

MAGNETOMETRIC DIAGNOSTICS OF GAS AND OIL PIPELINES

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Every year experts of Energodiagnostika Co. Ltd. and “Tomsk ETC” Co. Ltd. carry out a large scope of works on non-destructive testing of operated 720 mm, 1020 mm and 1420 mm pipes. Inspection is performed using the metal magnetic memory (MMM) method, as well as specialized instruments and scanning devices (SD) with the purpose of rapid pipes sorting by fit, unfit pipes and pipes requiring additional inspection and repairs.

The specific feature of the MMM method, which distinguishes it from other NDT methods, is that it detects stress concentration on defects, i.e. it evaluates the degree of their hazard in relation to the damaging development as well as provides the general stress-strain state assessment of the base metal and welded joints of gas and oil pipelines. Additional inspection by other NDT methods (visual examination, UT, the eddy-current method, wall thickness measurement, hardness measurement) is carried out after insulation removal on individual pipes, where stress concentration zones (SCZs) with developing defects are detected by the magnetic anomalies using the MMM method in the quick control mode.

According to the “Temporary instruction on reutilization of pipes during the overhaul of the linear portion of trunk gas pipelines”, approved by “Gazprom” JSC on 08.07.2005, the magnetic method based on the metal magnetic memory effect is used on the initiative of “Gazprom transgaz Tomsk” JSC as a preliminary inspection of pipes and pipe sections. It should be noted here that at the preliminary stage the inspection of pipes is performed using special scanning devices without the removal of insulation.

At present Energodiagnostika Co. Ltd. manufactures three types of SD:

- with full coverage of the entire pipe perimeter and with the number of the magnetic field measuring channels from 24 to 32;
- covering half-perimeter of the pipe (up to 24 measurement channels);
- with partial coverage of the pipes for the perimeter length of 300-400 mm (12 measurement channels).

Figure 1 shows the fragment of 1420 mm diameter gas pipeline inspection by the MMM method using the SC. Simultaneous inspection of the external and the internal pipe wall is ensured. The weight of the SC is 8 kg. The SD's sensors sensitivity (detectability of defects) ensures detection of defects according to STO Gazprom “Instructions on execution of works during overhaul of the linear portion of gas main pipelines”. The frost resistance of the SD is up to -40°C .



Figure 1.

Preparation of the pipe's surface is not required, and inspection may be carried out without the insulation removal. The natural magnetization of the pipe (the magnetic memory of metal) is used. Equipped with a display, the TSC-type instrument allows to register presence of defected areas directly during the inspection in the real-time mode and to give efficient recommendations on the additional inspection and clarification of the defect's parameters.

The SD movement is performed using the extension rod with the distance of 3 to 4 meters from the pipe (manual mode) or using the electric motor remote-controlled by operator on the distance of 5 to 6 meters from the pipe (automatic mode). The SC may be connected in line to the insulation removing unit.

Instead of the TSC-type instrument a laptop, connected to the SD through a special transducer, may be used as a set with the SD. In this case the inspection results along each pipe may be displayed on the computer screen as clockwork scanning directly after completion of the inspection.

During the inspection of gas pipelines using the SD with full pipe coverage the average speed of inspection is 3-5 minutes per one pipe with the length of 10-11 m. The most dangerous defects leading to pipes failure are detected in the real time mode directly during the inspection. The inspection results are recorded to the instrument's memory with their further printing out in the form of clock-hour scanning of the pipe, which indicates the coordinates of all the detected defects and stress concentration zones on the external and the internal surfaces (see figure 2).

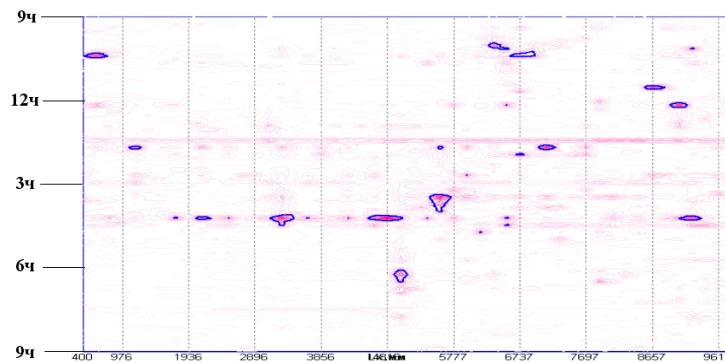


Figure 2. Distribution of defects and SCZs with maximum values of the H_p field gradient (dH_p/dx) on the scanning of the pipe # 7321 ($\varnothing 1020 \times 12$ mm).

At present, based on the more than 20-year experience in the development of the metal magnetic memory method and the TSC-type instruments, Energodiagnostika Co. Ltd. actively develops the non-contact magnetometric diagnostics (NCMD) of gas pipelines buried under the soil layer.

NCMD is based on measurement of distortions of the magnetic field of the earth (H_{earth}), conditioned by the variation of the pipe metal's magnetic permeability in the stress concentration zones (SCZs) and in zones of the developing corrosion-fatigue damages. The variation pattern of the field H_{earth} (frequency, amplitude) is conditioned by the pipeline deformation occurring in it due to the effect of a number of factors: residual manufacturing and assembly stresses, working load and self-compensation stresses at temperature fluctuations of the outside air and environment (soil, water, etc.).



Figure 3. Type 11 sensor.



Figure 4. Type 11-12 scanning device.

Nowadays we manufacture and use in practice two types of sensors for measurement of the three components of the magnetic field. One sensor allows measurement of the magnetic field along one generating line or along the pipe axis (figure 3) and another – simultaneously along three or four generating lines with coverage of the entire diameter of the pipe (figure 4). Our TSC-type instruments, when used as a set with the specialized sensors, can work both in the scanning mode with the length-counting unit and in the “timer” mode.

For operation in urban conditions (inspection of gas and oil pipelines, heating system pipelines and water ducts) we developed and performed practical testing of the NCMD sensor system model with a wheel providing the inspected segment’s length counting (figure 5). In field conditions on the uneven surface the wheel with the length-counting device may be used in the independent mode from the sensor parallel to the movement of an expert carrying out NCMD.



Figure 5. Type 11-12K scanning device.

We solved the problem of automatic assignment of the recorded magnetic field values in the “timer” mode to the length of the inspected pipelines segment by means of GPS-coordinator installation on the instrument. The versatility of the TSC-type instruments allows to use them both at NCMD and in prospect holes locations during the direct pipes inspection by the MMM method by means of connecting of another sensor type to the instrument.

In 2003 Energodiagnostika Co. Ltd. developed the methodical guideline (MG) on carrying out the non-contact magnetometric examination of gas and oil pipelines, water ducts and other objects using the TSC-type instruments.

The MG uses individual provisions and recommendations described in GD 51-1-98 “The technique for on-line computer diagnostics of local gas pipeline segments using the metal magnetic memory”, GD 12-411-01 “The instruction for technical state diagnostics of buried steel gas pipelines” and GD

102-008-2002 “The instruction for technical state diagnostics of pipelines by the non-contact magnetometric method”.

The MG and the above-mentioned instructions may be used by experts familiar with non-destructive testing methods and certified according to the requirements of the Russian Technical Supervision Body (Rostekhnadzor) at Energodiagnostika Certification Body (Moscow).

Experts during their training at Energodiagnostika Certification Body study theoretical and practical provisions on the MMM method, which are further used during the NCMD. It is not possible as well to develop NCMD without the improvement of the program software. It is known that during the diagnostics of many kilometers of pipelines using in-pipe flaw detectors (magnetic or ultrasonic) the major time is spent for decoding of the recorded data. Similar situation happens during the NCMD.

Due to the fact that by the moment of NCMD implementation we had already had the “MMM-System” program software, which had been developed by us for processing of the inspection results by the MMM method, we managed to master the new inspection technique relatively quickly.

During processing of the inspection results we emphasize the qualitative and quantitative relation of the magnetic signal parameters to the defect type and the dimension-type of the pipe. It is give an opportunity for quick software offset from noises and interferences.

In conclusion we would like to note the following.

The basic task of all diagnostic methods and instruments during the assessment of long-operated gas and oil pipelines is searching for and detection (or determination) of potentially dangerous segments with developing damages. As a result of the examination it is necessary to answer the following question: “Where and when should a damage or an emergency be expected?”. In case such problem is solved, then the possibility of timely replacement is ensured. Application of NCMD combined with the additional inspection of pipelines (UT, eddy-current, etc) in prospect holes, detected by NCMD, is aimed at solution of this very task. At the same time the Customer may have a question: “Is it possible to extend the results of the direct pipelines inspection in prospect holes to cover the entire length of the route where only NCMD was used?”. The answer to this question displays a degree of NCMD experts’ responsibility for the inspection results in front of the Customer. The cost of such complex diagnostics depends on the degree of responsibility.