



Regional Development Ministry of the Russian Federation  
Federal Agency for State Property Management

**Joint Stock Company**

**"Research and Development Centre "Stroitel'stvo"**

(JSC "RDC "Stroitel'stvo")

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№ 24 – 76 dated 16th July 2012

Deputy Director General  
"Termaflex Izolyaciya+" LLC  
**Mr. Bondarev D. A.**

The dynamic tests of the FLEXALEN flexible pre-thermally-insulated pipes system with the polybutene-made flow pipes in the thermal insulation of physically cellular (gas-filled) polyethylene on vibroplatform were conducted in the Building Seismic Stability Research Centre under the contract № 727/24-27-12/sk from 08.06.12 with the aim to evaluate the possibility of their use in the regions of the Russian Federation with the seismic activity of 7÷9 magnitude.

The FLEXALEN pipes specimens, connected via compression and welded joints were used for the tests.

The specified pipelines may be recommended for use in the regions with the seismic activity of 7÷9 magnitude. The detailed results of tests are provided in the V.L.Kucherenko CRDIBS Technical report.

Enclosure: The report regarding conducted tests.

Head of the Building Seismic  
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Doctor of Science

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V.L.Kucherenko CRDIBS

## **TECHNICAL REPORT**

on the subject: **«To conduct the dynamic tests of the FLEXALEN flexible pre-thermally-insulated pipes system with the polybutene-made flow pipes in the thermal insulation of physically cellular (gas-filled) polyethylene on vibroplatform by V.L.Kucherenko CRDIBS with the evaluation of the possibility of their use in the regions of the Russian Federation with the seismic activity of 7÷9 magnitude».**

(under the contract № 727/24-27-12/sk from 08.06.2012)

**Moscow 2012**



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“ \_\_\_ “ \_\_\_\_\_ 2012

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## 1. Introduction

The present technical report is prepared upon the results of the dynamic tests of the flexible pre-insulated polybutene-made pipes and their joints, intended for transportation of liquids for the water supply systems, as well as the industrial water transportation. The pipes are designed by the THERMAFLEX holding.

The dynamic tests were conducted at the specially designed by the V.L.Kucherenko CRDIBS test bench that represents the pendulum vibroplatform (Fig. 1.1), by means of which the dynamic effect, similar to seismic during earthquakes, is simulated.

**The bench tests target** is the serviceability evaluation of polybutene-made pipes, manufactured by the THERMAFLEX holding, during their use in the seismic regions of the Russian Federation with the intensity 7÷9 on the MSK-64 scale.

The report is documented in accordance with the requirement of the applicable regulatory documents. When describing seismic stability experimental investigations of polypropylene-made pipeline components for the public sewer and water disposal systems were used terms and definitions, contained in the applicable Construction Norms & Regulations 11-7-81\* [1].





**Fig. 1.1. Pendulum type vibroplatform**

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## **2. Tasks of the conducted experimental investigations.**

In accordance with the Federal law №184-FS from 27.12.2002 «Concerning Technical Regulation» the new construction product, developed and transferred to quantity production, as well as in case of product operating conditions change, is subject to obligatory evaluation and confirmation of correspondence for the safety requirements.

The important stage of such experimental investigations relating to the seismic stability evaluation matters are tests on the special benches (vibroplatforms) by means of the special vibration machines.

The obtained data as a result of dynamic tests allow to determine strength and performance characteristics of the tested structures under dynamic effect, as well as they are the basis for tested structures application area extension possibility evaluation with regard for the safety requirements, operating reliability and durability for the buildings constructed in the seismic regions of the Russian Federation.

The evaluation of the flexible pre-insulated polybutene-made pipes and their joints of THERMAFLEX holding production application possibility in the seismic regions of the Russian Federation on the platforms with the magnitude of 7÷9 includes the following stages:

1. The pipelines systems and their joints on the vibroplatform complex experimental investigations under the different dynamic load modes.
2. Adjustments regarding the pipelines and their joints construction solution, made to the organization standard or to the «Thermafex Izolyaciya +» engineering solutions manual and their approval with the V.L.Kucherenko CRDIBS and “RDC “Stroitel’stvo” JSC (if required due to tests results).



### **3. The flexible pre-insulated polybutene-made pipes joints, intended for liquids transportation, construction solution**

In the base of the THERMAFLEX pipeline system the pipes made of polybutene – the unique material combining the advantages of pipes made of cross linked PEX brand polyethylene and PP brand polypropylene – are laid down. Polybutene-made pipes are enclosed in the highly power-efficient thermal insulation made of THERMAFLEX physically cellular (gas-filled) polyethylene. Thermal insulation is protected from the mechanical damage by means of low pressure polyethylene-made extra strong corrugated casing with carbon addition, welded to the thermal insulation.

According to the «Thermafex Izolyaciya+» LLC data the specified pipelines are intended for duct-free underground and overhead open heat-supply (heating), hot and cold water supply engineering system, including with the freeze-and-thaw action protection heater cable. In addition this pipeline is intended for liquids of the water supply systems, as well as industrial water transportation.

The pipelines are operated under the ambient temperatures from -15 °C to 110 °C, upon that the pressure inside pipelines may vary from 16 to 8 bar respectively.

For the dynamic tests the pipes, included in the FLEXALEN 600 standard and comprised of two types of specimens, were manufactured:

- the first specimen was comprised of three pipes, connected between each other by means of special reducers (Fig. 3.1a);
- the second specimen presented the straight piece of pipe (Fig. 3.1b).

The used pipes product item: VS-RS125A75 (Ø of casing is 125, Ø of pipe is 75/61.2) and VS-R160A110 (Ø of casing is 160, Ø of pipe is 110/90).





In order to conduct dynamic testing by the Customer («Thermafleks Izolyaciya+» LLC) the pipeline components of the abovementioned product item and their joints were delivered to the CRDIBS. The Fig. 3.2 shows the assembled pipeline experimental specimen after its installation on the pendulum vibroplatform.

The pipeline system components for dynamic testing and their dimensions are accepted in accordance with the applicable engineering documentation.

When conducting dynamic tests the pipeline system was filled with water at the temperature of 95 °C and with the pressure of 11 bar (design pressure 10 bar).



a)



b)



**Fig. 3.1. The general view of the pipelines prototype models**

*Eraf*

a)



b)



**Fig. 3.2. The general view of the pipelines installed on the vibroplatform**

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#### **4. Pipeline testing for dynamic load effect program and method.**

The testing program includes the following stages:

1. Design features analysis.
2. Design parameters and the elements for the experimental measured fragments allocation selection and approval with the Customer.
3. Vibro-bench and measuring equipment preparation for the dynamic testing conduction.
4. Allocation of pipeline system load modes with the dynamic load corresponding to the force impacts, affecting the buildings during earthquakes of variable intensity (from 7 to 9 magnitudes).
5. Experimental investigations results processing and analysis.
6. Technical report formulation under the pipeline system test results with recommendations for operating reliability provision in case of seismic impacts.

The test bench is designed in the V.A.Kucherenko CRDIBS, vibrations generation of which can be realized by the following:

- impulses of pendulum platform, on which the pipeline system is installed, are generated by means of VID-12 vibration machine, fixed on the platform. Due to inertial force, generated by VID-12, one or another impact frequency spectrum on the pipeline and the platform amplitude of vibration specific level is provided. According to the tests, the maximum platform amplitude of vibrations value while using VID-12 amounts to 150 mm;



With due account for the abovementioned, the flexible pre-insulated polybutene-made pipes and their joints, manufactured at the «Thermaflex International Holding bv» production enterprise, dynamic tests program on vibroplatform includes the following stages.

1. The tests of the water-filled pipelines under the pressure of 11 bar and under the temperature of 95 °C are conducted with the change of frequency spectrum from 0 to 15 Hz on the fixed vibroplatform displacement amplitude.

Next, the amplitude value is changed and the frequency settings are carried out in the abovementioned spectrum. The duration of each of the indicated system dynamic load stages (at fixed amplitude and frequency) amounts to approximately 30 seconds.

2. According to the tests results (article 1) the exposure levels, corresponding to the system resonant vibrations, and the vibroplatform acceleration levels, corresponding to the intensity of 7÷9 on the MSK-64 scale, are set up.
3. After completing the tests in accordance with a specified vibroplatform amplitude-frequency spectrum change program the repeated tests are conducted with vibroplatform amplitude-frequency parameters combinations, corresponding to the system resonant vibrations and 7 magnitude effects. The repeated dynamic tests duration under the abovementioned combinations is 40-50 seconds.
4. If during the tests the pipelines imperviousness destruction or infringement occur, the ways to improve their reliability are developed together with the Customer, and tests are repeated according to the paragraph 1.2.



## 5. Building testing equipment for dynamic load. Means of dynamic properties measurement and registration

### 5.1. Equipment for dynamic loads creation

As was already mentioned, in order to create dynamic effects on the tested specimens a special bench was used.

The bench comprises a pendulum platform, suspended with the flexible (hoop steel-made) steel connections to the supporting load frame. The frame is rigidly clamped to the laboratory building power floor. The platform activation is realized by the VID-12M vibration machine, installed on the pendulum platform bracket (see Fig. 1.1).

VID-12M vibration machine allows to ensure necessary dynamic effects parameters for investigated specimens in a wide range of frequencies and inertial loads by means of the platform mechanical vibrations generation in a horizontal plane.

VID-12M control is realized from the control board located in the electric cabinet. The main pendulum vibroplatform technical characteristics are given in Table 5.1.

VID-12 machine general technical data

Table 5.1

No№	Parameter name	Value
1	Inertial force, generated be the machine under the highest essentric weight radius; - under 60 rpm (1 Hz) - under 180 rpm (3 Hz) - under 240 rpm (4 Hz) - under 300 rpm (5 Hz)	0,8 t 7,0 t 12,5 t 20,0 t
2	Frequency characteristic - lower frequency, Hz - upper frequency, Hz	0,4 25
3	Frequency trend	Without stages

Note: On considerations of separate parts strength and on the basis of vibroplatform weight at any rotating speed the inertial force if limited by the value 12 t.

## **5.2. Measurement and registration means for structures dynamic properties and the effect on them.**

Signals registration and measurement was carried out using specialized MIC-036 measuring and computing complex, designed for the collection, conversion, recording, processing, transmission and presentation of information, received from sensors. The complex performs the following functions:

- measuring, recording and primary processing of (frequency, digital, etc.) signals, obtained as a result of tests;
- measured values readings or transformed parameters displaying on the monitor;
- measured values readings or transformed parameters monitoring; evaluation of the their measurement and conversion results;
- conducted measurements self-diagnosis (operability analysis with the ability to call the diagnostic programs);
- measurement and conversion results archiving (data storage with the ability to view and analyze);
- measured parameters current values, failure codes and technological messages output to up-stream computer;
- the ability to connect printers, including for measuring results protocols documenting;
- ability to connect with other systems (connection to an existing local area network);
- the possibility of «potential-free contact» type signal delivery to turn the alarm on and to use in protection systems;
- the possibility of test analog signals delivery.



MIC-036 measuring and computing complex is additionally equipped with a laptop computer including a specialized application software package and peripheral devices, required for the automated signal processing process, as well as for processing results documenting (Fig. 5.1a).

To measure the acceleration, vibration frequencies, as well as dynamic displacements the AT 1105 10m one-component sensors-accelerometers are applied (Fig. 5.1b).

Sensors (accelerometers) characteristics are presented in Table 5.2.

Main AT 1105 - 10m accelerometer technical data

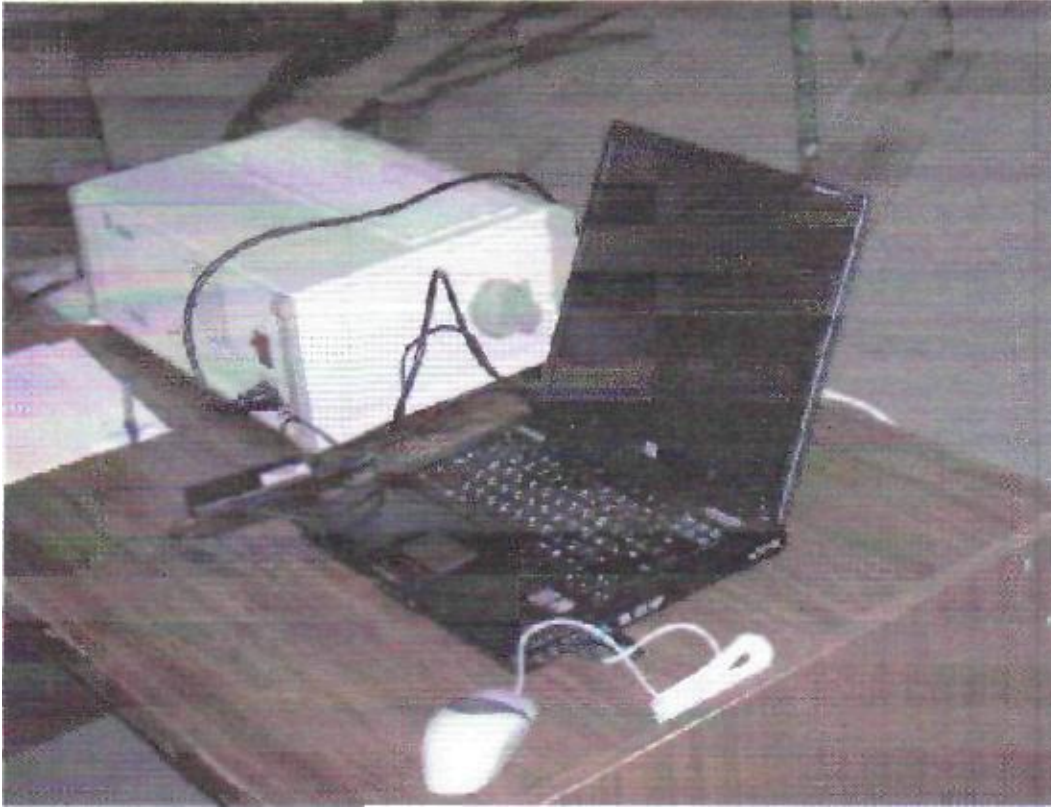
Table 5.2.

№	Parameter name	Value
1	Power supply from direct current power supply towards mid-point, V	$\pm 12 \pm 12$
2	Measurement range, m/s (g)	98,1 (10,0)
3	Frequency characteristic, - lower frequency, Hz - upper frequency, Hz	0 700
4	Operating temperatures range, °C	from +15 to +35

The sensor-accelerometer was installed for the specified dynamic loads on the vibroplatform.



a)



b)



**Fig. 5.1. a) MIC - 036 measuring and computing complex  
b) AT 1105 10m one-component sensors-accelerometers**

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## **6. The pipelines dynamic tests results**

### **6.1. Tests conduction method**

Pipelines system in-place tests were carried out using vibration (resonance) method, which allows to quantitatively measure the power load, simulating seismic effect in a wide frequencies range.

According to the vibration tests for specific loading levels were determined the tested fragment amplitude and frequency characteristics, representing the dependence of the building vibration amplitudes from the harmonic action frequency. As noted above, accelerometers heeled to vibroplatform, allowing to evaluate the dynamic effects level on the model and to compare it with the normative acceleration values.

As a result of the frequency effect and platform vibration amplitude change, the system dynamic characteristics (fundamental vibration frequency, dissipative properties, etc.), as well as the experimental model operation fundamental nature, were evaluated.

Experimental specimens components bearing on the platform were realized via special gaskets (see Fig. 6.1). The accepted bearing provides more stringent pipeline operating conditions under seismic effects in comparison with the pipeline, laid on a pound foundation bed. During the pipelines ends tests the plugs, aimed to provide the required pressure level during the test, were installed (Fig. 6.2).



## 6.2. Loading parameters allocation

**The duration of the seismic action.** According to the data [4,5] the duration of the main vibration process is 10 \* 40 seconds (the earthquake in San Francisco 18/04/1906 – strong vibrations lasted for 25 seconds, Mexico – 28.07.1957 – 15 seconds).

**The vibration periods.** According to the B.K.Karapetyan observations [6] maximum ground accelerations during earthquakes corresponded to the periods of 0.05 and 0.1 seconds ( $f \sim 20$  and 10 Hz). According to the I.L.Korchinski data [5]:

- with rigid systems ( $T=0 \div 0.05$ ), the maximum accelerations occur almost instantaneously with the start of vibrations (the area of the most high dynamic magnification factor values);
- the most characteristic seismic effects periods are in the range of short-period spectrum from 0.1 to 0.5 seconds ( $f \rightarrow *$  from 10 to 2 Hz);
- in [4] it is noted that as shown by numerous experimental investigations, regardless of the external effect frequency the construction typically oscillates with the frequency corresponding to the frequency of natural vibrations. The periods of natural vibrations of the major buildings are 0.1-2.0 seconds. That is, the dynamic load frequency, sustained by the building in terms of earthquakes will be mainly within the range of 0.5-10 Hz.

**The number of loading cycles.** Under the guidance of I.L.Korchinsky [5], R.S.Berdyayeva, G.V.Becheneva and V.L.Rzhevski were conducted the tests of reinforced concrete and steel frame specimens under the loading with the speed of 300:1000 cycles per minute, that, as specified in [4], corresponds to the building structures loading speed under seismic loads.

Based on the indicated investigations analysis the system dynamic loading parameters were adopted as the following:

- platform vibration frequency varied in the range from 1.9 to 7.6 Hz;



- the number of loading cycles ranged from 200 to 400 per minute;
- the dynamic (seismic) effects duration on the system varied from 20 to 50 seconds.

Loading stages are shown in Table 6.1 and are selected with the opportunity to evaluate the pipeline behavior at resonance. The indicated in the table amplitude-frequency characteristics and corresponding accelerations values comply with the values, obtained according to the data of accelerometers mounted on vibroplatform.

Dynamic loads were generated with the help of VID-12M vibration machine, by means of the mechanical vibrations excitation in the horizontal and vertical planes.

The acceleration values shown in Table. 6.1 correspond to seismic areas specified on the seismic zoning plan of the Russian Federation territory (Fig. 6.3).



### 6.3. Dynamic tests conduction conditions

Vibration tests were conducted during the daytime at the air temperature not less than 15 °C. Vibration tests conditions correspond to the normal and working conditions of the utilized type AT1105-10m accelerometers.

The full-scale polypropylene pipeline components, manufactured by «FTK ROSTR» LLC, dynamic testing results analysis allows you to note the following:

- in the process of testing vibroplatform acceleration according to the accelerometers data, mounted on it, varied from 0.9 to 9.9 m/s. The system vibration frequencies varied in the range from 1.5 to 10.6 Hz, the system vibration amplitudes varied from 1.62 to 28.67 mm.
- in the process of testing in case of coincidence between pipeline vibration natural frequencies values and vibroplatform vibrations frequencies the resonance occurred. This phenomenon was observed under the system vibrations with the frequency of  $f = 4.5$  Hz and amplitude of  $A = 1.85$  mm. At resonance, operational reliability of pipelines had not been violated;
- after completing the tests water pressure level check in the pipeline system was conducted. As it is seen in Fig. 6.4. the pressure in the pipeline after the test has remained the same and equaled to 11 bar.

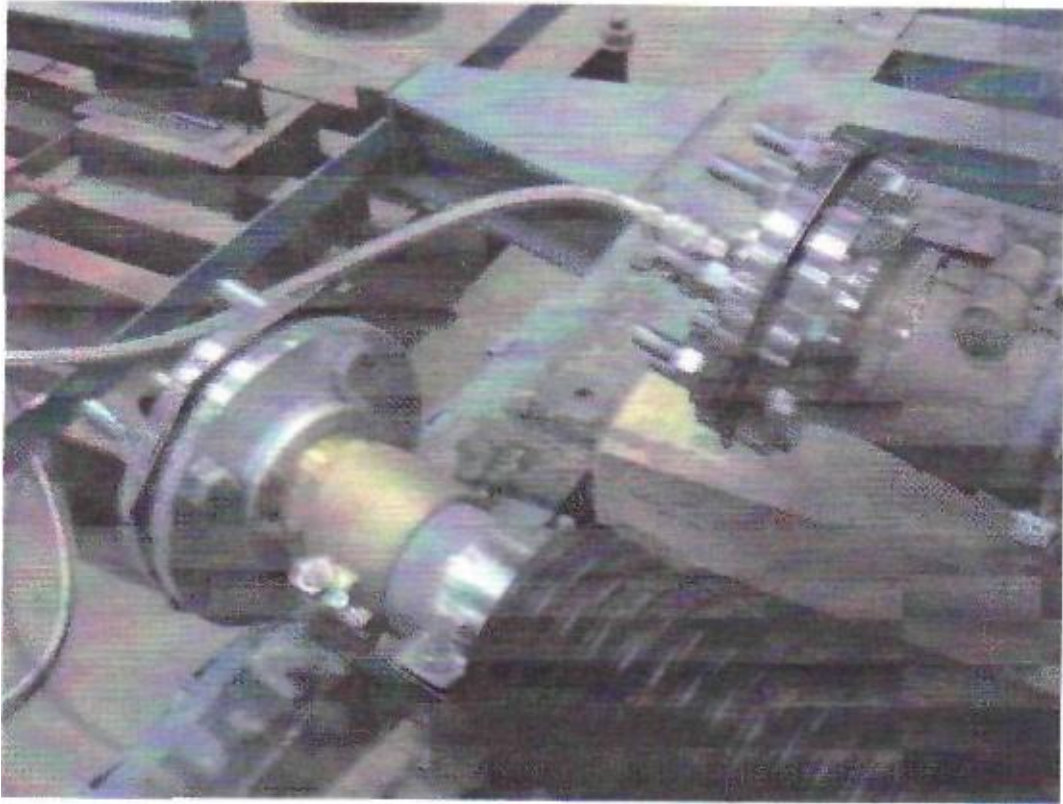




Fig. 6.1. The general view of vibroplatform with the prototype model, laid down on it

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a)



b)

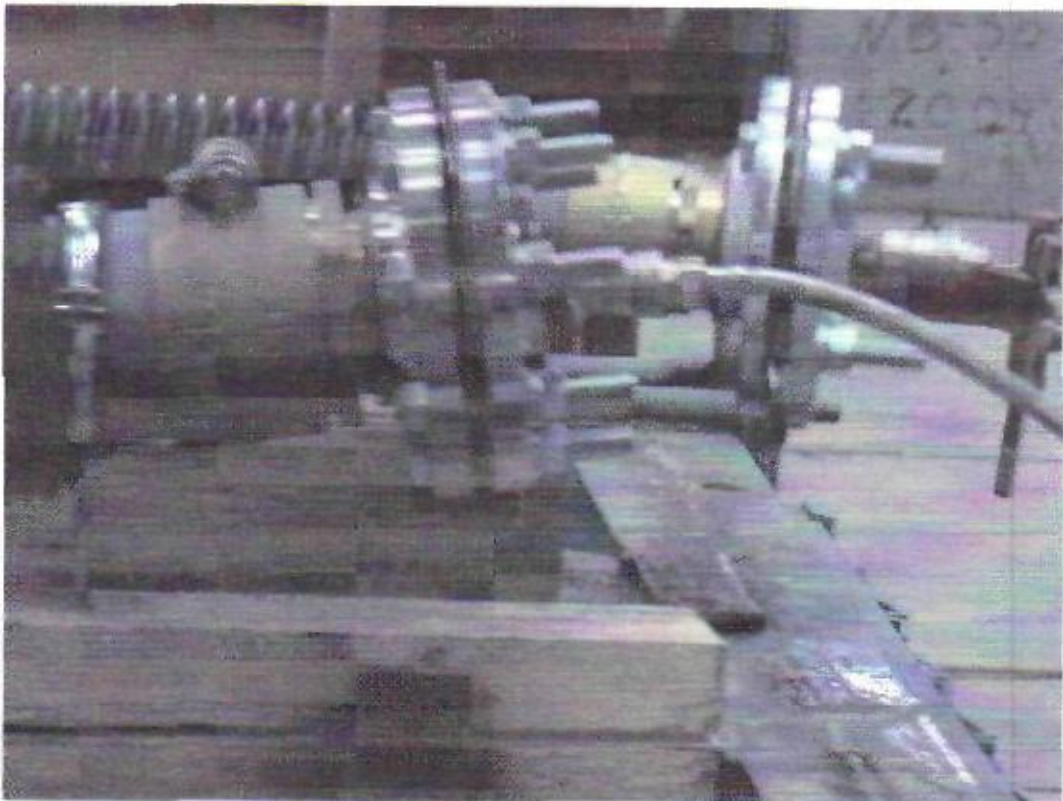


Fig. 6.2. The general view of pipelines plugs

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Table 6.1.

<b>№</b>	<b>f, Hz</b>	<b>A, mm</b>	<b>a, sm/s<sup>2</sup></b>	<b>magn.</b>
1	3.5	1.84	90	6.8
2	4,5	1,85	150	7,6
3	6	1,87	270	8.4
4	7,1	1.67	330	6,7
5	6	1.87	470	9.2
6	3,1	5.27	200	8.0
7	4.5	5.39	230	8.2
8	2,5	9.48	390	9.0
9	3,1	10,33	630	9,7
10	3,9	10,51	370	8.9
11	2,4	16,18	510	9.4
12	2.8	16,57	170	7,8
13	1.6	17,12	470	9.2
14	2,4	20,54	90	6.8
15	1.1	19,05	370	8,9
16	2	23,24	620	9,6
17	2,5	25,33	200	8.0
18	1.5	22,52	410	9,0
19	2	25,84	650	9,7
20	2,4	28,67	390	9,0
21	7,8	1,62	560	9.5
22	8,6	1.92	640	9,7
23	9,4	1,83	710	9.8
24	9.9	1,83	720	9,8
25	10.6	1.75	770	9.9





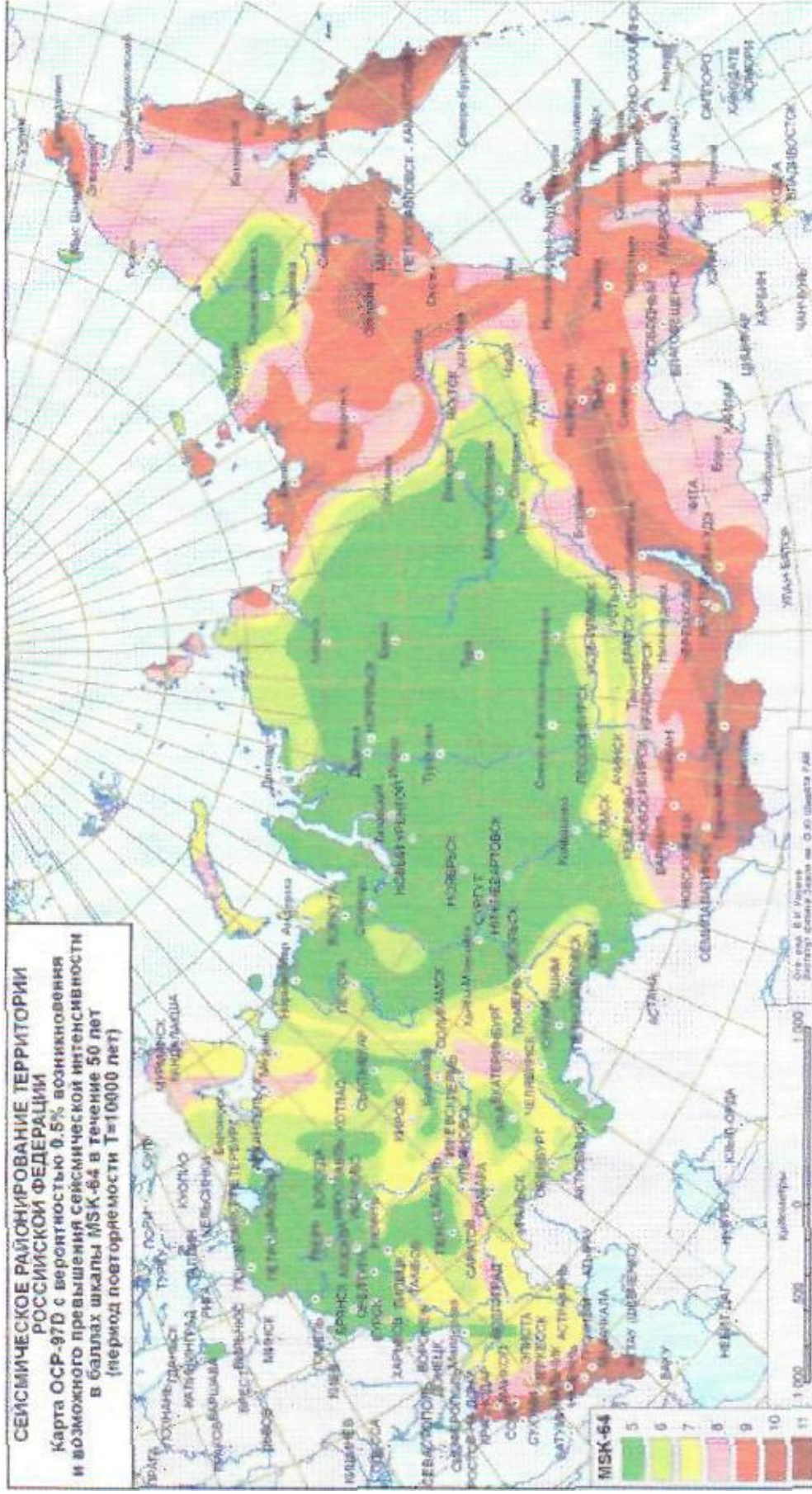


Fig. 6.3. The Russian Federation seismic zoning plan

*Zaf*



Fig. 6.4. Pumping station for pipeline pressure determination (on the scale of 1.1 bar)

*Zaf*

## 7. Conclusion. Summary and recommendations

On the basis of dynamic tests results of the flexible pre-insulated polybutene-made pipes and their joints, manufactured at the «Thermafex International Holding bv» production enterprise, may be mentioned the following:

1. In accordance with the experimental investigations on vibroplatform program of the Building Seismic Stability Research Centre the flexible pre-insulated polybutene-made pipes and their joints dynamic tests were conducted. During tests the dynamic loads, corresponding to 7÷9 magnitude effect, were simulated. Pipelines fragment was filled with water at the temperature of 95 °C and under the pressure of 11 bar during tests conduction.
2. In the process of tests vibroplatform acceleration due to the accelerometers data, mounted on it, was changing within the range from 0,9 to 9,9 m/s<sup>2</sup>, that exceeds value of acceleration, corresponding to the seismic effect of 9 magnitude (4 m/s) more then twice.
3. **In the process of testing in case of coincidence between pipeline vibration natural frequencies values and vibroplatform vibrations frequencies the resonance occurred. This phenomenon was observed under the system vibrations with the frequency of  $f = 4.5$  Hz and amplitude of  $A = 1.85$  mm. At resonance, operational reliability of pipelines had not been violated.**
4. **The flexible pre-insulated polybutene-made pipes and their joints, manufactured at the «Thermafex International Holding bv» production, enterprise, may be recommended for application in the regions of the Russian Federation with the seismic activity of 7÷9 magnitude.**

## 5. List of references

1. Code Design 14.13330.2011 (Construction Norms & Regulations II-7-81\* «Construction in seismic areas. Updated revision).
2. Polyakov S.V., «Buildings seismic structures», Publisher «Vysshaya shkola», M., 1969, 335 page.
3. Korchinskij I.L., etc., «Buildings seismic stable construction», Publisher «Vysshaya shkola», M., 1971, 319 page.
4. Karapetyan B.K. «Vibration of buildings, constructed in Armenia», Publisher «Ayostan», Erevan, 1967.