Research and Development Center “Transkor-K“

PIPELINES DIAGNOSTICS BY THE NON-CONTACT MAGNETIC TOMOGRAPHY METHOD

PIPELINE DIRECTION FINDERS

DIAGNOSTICS FACILITIES

CORROSION AND ECOLOGICAL MONITORING
Our enterprise positions itself as a leader in the field of development and innovation of advanced methods for technical diagnostics and non-destructive testing, in particular the technology of magnetic tomography.

Limited Liability Company “Research and Development Centre “Transskor-K” was founded in 2001 by a group of specialists of OAO “VNIIST”, the Ministry of the Power Generating Industry RF, with previous long-term experience in the field of pipeline transport.

The founders and specialists of the R&D Centre took direct part in working out some normative and methodical documents for oil and gas industry RF, regulating diagnostic inspection of pipelines with application of advanced methods (non-contact magnetic testing, assessment of corrosive aggressiveness taking into consideration factors of bio-corrosion). The R&D Centre is well known in Russia as an enterprise with highly qualified specialists and great potentiality enable to realize unique projects on technical diagnostics on the basis of application of proprietary new generation technology and devices.

The main field of activity is the development – manufacture – introduction into practice the unique non-contact system of non-destructive testing of pipelines by applying THE MAGNETIC TOMOGRAPHY METHOD, and also industrial objects safety expertise.

For the last 3 years our technology of metal pipeline diagnostics has passed the large-scale industrial approbation at the objects of OAO “Gasprom”; OAO AK “Transnefteproduct”; AK “Uztransgas”; OAO “Lukoil” in over-all extent more than - 9 000 km.
**The R&D Centre is an expert organization of Gosgortekhnadzor RF and Gosstroy RF** (Federal Committee for Mining & Industrial Supervision RF, Federal Committee for Construction Supervision RF); **is accredited by the Ministry of Industry, Science and Technology RF as a research organization**, is a member of the Russian Non-Destructive Testing and Technical Diagnostics Society and Moscow Chamber of Trade and Commerce.

**The Quality management system of the R&D Center** is certified according to **ISO 9001: 2000**.

The inventions of **the R&D Centre** are protected by the **Patents** of the Russian Federation; are awarded **the Gold Medal** at the International Invention Show in Geneva (Switzerland, 1999), at the Exhibition "Flaw detection 2002" in Barcelona (Spain), **the Silver Medal** at the "Arhimed-2004" Industrial Property Saloon in Moscow (Russia), **the Diploma** "For the best Domestic development in the field of pipeline Systems diagnostics" at the Exhibition "Pipeline systems. Repair. Redesign. Construction" (Moscow, November 2003), **the Diploma** from the Moscow Mayor Yuri Luzhkov at the 5-th Forum "High Tech of the XXI century " (Moscow – 2004), **the Diploma** at the International Fair in Zagreb (Croatia, 2004), at the Conference of the British Institute of Non-Destructive Testing (Torqway, UK, 2004), **the Diploma** at the International Exhibition “Russia – a partner of Germany (Hannover-2005). **the Silver Medal** at the International Summit of Innovation in Brussel “EUREKA-2005”.
Development of principally new devices and software programs to carry out diagnostics of technical and ecological condition of oil and gas industry objects, municipal pipeline systems; and carrying out the expert examination by the mentioned unique means: for the last 3 years – more than 8 000 km! The R&D Centre possesses its own auto-transport (mobility) and a system of mobile phones and means of satellite communication for field teams.

Research Activity

- in the field of materials science: the methods of non-contact non-destructive testing and flaw detecting not having analogues; determination of corrosive and bio-corrosive strength of metal and polymeric coatings, metal science research;

- corrosion testing: physics-chemical, bio-chemical, microbiological research targeting quantitative assessment of medium aggressiveness as regards underground metal constructions;

- ecological research: in the field of soil science, geology, cartography, ecology, micro-biology, geo-physics targeting study of anthropogenic and technological influence degree upon natural ecosystems.

- development of software programs and mathematical models for expert systems in the field of technical and ecological diagnostics of an object condition;

- development of normative and methodical documents;

- carrying out strength calculations of equipment and pipeline systems; safe operation term and maximum admissible safe working pressure in a faulty pipeline in accordance with internationally accredited and specifically developed methodic and agreed with domestic Technical Documentation;

- Innovation activity
1. **Technical diagnostics:** of main, field and technological oil/gas pipelines; gas, heat and water municipal pipe systems; product pipelines; pipes and facilities of steel and cast iron pipelines; gas boiler facilities; technological lines and assembly facilities; gas-burner units; tank and flowing-type water-heaters; industrial furnaces; technical devices for oil extraction production; tanks made of ferromagnetic materials.

2. **Non-destructive testing:** of main, field and technological oil/gas pipelines; gas, heat and water municipal pipe systems; product pipelines; pipes and facilities of steel and cast iron pipelines; gas boiler facilities; technological lines and assembly facilities; gas-burner units; tank and flowing-type water-heaters; industrial furnaces; technical devices for oil extraction production; tanks made of ferromagnetic materials.

3. **Industrial safety expertise:** of pipelines, boiler facilities, technological lines, units, technological assembly facilities and tanks made of ferromagnetic materials at:
   - oil and gas industry objects;
   - gas supply objects operating on natural and liquefied gas;
   - pump, gas distributing and compressor stations;
   - storage tank stations.
Specialists of the R&D Centre among which are 12 Candidates of sciences and 2 Doctors, have published in total more than 150 scientific works and are authors of more than 20 inventions, have passed training and are certificated as Experts SEPB (Industrial Safety Expertise System), have Qualification Certificates in the field of non-destructive testing NDT and Management Quality System ISO. The junior specialists of the R&D Centre are preparing for Ph.D. thesis presentation in Moscow State University, Russian State Oil & Gas University and other competent institutes with scientific specialization corresponding to the R&D Centre activity. The R&D Centre is a member of the Russian Non-Destructive Testing and Technical Diagnostics Society and Moscow Chamber of Trade and Commerce. The Quality management system of the R&D Center is certified by IQNet and Certification Association “Russian Register” according to ISO 9001: 2000.
ИТЦ «Транскор» с высоким качеством работ и надежного поставщика диагностического оборудования, отвечающего требованиям условий труда и культуру командной работы.
The R&D Center possesses methodical, normative, technical documentation and devises - equipment foundation to proper carrying out the complex non-contact diagnostics of technical condition of underground and riverbed pipelines made of ferromagnetic materials – on the basis of magnetic tomography method.

Our technology is regulated by RD 102-008-2002 (Management Directive) and means the application of a range of advanced devices to identifying the location, type and degree of defects caused the anomaly of a pipeline magnetic field.

The devises allow:

Carrying out in semiautomatic mode the non-destructive testing of pipeline metal technical condition and its insulating coating condition – in 100% volume;

The danger of faulty sections is evaluated depending on the degree of stress concentration in anomaly areas, determining:

- Magnetic anomaly degree:
  - 3
  - 2
  - 1

- Metal condition category:
  - Good
  - Admissible
  - Inadmissible

Recommendation on faulty sections safety increase:

- Monitoring without repair
- Scheduled repair
- Top-priority repair
A comparison between in-pipe and non-contact metal defect detections was carried out at OOO “Bashtransgas” OAO “GASPROM” object on the basis of two in-pipe examinations and a non-contact magnetometer diagnostics according to our technology.

The identification of the metal defects revealed in check-pits that were open according to the results of the in-pipe diagnostics demonstrated the following reliability of detection (% coincidence of actual metal condition with prognosis data):

- **In-pipe inspection** - 61 % (or 17 from 28 forecasted); at that in 39 % (11 from 28) the faulty insulation coating with insignificant general metal corrosion was subject to repair; that is the portion of dangerous defects among the detected ones totaled to a bit more than 20%.

- **Non-contact magnetometer inspection** – 89% (or 25 from 28 forecasted); at that the portion of the detected emergent defects subject to repair totaled to 63% (19 from 30).

According to the results of works executed to AK “Uztransgas” - our main Customer in 2003-2004 (6 000 km), an overhaul repair is being carried out on the basis of the Normative document developed by the R&D Center and approved by Gosgortekhnadzor of the Republic of Uzbekistan (Federal Committee for Mining and Industrial Supervision). The reliability of detection on the basis of defect identification in 110 checking-pits totaled to 93%; the metal defects related to local corrosion under delaminated insulation coating prevailed. Among the revealed defects 36% are the defects of rejection type and subject to repair by pipes replacement.

The application of our technology approved by national structures of Gosgortekhnadzor is widely proceeded in the Republic of Uzbekistan, Belarussia, Arab Republic of Syria, Croatia, Argentina, UK, USA.
Effectiveness of Method
(upon the verification in 150 checking pits)

- 100% volume diagnostics of objects not subject to the in-pipe inspection — WITHOUT PREPARING for diagnostics,
- Reliability of metal defects detection is not less than 90%,
- 5-10 times reduction of the opening-up works volume,
- Complete diagnostics and additional flaw detection testing (AFDT) within short term: 6,000 km during 13 months.
Non-contact inspection cost is at least half as much than in-line inspection cost because there is no preparation of pipeline to the inspection.

Annual volume of innovations – not less than 20,000 km and up to 80% of pipelines in Russia are not subject to in-line inspection.

Economical effect = \( \sum \) direct effect (inspection cost) + effect of pipeline faults preventing...
MAGNETIC TOMOGRAPHY
OF PIPELINES TECHNICAL CONDITION

There were developed devices for complex non-contact inspection and industrial safety examination of any pipeline made of ferromagnetic material according to RD 102-008-2002 “Directions for diagnostics of pipeline technical condition by non-contact magnetometric method”, M., AO VNIIST, 2003, coordinated with Gosgortehnadzor of the RF.

The software for pipeline efficiency estimation on the basis of non-contact examination data was created (calculation of allowable operation pressure, trouble-free operation period).

Volume of works done by a new technology – more than 8000 km!

Defects of base metal and welded joints are revealed owing to automatic recording of magnetic field anomalies during all-extent pipeline examination (100%) and the distance between a pipe and a device is up to 15 pipe diameters. Longitudinal, angular GPS-coordinates, danger degree and nature of defects are found. Reliability of metal defects detection in the process of non-contact magnetometric inspection is comparable with in-line inspection data. According to the data received in the open test pits the reliability is up to 89% at OOO “Bashtransgaz” objects, at OAO “Tatneft” oil pipeline and main gas-lines of AK “Uztransgaz” that are not subject to in-line inspection – more than 90%.

Aims of diagnostics inspection
- Industrial safety examination; detecting of pipeline sections with metal defects of any nature without opening of a pipeline (from earth surface) and without preparation to the inspection (in usual mode of pipeline operation);
- Type definition and hazard assessment of corrosion defects (pits, groove corrosion), mechanical damages (dents, corrugations, etc.), crack-like defects, stress corrosion cracking and technological defects of base metal and welded joints of metalwork according to relative indices of stress concentration level.
- Revealing of reasons and estimation of rates of local corrosion process including biocorrosion (microbiological factor taken into account).
- Corrosion forecast and integral estimate of insulation coating protective properties (including that which lost adhesion) by non-contact method of currents measurement.
- Estimation of defected pipe sections efficiency with calculation of trouble-free operation period and allowable operation pressure;
- Corrosion inhibitor and bactericide efficiency assessment with the use of non-contact monitoring, expert assessment of declared inhibitor properties, conclusion about inhibitor protection necessity;
- Working out an anticorrosion activity and mode of operation of inspected object
- Technical and economical examination of metalwork condition for damage risk insurance of hazard industrial unit;
- Information support for optimum administrative decisions about maintenance and overhaul of pipelines.

Technical facilities of non-contact diagnostics

Our organization elaborating and producing several devices for complex diagnostics:
- Portable pipeline detectors with built-in generator “Poisk/AMC” and “Nautilus” (riverbed pipeline, shelf) single out differentially a unit of inspection that is situated at the distance not more than 40 cm from other pipelines in common lane;
- Non-contact scanning magnetometer MBS-04 “SKIF” automatically records magnetic field parameters for revealing anomalies caused by defects of metal and insulation coating;
- portable electronic device for distance measuring on a greatly rugged terrain “ODA-01” makes location of defected pipe sections more easy;
- computerized expert system “ECOLOG-3” is intended for quantitative assessment of medium corrosiveness taking into consideration biocorrosion factors, and for ecological audit;
- acoustic searching complex device “ECHO” is used for location of stuck cleaning pigs, diagnostic tools, sites of pipeline cross-section reduction (paraffin deposits, air locks), leaks by non-contact method.

Advantages of non-contact magnetic tomography method

1. Suitable for non-piggable pipelines (that demand pig traps, markers…)
2. There is no need in preparatory work before the inspection (cleaning, run of geometrical tool) and a mode of operation change.
3. It doesn’t need magnetization of metal.
4. Different types of defects can be detected including longitudinal crack-like defects, defects of base metal and welds.
5. No limits to diameters of inspected pipelines (any cross-section) and to details of construction (bends, pipe wall thickness, sort of product, operating pressure, etc).
6. It is convenient for monitoring and data base filling in for pipelines certification as the inspection is carried out at any distance along the pipeline and with any minimal periodicity.
7. It permits considerable decrease of time of complete working cycle.
8. It guarantees minimal demand for Customer’s resources in course of preparatory works.

Our Center is certificated in Quality Management System ISO 9001:200
Municipal service pipelines

Special system for distance measuring

- Unique route finder

Corrosion under insulation coating of gas pipeline GUP “Mosoblgas”

60% of pipe wall thickness Ø 530×8 mm
Our method of pipeline technical condition diagnostics

Underground and underwater pipelines technical condition estimation technology (including pipelines that are not subject to in-line inspection) using MAGNETIC TOMOGRAPHY METHOD by NON-CONTACT SKANNING DEVICE MAGNETOMETER SKIF-MBS allows to reveal location (in longitudinal, angular and absolute geographical coordinates), type of defect and danger degree of pipeline sections with defects of metal. The method is based on registration of magnetic intensity anomalies in the zones with stress concentrators caused by mechanical loads or changes of metal structure. Defects of base metal and metal of welded joints can be detected (“metal loss” – internal and external corrosion; geometry changes; crack-like defects; “discontinuity” – delamination, non-metallic inclusions; weld defects; stress-deformed condition anomalies – pipe deformation on the sections with sag and soil slip).

Defects exposure is comparable with in-line inspection results and is not less than 80%.

Non-contact inspection is regulated by MD 102-008-2002 “Directions for diagnostics of pipeline technical condition by non-contact magnetometric method”, OAO VNIIST, 2003, coordinated with Gosgortehnadzor of the RF. Software of R&DC Transkor-K allows to estimate quantitatively the efficiency of pipeline sections with defects on the basis of calculations of allowable operation pressure and trouble-free operation period.

**This method enables:**

- to reveal defects of pipe metal from the earth surface (without opening of a pipe) in linear and angular coordinates with accuracy up to 1,5 m, type and danger degree of defects;
- to determine a nature of pipeline metal defects; to estimate the danger of pipeline metal defects; to forecast corrosion behavior, to monitor growth of defects on sections of any length, to create a data base on its actual technical status;
- to perform pipeline systems certification, introduce data on the detected flow location in the absolute geographic coordinate system (GPS), to examine a pipeline of any diameter with the rate up to 15 km/day by a team of 2 operators without changing of operation mode and without preparation of pipeline.
Types of faults to be detected: crack-like flows (lap, rolling skin, guide marks, stress corrosion cracking, delamination); weld faults, pipe wall thickness alterations (local corrosion pits, groove corrosion); compression marks, corrugations; deviation from the design laying axle, general level of stresses on a pipeline section.

- **Minimal length of the crack-like defects to be detected:** from 10 mm
- **Extension of defects to be detected:** 300 micro micron
- **Depth of defects to be detected:** starting with 5% up to 90% of wall thickness

Dimensioning errors:
- - pipe wall thickness loss 25%

Requirements to inspected surface: detection of defects and pipe section area change in in-service state with insulation coating and in the presence of bulk corrosion products.

Detection rate: up to 2 m/sec

Distance between the magnetometer and the pipeline (axle deviation, laying depth): up to 20 pipe diameters, dependent on operating pressure. Magnetometer design enables to track pipeline axle and laying depth.

Data logging: initial information is displayed in the control panel and recorded in the device memory with 0.25-0.5-m spacing. Memory size is sufficient to record data on a 30-km route. Initial data processing for magnetic anomalies indication is performed in real-time mode.

- Operating temperature range: from -15 °C to + 40 °C
- Diameter of a pipeline to be examined: 56 ÷ 1420 mm
- Pipe wall thickness: 2,8 ... 30 mm
- Protection class of external casing: IP-66
- Weight of device: 4.5 kr
- Power supply: PS1212 storage batteries or similar, 9 – 24-V external constant-current source
- Continuous run time: 8 hours at least
MAGNETIC TOMOGRAPHY TECHNOLOGY. PURPOSES. INITIAL REQUIREMENTS TO THE INSPECTION QUALITY. REQUIREMENTS TO THE METHOD, EQUIPMENT AND THE SOFTWARE.

Declaration of magnetic tomography purposes:

To provide the quality of the pipeline inspection, Research and Development Center “Transkor-K” has formulated the list of the positions postulating the necessary requirements based on the rules of the authoritative international organization «Pipeline Operator Forum» POF standard: «Specifications and requirements for intelligent pig inspection of pipelines» Version 3.0.1, 2004.

The magnetic tomography method, the software and the equipment aims at:

- non-contact continuous inspection of all pipeline extent (in 100 % volume) for revealing pipeline sections with defects which have arisen owing to the reject of manufacture or under affecting of operational factors of any nature:
  - geometrical (corrugations, dents, ovality),
  - corrosive or structural and mechanical changes,
  that is actually the flaw detection and determination of faulty sections coordinates (longitudinal, angular, GPS-coordinate) with accuracy ± 1,5 m;
- programm interpretation of the data for determination of type and hazard extent of defects, such, as:
  - «metal loss» owing to internal and/or external corrosion;
  - «discontinuity» (delamination, non-metallic inclusion);
  - «crack-like defects» of any orientation (risks, stress cracking);
  - welded joints defects;
  - geometry changes (corrugations, dents, ovality);
  - anomalies of distribution of stress-deformed condition on pipeline sections with sag, flexure, soil slip phenomena, etc.;

- estimation of pipeline sections technical condition and ranking of hazard extent of the revealed defects by programm calculated complex parameter \( F \) of magnetic anomaly - the magnitude of a stress concentrator reflecting correlation of mechanical stresses (levels of stress-deformed condition or magnitudes of local concentrators) with parameters of magnetic field in the vicinity of defects. Anomalies estimation on the ranks "3", "2" and "1" corresponding to "good", "allowable" and "inadmissible" class of technical condition.
- Faulty sections serviceability estimation on the baseline of calculations of TFOP (trouble-free operating period of time) and \( P_{adm} \).
**Requirements to the quality of control by magnetic tomography method**

- completeness of the initial information recording by a semi-automatic regime of measurements;
- speed of data processing;
- customer orientation;
- completeness of data acquisition concerning the parameters of technical condition - conducting of expert inspection aimed at selection of criteria of marginal state approach,
- adjustment of programm calculations «to installation»;
- uninterrupted perfection of the method efficiency in course of new knowledge accumulation;
- system interface (entering into a database of complex inspection). For example, during the inspection of ground constructions and transitions the device SKIF MBS-04 by means of the special menu provides the combination of the situational affixements with indications of the path-control transducer of the way of this device (odometer) in order to the subsequent automatic producing of the Inspection Report.

**Requirements for technical facilities of magnetic tomography inspection**

Requirements are generated on the basis of rules of the standard of the authoritative international organization «Pipeline Operator Forum» POF «Specifications and requirements for intelligent pig inspection of pipelines», and also - regarding the control of stress-deformed condition - positions of item 3.2., 3.3. of GOST P 52330-2005 «Non-destructive testing. Stress-strained state tests on industrial objects and transport. General requirements ».

Requirement of principle, according to item 3.2.-3.3. of the pointed standard, is inadmissibility of preliminary magnetization: «Physical methods and facilities of NDT should not influence on the magnitudes and character of internal (native and working) mechanical stresses distribution in the studied metal of the object of control, developed during its manufacture or maintenance».

Specification of non-contact scanning magnetometer “SKIF” of MBS-04 series (developed by R&DC “Transkor-K”) according to POF requirements is instanced below. The specification is given during a tender period to estimate the technical possibilities of R&DC Transkor-K equipment and to estimate them comparatively with other applicants equipment.