DIAGNOSTICS SYSTEM OF JSC GAZPROM’S GAS MAINS

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ABSTRACT

An efficient system of gas pipeline diagnostics and monitoring allows using the resource base at maximum and maintaining a high level of the gas transmission system reliability. An approach like this helps prevent failures, prolong the pipeline service life, allocate resources at best and cut operational costs. The modern inspection system ensures reliable operation of JSC Gazprom’s gas pipelines through timely detection, analysis and ranking of defects and appropriate managerial and technical decision-making.

Said system is particularly important for the gas mains in operation beyond their design service life since their operation is accompanied by a high probability of failures leading to considerable environmental impacts.

Over the past decade stress-corrosion cracking (SCC) has been one of the factors determining the technical condition of Russian 1,020-1,420 mm gas mains. While in the early 1990s the geography of SCC spreads was limited to northern sections of the gas transmission system, in the late 1990s SCC-related accidents started taking place in Western Siberia, the Ural region and the country’s central regions. In that situation SCC diagnostics became a priority in ensuring gas transmission facilities reliability.

Providing reliable operation of Gazprom’s pipelines by developing the system of diagnostics is a multifaceted problem that can only be solved through a comprehensive and integrated approach to existing innovations.

At present Gazprom pays much attention to developing in-line inspection (ILI) methods, which allow the Company to efficiently detect pipeline flaws along 100-120 km sections. Applying progressive ILI technologies leads to lower operational costs and higher operational security since it enables to give a prompt and reliable quantitative assessment of the pipeline technical condition, based on which repair tools & procedures and defect elimination steps are identified. In-tube diagnostics is also a major SCC detection method. In this regard, optimizing ILI technologies and enhancing their reliability is becoming a top priority challenge of the nearest future. The results achieved in the ILI sector encompass the development of:

- innovative high-efficiency corrosion detectors being the most reliable flaw detection devices used for the inspection of 1,420, 1,220, 1,020 and 720 mm gas mains;
- specialized SCC tools;
- improved control technologies including bypass systems allowing to regulate the control speed;
- automated in-tube diagnostics systems for compressor stations.
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1. INTRODUCTION

Worldwide practices show that diagnostics is an integral part of the gas transmission infrastructure maintenance. Reliable gas transmission to domestic and foreign consumers can be achieved only provided the technical condition is regularly inspected and trustworthy scenarios are generated.

Overhaul, recoating and preventive maintenance & repair schedules as well as scientifically and technically underpinned assessments of transmission infrastructure life span are prepared based on the data obtained through the inspection process.

Diagnostics of gas transmission facilities makes it possible to switch over to their operation in accordance with their actual technical condition.

Given an extended life span of most gas transmission facilities worth of a total of RUR 4.5 trln, the bulk of these facilities should be decommissioned and written off unless appropriate inspection and rehabilitation steps are taken.

The rules of gas transmission infrastructure diagnostics are set out in a number of legal acts and various state and industry documents primarily including the:

- Federal Law on the Technical Regulation from December 27, 2002;
- Federal Law on the Industrial Safety of Hazardous Production Facilities from June 20, 1997;

2. ORGANIZATIONAL STRUCTURE OF GAS MAIN DIAGNOSTICS

Based on the domestic and international experience of gas pipeline operation and research in the diagnostics sector, Gazprom has developed a Provision on the Comprehensive Inspection of the Transmission Part of the United Gas Transmission System (UGTS) Pipelines.

The organizational structure of gas main diagnostics is based on a centralized control system.

The main organizational tasks during the diagnostics process include:

- preparing consolidated inspection schedules based on the technical condition analysis and pertinent requests;
- exercising general control over diagnostic activities and arranging for the development of industry inspection tools;
- collecting and colligating information within a central database;
- providing a comprehensive analysis and forecast for the gas main technical condition.

The pipeline diagnostics process encompasses the following inspection types:

- In-line inspection;
- underwater crossing diagnostics;
- electrometric examination;
- aerial diagnostics involving helicopters;
- gas distribution station diagnostics;
- inspection aimed at extending the pipeline service life.

3. IN-LINE INSPECTION

Being the most efficient and informative method of diagnostics, in-line inspection (ILI) is a key component of the gas main diagnostics system. Recent years have seen a considerable increase in the flaw detector capacity. At present all fault finders (intelligent pigs) used by Gazprom belong to a high resolution class and have a strong potential for detecting and identifying various defects.
Whereas in the 1990s ILI primarily pursued the objective of detecting corrosion-related defects, after the year 2000 nearly all inspections were performed with the use of a full set of fault finding equipment allowing to detect all kinds of defects including longitudinal and transverse cracking.

![Image of ILI equipment](image)

**Fig. 1. The Russian made set of ILI equipment**

The Russian made set of ILI equipment includes a cleaning pig (SO), a magnetic cleaning pig (MOP), an electronic profiler (PRT), longitudinal (DMT) and traversal (DMTP) magnetization pigs (Fig. 1).

At present a substantial increase in the ILI quality has primarily led to the considerable minimization of accident risks driven by corrosion and stress corrosion.

It should be noted, however, that while magnetic intelligent pigs don’t detect 100% of defects, their use helped eliminate thousands of dangerous flaws, which could’ve led to failures, and that is an indication of the inspection efficiency.

Given that the recent growth of gas supply has intensified the pipeline operation, equipping intelligent pigs with bypass devices, which allow performing ILI without alterations in the gas transmission profile, is a pre-requisite for the present-day pipeline in-tube inspection.

From 2005 ILI has been performed only by intelligent pigs with regulated speed.

In our opinion, streamlining in-tube diagnostics activities should mainly include:

- improving the pig speed regulation system for the purpose of ensuring its operability under any gas transmission profile;
- detecting all types of flaws within a single pig run;
- increasing diagnostics efficiency by a consistent analysis of ILI, electrometric and other data;
- optimizing and varying ILI cycles based on stress-corrosion development velocity and operation risks forecasts.

### 4. UNDERWATER CROSSING DIAGNOSTICS

Underwater crossings are among the most potentially risky sections of the gas main system. Special standards should be applied to their operation since the repair and rehabilitation of crossings require considerable material and financial resources.

To determine the technical condition of underwater crossings, Gazprom has developed instrument sets that are widely used by all its gas transmission affiliates.

These instrument sets include:

- acoustic and electrometric modules;
- a side-scanning sonar;
- a navigation system;
- layout search equipment.

The instrument sets give an opportunity to promptly obtain adequate and precise online information on the technical condition of a pipeline underwater section, namely:

- to determine the pipeline 3D position;
- to detect and forecast the pipeline wash-outs and loose parts;
- to perform an instrumental hardware monitoring during the pipeline reconstruction and overhaul period;
- to identify the pipeline burying depth and conditions;
- to detect places with potentially damaged insulation;
- to investigate the bottom profile and microforms;
- to perform a geodetic survey for the pipeline route and damaged places.

There are 834 various-sized underwater crossings with 1,734 lines in the gas transmission system. Such a considerable number of pipelines with unequal cross sections have long been a serious obstacle for the in-tube diagnostics evolution. At present the development of unequal pipeline diagnostics technologies is accompanied by the continuous expansion of underwater crossing ILI scope.

Two flaws have been eliminated by cutting-in spools with the use of a caisson chamber. The timely detection of defects through ILI methods and scheduled repairs save considerable resources.

Nowadays great attention is paid to the hydrological characteristics of crossings as well as to the transformation of the river floor and banks with the view of giving substantiated recommendations on the crossings protection and river canalization.

Considering that most gas mains are unfit for in-tube diagnostics, new types of on-site and aerial inspection are being aggressively developed.

Since 2005 successfully tested automated monitoring systems have been installed at the most important river and road crossings. The systems are used by compressor station operators to execute remote control over crossings.

The method of noncontact magnetic diagnostics has a widespread application. It offers the opportunity of executing control without direct access to the facility under inspection and without changes in pipeline operation.

**5. OTHER TYPES OF ON-SITE INSPECTION**

Electrometric measurements remain a major inspection type for the pipelines unprepared for in-tube diagnostics.

With an identical amount of electrometric inspections performed in 1998 and in 2002, the total length of pipeline sections with damaged insulation has increased. To that end Gazprom has timely adopted a Program aimed at re-insulating separate pipeline sections.

Since 1998 the Company has been performing on-site stress corrosion diagnostics for the pipelines not equipped with pig receivers and launchers including the ones in extended pits. From 1998 to 2003 five thousand kilometers of pipelines were inspected with stress-corrosion faults found.

When implementing its Measures for Higher UGTS Resistance to Failures Gazprom performs pipeline inspections using laser and thermal imaging devices installed on helicopters. Said inspections are performed to solve the following tasks:

- control leakages;
- control the pipe geometry and assess its stress/strain;
- control the pipeline laying depth;
- detect flood and swamp zones along pipeline routes;
- control security zones.

“Intellectual insertions” equipped with strain-gauge sensors are installed in potentially dangerous areas (landsides, karsts) to monitor stress/strain conditions.

Special techniques have been developed to select a certain location for the installation of intellectual insertions in areas with tectonic processes and landslides. These techniques were first probed at the onshore section of the Russia–Turkey pipeline.

The development of nondestructive control technologies has recently lead to new sci-tech discoveries allowing to implement a new waveguide inspection method. The waveguide method is the only way of inspecting of the pipeline elements which are hard or impossible to reach. These elements include motor or railroad crossings, river crossings and compressor station piping with complex configuration.

The waveguide control method is a kind of acoustic logging. It is based on the propagation of low-frequency acoustic vibrations (20-100 kHz) within pipeline walls in the axial direction over a long distance (up to 100 meters). Flaws are detected with a transmission device (aerial system) mounted on a pipe, which generates an ultrasonic pulsed signal traveling freely in the axial direction along the pipe body. If an ultrasonic signal localizes a crack, wall thinning, lamination or other degradation of metal integrity, part of the wave energy is reflected in the reverse direction and registered by the receiving device. The distance between the receiving device and the fault area is determined by the delay time, and the defect size is measured by the signal amplitude.

According to preliminary estimates, the waveguide method allows to locate faults with the equivalent cross-section area exceeding 5% of the waveguide’s section area.

One of the most promising methods of detecting stress-corrosion is the impedance spectroscopy permitting to determine the pipeline technical condition and wrapping lamination. The procedure assumes sounding of the pipeline from the ground surface by alternating currents of broad-spectrum frequencies to define the wrapping condition and the areas of film insulation delaminating from the pipeline body. This method was tested at Volgotransgaz and Mostransgaz pipelines, which resulted in the development of practical recommendations to use the method for detecting wrapping defects.

6. GAS DISTRIBUTION STATION (GDS) DIAGNOSTICS

Due to a considerable service life Gazprom’s gas distribution stations undergo regular inspections. Continuously upgraded, inspection technique and tools help detect the pipeline and GDS equipment defects, ensuring, thus, their safe operation.

Over the entire period of diagnostics, inspections have been performed at more than 2,200 gas distribution stations, with various flaws (including wall thickness, weld joint faults etc.) detected. Inspection results allow gas transmission companies to draw up technically viable schedules for the overhaul and reconstruction of gas distribution stations.

In accordance with the requirements of the Federal Law on the Industrial Safety of Potentially Hazardous Industrial Facilities, the pipeline life span extension is one of the most crucial challenges.

In 2001 Gazprom developed and approved the Provision on the Gas Main Life Span Extension Rules embracing a whole set of administrative and technical measures on diagnostics and expert examination of pipelines. At the same time the Company developed the Regulations on the Prolongation of Gazprom’s Gas Main Safe Operation.

Pipeline inspection and tests have showed that there is no considerable metal degradation within forty or more years of operation. That is why the pipeline life span is mainly dependent on the defect nature & parameters and the stress level.
To ensure reliable operation of its gas mains, Gazprom performs a range of sophisticated diagnostic activities that include:

- developing and introducing instrument devices and inspection technologies;
- examining the pipeline technical condition;
- conducting trial survey of the pipeline reliability and life span;
- developing regulatory and technical documents and automated data systems.

Fulfilling these tasks along with performing necessary overhaul, recoating and reconstruction activities allows Gazprom to supply scheduled volumes of sustained natural gas deliveries to domestic and foreign consumers, and to fulfill promising plans aimed at boosting gas supplies.

7. CONCLUSION

The above analysis of gas mains shows that in view of the pipeline diagnostics system development Gazprom’s gas transmission system reliability is in line with European and US standards.

ILI remains and will be a major flaw detection method in the nearest future. The high efficiency of this diagnostics method has allowed to inspect 67 thousand km of pipelines in 2001-2004 time period, including 35 thousand km examined by stress-corrosion flaw detectors. That is why within the pipeline diagnostics system development a major focus is being placed on improving ILI technologies and tools, namely information capacity, uniqueness (pipeline positioning, longitudinal and traverse flaw detection) and technological efficiency.

8. LIST OF FIGURES

Fig. 1. The Russian made set of ILI equipment