Bobachev A.A., Bolshakov D.K., Ivanova S.V., Modin I.N., Pervago E.V., Shevnin V.A.

Study of working and projected pipelines with electrical methods.

MSU, Geological faculty, 119899 Moscow, Russia.
Fax: (007-095) -9394963, E-mail: sh@geophys.geol.msu.ru

Proceedings of EAGE 60th Conference, Leipzig - 1998. P127.

Pipelines are the systems of life-support of a modern society. In pipes oil and gas, tap and technical water, water for heating are supplied; household and industrial sewage are removed. The large part of pipes is dipped in ground. At long interaction of pipes with ground the corrosion arises, ground deformations cause stress and strain in pipes, result in fractures' formation. There are many reasons of fractures' formation: damage at digging work, ground deformations, wrong stacking of pipes, non tight connection of different valves and hydrants. To prevent corrosion, cathodic protection of pipes with DC current is applied. At cathodic protection negative potential connects to a pipe, while the positive pole grounds in the surrounding. In places of pipe isolation's infringement electric current flows down from a pipe and protects it from corrosion. The corrosion danger depends on a ground resistivity; the lower is resistivity, the higher is corrosion danger. The ordinary pipes in ground have limited term of operation about 25 years. Many pipes are under high pressure, and contain combustible or toxic substances. The accidents on pipelines occur rather frequently, some bring a huge damage, and their elimination requires large expenses. Replacement of pipes after completion of service life is very expensive operation. Pipelines under operation need constant monitoring over their condition; timely revealing of various damages in pipes and their repairs are necessary.

A separate problem is a leak of water from water supply system. This system is mostly branched. Losses of water do not represent such danger, as leaks of oil or gas do. At the same time the clean water is a valuable product, and its losses result in heavy losses, both direct from loss of water, and indirect, from leaks humidifying surrounding ground. Water leakages from tap water pipenet in the different countries is estimated on different techniques; therefore it seems difficult to compare results. The lowest losses are characteristic of cities in Western Germany - 5 - 10 %. In London its range up 20-25 %, in Rome - 27 %, in Izmir (Turkey) up to 40 %, in China (with the population 1.2 billion) its range up 15-20 %, in Malaysia and on Philippines up to 30 %.

Geophysical methods can help at the decision of many problems of pipes control. The first problem is a trace study for a pipeline construction, particularly in the most crucial places, for example on river crossings. Recently the project has become to be considered as more reliable to stack a pipe under the river in a sub-horizontal borehole, placed in the most safe layer.

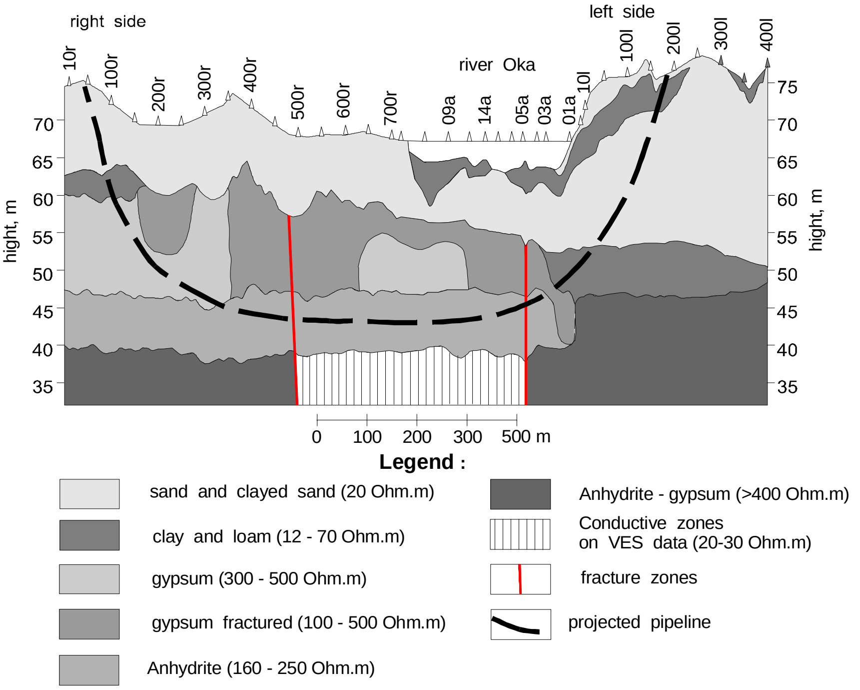

Fig.1. Geological cross-section for the projected pipeline crossing river Oka.

When the stacking of pipes is completed, a number of other problems arise. One of them -- is exact determination of the pipe's site and depth. The actual site can differ from planned at construction. The depth can be changed during stacking. Sometimes at river crossing the pipe laid on river bottom can be covered with loose sediments or outcropped at the bottom. The last situation is dangerous. Soil around a pipe has different degree of corrosion activity. The important problems are the control of cathodic protection, control of pipe areas physically worn out, control of wall thickness, detection of microfractures, leakages from pipe, etc. These are problems of different complexity and therefore geophysical methods' possibilities to decide these problems are different.

At researches in places where pipeline crosses the river a number of aquatorial and land geophysical methods can be used. Among them there are aquatorial seismoacoustics and VES, land studies with a georadar, resistivity sounding (TES technology) and land and aquatorial boreholes drilling. Seismoacoustics gives detailed stratification of the top layers in aquatoria limits. Together with electrical methods it allows to estimate each layer lithology, and to determine a degree of their safety. Land and aquatorial electrical survey allow to connect in a uniform cross-section land and aquatorial studies. On fig.1 a final cross-section drawn on geophysical data and drilling in a place of projected pipeline crossing beneath river Oka in central Russia is shown.

Among methods of pipelines' inspection georadar survey and trace-searchers prevail. On our opinion to these methods resistivity sounding and profiling, self potential method and pipe tracing with magnetic antenna should be added. Magnetic antenna measures electromagnetic field exited in pipe with industrial noise, or cathodic protection or special AC source. The instrument ERA allows to carry out all these studies with the same tool.

The pipes in urban areas are in ground, which surface is closed with asphalt. For pipes study in urban areas non-contact methods are required. With ERA instrument it is possible to fulfill resistivity sounding and profiling on low frequency alternating current without galvanic grounding. For non-contact measurements of electrical field on frequency 4.88 Hz - active electrodes are used, and on frequency 625 Hz - electrical antenna is applied.

For an estimation of a pipe position in plan and on depth studies with magnetic antenna are very convenient. For this purpose it is possible to apply several techniques:

1. Tracing a pipe position on frequency 50 Hz (passive detection). In an environment there is the significant level of noise on frequency 50 Hz from near and distant industrial sources. This EM noise causes occurrence in a pipe induced currents, and anomalous of a magnetic field of frequency 50 Hz occurs above a pipe. At studies of horizontal magnetic field's component with the help of magnetic antenna, directed normally to a pipe axis, maximum of Hy will be observed.

2. If the pipe is under cathodic protection, its detection and tracing can be carried out with the help of a magnetic antenna on frequency 100 Hz. It is more noise-resistant technology.

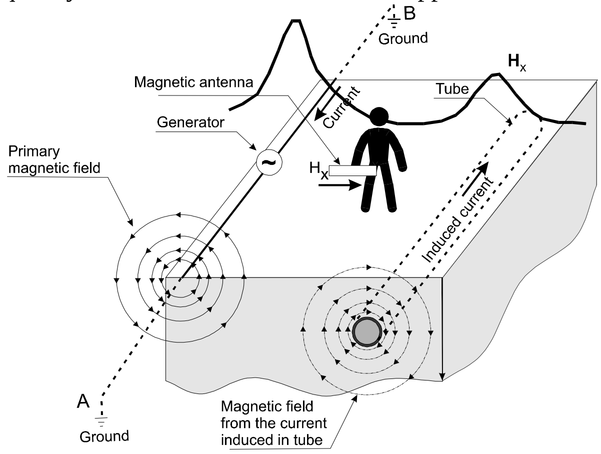

Fig.2. Study of pipe position with magnetic antenna

3. If it is possible to connect of one or two poles of a current line from the generator 625 Hz to the pipe, its tracing is possible with magnetic antenna on frequency 625 Hz.

4. If in parallel the pipe to put wire, with electric current 625 Hz, the pipe exited by this current can be out with the help of a magnetic antenna (fig.2).

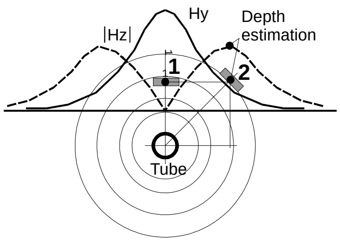

Fig.3. Depth estimation with magnetic antenna

For estimation of pipe depth it is necessary to know a pipe projection on ground surface and its direction. Departing from a pipe normally to it with magnetic antenna inclined under 45° it is possible to receive maximal signal on a distance from the pipe projection equal to the depth of its center. Hz component maximums are at the same distance (fig.3).

References.

1. Kharkovsky K.S. Grounds for application of electrical methods to corrosion study over underground pipelines. Proceedings of international geophysical conference EAGO-EAEG-SEG. "Moscow'97", September 1997. H3.1

2. Electrical profiling with non-grounded working lines. Leningrad, 1985, 96 pp. The authors: A.S.Nahabtcev, B.G.Sapognikov, A.I.Jabluchansky. (In Russian).

3. Electrical prospecting by resistivity method. MSU edition, Moscow, 1994, 160 pp. (In Russian).

4. I.N.Modin, D.K.Bolshakov, B.G.Sapognikov, V.A.Shevnin. Non-contact resistivity measurements. Proceedings of 58-th Annual EAGE conference, 3-7 June 1996, Amsterdam, The Netherlands. P-51.

5. S.V.Dunchevskaya, A.V. Dunchevskiy. Geophysical monitoring of underwater pipelines and presentation of surveyed results. In Proceedings of SEG-EAGE-EAGO conference “Moscow’97”, H4.5.

6. Xian Jun Feng. Technical Research of Leak Control about Chinese Tap water. In book: "Engineering and environmental geophysics for the 21st century". Proceedings of the International Symposium on Engineering and environmental geophysics, Chengdu, China, 1997. P.504-510.