INDUSTRIAL SAFETY PROVISION OF OAO GAZPROM
UNDERGROUND GAS STORAGE FACILITIES

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(O Slide 1)

OAO Gazprom Underground Gas Storage (UGS) system plays major part in providing uninterrupted operation of Unified Gas Supply system in Russia and reliable export supply.

Nowadays Gazprom has 25 UGS in operation.

UGS facilities are concentrated along the main pipelines and near the major gas consuming regions practically in all climatic zones: from Punginsky UGS in permafrost zone to Krasnodarsky UGS on the North Caucasus where average winter temperature is about 0˚C.

Pool of wells providing such productivity amounts to 4000 units, length of industrial pipelines connecting wells with gas-gathering stations and compressor stations is over 3000 km.

UGS of all types and sizes were designed and built in the former USSR and Russia: in depleted oil and gas fields, in aquifers, in solution-mined salt cavities.

Uninterrupted operation of UGS facilities is of great importance for gas-transport system. The level of man-caused risks largely depends on secure and efficient operation of UGS facilities. That is why industrial safety control of UGS facilities is a challenging scientific and technical problem.

Activities dealing with industrial safety provision cover all major types of UGS technological and power equipment – from compressor stations flow lines and stand-by diesel-eclectic stations to cable lines and these activities take place at the following objects:

(Slide 2)

- Wells of various application
- X-mas trees, well column heads and hook-up of wells;
- Underground industrial pipelines (wells flow lines, gathering pipelines, gas-distribution, gas-gathering and gas treatment stations);
- Pressure vessels (dust arresters, filters-separators, absorbers, etc.);
- Shut-off and control valves and above-ground pipelines of gas- treatment, gas-gathering (gas-distribution) stations;
- Power equipment (including parameters of electromagnetic compatibility);
- Transmission and compressor stations equipment.

System work is supported with unified normative and technical documentation, unified database with the results of expert-diagnostic works, and unified requirements for measuring instruments and algorithm of results processing.

Automated system of UGS facilities industrial safety provision should solve the following problems:

(Slide 3)

- Decrease the risk of emergencies and accidents primarily resulting in deaths of people;
- Decrease the ecological damage of UGS operation and economic losses resulting from mitigation of consequences of possible failures and emergencies;
- Stimulate production of domestic high-technology diagnostic equipment and instruments for monitoring technical condition and for non-destructing testing;
- Optimization of costs dealing with maintenance and repair of UGS facilities by means of multi-level complex diagnostic system.

It should be noted that the system should meet the following requirements:
1. The system should find its application at all UGS facilities;
2. The system should be cost-effective (diagnostics should cost less than the inspected equipment);
3. The system should be implemented as soon as possible.

The basic principles of automated system for UGS facilities industrial safety provision were developed with the view of these requirements:

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The system:
- Has easily replaceable module structure;
- Is a real-time, multi-level system;
- Provides quick realization of corrective measures and emergency-eliminating operations, as well as quality control;
- Has database of all diagnostic information which is an integral part of the system;
- Allows step-by-step increase in number of objects and parameters under control;
- Uses advanced information technologies and data-measuring systems; is integrated in modern communication channels and automatic control system of technological processes;
- Applies diagnostic algorithms based on physical and mathematical process models in the frames of statistic theory of signal detection against a background of interference and theory of samples recognition.

Before developing the system the statistical analysis of technical condition of all Gazprom major UGS facilities was carried out and optimal set of diagnostic characteristics was determined.

Besides, the basic principles used during the system development provided the following:
1. Step-by-step implementation of the system, which brought positive economic results already during the first years.
2. This is a learning system – storing information in the database allows to increase the amount of statistic data and to make diagnostic characteristics more precise as the result of statistic processing, and applying new physical and mathematical models for defect formation.
3. Switch from detecting defects to predicting their formation (using information on parameter dynamics).
4. Possibility to carry out planned repair works on the basis of technical condition.
5. This is a developing system.
6. The volume of subsystems is defined on the basis of risk analysis.

Now let me show you some examples of our work and the achieved results in industrial application of some modules of automated system for providing safe operation of UGS facilities in Russia.

In Slide 5 one can see an example of using automated subsystem for surface industrial and main pipeline support structures control and regulation. The necessity of this work was caused by violation of industrial safety regulations in case of subsidence of main and industrial pipelines supports. Unfortunately, it is a common case, especially at the technological piping of compressor stations in the northern regions of the country.

Slide 6 explains the purpose of the data-measuring and control system.
Slides 7 and 8 show the scheme of system operation.

The next example of our work and industrial application of automated control subsystem for main pipeline and auto-and railway crossovers control is shown in Slide 9.

Corrosion of the pipe in the result of effect of medium between the pipe and the protective casing, accumulation of gas in the tubular annulus and deformations cause emergencies and incidents at the main pipeline crossings. Traditional diagnostic examination based on periodic collection and processing of parameters information about the condition of the object under examination can not guarantee its good technical condition in the period between the examinations taking into account complex environmental effects. Such examinations have seasonal nature due to difficulty of access to the object and limitations imposed on measuring instruments by climatic conditions.

Therefore the idea of developing automated subsystem for main pipeline and auto-and railway crossovers control (SKP) seemed to be extremely relevant. Main pipeline and auto road crossovers are built in accordance with the prescribed design regulations. The pipeline is placed in a special protective casing – a tube which has bigger diameter than the pipe. The casing is meant to protect the gas pipeline from various mechanical exposures and to take gas away from the road in case of its leakage from the pipeline.

Slides 10 and 11 show how to solve this problem. The subsystem allows carrying out automatic control of a set of technical condition parameters of main pipeline and auto-and railway crossovers:

- To determine a pipeline protective potential;
- To measure ohmic resistance between the pipeline and the protective casing;
- To measure concentration of inflammable gas in the crossover bleeder;
- To evaluate crossover pipeline mode of deformation.

Control of the abovementioned parameters and dynamics of their seasonal alterations gives a complex picture of an object technical condition and allows predicting it.

Metrological examination of crossover control subsystems is carried out through periodic calibration of recorders – comparison of state-approved engineering performance standard and the received values of parameters. If the error exceeds the set limit, the certain units are subject to replacement.

Example of industrial application of automated system for technological equipment gas leakage control

UGS technological facilities refer to hazardous industrial objects which could produce zones with explosive atmosphere in case of gas leakage. As the volume of transported gas and operating pressure is considerable, the consequences of leakage can be very severe. The fact that natural gas has no color and smell adds to the problem and makes its detection problematic. The automated system for gas leakage control is designed for continuous monitoring of level of gas leakage from a technological object.

(Slide 12)

The main conceptual idea of the subsystem is to place methane sensors and wind speed and direction sensors in the equal distance from the leeward side of technological object taking into account the local wind rose and measurement vector.

Data-measuring units for monitoring the tightness of control and shut-off valves of UGS facilities main and industrial pipelines form an independent block of the system (Slide 13).

Non-toxic and non-inflammable gas, gas mixture or fume of volatile gas such as sulfur hexafluoride (SF6), carbon tetrachloride (CCl4), tetrafluormethane (CF4) and likewise are used as indicating gas, the type of indicating gas should be input in the software of a user terminal.

An important feature of the system is that it need not be cut into the pipeline before or after conducting the measurement – all the work is done through the drain valve of a ball cock without interrupting the technological process and changing the mode of technological equipment operation (Slide 14).

Automated Subsystem of Pipeline Cathode Protection Stations Control

Slide 15

Linear main pipeline cathode protection stations (SKZ) represent one of the most important units from the point of pipeline integrity. They protect the pipeline from chemically active environment which causes corrosion.
Operation of cathode protection stations depends on power supply and requires keeping the necessary level of protective potential value. Fluctuation of the value can result in negative effects, such as increase of corrosion or hydrogenation of pipeline metal.

The purpose of SKZ control is to provide long-term keeping of the set SKZ technical characteristics ensuring pipeline operational conditions and meeting the requirements of normative and technical documentation on corrosion protection.

System of database management PostgreSQL takes the central place in the SKU SKZ software complex (Slide 16). It provides information transfer between the software modules of the subsystem and is responsible for data storage (values of analogue and digital parameters, alarms, operator’s commands, etc.) All the rest software modules get information directly from PostgreSQL DBMS (Database management system), process it and record the changes. In such a way software modules interaction is possible only via the database, which contributes to its development.

Magnetic - Pulse Flaw Detection (MID) Equipment

One of the most promising methods of technical condition evaluation of casing string in oil and gas wells is magnetic - pulse flaw detection by means of magnetic - pulse flaw detection equipment. (Slide 17)

The equipment allows to examine multi-string wells and perform walls thickness gauging, detect thinning in the result of abrasive wear or corrosion, detect casing string and tubing defects, determine the position of a well structural elements, bottom-hole equipment and perforation intervals in oil, gas and other wells up to 6000 meters deep, having total thickness of casing strings up to 25mm and maximum diameter up to 325mm.

Distinguishing features of the magnetic - pulse flaw detection equipment are:

- Possibility of performing magnetic - pulse flaw detection without removing the tubing, i.e. without multi-casing well workover.
- High comprehension of resulting information and its mathematical processability.

Our specialists annually perform industrial safety expert appraisal of over 150 UGS wells in Russia in gas medium, using MID equipment and without killing the wells, which cuts the expenses for diagnostics and repair.

The results of our work find wide application and provide safe operation of UGS facilities, as well as hydrocarbon production and transportation facilities.

Since the implementation of the system, emergency level of the facilities and operational costs have decreased.
Industrial Safety Expert Appraisal and Technical Diagnostics of JSC “Gazprom” Underground Gas Storage Facilities

- Wells of various application;
- X-mas trees, well column heads, hookups of wells;
- Underground industrial pipelines (wells pipelines, gathering pipelines, gas-distribution, gas-gathering and gas-treatment stations);
- Pressure vessels (dust arresters, filters-separators, absorbers, etc.);
- Shut-off and control valves;
- Well workover equipment;
- Power equipment энергетическое оборудование;
- Booster and UGS compressor stations equipment
Automated system for providing industrial safety of UGS facilities should solve the following problems:

- Decrease the risk of emergencies and accidents primarily resulting in deaths of people;
- Decrease the ecological damage of UGS operation and economic losses resulting from mitigation of consequences of possible failures and emergencies;
- Stimulate production of domestic high-technology diagnostic equipment and instruments for monitoring technical condition and for non-destructing testing;
- Optimization of costs dealing with maintenance and repair of UGS facilities by means of multi-level complex diagnostic system.

Basic principles of automated system for UGS facilities industrial safety provision

- Has easily replaced module structure;
- Is a Real-time, multi-level system;
- Provides quick realization of corrective measures and emergency-eliminating operations as well as quality control;
- Has database of all diagnostic information which is an integral part of the system;
- Allows step-by-step increase of objects and parameters under control volume;
- Uses advanced information technologies and data-measuring systems; is integrated in modern communication channels and automatic control system of technological processes;
- Applies diagnostic algorithms based on physical and mathematical process models in the frames of statistic theory of signal detection against a background of interference and theory of samples recognition.
Example of using automated subsystem for surface industrial and main pipeline support structures control and regulation

Deformation of industrial pipelines in the result of pile foundation shearing

a) design position

6) subsidence of rock

Example of using automated subsystem for surface industrial and main pipeline support structures control and regulation

Automated system for control and regulation of booster compressor stations (CS) pipelines support structures is used for:

- Real-time support load control and development of recommendations for support regulation;
- Increasing safe operational lifetime of above-ground pipelines;
- Decreasing the number of stoppage and downtime;
- Decreasing costs for diagnostic services;
- Decreasing costs for support structures workover and maintenance.
System of control and regulation of booster compressor stations (CS) support structures control and regulation

Graph showing changing loads on support No. 7 DCS-3 of “Gazprom dobycha Urengoy” LLC in the period of soil frost penetration and support regulation (screen printout)
Example of industrial application of automated control subsystem for main pipeline and auto-and railway crossovers control

Drawing of a typical main pipeline and railway crossover equipped with automated control system (SCC)

1 – main pipeline
2 – protective casing;
3 – railway;
4 – bleeder;
5 – hardware-software complex container for crossover control system;
6 – methane sensor;
7 – stand;
8 – two-way radio antenna;
9 – reference electrode
Data-measuring system – hardware-software complex for pipeline crossings industrial safety control (in metal)

Example of industrial application of automated system for technological equipment gas leakage control

Structural scheme of automated local system for gas leakage control at the hazardous industrial facility

1 – technological facility (Compressor station shop, well, etc)
2, 3, 4 – methane sensors;
5 – sensors for wind speed and direction;
6 – cloud of leaking gas
Scheme of measuring gas expenditure through the untight Ball Cock gate with the help of gate tightness control subsystem ZRA

View on the gate tightness control subsystem ZRA installed on a ball cock Du1000 of high-pressure pipeline
Automated subsystem of pipeline protection cathode stations control (SKU SKZ)
SKU SKZ Structural scheme

Structural scheme of SKU SKZ software complex
Equipment for magnetic - pulse flaw detection MID-K

Is designed for technical condition evaluation of steel casing string and tubing in oil and gas single and multi-casing structure

Advantages: Possibility of simultaneous flaw detection and thickness gauging of two casings (without removing the tubing) with determination of thickness variations and transverse and longitudinal defects.