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## ULTRASONIC METHOD OF SCALING PREVENTION

During operation of heat-exchange equipment there appear carbonate scale causing significant increase in fuel consumption and maintenance expenditures as well as a decrease in efficiency and overhaul terms.

Cleaning of heat-exchange equipment is usually done mechanically or with the use of chemicals (e.g. acids). Both ways are time-consuming and may cause damage to the heating surfaces. Moreover, during overhaul intervals the scale reappears bringing about waste of fuel and new maintenance spending.

In recent years, along with the chemical method of incrustation prevention reagentless methods and in particular the ultrasonic one become more and more widespread.

The ultrasonic anti-scaling method provides in-boiler preparation of water. It is based on the use of a special unit that excites ultrasonic vibrations in water filling heat-exchange equipment. These vibrations produce a great number of cavitation bubbles in the depth of water. The bubbles act as nuclei of crystallization around which carbonates causing hardness of water begin to precipitate forming finely divided sludge. Vibrations of heating surfaces prevent deposition of the sludge on the pipe walls. Thus particles of insoluble salts do not reach the walls of equipment remaining in a suspended state and can be easily removed by the flow of water or air blowing.

Moreover, ultrasonic vibrations conduce to destruction of the existing scale. Acting on the heating surface, they produce alternating forces that reduce the strength of bonds in the carbonate scale and those between the scale and the metal thereby causing the appearance of flaws. Due to capillary pressure water penetrates through the flaws to the heating surface where it instantly evaporates causing the scale to fall off. Small particles and flakes of peeled scale concentrate in the bottom part of the heat-exchange equipment and can be removed with periodic blowing.

The action of ultrasound is not limited only to preventing carbonate incrustation and maintaining a high efficiency of thermotechnical equipment. Ultrasonic vibrations also enhance heat transmission from the heating surface due to better circulation of water at the pipe walls and its higher speed because of lower hydrodynamic resistance of pipes with oscillating walls. Improved circulation at the interface of the two mediums, metal and water, results in faster removal of vapor and gas bubbles from the heating surface and consequently, a more effective heat transfer.

The phenomenon of hydrodynamic resistance reduction is especially noticeable in micron flaws that constitute natural defects on the internal surface of pipes. Such flaws normally (without ultrasonic) contain some atmospheric oxygen that is easily extruded under the influence of ultrasonic vibrations. As a result, one of the causes of pipe metal corrosion is excluded. Long exposure of the internal surface of pipes to ultrasonic pulses causes the most compliant areas around the flaws to deform. These deformations bring about partial closing of the flaws and cold-hardening of their peripheries thereby reducing absorption of oxygen when the water is drained from the pipes. The internal surface of pipes becomes smooth and its overall area shrinks, minimizing probability of corrosion. This produces an effect of rust protection which to some extent replaces passivation of the pipe surface.

The above-mentioned factors are interrelated and their combination is the cause for positive influence of ultrasound over processes of carbonate incrustation and pipe metal corrosion as well as efficiency of heat-exchange equipment.

Use of the ultrasonic method eliminates pollution of environment with harmful sewage of water-treatment installations. Besides, the specific cost (per 1 m<sup>3</sup>) of water preparation this way is about 200-250 times smaller than that of the chemical method.

Capital investment associated with buying, mounting and adjustment of the USP devices pay for itself within several month of their operation.



## THE USP-FAMILY ANTI-SCALING DEVICES

The USP-family anti-scaling devices are intended for scaling prevention in various heat-exchange equipment. They are designed for operation in continuous mode.

The device can be mounted on low-pressure steam and hot-water boilers, condensers, desalters, network waterheaters and other kinds of heat-exchange equipment used in heat-and-power engineering, oil, shipbuilding, the food industries and public economy, etc. The device consists of a pulse generator and impact excitation magnitostriectors and features higher output capacity as compared with analogs. It provides connection of up to 6 magnitostriectors to one generator permitting use of the device with high-capacity heat-exchange installations.

The device has built-in overload protection with automatic restart (after the abnormal mode is over) and operating-time indication. The working frequency can be adjusted in each channel providing maximum efficiency of magnitostriectors.

The magnitostriector is made of the new material "Diferal" whose manufacture technique is protected by a patent. It features high mechanical strengths and has Curie point at 560°C.

The main function of the generator is production of electric pulses and their transmission to the magnitostriectors. The latter convert electric energy to mechanical one.



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Device type	USP-300 USP-300M	USP-500 USP-500M	USP-900 USP-900M	USP-1000 USP-1000M
Supply voltage, V	220 <sup>+10</sup> -15			
Mains frequency, Hz	50, 60			
Operating frequency range, kHz	18 - 7,5 %			
Power consumption, kV·A	0,25	0,35	0,35	0,45
Number of magnitostriectors, pcs.	2	3	4	6
Operating mode	continuous			
Generator overall dimensions, mm	520x350x200			
Magnitostriector overall dimensions, mm	347x62x57			
Generator mass, kg, maximum	15	19	21	23
Magnitostriector mass, kg, maximum	3,5			
Protection degree of generator/magnitostriector	IP32 / IP40			

### DEVICE INSTALLATION AND ITS PREPARATION FOR WORK

Installation of the device should be performed by the Manufacturer or specially trained personnel.

Prior to installation the heat-exchange equipment should be cleaned of existing scale. Otherwise, the pipes can be clogged up with sludge due to the intense peeling of the scale off the heating surface. This may cause damage to the equipment.

The magnitostriectors are fastened to elements of the heat-exchange equipment by electric welding. The exact place of mounting should be as close as possible to the points of highest calorific intensity, wherein the process of scaling is also most intense. Action on these points provides optimal distribution of ultrasonic energy over the heat-exchange surface and produces maximum effect.

Generally, the welding points of magnitostriectors are found on elements uniting pipe bundles and shields e.g. tube plates, manifolds etc.

The number of magnitostriectors should be chosen based on the design features and parameters of the heat-exchange equipment, such as construction, capacity, the heat-carrier circulation scheme and hardness of the water.

Welding is the most critical operation while mounting the magnitostriector. The quality of welding considerably influences the transfer of energy from the magnitostriector to the heating surface and, consequently, the device efficiency as well as the safety of the heat-exchange equipment.

Welding the magnitostriector to the outer surface of the heat-exchange equipment does not cause any internal damage to the material of its walls since the weld is not exposed to the pressure inside the equipment.

The generator is installed in a horizontal or vertical position providing maximum convenience for maintenance, with the ambient temperature being within -5...+40 °C. It is connected to a single-phase a.c. supply with a frequency of 50 or 60 Hz with a cable protected against mechanical damage. The case of the generator must be thoroughly grounded, the corresponding terminal provided.

The winding of the magnitostriector is connected to the generator with a cable whose cross-section is no less than 1.5 mm<sup>2</sup>. The cable must be protected against mechanical damage and its length must not exceed 10 m. The limitation of the cable length is

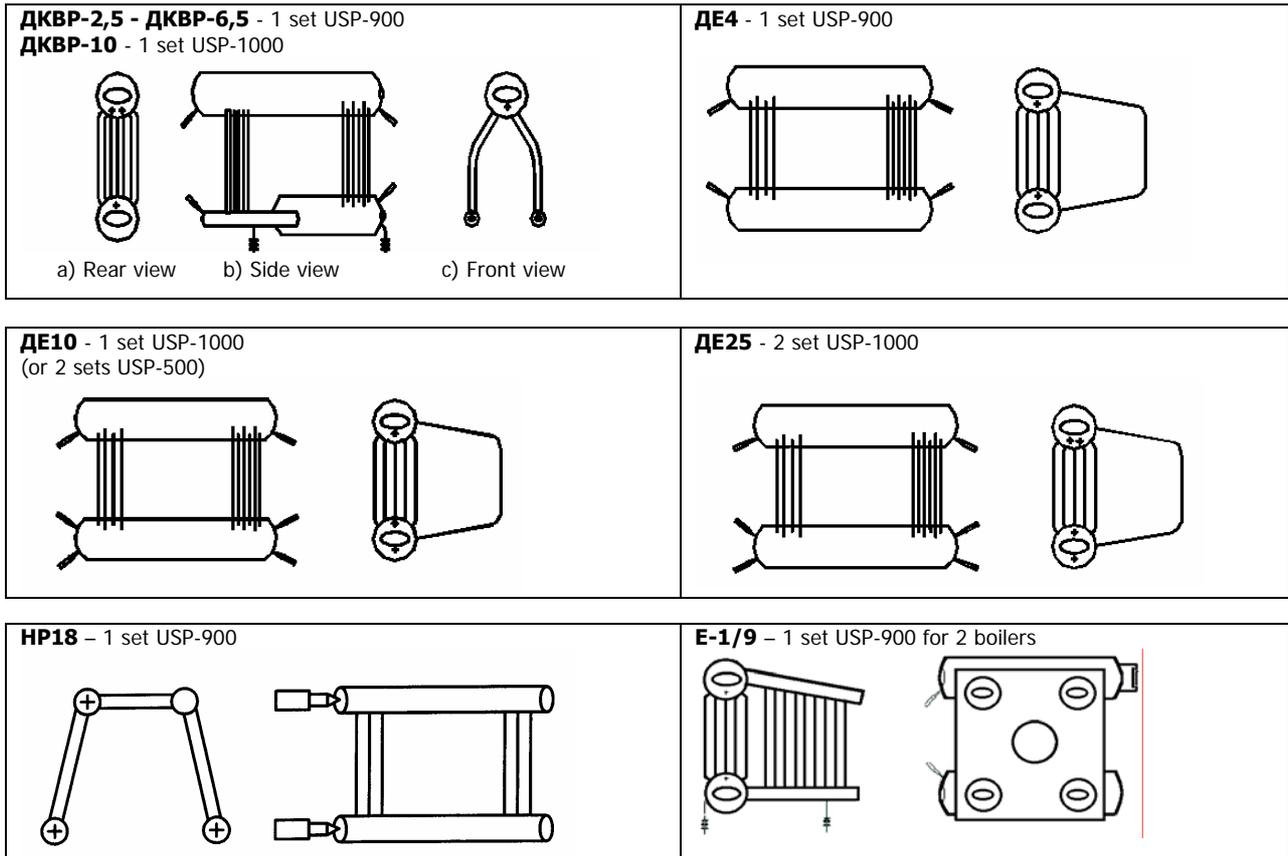
conditioned by rise in losses therein if the length is higher. The wires are connected to the generator via dedicated terminals with marking.

In order to provide the most effective operation of the device the magnetostrictor frequency should be adjusted so that the natural frequency of the system "magnetostrictor-boiler" is equal to that of the electric pulses. Each channel of the generator is adjusted separately to obtain maximum amplitude of oscillations under load.

Some examples of the magnetostrictor location and recommendations concerning the number and type of devices (for water hardness of 5 mg/liter) are shown in the table below. Of course the said examples do not cover all possible mounting ways and equipment designs. The number of magnetostrictors and, consequently, the device version chosen depends on design features and parameters of the heat-exchange equipment, such as construction, capacity, the heat-carrier circulation scheme and hardness of water.

## INSTALLATION EXAMPLES

### Boiler



## Operating Manual

After installation and adjustment the device is at the User's disposal.

1. When operating the device, all relevant safety rules must be observed.
2. Only qualified personnel should be allowed to operate and maintain the device. The personnel should be acquainted with safety rules and the operating manual.
3. Prior to the first switch-on, it should be checked if the device is correctly connected and grounded.
4. Check mains voltage.
5. Turn the device on by moving the switch on the generator to the position "ON". LED indicator "I" should light up.
6. Checkup of the device should be carried out daily with indicators on the front panel of the generator. Condition of the magnetostrictors can be checked by their token sound.

7. Technological Recommendations:

- 7.1. If the heat-exchange equipment is stopped in connection with heating season termination, emergency situation or for maintenance inspection, water should be drained after the boiler and pipes have been cooled down to 50°C. During draining the device can be left working.
- 7.2. After water is drained from the equipment the heating surfaces must be washed with water jet with pressure of 0.2–0.3 MPa. The device can be switched off then.
- 7.3. Not less than once a week, the feeding cables and grounding circuit must be inspected.
- 7.4. If any of them has been found damaged, the personnel must act as follows:
  - turn the generator off by moving switch "Mains" to position "OFF";
  - remedy the fault;
  - move the switch "Mains" to position "ON";
  - make sure that the generator is on by checking the state of the indicators on the generator's front panel.
8. When repairing the heat-exchange equipment or other installations nearby the appropriate measures should be taken to protect the device against mechanical damage and penetration of water.
9. During air blowing of the heat-exchange equipment the corresponding safety rules must be observed.
10. Apart from regular blowings, the boiler should be washed every 1.5-2 months to remove the sludge from the inside.