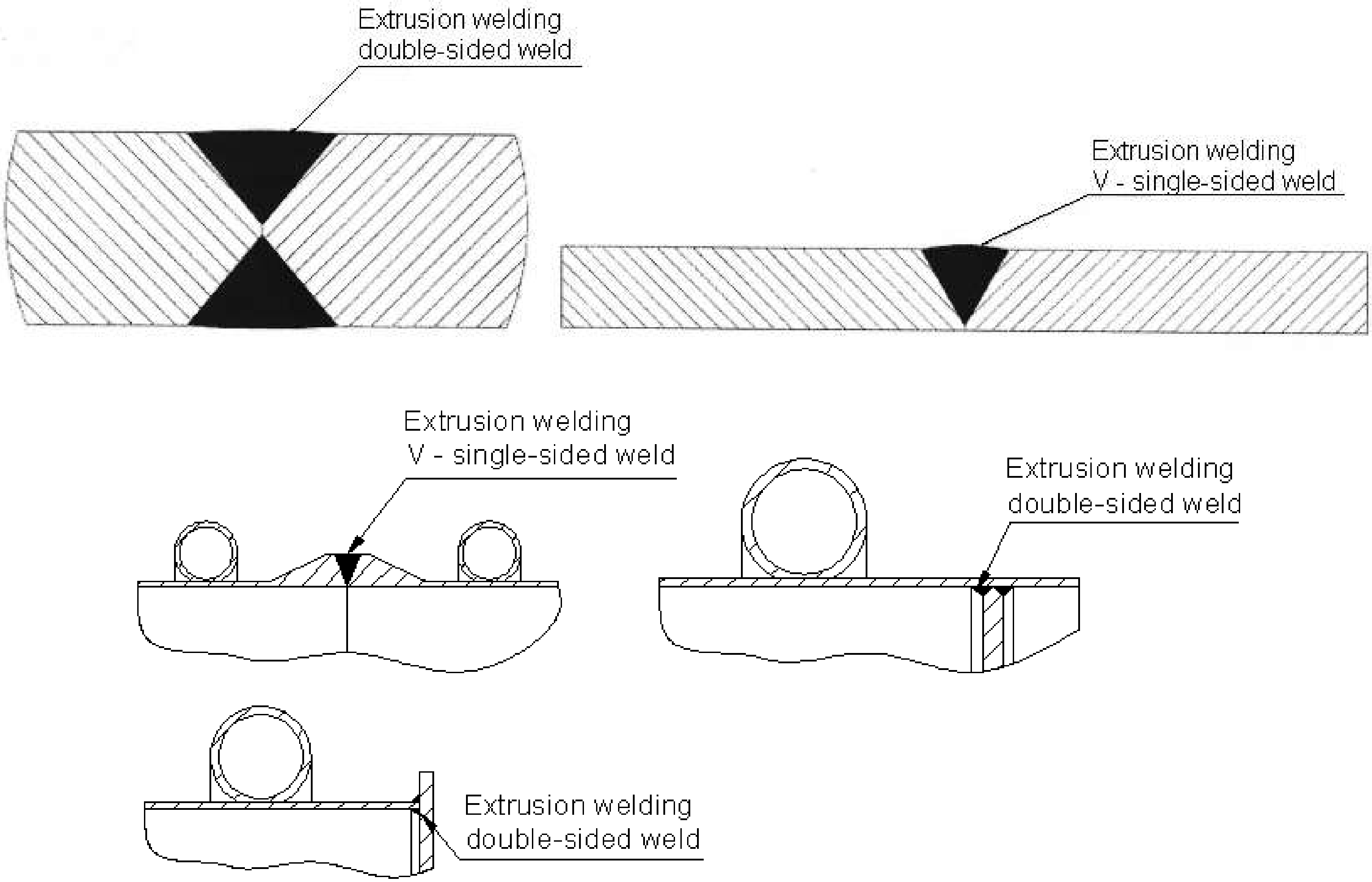

Extrusion welding
double-sided weld
Extrusion welding
V - single-sided weld
Extrusion welding
V - single-sided weld
Extrusion welding
double-sided weld
Extrusion welding
double-sided weld

Figure 3.11

4. Program and method of dynamic load tests of pipe conduit

The test program includes next steps:

1. Analysis of the structural features
2. Choice and coordination of the structural parameters and the elements for the experimental model with Customer
3. Preparation of the vibration stand and measuring equipment for conduction of the dynamic tests
4. Assignment of loading modes of the pipeline system by dynamic forces corresponding to force impact on structures during an earthquake of different intensity (degree of intensity from 7 ÷9 magnitude)
5. Processing and analysis of the results of the experimental researches
6. Technical report preparation by the results of pipeline system tests with recommendations concerning assurance of exploitation reliability during earthquake actions

Testing stand is constructed in the JSC Research Center of Construction, Research Institute of Building Constructions named after V. A. Kucherenko; vibration excitation of this stand carries out by next way:

- Oscillations of the balance-wheel platform- pendulum where the pipeline system is installed initiate with the help of the vibration machine which is installed on the vibration platform. Due to inertial force initiated by the vibration machine various frequency spectrums of impacts on the conduit and the level of oscillation amplitude of the vibration platform are received. As the tests show the maximum quantity of the oscillation amplitude of the vibration platform is 150 mm.

The dynamic tests program of the conduit elements of the trade mark “KRAH PIPES” on the vibration platform includes next steps.

1. The tests of water-filled conduits are conducted with the change of frequency spectrum from 0 to 15 Hertz with the fixed displacement amplitude of the vibration platform. Then the value of amplitude changes and the frequencies are set in the specified spectrum. The duration of all the specified dynamic loading (with the fixed amplitude and frequency) is approximately 30 seconds.
2. By the tests results the levels of impacts are set corresponding to the resonance oscillation of the system and the accelerations levels of the vibration platform correspond to 7÷9 magnitude by the MSK-64 scale.
3. When the tests are performed the repeated tests with combinations of amplitude frequency parameters corresponding to the resonance oscillation of the system and 7÷9 magnitude impacts are conducted in accordance with testing program of measuring of amplitude frequency spectrum of the vibration platform
4. If during the tests there are destructions or pipelines leakage failure then the solutions to increase reliability are elaborated together with Customer and tests are repeated once again.

5. Equipment for dynamic load tests of constructions. Measuring and registrarial equipment for dynamical characteristics

5.1 Equipment for generation of dynamic loads

As previously noted, for creation of dynamic impact on experimental models the special stand is used.

Stand consists of pendulum platform suspended on flexible (from flat-rolled steel) steel connections on base load frame. Frame is rigidly fixed in the reinforced floor of the laboratory building. Activation of the platform is performed by vibration machine which is installed on the cantilever of the pendulum platform (fig. 5.1).

Vibration machine provides required parameters of dynamic impacts on the samples in wide range of frequencies and inertial loads by excitation of mechanical oscillations of the vibration platform in horizontal plane.

The vibration platform operation is carried out from the desk switchboard which is placed in the electrical cabinet. The main technical characteristics of the pendulum vibration platform are presented in the table 5.1

The main technical data of vibration machine Table 5.1

#	Parameter	Value
1	Inertial force created by machine with minimum radius of vibrator eccentric mass - 60 rotations per minute (1 Hz) - 180 rotations per minute (3 Hz) - 240 rotations per minute (4 Hz) - 300 rotations per minute (5 Hz)	 0.8 tons 7.0 tons 12.5 tons 20.0 tons
2	Frequency characteristic - Lower frequency, Hz - Upper frequency, Hz	 0.4 25
3	Frequency trend	without stages

Note: for reasons of strength of machine parts and on the basis of vibration machine weight, inertial force is restricted by quantity 12 tons at any rotational speed.

5.2 Equipment for measurement and registration of dynamical characteristics of constructions and impact on them

Measurement and registration of the signals are carried out with the help of the special measuring and computing complex MIC-036 designed for gathering, converting, registration, computing and transfer of information from sensors.

Measuring and computing complex MIC-036 performs the next functions:

- Measurement , registration and primary machining of signals (frequency and discrete signals, etc.) , received from the tests
- Display of values of the measuring quantities or transforming parameters
- Control of values of the measuring quantities or transforming parameters; assessment of the results of measurement and transformation
- Self-diagnostic of conducted measurement (analysis of workability with the opportunity of the fetching of diagnostic programs)
- Archiving of the results of measurement and transformation (storage the data with the opportunity of browsing and analysis)
- Output of current values of the measuring parameters , alarm codes and technical messages on the electronic computing machine of upper level;
- The opportunity for the connection with printing devices for creation of data sheets of the measurements
- The opportunity for the connection with another systems (connection in the existing local computing network)
- The opportunity for outputting signal of “dry contact” type for turning on the alarm and using in protection systems.
- The opportunity for test analog signal outputting

The measuring and computing complex MIC-036 additionally equipped by a laptop with a special program pack of application programs and peripheral devices which are necessary for automated process of signal processing and also for documentation of processing results. (fig. 5.2, a).

One-component sensors -accelerometers AT 1105-10m (fig. 5.2 b) are applied for measurement of accelerations, oscillation frequencies and also dynamical displacements.

Characteristics of accelerometers are presented in table 5.2

The main technical characteristics of accelerometer AT 1105-10m

Table 5.2

#	Parameter	Value
1	Power from direct-current power supply relatively middle point, B	±12±12
2	Diapason of measuring, m/s^2 (g)	98.1 (10.0)
3	Frequency characteristic - Lower frequency, Hz - Upper frequency, Hz	 0 700
4	Diapason of working temperatures	From +15 to +35

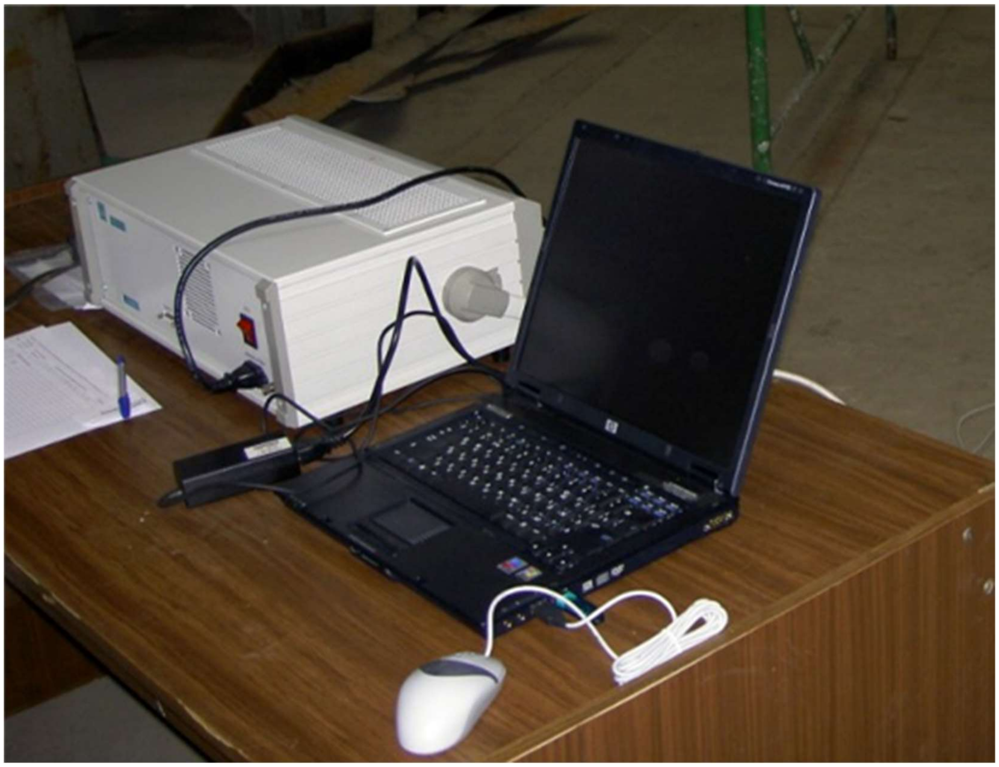
The points of accelerometer's location are chosen from the next conditions:

- Places where by calculation results maximum accelerations and displacements are expected
- One sensor is installed on the vibration platform for the control of specified dynamic loads.

The total number of controlled points (the number of accelerometers) is four.

The scheme of sensors location is presented in the fig. 5.3

Figure 5.1



a)

b)

Figure 5.2

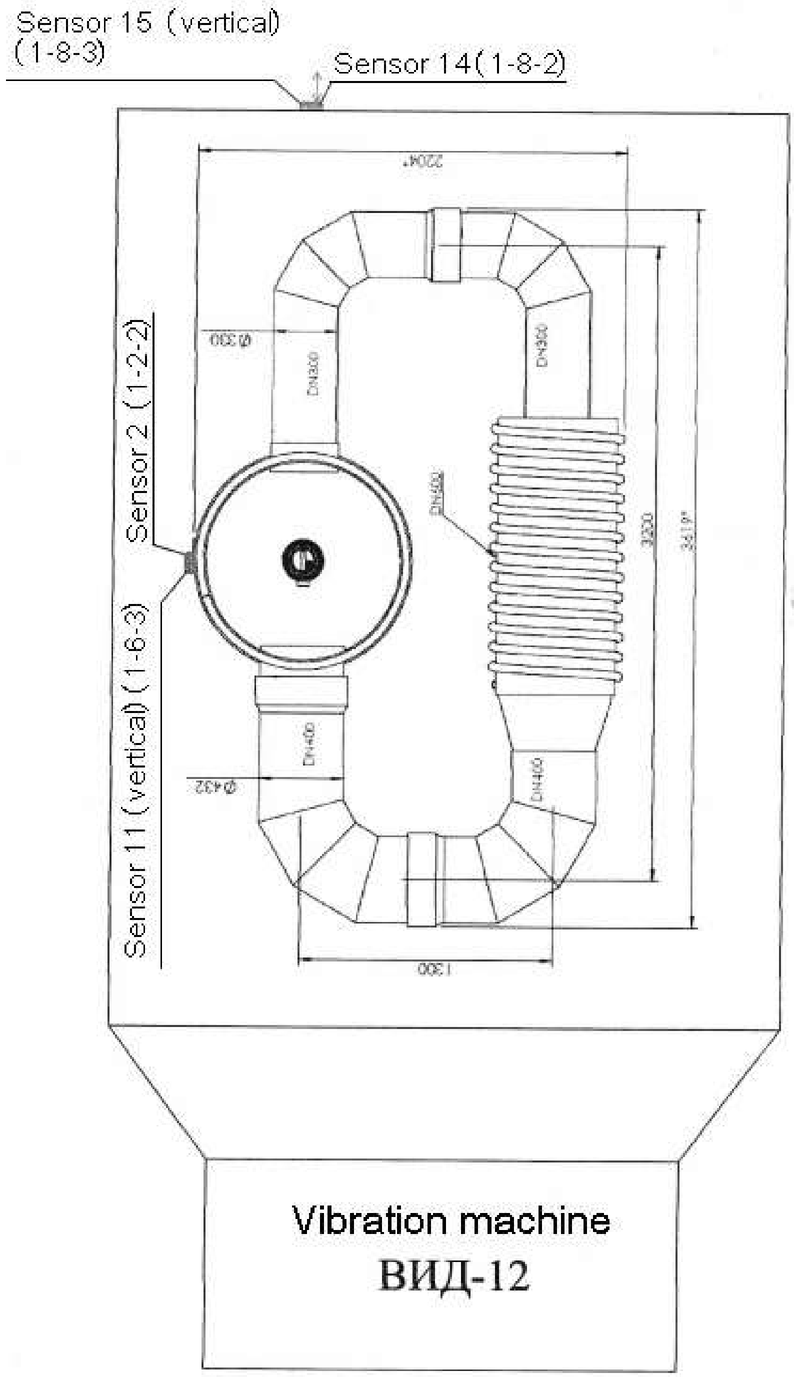

Sensor 15 (vertical)
(1-8-3)
Sensor 14(1-8-2)
Sensor 2 (1-2-2)
Sensor 11 (vertical) (1-6-3)
2204*
Ø330
DN300
DN300
DN400
DN400
DN400
Ø432
3200
3419*
1300
Vibration machine
ВИД-12

Figure 5.3

6 The results of the dynamic tests of pipe conduit

6.1 Method of tests conduction

Full scale tests of conduit system are performed using vibrational (resonance) method which helps to measure quantitatively the power load which imitates earthquake action in the wide frequency diapason.

Amplitude frequency response for the tested fragment is determined using vibration tests data. Amplitude frequency response is an oscillatory amplitude function of frequency of harmonic action. As previously noted, accelerometers are installed on the next elements of the experimental model:

- On the vibration platform; it allows to assess the level of dynamic impact on the model and compare it with the normative values of accelerations.
- Direct on one of the fragments of tested system

By results of measurement of frequency and oscillation amplitude of the vibration platform, dynamic characteristics of the system (frequencies of main tone of oscillations, dissipative properties, etc.) and job characteristic of experimental model are estimated.

The supporting of experimental model elements on the platform carries out by the special packing plate (fig.6.1). This supporting has more stick conditions of the exploitation of conduit subjected to earthquake action to compare with pipeline on a ground bed of earth foundation.

6.2 Assignment of loading parameters

The duration of earthquake action

According to the data of [4,5] the duration of the main part of the oscillation process is 10÷40 seconds (the earthquake in San-Francisco in 18.04.1906 highly oscillatory mode was 25 seconds, Mexico in 28.07.1957 – 15 seconds).

Oscillation periods

By the works of B. K. Karapetyana [6] maximum accelerations of the ground during the earthquakes correspond to periods 0.05 and 0.1 seconds (f=20 and 10 Hz). By the works of I. L. Korchinskiy [5]:

- In rigid systems (T=0÷0.05) maximum accelerations appear almost instantly with the beginning of the oscillations (zone of maximum value of dynamic coefficient);
- Most characteristic periods of earthquake action are in diapason of short period spectrum from 0.1 to 0.5 seconds (frequency from 10 to 2 Hz);
- As noticed in [4], a lot of experimental researches show, that structure oscillates with the frequency of oscillations which corresponds to natural vibration frequency, regardless external effects. Periods of natural oscillation for most of the buildings are 0.1-2.0 seconds. So the frequency of dynamic load in structure during the earthquake will be mainly in interval 0.5-10 Hz.

The number of load cycle

Under the leadership of I. L. Korchinskiy [5], R. S. Berdyaeva, G. V. Becheneva and V. A. Pzhevskiy the tests of reinforced concrete and steel beam samples under the loading with velocity 30÷1000 cycles per minute were performed; this as specified in [4] corresponds to loading velocity of building structures subjected to seismic loads.

On the basis of specified studies analysis the parameters of dynamic loading of the system are:

- The oscillation frequency of the platform is changed in the interval from 1.9 to 7.6 Hz;
- The number of loading cycles is from 200 to 400 per minute;
- The duration of dynamic (seismic) action on the system is changed from 20 to 50 seconds.

Stages of loading are presented in the table 6.1 and are chosen in such a way as to have the opportunity for estimating the pipeline behavior during the resonance.

Specified in the table amplitude frequency characteristics and corresponding to them quantities of accelerations correspond to values which are received using the data of accelerometers installed on the vibration platform.

The values in the table 6.1 according to their color grade correspond to seismic zones specified in the seismic zoning plan of Russian Federation (fig. 6.2)

Parameters of dynamic loading of the platform

Table 7.1

# of mode	Frequency,*f*,(Hz)	Amplitude, ***A****(mm)*	Acceleration, ***a***(m/s^2)	magnitude
1	4.2	4.1	2.86	8.5
2	4.7	4.3	3.76	8.9
3	1.9	9.6	1.36	7.4
4	3.1	8.4	3.17	8.7
5	3.7	9.1	4.92	9.3
6	1.9	12.4	1.76	7.8
7	2.8	11.3	3.49	8.8
8	3.4	11.2	5.09	9.3
9	1.3	16.4	1.09	7.1
10	2.1	16.4	2.85	8.5
11	2.6	15.5	4.13	9.0
12	1.2	23.1	1.31	7.4
13	1.9	20.9	2.98	8.6
14	2.5	20.8	5.12	9.4
15	1.0	33.2	1.31	7.4
16	1.6	27.3	2.76	8.5
17	1.9	27.5	3.91	9.0
18	2.3	24.1	5.02	9.3
19	5.9	0.8	1.04	7.1
20	6.7	0.8	1.42	7.5
21	7.5	0.7	1.57	7.7
22	8.1	1.0	2.60	8.4
23	9.1	1.1	3.59	8.8
24	9.5	1.0	3.61	8.9
25	10.4	0.9	4.04	9.0
26	11.4	1.1	5.69	9.5
27	1.8	25.9	3.16	8.7
28	2.1	25.8	4.48	9.2
29	2.3	27.6	5.75	9.5
30	2.6	27.0	7.20	9.8
31	2.9	25.2	8.36	10.1

6.3 Conditions of dynamic tests conduction

The vibration tests were conducted in the day time at air temperature lower than +15˚C. Conditions of vibration tests conduction correspond to normal and working conditions of accelerometer AT1105-10m application.

Analysis of full scale dynamic tests results of conduit of trade mark "KRAH PIPES" made from polyethylene allows to point next:

- During the tests the vibration platform acceleration, by the data of accelerometers which were installed on the platform, was changed in interval from 1.04 to 8.36 m/s^2. Oscillation frequencies of the system were changed in interval from 1.0 to 11.4 Hz, the oscillation amplitudes were changed in interval from 0.7 to 33.2 mm.
- **During the tests when the values of natural oscillations frequencies of conduit coincided with the oscillation frequencies of the vibration platform, the resonance occurred. This phenomenon was observed when the system oscillated with the frequency *f* = 10.4 Hz. At the resonance the maintenance reliability was not broken.**

a)

b)

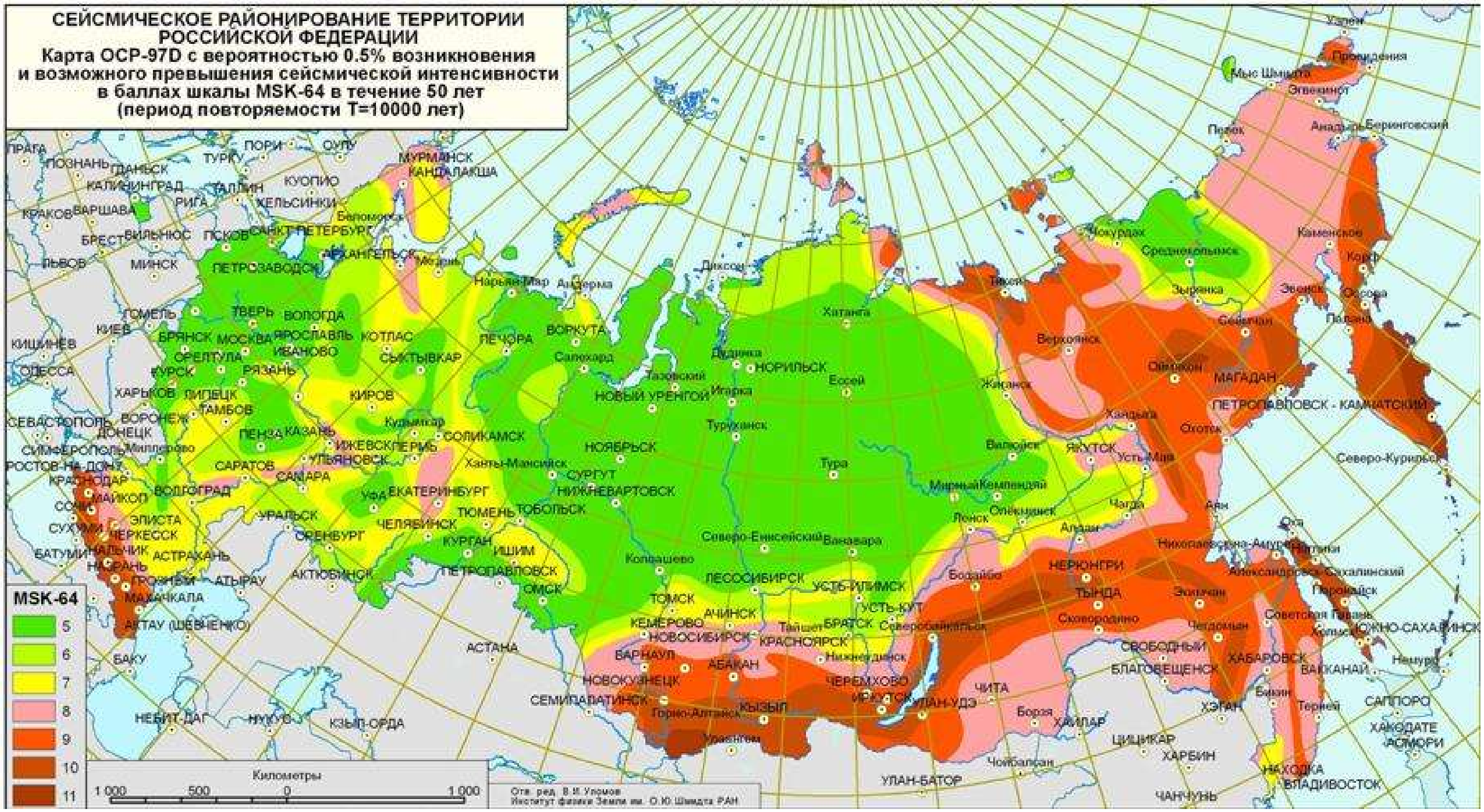


Figure 6.2 Seismic regionalization of Russian Federation

7. Conclusions and recommendations

On the basis of dynamic tests results analysis of conduit elements of trade mark ‘’KRAH PIPES” it may be noted that:

1. In accordance with the program of experimental researches on the vibration platform of Research Institute of Building Constructions the dynamic tests of polyethylene elements of conduit made by ТУ 2248-001-30233670-2011 and ТУ 4859-002-30233670-2011. During the tests dynamic loads corresponding to 7÷9 magnitudes were simulated. The fragment of pipeline during the tests was filled of water.
2. During the tests the vibration platform acceleration, by the data of accelerometers which were installed on the platform, was changed in interval from 1.04 to 8.36 m/s^2 what exceed the value of acceleration corresponding to earthquake action 9 magnitudes. (4 m/s^2)
3. **During the tests when the values of natural oscillations frequencies of conduit coincided with the oscillation frequencies of the vibration platform, the resonance occurred. This phenomenon was observed when the system oscillated with the frequency *f* = 10.4 Hz. At the resonance the maintenance reliability was not broken.**
4. **Polyethylene elements of pipe line system of trade mark ‘’KRAH PIPES” incudes the pipe with the next types of connection: electrofusion, connection with the help of the rubber gasket, connection with the help of the hand extruder, and also pipe fittings, reservoirs, wells, and pump stations which are recommended for application in Russian Federation in regions with seismic intensity of 7÷9 magnitudes.**

List of references

1. СП 14.13330.2011 (СНиП II-7-81* "Building in seismic dangerous regions. Revised edition").
2. ТУ 2248-001-30233670-2011 "Polymeric pipes "KRAH" and connection parts for them". 2009 year
3. ТУ 4859-002-30233670-2011 "Welded polyethylene wells "KRAH" for free-flow pipelines". 2011 year
4. Polyakov S. V. "Earthquake-resistant building structures". Publishing house "High school; 1969 year, 335 pages.
5. Korchinskiy I. L. and others "Earthquake-resistant construction of houses". Publishing house "High school"; 1971 year, 319 pages.
6. Karapetyan B. K. "Oscillation of structures erected in Armenia", publishing house "Ayostan", Erevan, 1967 year.

Appendix 1.

THE RESULTS OF THE DYNAMIC TESTS

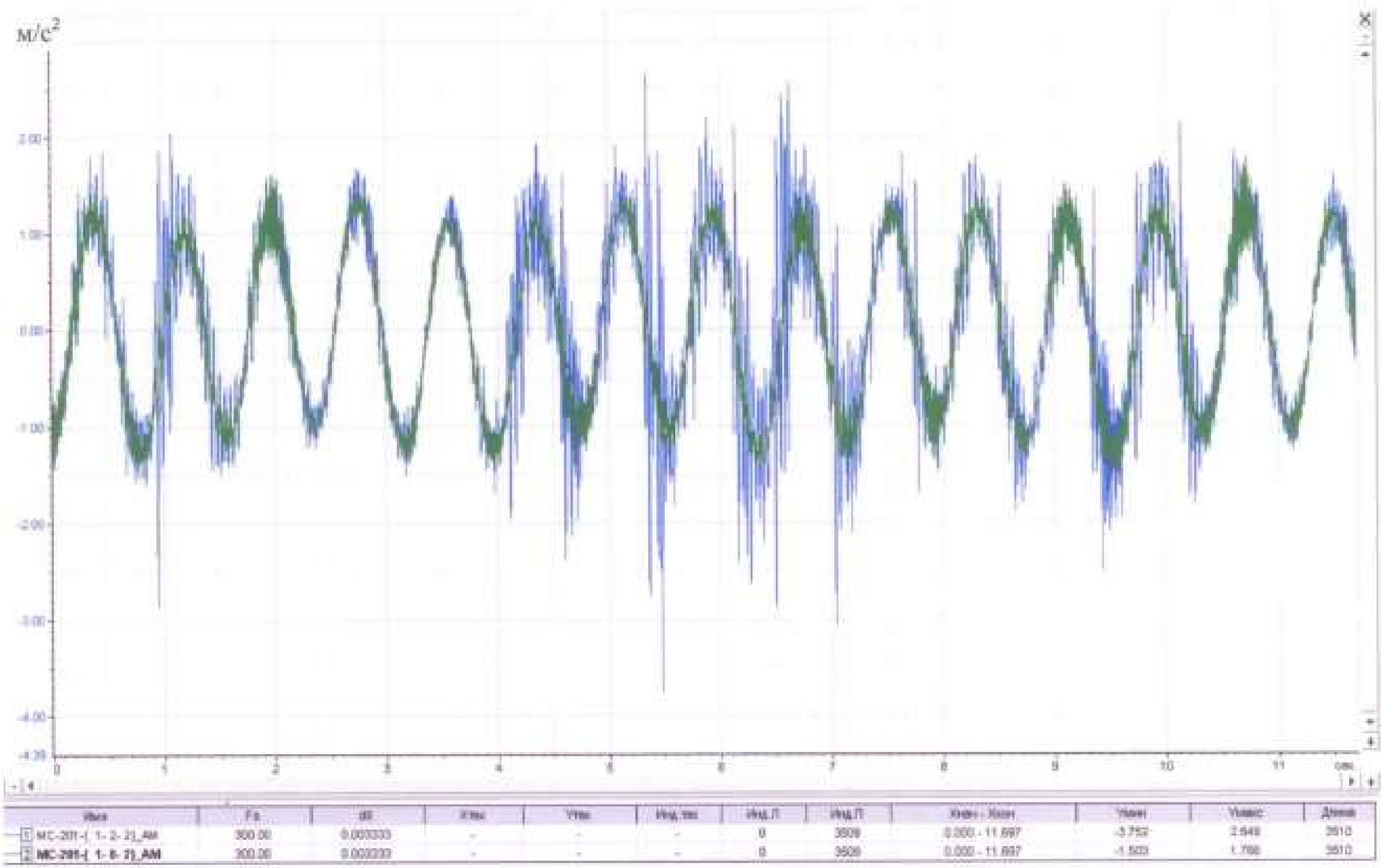


Figure 1-1 Accelerograms (m/s^2) recorded from sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #9 (frequency f = 1.3 Hz; amplitude A = 16.4 mm)

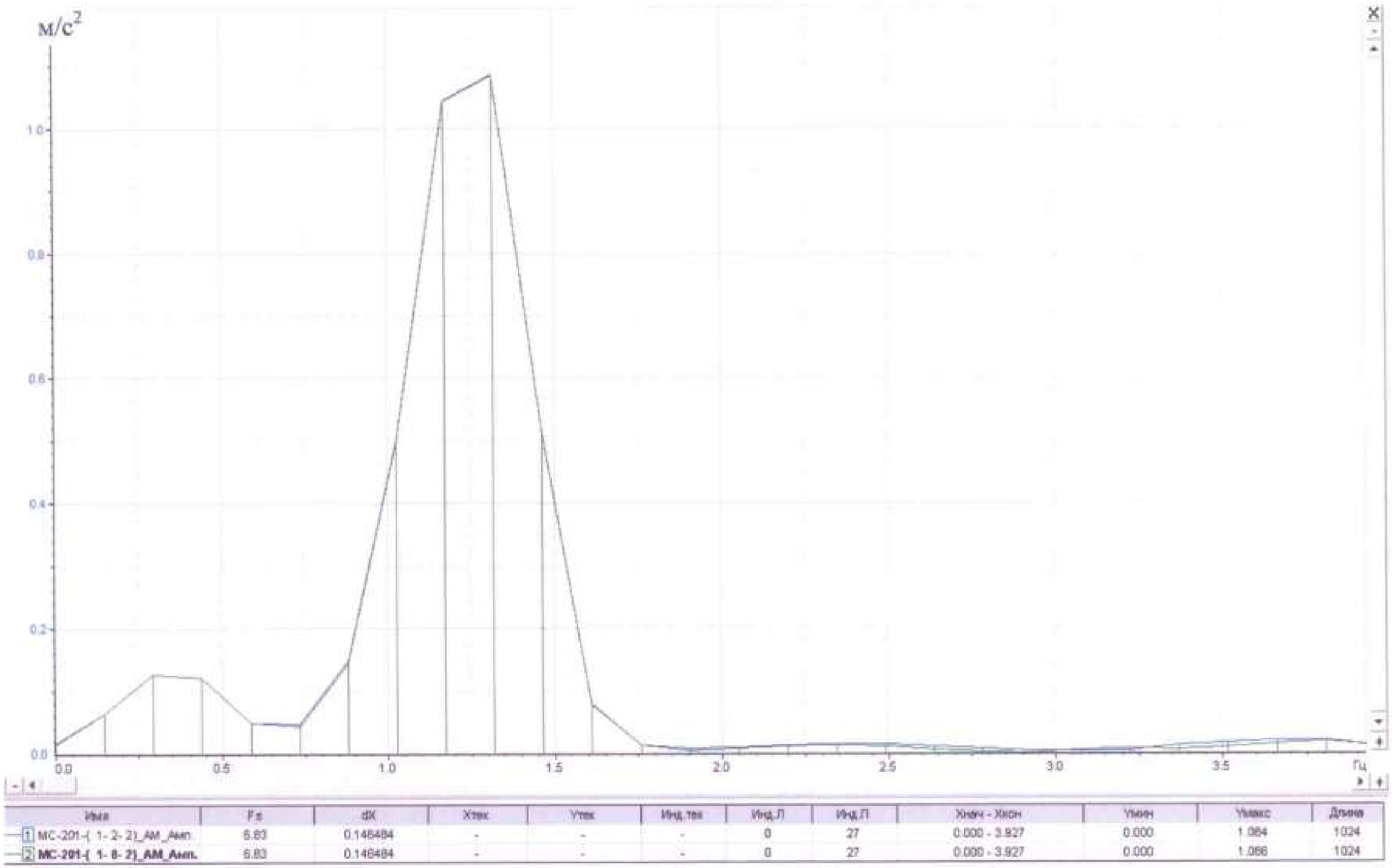


Figure 1-2 Spectrums of the maximum value of accelerations (m/s^2) for sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #9 (frequency f = 1.3 Hz; amplitude A = 16.4 mm)

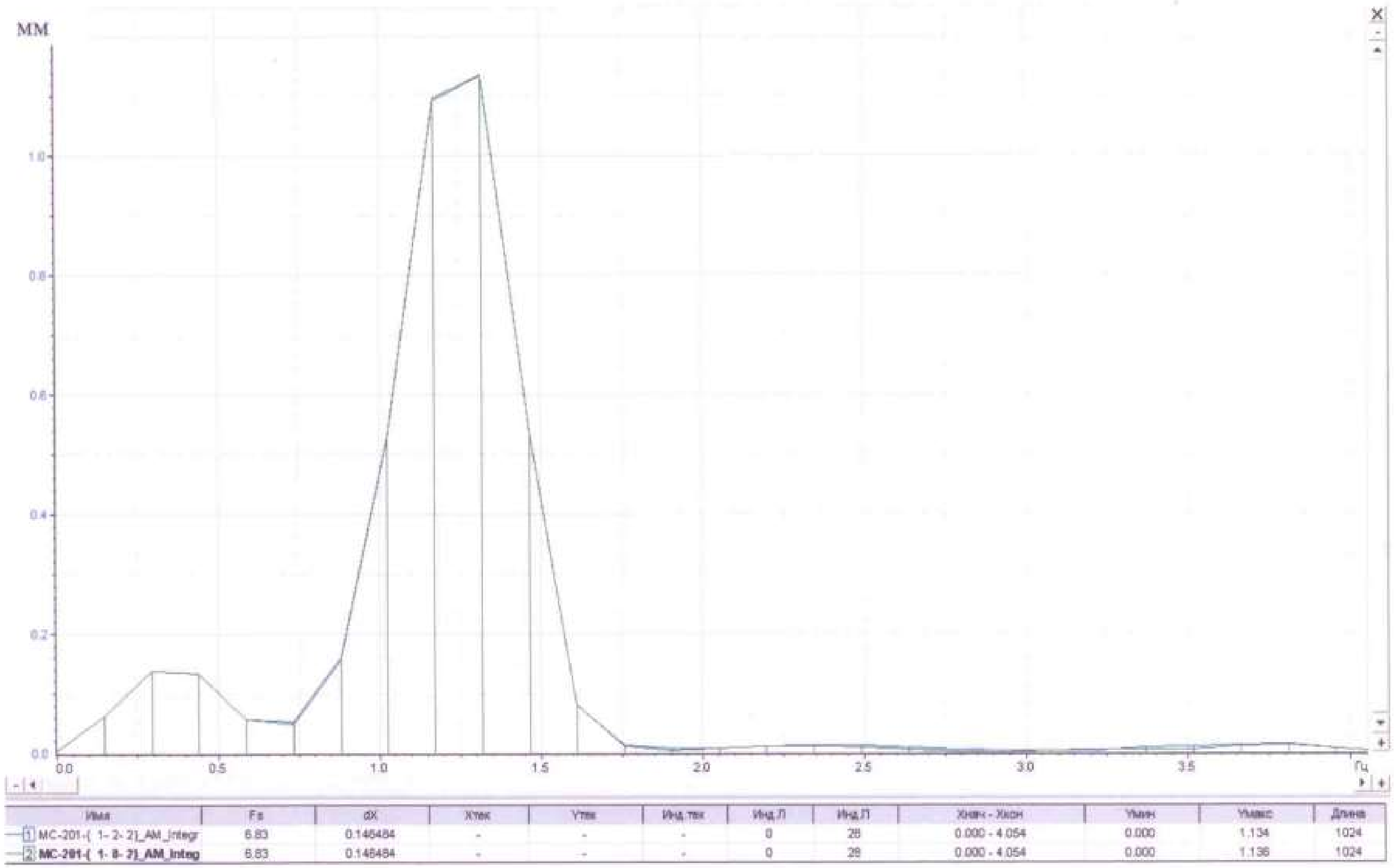


Figure 1-3 Spectrums of the maximum value of amplitudes (mm) for sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #9 (frequency f = 1.3 Hz; amplitude A = 16.4 mm)

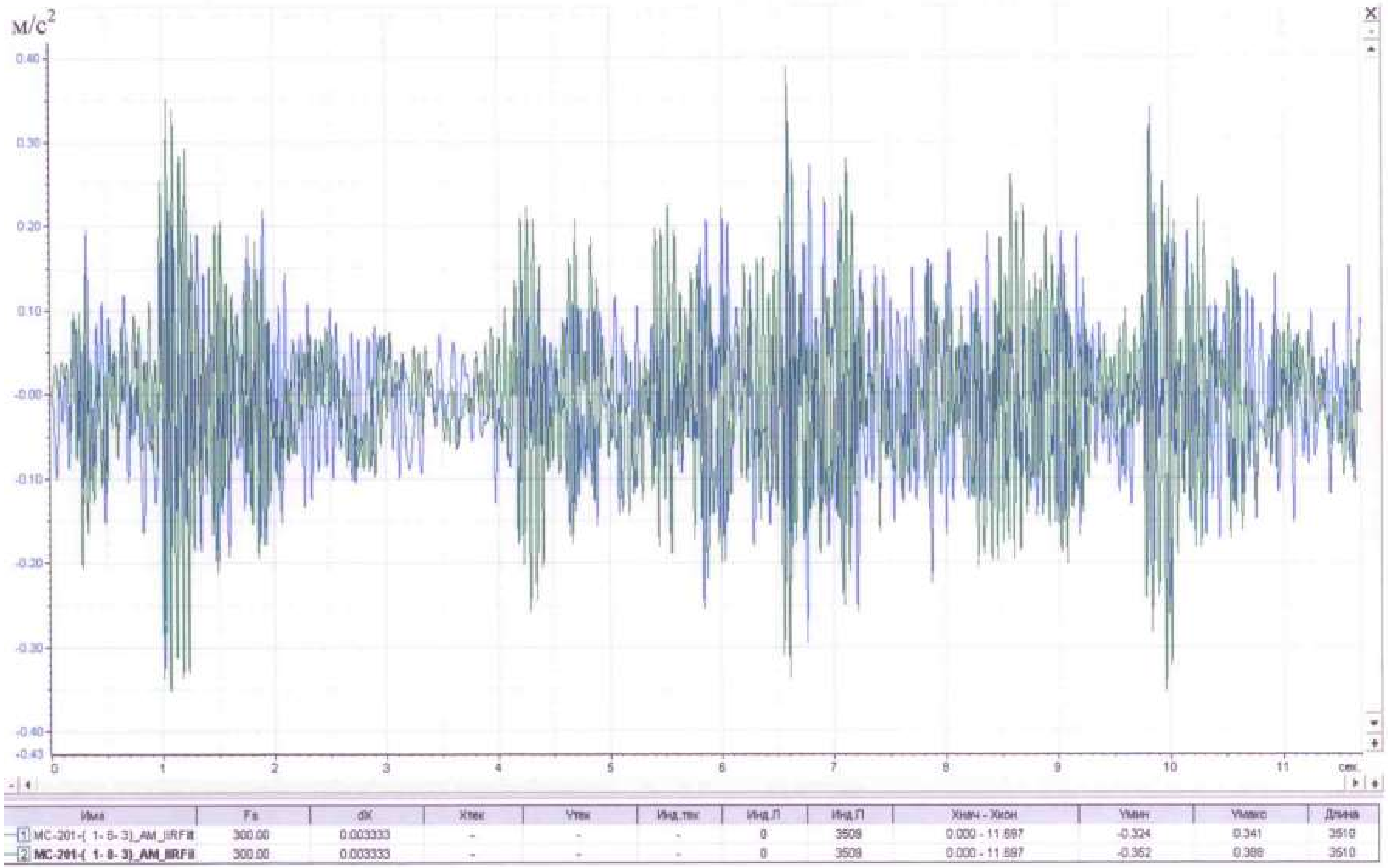
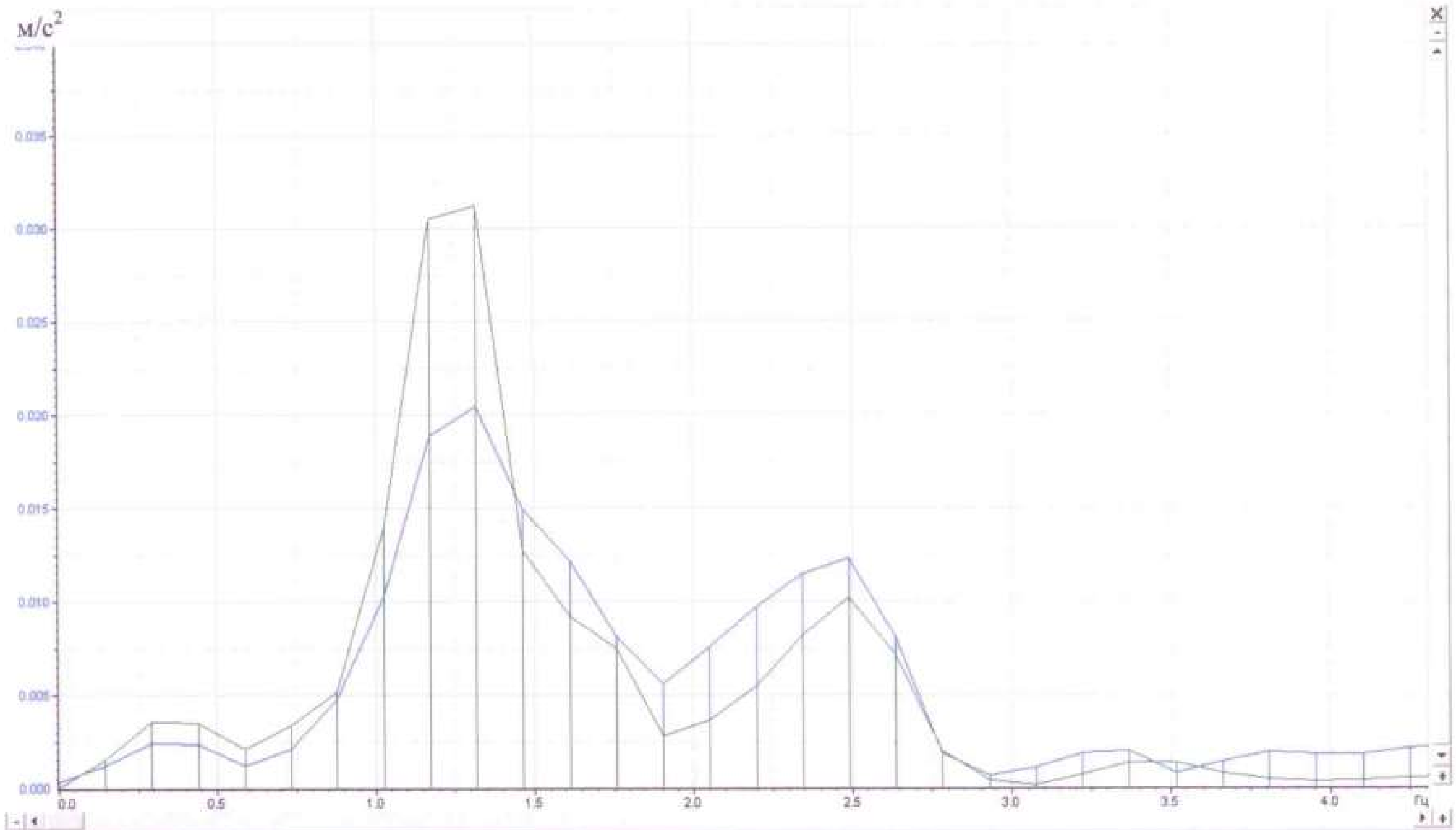


Figure 1-4 Accelerograms (m/s^2) recorded from sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #9 (frequency f = 1.3 Hz; amplitude A = 16.4 mm)



Имя	Fs	dX	Xтек	Yтек	Инд.тек	Инд.Л	Инд.П	Xнач - Xкон	Yмин	Yмакс	Длина
1 MC-201-(1- 6- 3)_AM_IIRFil	6.83	0.146484	-	-	-	0	29	0.000 - 4.307	0.000	0.036	1024
2 MC-201-(1- 8- 3)_AM_IIRFil	6.83	0.146484	-	-	-	0	29	0.000 - 4.307	0.000	0.032	1024

Figure 1-5 Spectrums of the maximum value of accelerations (m/s^2) for sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #9 (frequency *f* = 1.3 Hz; amplitude *A* = 16.4 mm)

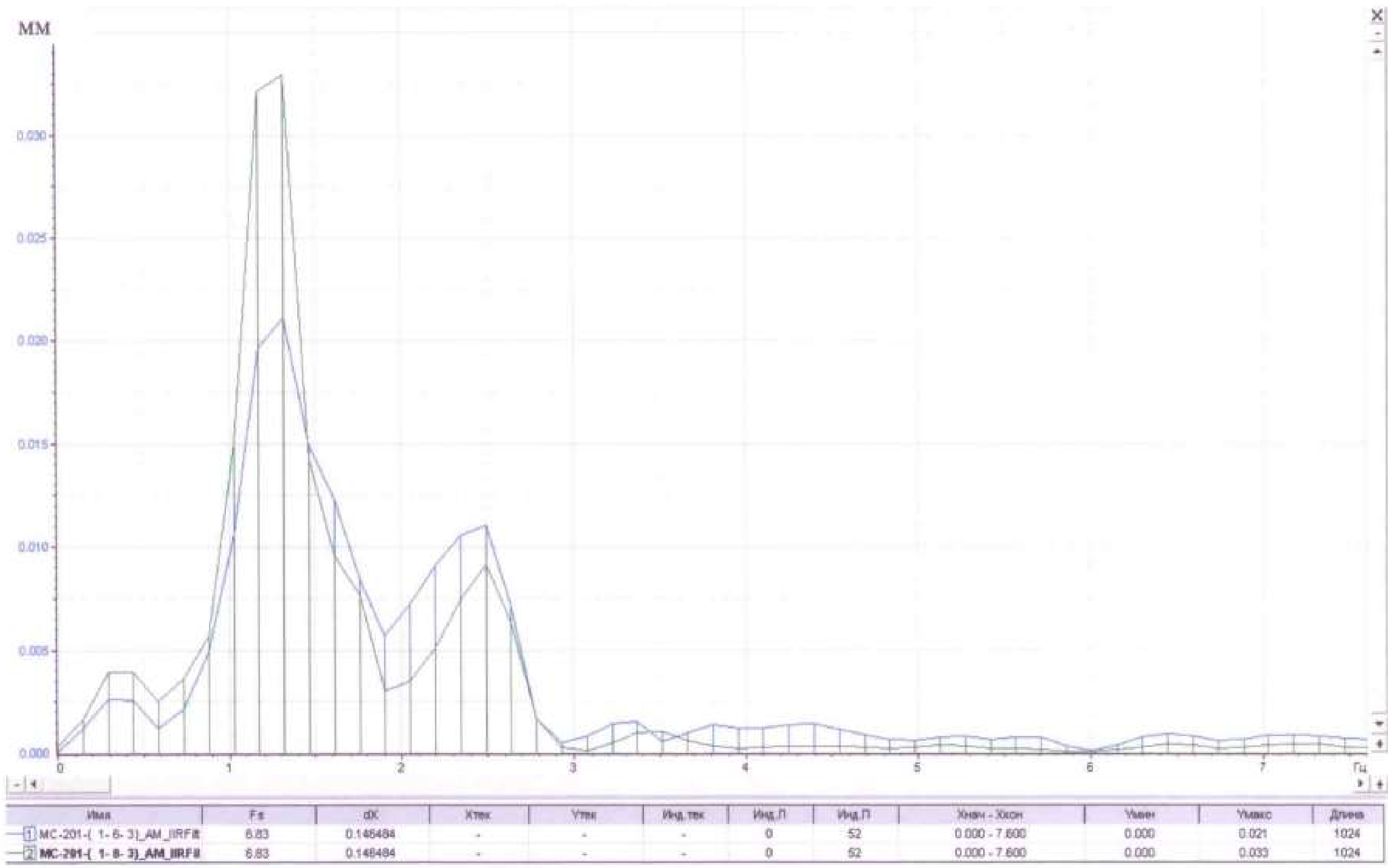


Figure 1-6 Spectrums of the maximum value of amplitudes (mm) for sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #9 (frequency f = 1.3 Hz; amplitude A = 16.4 mm)

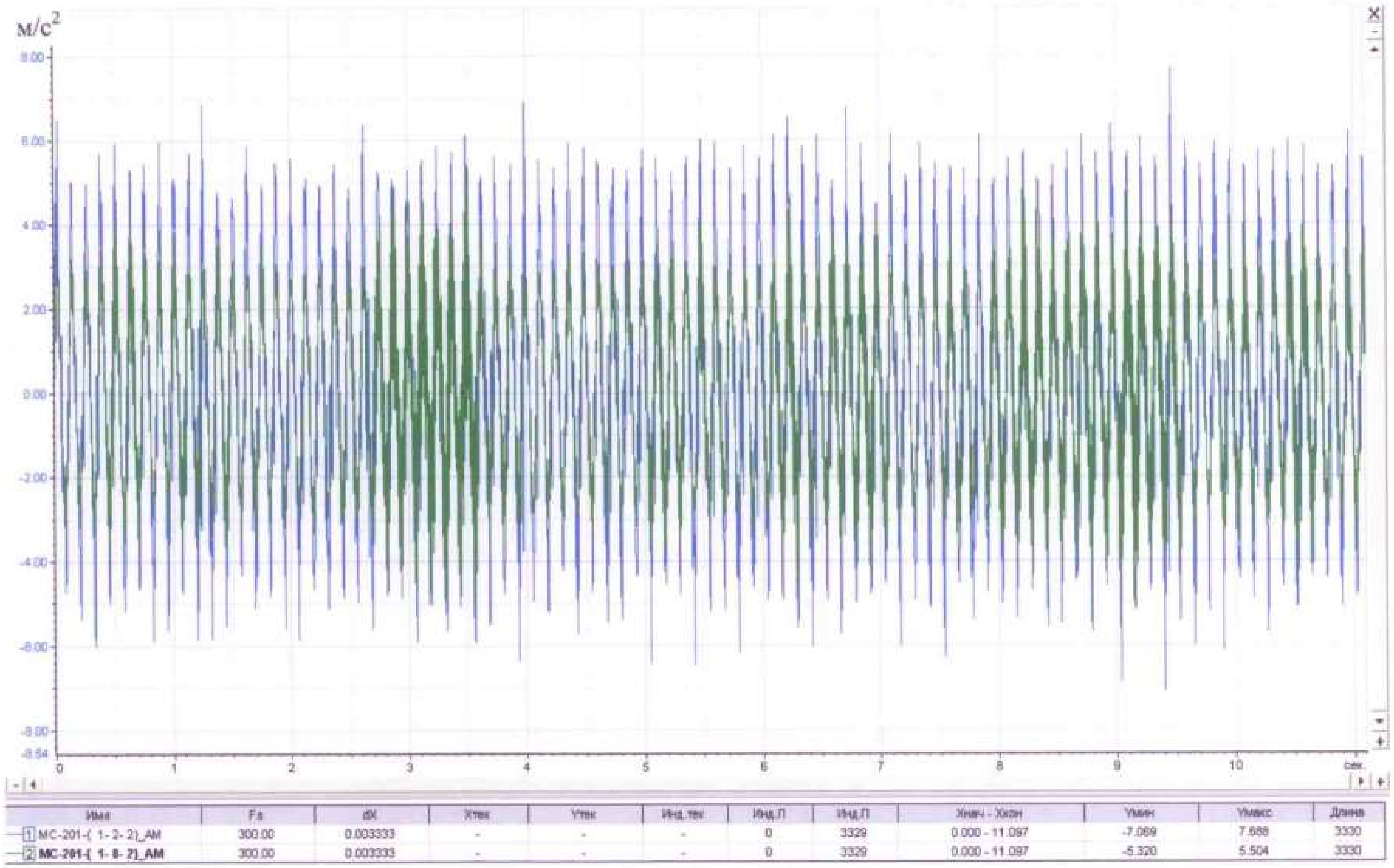


Figure 1-7 Accelerograms (m/s^2) recorded from sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #22 (frequency f = 8.1 Hz; amplitude A = 1.0 mm)

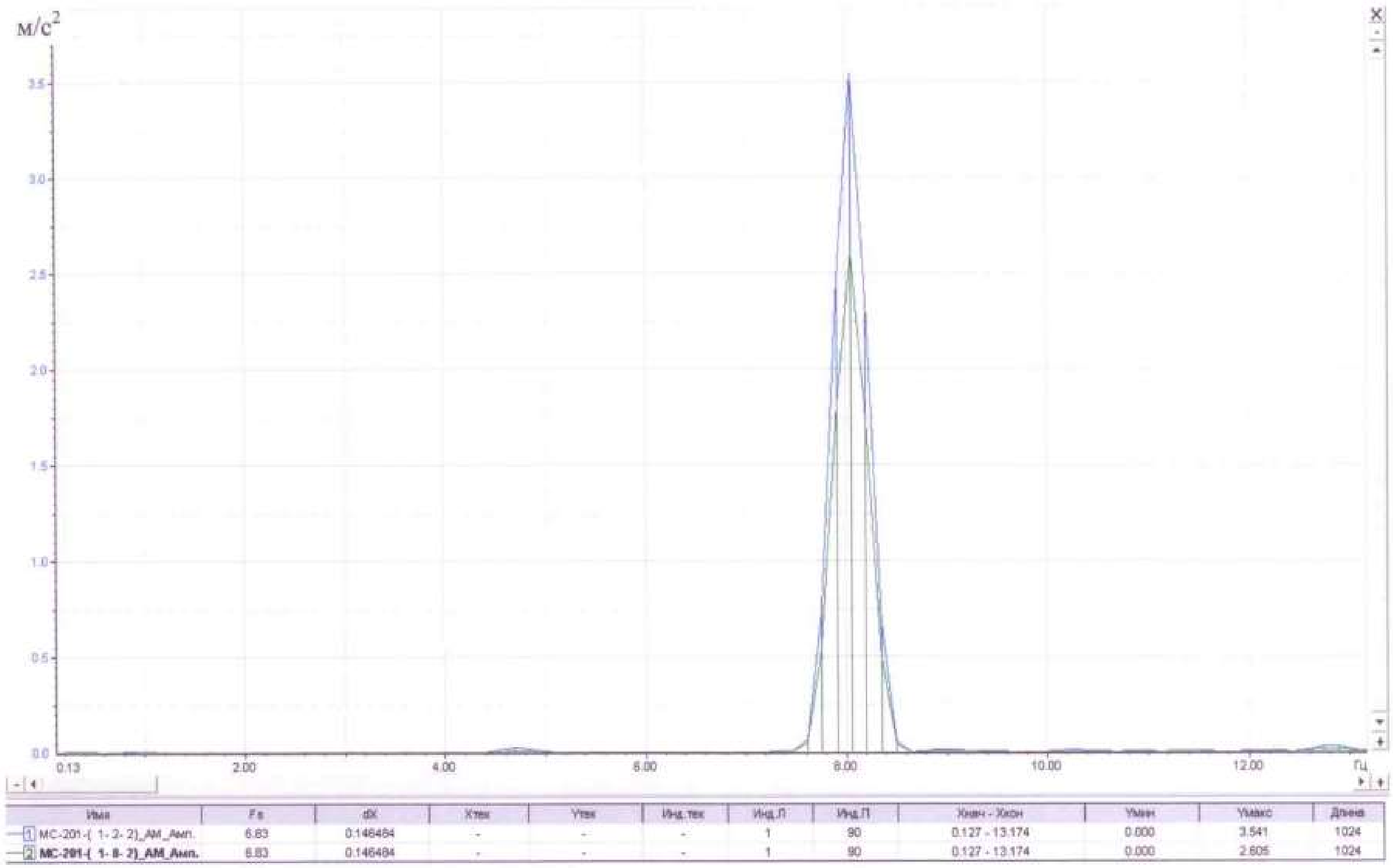


Figure 1-8 Spectrums of the maximum value of accelerations (m/s^2) for sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #22 (frequency f = 8.1 Hz; amplitude A = 1.0 mm)

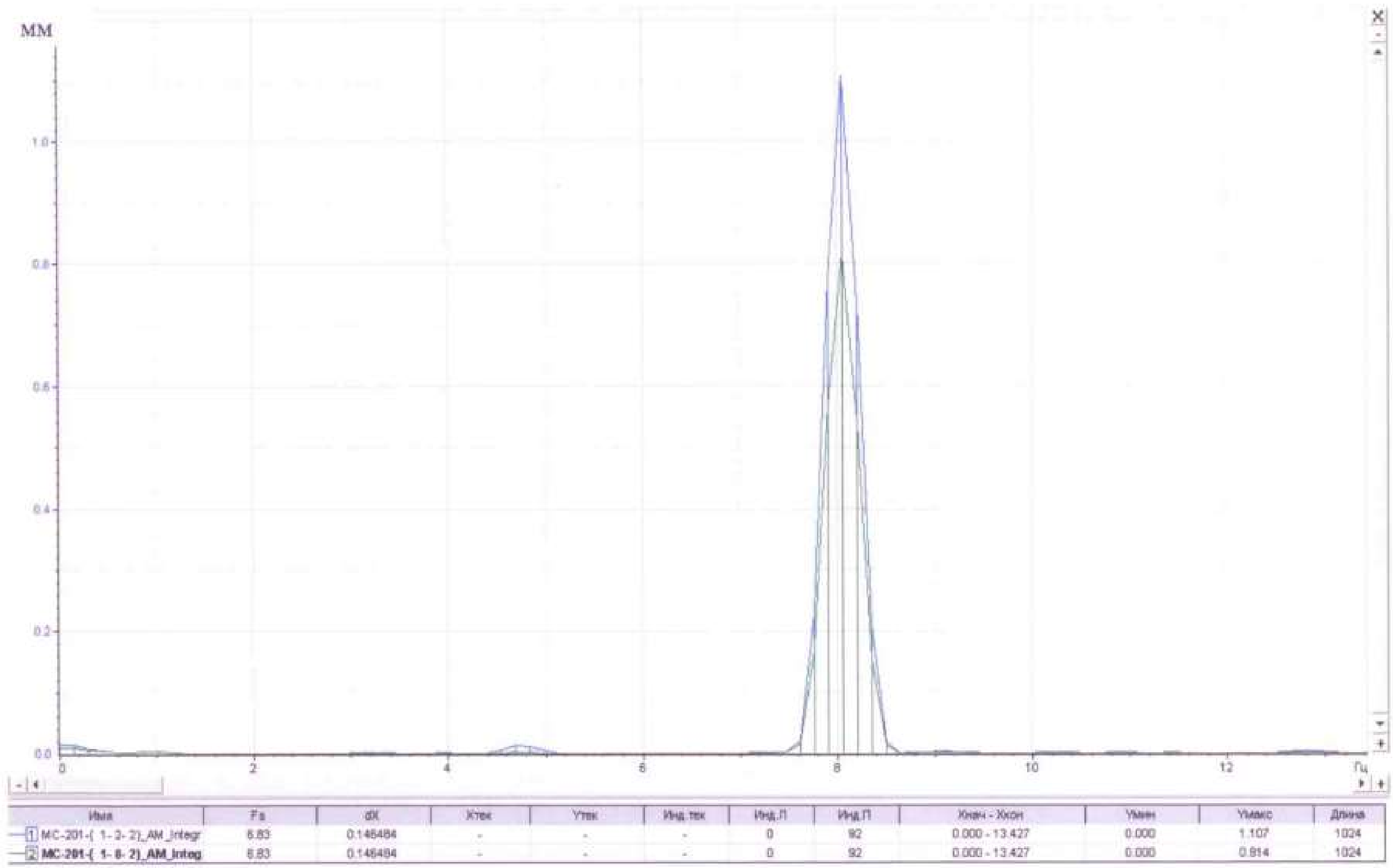


Figure 1-9 Spectrums of the maximum value of amplitudes (mm) for sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #22 (frequency *f* = 8.1 Hz; amplitude *A* = 1.0 mm)

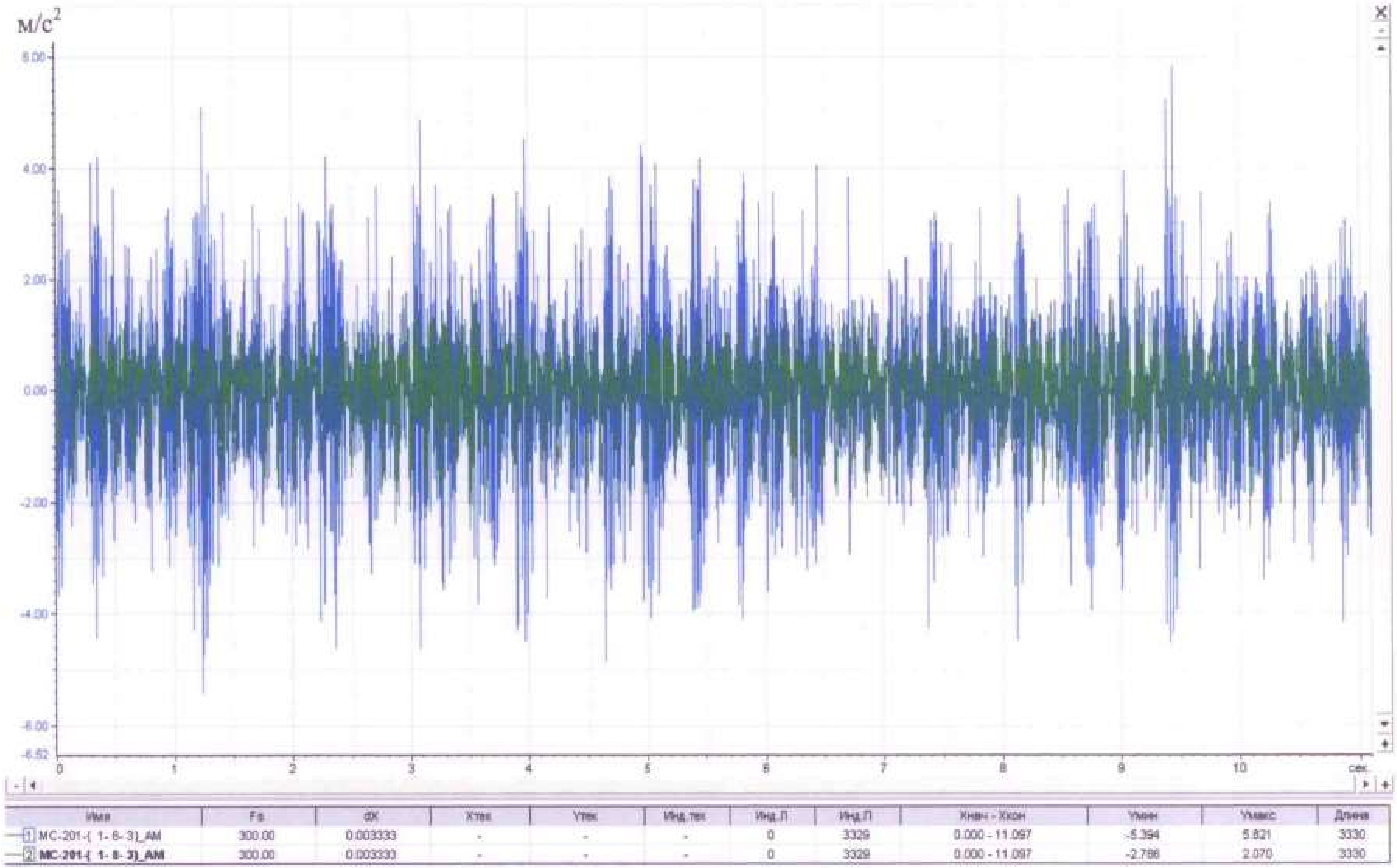


Figure 1-10 Accelerograms (m/s^2) recorded from sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #22 (frequency f = 8.1 Hz; amplitude A = 1.0 mm)

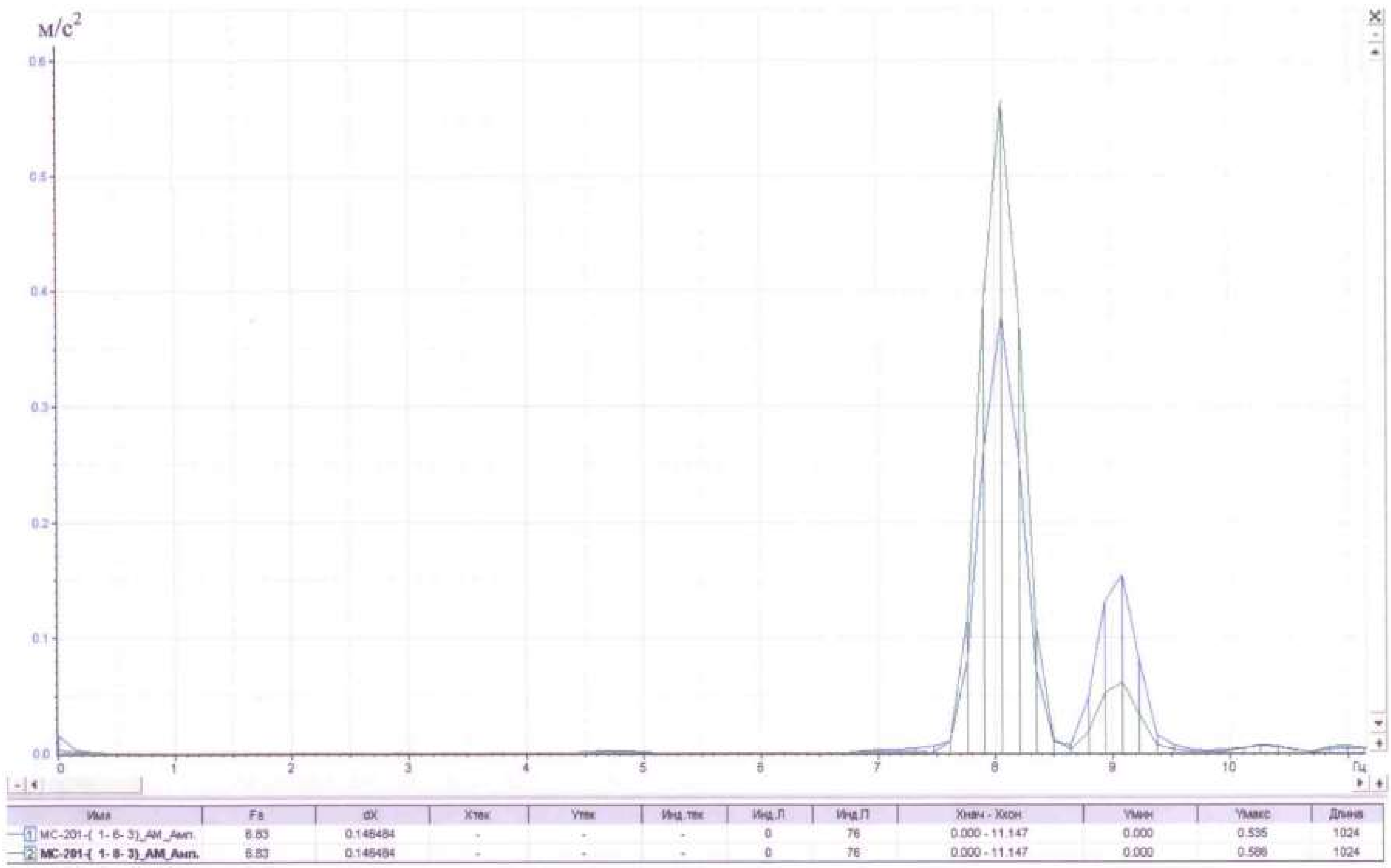


Figure 1-11 Spectrums of the maximum value of accelerations (m/s^2) for sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #22 (frequency f = 8.1 Hz; amplitude A = 1.0 mm)

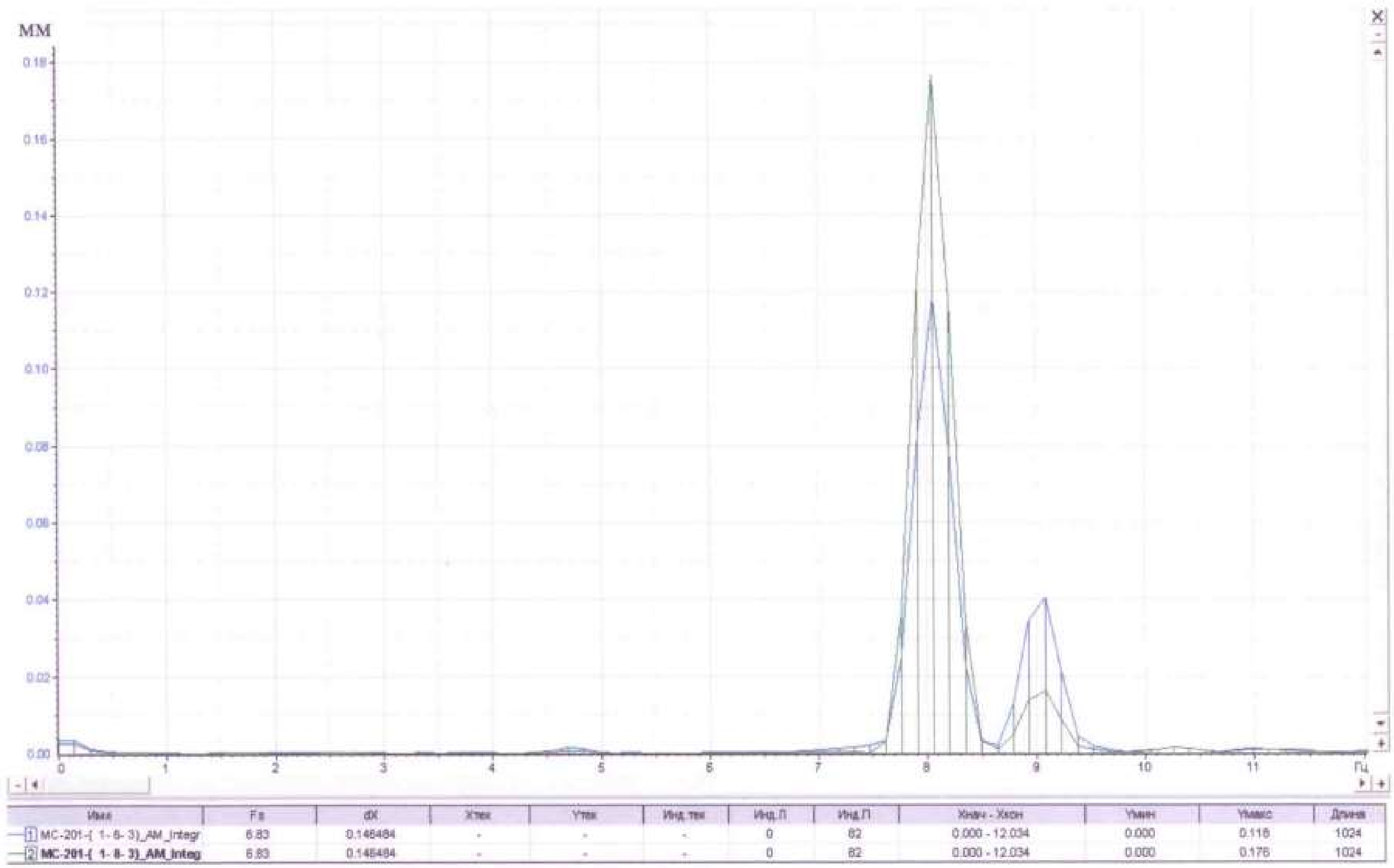


Figure 1-12 Spectrums of the maximum value of amplitudes (mm) for sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #22 (frequency f = 8.1 Hz; amplitude A = 1.0 mm)

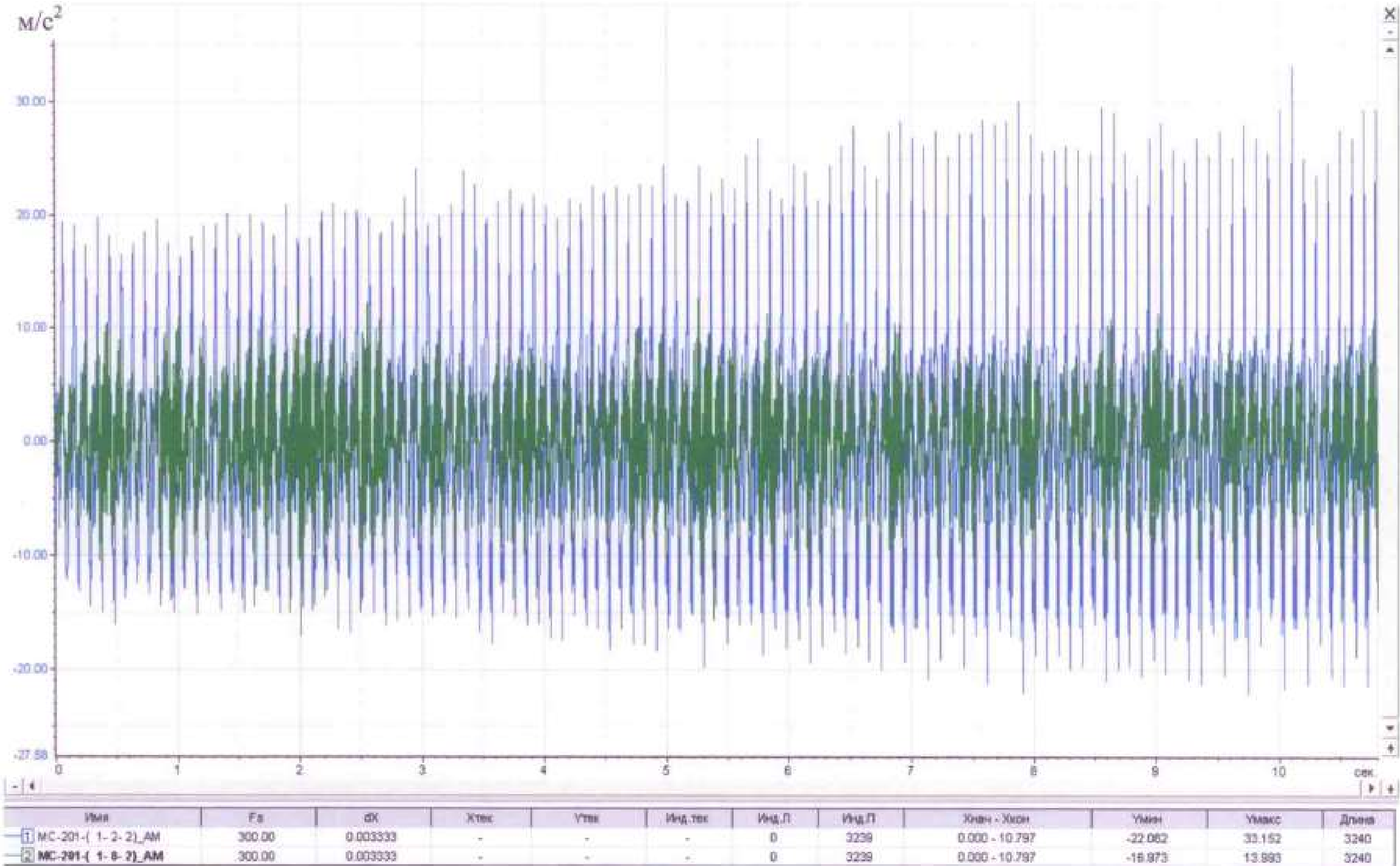


Figure 1-13 Accelerograms (m/s^2) recorded from sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #25 (frequency f = 10.4 Hz; amplitude A = 0.9 mm)

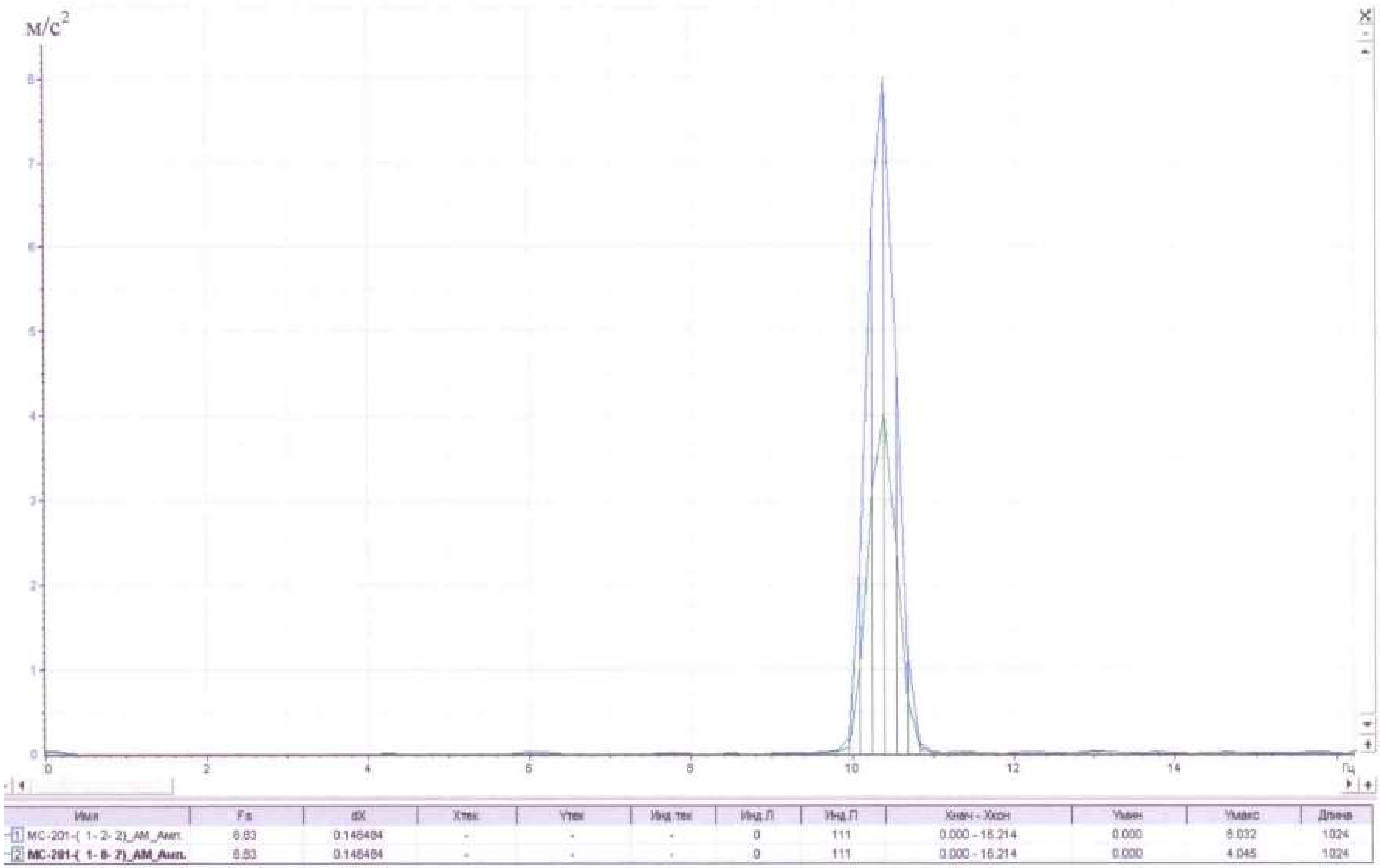


Figure 1-14 Spectrums of the maximum value of accelerations (m/s^2) for sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #25 (frequency f = 10.4 Hz; amplitude A = 0.9 mm)

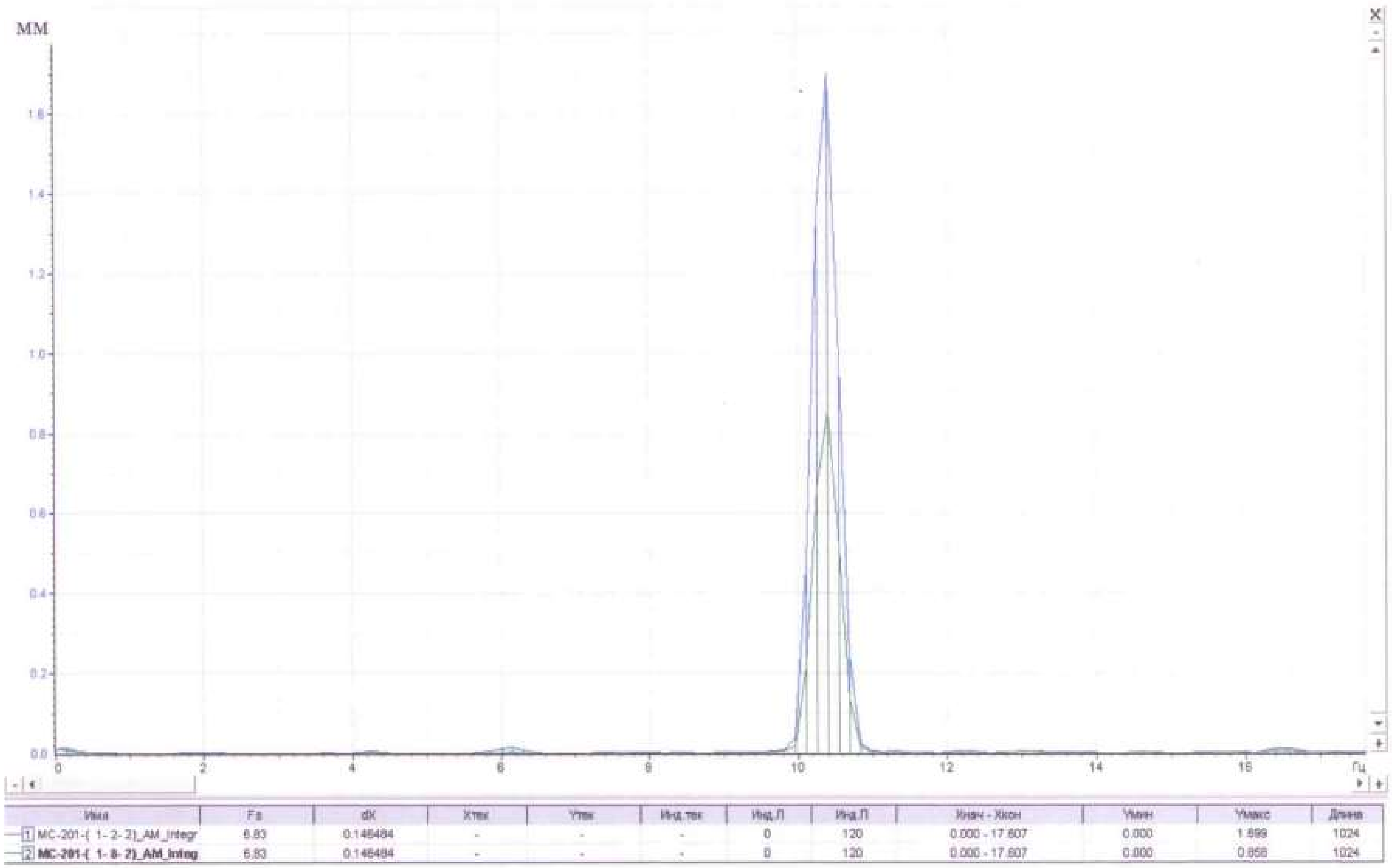


Figure 1-15 Spectrums of the maximum value of amplitudes (mm) for sensor 1-2-2 (blue) and sensor 1-8-2 (green).The test mode #25 (frequency f = 10.4 Hz; amplitude A = 0.9 mm)

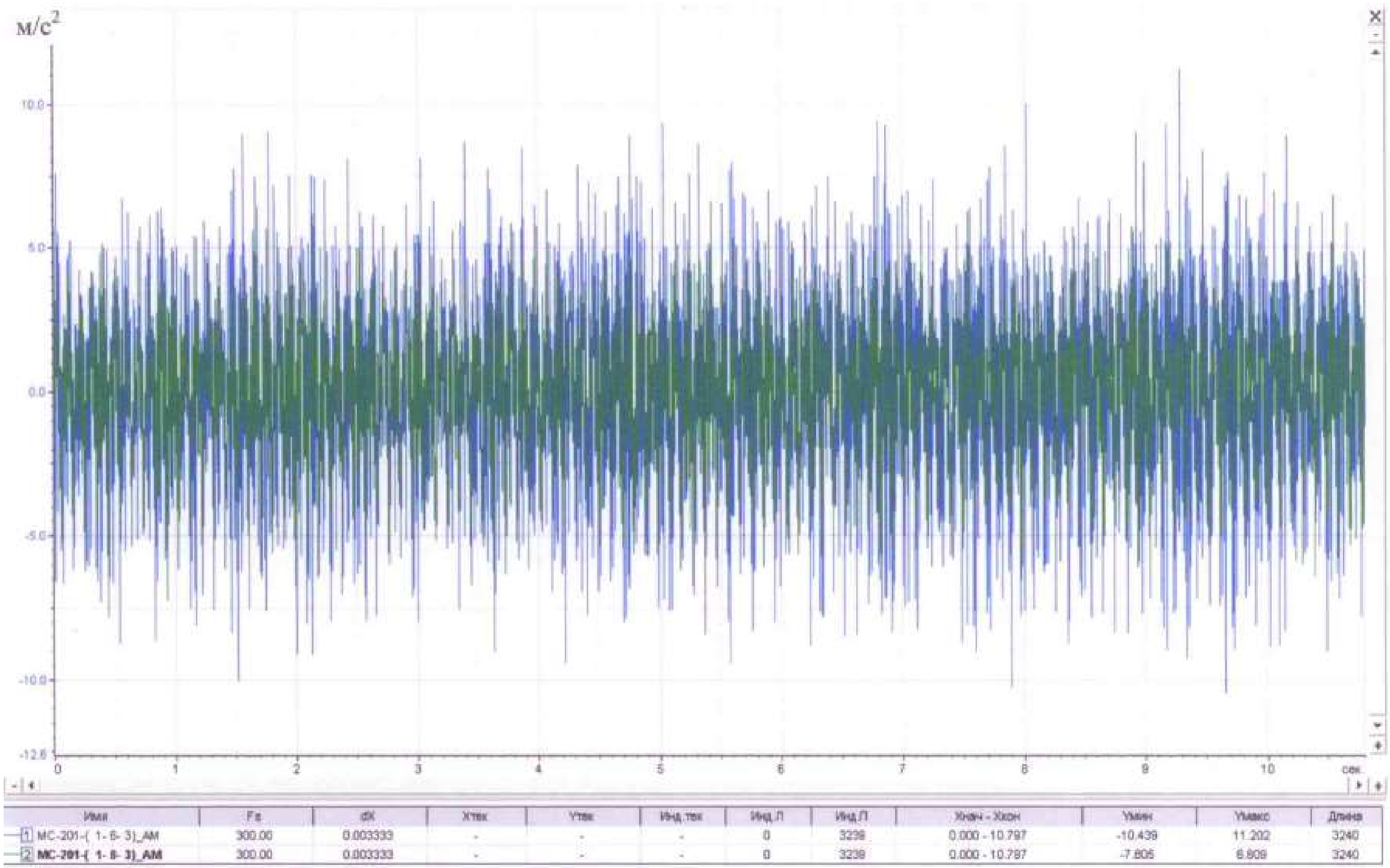


Figure 1-16 Accelerograms (m/s^2) recorded from sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #25 (frequency f = 10.4 Hz; amplitude A = 0.9 mm)

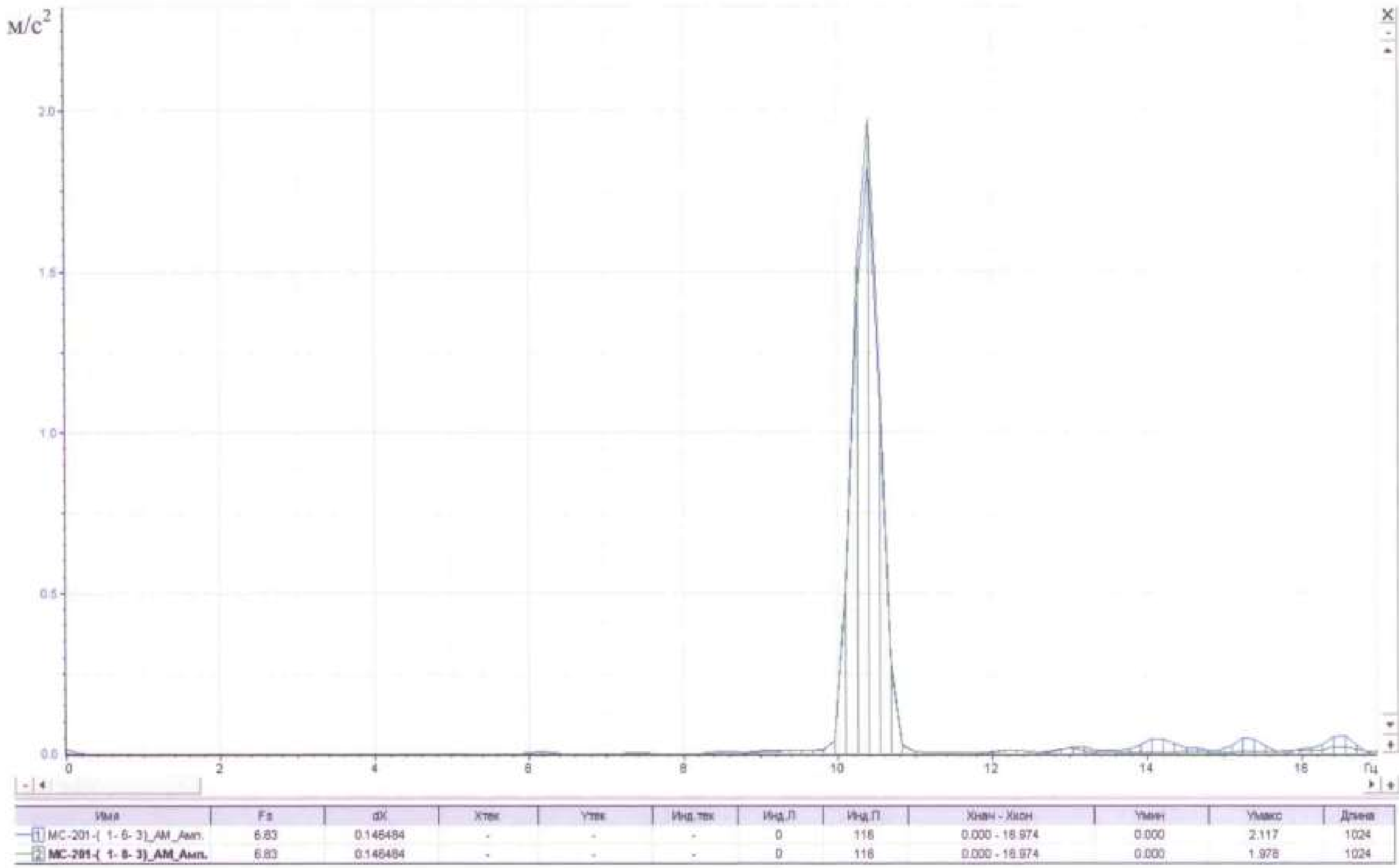


Figure 1-17 Spectrums of the maximum value of accelerations (m/s^2) for sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #25 (frequency f = 10.4 Hz; amplitude A = 0.9 mm)

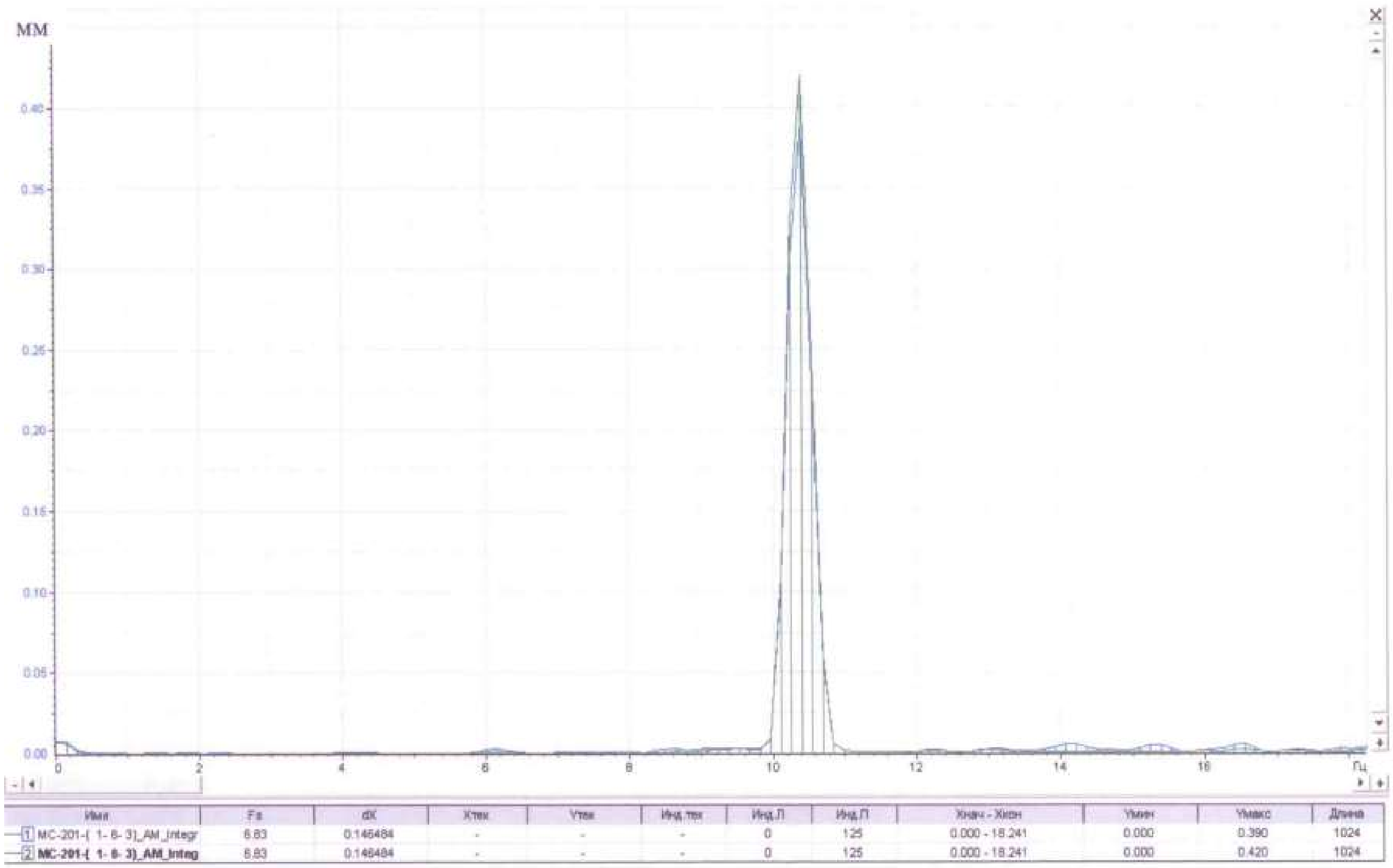


Figure 1-18 Spectrums of the maximum value of amplitudes (mm) for sensor 1-6-3 (blue) and sensor 1-8-3 (green).The test mode #25 (frequency *f* = 10.4 Hz; amplitude *A* = 0.9 mm)

Appendix 2.

CERTIFICATE

Self-regulatory organization based on membership of persons who conducted engineering surveys

Uncommercial partnership

Central association of organizations for engineering surveys for civil engineering "Centre of engineering surveys"(uncommercial partnership "Centre of engineering surveys")

129090, Moscow, Big Bolkanskiy alley, 20/1
Identification number in state register of self-regulatory organization is
СРО-И-003-14092009

THE CERTIFICATE

Of admission to the work or works, which affect the safety of capital construction projects

August 26^{th} 2010 # СРО-И-003-14092009-00423

Given for member of self-regulatory organization:

JSC Research Center of Construction, Research Institute of Building Constructions

ИНН 5042109739, ОГРН 1095042005255, Russian Federation, 141367, Moscow region, Sergievo-Posadskiy district, village Zagorskie Dali, 6/11

Grounds for issuing the certificate: the decision of uncommercial partnership "Centre of engineering surveys" administration;

Minute #35 from August 26^{th} 2010 year

The present certificate confirms the permit-to-works specified in appendix to the present certificatewhich affect the safety of capital construction projects.

The certificate is invalid without appendix.

The certificate is without limitation of the period of validity and validity area

The certificate is given instead of previous certificate #423

President Signature Stamp

General Director Signature

General Director   Signature   Stamp

Self-regulatory organization uncommercial partnership "Oboronstroy project"

Self-regulatory organization uncommercial partnership "Transregional association of project organizations Oboronstroy project"

Identification number in state registers of self-regulatory organization isСРО-П-118-18012010

THE CERTIFICATE

Of admission to the front end engineering designof capital construction projects

#П-02-0025-5042109739-2010

Is given by Self-regulatory organizationuncommercial partnership "transregionalassociation of project organizations Oboronstroy project"

ForJSC Research Center of Construction, Research Institute of Building Constructions

ИНН 5042109739, ОГРН 1095042005255, Russian Federation, 141367, Moscow region, Sergievo-Posadskiy district, village Zagorskie Dali, 6/11

Grounds for issuing the certificate: minute # 20 from July 21st 2010 year

The present certificate confirms the permit-to-works specified in appendix to the present certificate which affect the safety of capital construction projects.

Valid from July 21st 2010 year

The certificate is invalid without appendix.

The certificate is without limitation of the period of validity and validity area

The certificate is given instead of previous certificate #П-01-0025-5042109739-2010

From February 4th 2010 year

General Director Stamp Signature I. G. Yasakova

Of Self-regulatory organization uncommercial partnership "transregional association of project organizations Oboronstroy project"

General Director Stamp Signature I. G. Yasakova

Of Self-regulatory organization uncommercial partnership "Transregional association of project organizations Oboronstroy project"

APPENDIX #1
to competency certificate
#П-02-0025-5042109739-2010

The list of types of works which affect the safety of capital construction projects, to which the member of self-regulatory organization uncommercial partnership "Transregional association of project organizations Oboronstroy project", JSC Research Center of Construction, Research Institute of Building Constructions has the certificate.

#	Name of work type	The permission to works which affect to safety of highly dangerous facilities, technically complicate facilities, and structures envisaged by Town-Planning Code of the Russian Federation
1	1.Works on preparing a scheme for a planned land plot organization 1.1 Works on the preparation of the general land plot 1.2 Works on the preparation of the scheme of planning organization tracks the linear object 1.3 Works on the preparation ofthe scheme of planning organization of easement area of line structures	 Yes Yes Yes
2	2. Works on the preparation of the construction and architecture solutions	Yes
3	3.Works on the preparation of the constructive solutions	Yes
4	4. Works on the preparation of the data on internal engineering equipment,internal networks of engineering and technical support, list of engineering and technical operations: 4.1 Works on the preparation of projects ofinternal engineering heating systems,ventilation systems,air conditioning systems, smoke ventilation, heat supply systems, refrigeration supply. 4.2 Works on the preparation of the projects of internal engineering water supply and waste water disposal systems 4.3 Works on the preparation of the projects of internal electrical supply systems 4.4 Works on the preparation of the projects of internal low current systems 4.5 Works on the preparation of the projects of internal dispatching, automatization and engineering systems administration 4.6Works on the preparation of the projects of internal gas transmission system	 Yes Yes Yes Yes Yes Yes
5	5. Works on the preparation of the data on external networks of engineering and technical support, list of engineering and technical operations: 5.1 Works on the preparation of projects ofexternal engineering heating systems and their constructions.	 Yes

	5.2 Works on the preparation of projects ofexternal water supply and waste water disposal systems and their constructions. 5.3 Works on the preparation of projects ofexternal electrical supply systems up to and including 35kV and their constructions. 5.4 Works on the preparation of projects ofexternal electrical supply systems less then and including 110kV and their constructions. 5.5 Works on the preparation of projects ofexternal electrical supply systems up to and including 110kV and their constructions. 5.6 Works on the preparation of projects ofexternal low current systems. 5.7 Works on the preparation of projects ofexternal gas transmission system	Yes Yes Yes Yes Yes Yes
6	6. Works on the preparation of technological solutions: 6.1 Works on the preparation of technological solutions of residence buildings and their complexes 6.2 Works on the preparation of technological solutions of civic buildings and structures and their complexes 6.3 Works on the preparation of technological solutions of industrial buildings and structures and their complexes 6.4 Works on the preparation of technological solutions of transport purposes objects and their complexes 6.5 Works on the preparation of technological solutions of hydrotechnical structures and their complexes 6.6 Works on the preparation of technological solutions of agricultural objects and their complexes 6.7 Works on the preparation of technological solutions of special purposes structures and their complexes 6.8 Works on the preparation of technological solutions of oil and gas industry structures and their complexes 6.9 Works on the preparation of technological solutions of objects of waste collection, processing, storage and recycling and their complexes 6.10 Works on the preparation of technological solutions of nuclear power generation industry objects and their complexes 6.11 Works on the preparation of technological solutions of military infrastructure and their complexes 6.12 Works on the preparation of technological solutions of waste treatment facilities and their complexes	Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes
7	7. Works on development of special sections of project documentation 7.1 Engineering and technical procedures of civil preparedness 7.2 Engineering and technical procedures of prevention of emergency situations of natural and industry-related origin 7.3 Development of a declaration of industrial safety of hazardous production facilities 7.4 Development of a declaration of safety of hydraulic	Yes Yes Yes Yes

	structures 7.5 Development of justification for radiation and nuclear protection	Yes
8	8. Works on development of organization of construction projects, demolition and disassembly of buildings and constructions, life extension and conservation	Yes
9	9. Works on development of environment preservation projects	Yes
10	10. Works on development of fire protection projects	Yes
11	11. Works on development of projects of measures for access for people with limited mobility	Yes
12	12. Works on survey of building constructions	Yes
13	13. Works on organization of project documentation; by employed developer or employer by virtue of the treaty, by legal entity or self-employed entrepreneur (general design engineer)	Yes

General Director Stamp Signature I. G. Yasakova

Of Self-regulatory organization uncommercial partnership "Transregional association of project organizations Oboronstroy project"

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APPENDIX #2

To certificate of admission to certain kind or kinds of works, which affect the safety of capital structures.

26.08.2010

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The list of types of works which affect the safety of capital construction projects, to which the member of self-regulatory organization uncommercial partnership "Transregional association of project organizations Oboronstroy project", JSC Research Center of Construction, Research Institute of Building Constructions has the certificate.

#	Name of work type	The permission to works which affect to safety of highly dangerous facilities, technically complicate facilities, and structures envisaged by Town-Planning Code of the Russian Federation
1	1.Works in within engineering and geological research 1.1 Creation of new geological networks 1.2 Geological survey of deformations and yeilds of buildings and structures foundations, ground motion and dangerous natural processes 1.3 Development and renewal of engineering and geological 1:200-1:5000 scale plans, including digital form, survey of underground utility systems 1.4 Tracing of linear objects 1.5 Engineering and hydrographic works 1.6 Special geodesics and topographical works during the construction and reconstruction of buildings and constructions	 Yes Yes Yes Yes Yes Yes
2	2. Works within engineering and geological research 2.1 Engineering and geological survey in 1:500-1:25000 scale 2.2 Surface excavation, open pit and underground mining with testing, laboratory study of physical and mechanical properties of soils and chemical properties of underground water probes 2.3 Research of dangerous geological processes with ground protection documentation development 2.4 Hydrogeological research 2.5 Engineering and geophysical research 2.6 Engineering and geocryological research 2.7 Seismic andseismotectonic research of territory, seismic microzonation	 Yes Yes Yes Yes Yes Yes Yes
3	3. Works within engineering and geotechnical research 3.1 Surface excavation, open pit and underground mining with testing, laboratory study of physical and mechanical properties of soils for specific foundation base calculation scheme 3.2 Field soil study; determining of standard durability and deformation properties (stamp test, shift test, pressiometric tests,	 Yes Yes

	cutting tests). Sample and natural piles testing. 3.3 determining of standard physical and mechanical properties of soils via static and dynamic penetration tests, sound procedure 3.4 Physical and mathematic modeling of mutual interaction of buildings and geological environment 3.5 Special research of soils properties by nonstandard calculation methods including non-linear methods of buildings foundation base calculation 5.6 Geotechnical control of building and surrounding grounds construction	 Yes Yes Yes Yes
4	4. Buildings foundation soils condition survey	Yes

General Director Stamp Signature L.G. Kyshnir

General Director Stamp Signature A.V. Akimov

General Director Stamp Signature I. G. Yasakova

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Appendix 3.

VIDEO RECORDING OF EARTHQUAKE ACTIONS TESTS