

INTEGRATED DIAGNOSTICS OF BRANCHES OF MAIN GAS PIPELINES

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Exploitation of pipelines on the technical condition ensures optimum spending of funds, necessary for their maintenance and repair. Due to the fact, that service life of many pipelines exceeds the estimated value, meaning and importance of non-destructive testing and technical diagnostics, as well as the economic efficiency of their use only increase.

One of the main areas, developed by our company, is determination of the technical condition of underground pipelines, unprepared for in-line flaw detection. These pipelines include almost all branches of gas pipelines, connection pipes, some sections of main gas pipelines and other objects. Integrated ground-based diagnostics technique of such gas pipelines includes the following steps:

- engineering, executive and operational documentation, as well as the results of previous inspection of the pipeline are studied for the entire period of operation;
- integrated ground-based diagnostics without opening of the pipeline with using electrometric, magnetometric, radio are performed;
- the bore pits are appointed in located potentially dangerous areas by results of the analysis of documentation and ground-based diagnostics;
- diagnostics of the insulating coating, base metal and welded joints is performed in the bore pits, and if necessary mechanical stresses and other physical and mechanical parameters of the metal are measured;
- works on the diagnostics of underground gas pipeline are completed with the report, which includes a list of all defective areas, diagrams, schemas, maps and graphics, calculations of insulating cover's degradation on the entire length of the pipeline, with results of bore pits' screening, findings and actions, necessary to ensure the continued safe operation.

Contactless integrated diagnostics is carried out using ground-based methods, that let get information about the state of gas pipeline's electrochemical protection, the state of insulating cover, the depth of pipes, anomalies in their stress-strain state, gas leaks, as well as landscape-geological changes on the pipeline's route.

Equipment, which allows to determine the electrical parameters of electrochemical protection, the depth of pipes, the degree of electrical protection of the pipeline along its entire length, locations of insulation damage and corrosion-dangerous sections of the pipeline, is used during electrometric inspection.

Magnetometric inspection reveals anomalies in the magnetic field above the pipeline. Magnetic anomalies are formed as a result of magnetoelastic effect in the areas of stress concentration in gas pipeline's steel pipe. Spasmodic change of a magnetic field shows an increased level of stress in the pipeline. This change may indicate the presence of local defect in zones of welded connection or base metal, as well as the presence of extraneous ferromagnetic objects near to the gas pipeline.

Radar screening is carried out using ground penetrating radar on profiles, crossing the axis of the pipeline. It allows to determine the depth and size of underground objects, as well as to assess the engineering-geological features of gas pipeline's route. Radar investigation is carried out if necessary to clarify the results, obtained by other methods, or can be used independently on complex areas of the route.

The arrangement and pipeline's geographic location cartography are carried out with GPS-receiver in characteristic waypoints. Instrumentation (range finders, tape measures, odometers, etc.) is used to refine the field of bore pits' survey concerning local natural and artificial reference points.

Thermal-vision investigation is carried out to assess the state of the pipeline route, violations in the protected zone, to identify the landscape-geological changes, to detect possible gas leaks from indirect signs, such as the change of soil's temperature, the color of vegetation and features of its

growth. Thermal-vision systems, which are placed on the light aircrafts (gliders or helicopters), are used to carry out thermal-vision inspection. Use of pilotless flying machines is possible.

Based on the analysis of operational and engineering documentation and data of the pipeline's contactless integrated diagnostics, places of bore pits' inspections are established in the most dangerous areas. Bore pits' inspection is carried out to assess the state of the insulating coating, the detection of surface and internal defects in pipeline's metal, to assess physical and mechanical properties of base metal and welded joints, caught in a zone of bore pit.

During the investigation of bore pit's insulating coating the thickness of insulation is measured, the state of its surface is assessed, the areas of insulation damage are measured, the degree of insulation's adhesion to the pipe and the presence of moisture under the insulation are determined.

Magnetometric screening of the metal in the bore pits is carried out without removing the insulating cover, thus areas with high mechanical stresses are identified. Additional screening is conducted by other methods at these sites in order to clarify the state.

Visual and measuring control is used during the examination of pipeline's metal in the bore pits. The investigation of base metal reveals the their quantity, depth and total area on open sites.

The purpose of the ultrasonic thickness gauging in the bore pits is to determine the actual thickness of the pipeline's walls and possible bundles in the metal of the tubes. Thickness measurement is carried out in weld zones (if the seam is in the pit-zone), in zones of corrosion damage and on the pipe's perimeter section.

During screening of welded joints in the pits visual and measuring, control, ultrasonic and radiation testing are used, the hardness, coercive force and other parameters are measured.

All the welded joints in the pit are subject to external inspection and measurements to identify surface cracks, corrosion, inflowes, undercuts, burn-through, non-melted craters, fistulas, porosity and other technological defects, displacement of axes and offset edges of connected elements.

Ultrasonic testing of welded joints in pits is carried out to identify the internal and external defects. Ultrasonic testing is the main method of checking their quality. Magnetic, capillary and radiographic methods are used additionally, if necessary.

Magnetic particle and eddy current methods for testing of metal tubes in the pits are used to confirm the results of visual, ultrasonic and magnetometric methods of control.

Measurement of hardness on the tube and in the heat affected zone of welded seams is carried out to determine the physical and mechanical properties of the metal in the pits. The coercive force is determined with coercimeters in the areas of hardness measurements. The measured values of hardness and coercive force should not exceed the allowable value. In need of carrying out of metallographic investigations and application of destructive methods of metal's control, laboratory measurements are carried out on the samples from the emergency reserve of the same grade of steel and/or on the samples, cut from the investigated pipeline.

The integrated monitoring systems are used most effectively on the potentially dangerous parts of pipelines (such as jumpers, the mutual intersection, underwater and road crossings, the geologically active sites). Such systems let control the emergence and development of defects in metal, promptly take measures on repair. Application of these systems lets reduce breakdown susceptibility of responsible pipeline's sites and at the same time save money on repair and replacements of equipment.

To improve the quality of diagnostics and reducing its complexity, our company developed the thermal-vision complex of gas pipelines' air investigation, as well as a diagnostic instrument complex "M-1", having unique technical characteristics. It uses electrometric, magnetometric and other methods simultaneously. Instrument complex "M-1" allows to spend the examination with the step of measurements which is not exceeding 10 cm, that creates new possibilities for detailed examination and periodic monitoring of the depth of the pipeline and the state of insulation, as well as for revealing of zones of magnetic anomalies and binding them on district.

Application of ultrasonic, radiographic, electromagnetic, magnetic, visual and measuring methods of nondestructive testing for definition of defects in the metal, the evaluation of stress-strain state by X-ray and calculated methods, carrying out of laboratory tests of samples help to determine the actual state of the metal, to predict the further damage's progress and to initiate repair activities. Bore pit inspections of connection pipes between gas pipelines and pipelines' mutual intersections are especially difficult and diverse. Almost all modern diagnostic and monitoring are used in carrying out these works.

At diagnostics of crosspieces T-connections, crane components and surrounding areas are subject to 100% flaw detection in the pits. Usually the whole body of the pipe is broken up for non-extended crosspieces (up to 100 m). Comprehensive ground inspection and 100% flaw control in the pits of the T-joints, crane sites and adjacent areas is carried out for extended crosspieces. Diagnostics of areas of mutual intersections and extended crosspieces is made on methods of ground-based inspections, applied to the diagnostics of branches of main gas pipelines.

To quantify the stress-strain state of the structures, significant number of contact methods are used: strain gauges, electromagnetic, magneto-elastic, magneto-anisotropic, acoustic, etc. All these methods of determining stresses in actual practice operation of gas pipelines give different results. Currently we are developing application technique of the X-ray diffractometers to assess the current and residual stress on the most loaded parts of pipelines. Diffractometric X-ray method is the only direct method of determining stresses. From our point of view, the method of X-ray diffraction can be the core for a quantitative estimation of the stress-strain pipelines' state in the field, because it provides reliable information about the stresses in the metal's surface. These are the places, where the most dangerous defects are generated during the operation.

Interest to the application of acoustic emission is growing all over the world. This is the method, that can detect the emergence of the most dangerous defects - cracks. Long-range transducers can cover zones length of at least 10 m. However method application requires to change the workload of the construction to cause the corresponding acoustic signal. Already now the method can be applied in hydro- and pneumatic investigations when they are provided by the documentation. Increased requirements are shown to work of operators-defectoscopists.

It is necessary to provide continuous monitoring of a technical condition of gas pipelines' branches, including using "smart" spots. At a variety of types of defects and places of their origin it is impossible to provide the authentic control of the technical condition of gas pipeline only with one method of nondestructive testing. This problem can be solved by methods of acoustic emission, methods of measurement of design position by means of linear displacement sensors, methods of an estimation of a corrosion condition of structures, based on witness samples and other methods.

In the near future stand-alone automatic shells flaw detectors for pipe-internal diagnostics branches of main gas pipelines of small diameter should be created. At present pipe-internal diagnostics is the primary method of assessing the technical condition of main gas pipelines of large diameter.

Great volume of work on the diagnostics of gas pipelines is necessary on an estimation of a technical condition of pipes during major repairs of the insulating coating (re-insulating). Work on the diagnostics in the process of re-insulating are often held in bad climatic conditions, in the presence of old insulation's traces on the pipe's surface and difficult access of operator-defectoscopist to the pipeline. In these conditions the automatic flaw detectors, based on the acoustic, magnetic and other methods of diagnosis, are required to apply.

In group of magnetic scanning flaw detectors it is necessary to allocate "DNS 1000-1400" (ZAO "GasPriborAvtomatikaServis"), that allows to improve the quality and reliability of pipes' diagnostics without decrease in rates of works on insulation replacement.

In group of ultrasonic scanners it is necessary to allocate "Avtokon-MGTU", designed by NUC "Svarka i kontrol" at the MGTU named by N.E. Bauman. This scanner allows to carry out a diagnostics of full pipe's "body" in the automatic mode. In case of re-insulation its application becomes complicated necessity of thorough training of pipe's surface and application of a contact

liquid. So the future seems appropriate to use the contactless electromagnetic-acoustic method (EMA-method).

Integrated ground-based inspection of gas pipelines is a complex process, that involves experts in the field of nondestructive testing, durability and reliability. However, in many cases, ground diagnostics is the only opportunity to assess the technical state of pipelines, primarily branches of main gas pipelines.

Improving of reliability and durability of branches of main gas pipelines may be in three main directions.

First, it is necessary to improve the physical and mechanical properties of pipe steels and to improve the technology of manufacturing sheets and pipes so, as to prevent the emergence of the origins of defects in the manufacturing process (marks, scratches, micro-cracks, etc.; sites with altered properties of the metal, plastically deformed, with non-metallic inclusions, which differ in structure, chemical composition of metal, etc.). For example, analysis of brakes of gas pipelines and investigation of pipes' defects by non-destructive methods proves, that the stress concentrators and other anomalies, that initiate the growth of stress-corrosion cracks, occurs, as a rule/ at this stage. Therefore it is necessary to strengthen a role of non-destructive testing in the production of pipes, to use new insulating materials, etc.

Secondly, the sensitivity to defects and reliability of the methods and means of non-destructive testing and technical diagnostics in the pipeline operation, including through the creation of new means of intra-tubal diagnostics of small-diameter tubes, monitoring of its technical condition, the development of engineering methods of determination of mechanical stresses, of residual life, the risk of operating, etc. - should be enhanced.

Thirdly, the productivity of the diagnostics in conjunction with the decrease of its complexity, demands increase. It is reached mainly by use of information technologies, mechanization and automation of scanning processes of control objects, the transition to embedded control systems and integrated system of diagnostic monitoring.

Due to extensive experience in solving large scientific and technical problems problems, ZAO NPC "Molniya" can actively participate in organizing and carrying out works to improve the reliability, performance and effectiveness of non-destructive control and technical diagnostics in the oil and gas industry.