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### Gas transmission facilities: Reliability and repairs

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## Major gas transmission facilities: Conceptual approaches to integrity management

**Alimov S.V.** (OAO Gazprom, RF, Moscow), **Ivanov I.A.** (OOO Gazprom Transgaz Surgut, RF, Surgut), **Nefedov S.V.** (OOO Gazprom VNIIGAZ, RF, Moskovskaya Obl.), **Pasechnikov A.N.** (OAO Gazprom, RF, Moscow), **Karnaikhov M.Yu.**, **Redikul'tsev S.A.** (OOO Gazprom Transgaz Surgut, RF, Surgut), **Basin M.B.**, **Mikhaylenko A.G.**, **Veremenko I.A.** (OOO Gaztransit, RF, Moscow)

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This paper focuses on methodology development targeting gas transmission technical and integrity management based on plurality of Gazprom's repair plants and company-wider operations planning practices. One useful example highlights system implementation on a chosen gas pipeline and describes the key distinctive features of gas industry facilities covering large areas. In addition, the paper proposes conceptual approaches to target technical assessments, drawing conclusions from operations analysis of gas compressor stations. It was found that such pipeline-related methodologies need additional rethinking and revisions, and existing standards and guidelines

should be extensively adjusted to provide a better level of detail to meet new considerations given the present-day environment.

**Keywords:** gas transmission, pipelines, gas industry, major facilities, compressor station, technical status, integrity, management, control, risks, loss, assessment, information management, analysis, systems.

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## Robot-based scanners for internal inspection of Gazprom's compressor station piping

**Aksyutin O.E.**, **Sidorotchev M.E.** (OAO Gazprom, RF, Moscow), **Karnaikhov M.Yu.**, **Pshentsov O.S.** (OOO Gazprom Transgaz Surgut, RF, Surgut), **Voronchikhin S.Yu.** (ZAO Introsan Technology, RF, Chaykovskiy), **Samokrutov A.A.** (OOO Acoustic Control Systems, RF, Moscow), **Sedelev Yu.A.** (OOO ENTE, RF, Chaykovskiy)

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Timely updated and correct information regarding actual pipeline status and operating conditions, including inspection periods, is believed critical for sustaining management and integrity monitoring and control systems across Gazprom's compressor stations. This paper describes an internal standalone robot-based scanner and fault locator, A2072 IntroScan, as well as its design aspects

and diagnostic opportunities, and documents pilot test summary produced for several compressor stations run by Gazprom Transgaz Surgut.

**Keywords:** piping, compressor station, internal diagnostics, scanners, fault locator, technical monitoring, integrity, control.

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## Inspection pigging efficiency improvements will benefit gas pipeline overhauls planning

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This paper summarises gas pipeline flaw detectability analysis assuming TFI and MFL magnetic flaw detectors are used. In addition, the authors propose future R&D and experimental research areas aiming to gain progressive improvements with internal pipeline diagnostics. A packaged approach to activities in these areas is expected to help improve quality and performance of major gas pipeline

overhaul programmes as well as gasline operating reliability and security while optimising repair and diagnostics costs. Additional details across all R&D steps are provided by the authors here.

**Keywords:** inspection, pigging, gas pipelines, diagnostics, stress-corrosion cracking, flaw location, threshold, overhauls, flaw recognition, duration, field tests.

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## Gas distribution station overhauls and gas pipeline maintenance: Key criteria

**Kolotovskiy A.N.** (OAO Gazprom, RF, Moscow), **Topilin A.V.**, **Zakharov A.V.**, **Sukholitko A.A.**, **Esin Yu.I.** (OAO Orgenergogaz, RF, Moscow)

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This paper addresses the key physical status indicators for gas distribution stations and highlights a critical need to re-examine the existing design specifications concerning gas distribution station overhauls, across Gazprom. Station overhaul criteria and a justification procedure were proposed, both aiming to support timely decisions. In addition, key pipe and fittings physical characteristics were typified and described in more detail, along with service management guidelines. Finally,

a brief summary of existing service practices is complemented by a presumably promising new service management scheme.

**Keywords:** service life, operation, efficiency, safety, gas distribution, piping, fittings, workover.

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## Big Urengoy field gas treatment units: Sustaining operations of gas booster stations

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This paper addresses the key issues arising with sustaining production in Big Urengoy fields combining different, and strongly varying, operating history. Under falling production, several booster stations were brought online at Cenomanian gas treatment units. The stations are configured as two compressor sections. Relatively reliable operations were sustained by packaged actions mainly focused on timely upgrades of, and retrofitting these booster stations along with introduction of a range of joint production schemes. Progressive expansion of this booster station complex is believed critical for maintaining output from these mature Big Urengoy fields where production is reported to be increasingly falling.

**Keywords:** Cenomanian play, gas treatment, upstream plant, booster compressor, station, changeable flow channel, on-site utilities, joint production, schemes, double casing design, compressor.

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## Planning lateral gasline overhauls

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A new pipeline internal diagnostics and corrosion observation summary has been produced by Gazprom recently. Based on this summary, Gazprom has developed a new methodology approach designed to quantify technical status of its gas laterals. This approach helped, the company, using a common estimation scale, to identify gas pipeline technical status, combining both gaslines covered by smart inspection pigs and those which do not qualify for such tools. In addition, Gazprom proposed another methodology aimed to find the percentage of pipe laterals which are subject to replacement under workover project design assuming their subsequent recoating.

**Keywords:** gas pipelines, laterals, recoating, repairs, corrosion, status, physical conditions, service life, diagnostics, inspection pigs.

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## Orgenergogaz as part of Gazprom's maintenance and repair framework

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Operating costs required for sustaining gas production, transport, storage, and distribution facilities are a key component of end-user price. Maintaining reliable performance of a country-wide gas transmission system (ESG) and progressive cutting operating costs, using the most recent, highly effective equipment maintenance and repair technologies, remain among the core strategic goals for Gazprom.

Orgenergogaz is one of leading organisations to be deeply involved in major overhaul project maintenance and support services within Gazprom. This paper specifically focuses on a number of challenges for the domestic gas sector and offers potential solutions which are expected to mitigate or resolve such issues.

**Keywords:** overhauls, gas pipelines, projects, examination, diagnostics, maintenance, operating costs.

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## Gazprom's large-diameter pipeline overhaul efficiency analysed

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Extensive gas pipeline diagnostics using internal inspection pig-ging tools, both before and after major overhauls, was followed by efficiency analysis using service life as a key target defined by a 2011–15 Gazprom's gas pipeline overhaul programme. It was found analytically that despite numerous faults found, actual pipeline physical conditions appeared to remain at or under 0.026, while time to failure, in the worst case, being longer than the target, or 25 years. The authors summarise their findings in this paper in more detail.

Keywords: gas pipeline, repairs, overhauls, recoating, corrosion, damage, MTBF, time to failure.

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## Comprehensive approach to Gazprom Transgaz Krasnodar facility inspections: Nonintrusive testing procedures

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Gazprom's Krasnodar subsidiary is involved in gas pipeline services covering three Russian regions: Rostov, Krasnodar, and Adygeya. Special emphasis is placed here on uninterrupted and trouble-free operation of equipment used for gas shipments, along with routine monitoring and diagnostics practices. The paper highlights an example of a comprehensive approach to asynchronous motor (on compressor gas cooler floors) inspection, combining two or more monitoring methods. Obvious information coverage and accuracy benefits of this approach are noted, against the case when each addressed nonintrusive testing method is used individually.

Keywords: heat control, vibration diagnostics, defects, electric motor, inspections, nonintrusive methods, monitoring, gas pipelines.

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## Process control system reliability and performance improvements target gas pipelines in Far North field areas

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This paper addresses two key methods focused on process control system reliability and performance improvements targeting gas pipelines in field areas. Both methods assume avoidance of or minimising the implications of measurement data channel outage commonly leading to information loss which affects normal upstream operations. The methods centre on measurement cross-control covering all information channels using proprietary algorithms built into these control systems. The algorithms help identify and isolate channel outage, and model readings of faulty devices. This is expected to deliver effective solutions for process control system management in case of insufficient source information coverage which could be the case for the Far North field operating environment.

Keywords: process control system, gas treatment unit, upstream, information, channel, data transfer, methods, redundancy, models, sensors.

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## Gas transmission facilities: Assessment of risks associated with missed repair deadlines

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This paper proposes a new methodology which is expected to help meeting a critical goal: assessment of repairs-related risks for a target gas pipeline facility, and setting up necessary time margins. Two statistical tools, combined, are used to solve this problem – bootstrap and Gram-Charlier approximation series. The bootstrap enables to produce bias-adjusted assessments of random value statistics (moments), while the Gram-Charlier curves offer to recover an unknown distribution time function related to repair operations, using bootstrap-produced assessments. When rejecting related quintiles on a distribution curve and setting up a required “risk appetite”, it appears possible to define reasonable planned repair deadlines as well as desirable time margins.

**Keywords:** gas transmission system, repairs, overhauls, approximation, risks, deadlines, bootstrap, Gram-Charlier, time margins, assessments, statistics, approximation.

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## Fluctuation analysis for gas transmission system reliability monitoring

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This analysis includes the underlying norms and regulations, common reliability requirements to gas transmission system, and existing standards concerning monitoring system development practices. The paper presents an innovative software package designed for gas pipeline physical condition and reliability predictions, aiming to improve management decisions regarding timely preventive measures. The main value of this study, for practical needs, comes from a set of decision support prediction models and methods, along with real-time reliability monitoring tools designed to encourage the gradual switching from reactive gas pipeline maintenance and repair systems to predictive methods mainly driven by reliability expectations and timely data inputs.

**Keywords:** monitoring, reliability, maintenance, assessments, analysis, predictions, model, decision making, gas pipelines, software.

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## Pipeline construction projects and overhauls: Concrete-coated pipe water crossings – strength and stability estimates

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Building on existing normative base governing the civil, industry, and hydro engineering areas, a new methodology has been developed in Russia. It mainly focuses on strength and stability estimates for major concrete-coated pipes used in water cross-ing construction projects and major overhauls. Main methodol-ogy provisions include ballast coating thickness adjustments, defining key forces, crack opening, tolerable bending radius, along with strength and stability tests. This methodology ap-proach is expected to help improve water crossing operating reliability when addressing both greenfield projects and major crossing overhauls.

**Keywords:** pipelines, water crossing, strength estimates, stability, concrete coating, crack opening, bending radius, construction, overhauls.

## Major gas pipelines: Cleaning and diagnostic pig acoustic monitoring system

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This is a brief description of technical solutions related to acoustic monitoring of cleaning and diagnostic pigs movement along large-diameter gas pipelines as well as commercial testing summary. These solutions centre on one original method: pig speed measurements based on frequency of hits against pipe welds while passing, pig signal acquisition length could be 45 km or greater for this method as a result. Related automation system was ordered by Mostransgaz (presently Gazprom Transgaz Moscow), and after extensive pilot tests it was acknowledged to *meet all requested specifications*.

**Keywords:** cleaning pig, diagnostic pig, process control, system, gas pipeline, valve assembly.

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## Bitumen-polymer materials and coatings for gas pipeline corrosion protection under repairs

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This paper focuses on bitumen-polymer coatings and properties of these materials. Such high demanding pipeline application, coupled with challenging operating conditions, step up quality and reliability requirements. The authors highlight typical designs of modern protective coatings based on bitumen and polymer materials and application technologies, and also document related coating specifications. The key characteristics of these materials are well known and are commonly available in litera-ture. In addition, there is vast field experience today, including the application and operation such as recoating practices with existing large-diameter gaslines. All these data are to evidence higher efficiency and reliability of this coating choice. Various overhauls-related aspects are additionally addressed here.

**Keywords:** bitumen-polymer materials, pipeline, hot and cold application technologies, mastic

## Innovative solutions for reliability management under offshore gas development in Russia

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GiprospeTsgaz R&D and project engineering institute has devel-oped a new subsea development concept for gas fields in Russia's Arctic areas. The concept assumes abandonment of offshore plat-forms for initial gas treatment under field development, focusing on their replacement by subsea gas treatment units and compressor stations. Engineering studies under this concept placed special emphasis on reliability and independence of such subsea systems. This is mainly attributable to major challenges associated with repair work in the harsh Arctic offshore environment: repair and rehabilitation operations commonly appear impossible for 10–11 months a year. In addition, GiprospeTsgaz is coming with its new subsea equipment design methodologies including redundancy requirements for Arctic offshore development projects.

**Keywords:** concept, field development, Arctic offshore, reliability, risks, management, gas treatment, subsea pipeline, treatment plant.

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## Analysis of flaws identified under diagnostics supporting compressor station piping major overhauls

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This paper analyses flaws identified under diagnostics supporting major overhauls covering both compressor station piping and compressor station gathering lines. Pipeline technical status was shown to be mainly driven by stress-corrosion cracking intensity. Therefore, operating loads appear critical for safe operations of pipelines under heavy SCC impacts. This conclusion drives better stress-corrosion cracking protection system designs which is expected to benefit compressor station piping operating reliability.

**Keywords:** flaws, diagnostics, compressor station, piping, gathering lines, stress-corrosion cracking, repairs, integrity.

## Major gas pipeline shut-off valve functional tests in normal operating conditions

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This paper addresses shut-off valve functional testing methods using an existing gas pipeline. The author proposes short-lived shutting off the flow in a target pipeline, using a valve under test, to analyse pressure drops in both steady-state conditions and under transients. Related pressure formulas have been produced for the steady-state case. The study assumes a transients model designed to simulate valve shut-offs, both complete and incomplete, with respective transient patterns. It was concluded that pressure growth rate appears essentially indicative of valve closure degree. Study conclusions could become central for a new operating procedure targeting existing gas pipeline shut-off valves.

**Keywords:** gas pipeline, shut-off valve, model, transients, steady-state, pressure, procedures, functional test.

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## Improvements with environmental performance of pipeline repairs under challenging natural conditions

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Tyumen Oil and Gas University (TyumGNGU) is coming with its innovative technology built around leak-free pipeline shutoffs and full displacement of flowing product from affected zone using fumed polymer plugs. The proposed method is expected to reduce hydrocarbons leak probability and potential leakage volumes under repairs, and to cut time requirements associated with subsequent pipe purging and bringing it to normal operations. The authors first used their original methods combined with commercial approval procedures. The proposed technical solutions or exclusion some work elements from the main process chain, both are expected to cut repair costs and bring significant quality improvements.

**Keywords:** environment, reliability, repairs, maintenance, polyurethane, pipeline, leaks, purging.

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## Gas tightness monitoring methodology improvements

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This paper analyses gas tightness factors applicable to gas distribution grid tests undertaken in compliance with Russian industrial safety regulations. It considers gas tightness remote monitoring procedures which could help avoiding potential emergencies and any humans injury caused by fragments. In addition, related impact factors are analysed and compared. The approach is built around acoustic emission and proximity acoustic methods. The entire setting was to justify both stages and factors which are believed critical for a chosen tightness control methodology designed to sustain lower emergency risks.

**Keywords:** tightness, monitoring, control, industry facilities, hazards, methods, acoustic emission, proximity meter, acoustic tools, sensitivity, threshold, samples, specimen, testing, procedures, safety rules, emergencies, risks.

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## Moskovo compressor station: Operating experience with tribodiagnostics sub-system

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The paper compares bearing assembly diagnostic systems commonly employed with gas pipelines. It provides a brief summary of experience to date with tribodiagnostics tools targeting an automated diagnostic maintenance system designed for Moskovo KS-18A compressor station run by Gazprom's operator in Ufa area (Bashkortostan). It also justifies its potential applications with AL-31ST engines. Further, the authors detail some specific aspects of this Moskovo compressor station system and highlight numerous benefits of the addressed tribodiagnostics sub-system achievable during routine operations. Building on these considerations, the authors came to a conclusion about performance benefits when sourcing the causes of flaws with friction elements.

**Keywords:** tribodiagnostics, diagnostics, reliability, gas compressor, engine, bearing assembly, monitoring, maintenance, system, automation, wear, mechanicals, flaws, friction, identification.

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## Upstream oil and gas reliability overview

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This paper addresses numerous issues related to reliable operations of oil and gas facilities, focusing on a software module designed for spare parts and accessories monitoring and automation along with correct parts inventory and allocation. The proposed model was made central for minimisation of a target function – repair procedure start-up waiting time, following outage of or damage to oil and gas well drilling equipment. A neural network model was chosen as it enables to assess remaining life given a preferred equipment operation strategy. These and other considerations are discussed in this paper.

**Keywords:** pre-emergency situations, neural network classifier, spare parts, failsafe operations, oil, gas, drilling, wells, repairs.

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## Improvements with prioritising gasoline segments taking out of service for repair

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This paper analyses the present Gazprom's approaches to building major gas pipeline overhaul programmes. It was noted that such approaches appear often affected by insufficient source information regarding various operating history aspects associated with individual pipeline segments. With this in mind, extensive experimental studies have been undertaken, coupled with underlying analytical considerations, yielding a new methodology targeting a range of additional factors which

are believed indicative of operations-related aspects related to a gasoline section under study. Building on the produced data, it was possible to analyse priorities for taking the chosen pipeline sections out of service for planned repair.

**Keywords:** gas pipeline, overhauls, planning, operation, analysis.

## Studies of dead-end valve fittings heating under gas pipeline initial filling

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The paper summarises model-based estimates and experiments concerning gas flow in pipe leading to excessive heating of valve parts under initial gas pipeline filling. It was found that valve assembly dead-end heating appears mainly attributable to gas eddy flow causing pressure oscillations in dead ends (Hartmann-Sprenger effect). The authors indicate impacts of gas offtake riser connection point on main bypass line under riser gas heating. A correlation between riser temperature heating and gas pressure pulsations was established. It was found that the heating phenomenon could be evident only for gas flow rates nearing the speed of sound. The study offers heating avoidance measures believed applicable to pipelines both under design and operation.

**Keywords:** gas pipeline, filling, riser, gas offtake, eddy flow, gas flow model, Hartmann-Sprenger effect, heating up.

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