THE TECHNOLOGIES OF FUTURE
IN YOUR HANDS TODAY

UNIQUE METHOD OF
THE CONTACTLESS
PIPELINES
INSPECTION

POLYINFORM
Providing industrial and environmental safety
Technologies and Innovations Center

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SINCE 1989 ON THE MARKET

- 7 doctors of sciences
- Up to 200 professional employees
- Own scientific and industrial equipment

OUR CUSTOMERS:

"Halliburton" (USA); "Total Fina Elf" (France); "Mahrukat" (Syria); USAID (USA); Unilever SNG (Great Britain); NKK Corporation (Japan); "Lukoil" Oil Company; "Transneft" Corp; "Lukoil" Co. Ltd; "Diamonds of Ruissia-Sakha" Co. Ltd; "TNK-BP" Corp; "Moscow Oil Refinery" Corp; "Rosneft" Corp; Russian Open Society "United Power Systems of Russia"; "Jukos" Inc; JSC "Russian Railways"; Ministry of Defense of the Russian Federation; Ministry of the Natural Resources.
POLYINFORM MAIN ACTIVITY

- Providing environmental safety
  - Soil remediation and liquidation of accidental oil products spills
  - Decontamination of water surface and ground and waste water
  - Cleaning of reservoirs and sludge pits
  - I-IV hazard class waste disposal

- Industrial construction
  - Design and construction of special sites for waste processing;
  - Design, construction and maintenance of treatment facilities
  - Engineering preparation of the sites for construction

- Industrial safety expertise
POLYINFORM MAIN ACTIVITY

**Industrial safety expertise**

- **Contactless magnetometric inspection**
- Electometry
- Visual inspection control
- Ultrasonic thickness and hardness measurement
- Ultrasonic defectoscopy
PROBLEM

- Pipelines TEAR-AND-WEAR, operating for more than 20 years

- Lots of the pipelines (about 30%) are IMPASSIBLE for in-tube (traditional) inspection

- NO ADEQUATE SOLUTION for inspection of underwater pipelines
Paradigm of environmental friendly business means *industrial safety*

KMD-01M - our solution for expertise of industrial safety
The principally new approach to pipelines technical inspection by contactless magnetometric diagnostic method using high-tech system KMD-01M

The contactless magnetometric diagnostic system KMD-01M consists of:

- 3-component magnetometers unit
- Data saving and visualization unit
- Additional equipment
The purpose is to detect defective parts of pipelines and localization of high tension and to define places for digging out for selective repair of underground pipelines. KMD-01M allows detecting of corrosion and deformation damage as well as localization stress state of underground steel pipelines without changing their operating mode.

KMD-01M allows highly effective complex assessing of the technical state of the inspected pipeline. The inspection is executed in accordance with the RD-12-411-01 approved by State Technical Supervision Agency of Russia.
The systems work is based on the group of physical effects, based on Villari effect:

1. **Magneto-elasticity effect itself** – the changing of the induction in a ferromagnetic which is situated in the outer magnetic field under the impact of the mechanical stress;

2. **Magneto-mechanical effect** - the changing of the vector of residual magnetization of the ferromagnetic products in the direction of maximum stress.

3. **Magnetic plastics** - the effect of forming of the formation of domains and domain boarders in the accumulation of dislocations in the areas of stress concentration;

4. **The effect of magnetic field dispersion** by structural and mechanical irregularities under the natural magnetization of the metal.

*Effects 1-3 can not be fully realized in the single-component fluxgate sensors*
The tree-component vector sensors are used in the device as the primary transducers. The main principal of their work is based on the **anisotropic magnetoresistive effect (AMR-effect)**.

AMR-sensors has pure active resistance, low weight and low hysteresis

**4 three-component sensors provide measuring and calculation of following quantities:**

- 12 components of the magnetic field,
- 6 gradients of magnetic field components,
- 4 full vectors of magnetic induction,
- 2 gradients of full vectors of magnetic induction,
- 2 angels between full vectors of magnetic induction.

The dispersion of the magnetic induction distorted due to the stress concentration caused by a defect.
The main sensitive element of magnetic field sensors is magnetoresistor, made as the nanofilm on a silicon basement.

Magnetoresistive nanofilms provide high sensitivity of the device, speed, selectivity and noise immunity.

The volt-oersted characteristics of magnetic sensors

1 oersted = 1000/(4π) \( \text{A/m} \approx 79.6 \text{ A/m} \).

1-thin-film magnetoresistor,
2- monolithic magnetoresistor,
3- ferroprobe, 4- Hall sensor.

In the linear part of the diagram the thin-film magnetoresistor is an order more sensitive than other magnetic transducers.
Discovering, localization and classification of defects is performed remotely by means of interpretation of constantly registered parameters of the magnetic field.

The signal received from the magnetic sensors is processed with the help of analog-digital converter into the code, going to a computer.

The software allows processing of the received data and displaying it on the monitor in a real time.

Example of the different local defects magnetogram
Antenna unit is designed for converting the induction of the magnetic field into the electric voltage

The controller commands the modes of magnetoresistive transducers and generates a digital signal for transmission to the personal computer

The unit of recording and primary data processing is used for controlling the device and visualization of magnetograms in real time mode

GPS receiver is used for automatic linking the received data in the geographical and linear coordinates
New design, technological solutions and software developed for the diagnostic equipment are protected by patents.

In 2010 the project received a positive conclusion of the Scientific-Technical Council of State Corporation "Russian Corporation of Nanotechnologies", signed by three active members of the Russian Academy of Sciences.

In 2011 the project has passed the technical expertise of 10 independent experts of the Skolkovo Found for receiving the status of the innovation project. The company became a participant of Skolkovo Found.
The system is certified by State Standard of Russia as a measuring tool. The inspection method and the system are patented in the State Register of the Useful Models of Russia (9 patents). The company processes the License on the activity on executing of expertise of industrial safety.
ADVANTAGES

- REMOTE diagnostics of pipelines' state
- STopping or CHANGING the mode of operating is NOT REQUIRED
- ON-LINE detecting of anomalies
- HIGH EFFICIENCY (up to 20 km daily per 1 crew)
- NO PREPARATION NEEDED
- ACCURACY for the critical level defects up to 93%
- Creating DIGITAL MAP of the defects with GPS links and AUTOMATIC TRACING
- Inspection of the IMPASSIBLE for in-tube and contact defectoscopy methods AREAS
## SPECIFICATION OF KMD-01M

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>The distance between the magnetometers block and the pipeline</td>
<td>Up to 10 pipes diameters depends on operating pressure</td>
</tr>
<tr>
<td>The diameters of inspected pipelines</td>
<td>from 159 mm</td>
</tr>
<tr>
<td>The instrumental error of localization (coordinates)</td>
<td>is determined by GPS error (± 0,5 m)</td>
</tr>
<tr>
<td>The definable degree of metal loss</td>
<td>from 10 - 20 % of a wall thickness (depends on the pipeline's specification)</td>
</tr>
<tr>
<td>Productivity</td>
<td>Up to 20 km daily per one crew (2 persons)</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>From - 35 °C up to + 55 °C</td>
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</table>
OBJECT: field pipeline (diameter 273 mm) Oil Company «PetroChina» (China), 2012

Scope of work: Diagnostics of the pipeline with the help of magnetometric system KMD-01M

OBJECT: field and gas gathering pipelines (ø 159 - 600 mm) of Oil Company «Lukoil - West Siberia», 2010

Scope of work: Inspection of pipelines via NDT (nondestructive testing) methods with the help of magnetometric system KMD-01M

OBJECT: filed oil pipeline of TPP «Langepasneftegaz», (ø 159-420 мм), of Oil Company «Lukoil - West Siberia», 2011

Scope of work: Inspection of the pipeline with the system of magnetometric diagnostics system KMD-01M

OBJECT: main water pipeline and oil pipeline (ø 1220 mm and ø1020 mm), OA "KazTransoil" (Kazakhstan), 2012

Scope of work: Diagnostics of pipelines with the system of magnetometric diagnostics system KMD-01M
EXPERIENCE

The diagnostics using the system KMD-01M was carried out on the pipelines of different types, destinations and level of readiness for operating:

OOO «Lukoil - West Siberia», Russia
- gas collecting pipeline TPP «Yamalneftegaz», ø 260-400 mm
- field oil pipelines TPP «Kogalymneftegaz», «Pokachineftegaz», «Langepasneftegaz», «Urajneftegaz» - ø 159-400 mm

OOO «Lukoil - West Siberia», Russia
- gas collecting pipeline TPP «Yamalneftegaz», ø 260-400 mm
- field oil pipelines TPP «Kogalymneftegaz», «Pokachineftegaz», «Langepasneftegaz», «Urajneftegaz» - ø 159-400 mm

OAO «Bashneft», Russia
- field pipeline, ø 159-420 mm

OAO «Oil Company «Rosneft», Russia
- field pipeline «RN-Uganskneftegaz», ø 530 mm

«Saudi Aramco», Saudi Arabia
- main pipeline, ø 31”

Oil Company «CNPC», China
- main gas pipeline, ø 600 mm

Oil Company «PetroChina», China
- field oil pipelines «Shi Xi Oil Field», ø 273 mm

Oil Company «Sinopec», China
- main oil pipeline, ø 426 mm

AO «KazMunayGaz», Kazakhstan
- main gas pipeline «Middle Asia - Center», ø 1220 mm

AO «KazTransOil», Kazakhstan
- main oil pipeline, ø 1020 mm
- main water pipeline, ø 1220 mm
# THE TECHNIQUE OF PIPELINES COMPLEX DIAGNOSTICS

## STAGES OF WORK

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
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<tbody>
<tr>
<td>I stage (PRIMARY)</td>
<td>Collecting all necessary information about the pipeline and preparing the measuring equipment</td>
</tr>
<tr>
<td>II stage (FIELD)</td>
<td>Field inspection with KMD-01M – magnetometric contactless measuring with the simultaneous data visualization and GPS coordinates linking</td>
</tr>
<tr>
<td>III stage (EXPRESS ANALYSIS)</td>
<td>Express analysis of the magnetograms, choosing the places for control pits</td>
</tr>
<tr>
<td>IV stage (CONTROL OPENING)</td>
<td>To calibrate the analytic software for defects ranging the control opening allows direct contact control measuring in pits should be made</td>
</tr>
<tr>
<td>V stage (CAMERAL PROCESSING)</td>
<td>The processing and interpretation of the received data is held in the Analytic Center</td>
</tr>
<tr>
<td>VI stage (ADDITIONAL CONTROL)</td>
<td>By the customers request the opening of the pipeline can be made for the NDT - additional control by non-destructive methods (measuring of thickness and hardness)</td>
</tr>
<tr>
<td>VII stage (REPORT)</td>
<td>The report and the final condition conclusion on the technical state of the pipeline including the digital maps of the discovered anomalies is made</td>
</tr>
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</table>
Complex is operated by two operators:

**The first operator** locates the pipeline with the pipeline finder as well as links the route with the GPS receiver to the reference points.

**The second operator** measures the fluctuations of the constant magnetic field with the magnetometers.

Based on the received data the areas of stress concentration due to the corrosion tear-and-wear, stressed-deformed condition, pipelines geometry failure, and other defects are defined.

While measuring the system automatically records the GPS-geographical coordinates.

The processing and interpretation of the received data take place after the measuring.
TYPES OF DEFINABLE DEFECTS

KMD-01M detects anomalies of the magnetic field caused by various types of defects:

- Stress-deformed state
- Corrosion fatigue
- Defects related with loss of metal and failure of metal's solidity
- Changing the pipelines geometry
- Unauthorized inserts
Magnetograms of various defects

Magnetogram of the defect part of the pipeline

Magnetogram of undamaged part of the pipeline
The super critical level anomaly caused by stressed-deformed state (bend) of the pipeline due to the drift of sand.

Magnetogram of the part of the pipeline with the stress state of high critical level.
STRESSED-DEFORMED STATE

Magnetogram of the stressed-deformed state in the zone of anomaly, caused by the pressure of soil

Magnetogram at the zone of anomaly after removing of soil during the test digging out

The part of the pipeline under the stress caused by the uneven pressure of the soil
Zone of the corrosion defects marked as the result of the contactless inspection with KMD-01M. The coincidence of the measured coordinates of the anomaly with fact is well seen (± 0.5 m)
LOCAL DEFECTS OF PIPELINE

Open pit at the anomaly location. Executing of additional control - ultrasonic thickness measuring

Example of magnetogram, the loss of metal is over 30%
The open pit at the place of anomaly. Local defects of the pipeline (outer pit corrosion) appeared as the result of penetration of highly aggressive ground water through the damages of pipeline's isolation.

The accuracy of corrosion centers detection with the help of KMD-01M was 0.5 m

The loss of metal at anomaly zone - 35 -50 %
The part of the pipeline under the danger of an accident. The pipeline is under operating since 1986. The loss of metal - over 50%
The loss of metal 100% - hole

Open pit №7, hole,
Loss of metal 100%

The fragment of the magnetogram of the part of the pipeline
INSPECTION DURING COLD SEASON

Executing diagnostics on ski

Using snowmobile for diagnostics of the field pipeline
The speed - 20 km/h
Examples of maps of anomalies caused by various defects with the geographical coordinates.
The device operated by a diver allows inspection at the depth of up to 40 m. The received data is written to the flash memory for further processing.

Waterproof display allows the operator to monitor anomalies in real time.
KMD-01M system successfully passed through the arbitrage tests at the objects of ZAO "LUKOIL-West Siberia", OAO "Sibur neftehim", OOO «Bashneft-Dobycha» and PetroChina (China), and received positive expert conclusions from State Corporation "Rosnano" and "Skolkovo" Fund.
PROJECTS IMPLEMENTING

- Local staff hiring
- Local assemblage facilities organizing
- Local engineers training
**PLANNED DESTINATIONS AND DEVELOPMENT**

**Placing the device at a all-terrain car**

- Purpose: increasing the productivity up to 50 km daily per a team (depending on the route).

**Placing the device at a submersible**

- Purpose: inspection of underwater pipeline passages

**Placing the device at a pilotless aircrafts**

- Purpose: increasing the productivity and extending the areas available for inspection (deserts, swamps and taiga).
OUR SOLUTION FOR INDUSTRIAL SAFETY EXPERTISE

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