Abstract

The problems of man-caused, ecological and antiterrorist safety which are the basis for the development of modern society require consistent development of means and methods of non-destructive testing (NDT) and technical diagnostics (TD). At present NDT and TD have developed into an independent industry uniting thousands of scientific and industrial companies and firms where a great number of scientists, engineering personnel and employees are working. The NDT and TD methods are based on the influence of physical fields and chemical substances on an object under inspection and the analysis of their changes as a result of interaction with the object. NDT helps to investigate material structures, reveal discontinuities, measure dimensions (thickness of coatings and walls), study the internal structure of materials and their strain-stress distribution, find criminal objects, degradation of buildings and determine the residual life of objects. Nowadays, many thousands of NDT devices and inspection installations are manufactured all over the world at the expense of more than $10 billion. In many countries, the companies, firms and independent specialists are united into national NDT societies.

Keywords: NDT, technical diagnostics, technogenic, ecological and anti-terrorist safety

1. Historical background

The documented history of the RSNTTD dates back to the first conference on NDT in Leningrad (now, St. Petersburg) in 1956. In 1963 a special Scientific Council on “New Welding Technologies and Welded Structures” was established under the presidency of academician Paton B.E. and the NDT section was set up.

The RSNTTD in its present status is the successor of the former Society on NDT, established in 1989 on the basis of specialized scientific committees of the USSR.

The first Congress of the Russian NDT Society was held on 6 December 1991. It determined the goals and objectives of the Society in new terms, when the USSR ceased to exist. Both the former USSR and the present Russian NDT Societies took active part in the work of international organization for the standardizations and NDT institutions.

The RSNTTD is a society opened for institutions and individual specialists interested in NDT and TD. At present, there are some 400 juridical members and more than 3000 individual members in the Society. Practically all leading organizations involved in oil, gas, metallurgical, airspace, chemical and other industries as well as institutes developing NDT instruments and equipment, companies manufacturing NDT equipment and educational institutes and universities are members of the RSNTTD.

The RSNTTD is the member of the International (ICNDT) and European (EFNDT) organizations, ABC European Industrial Database, European Academy, and Russian Academy of Sciences.

The RSNTTD has Agreements on Cooperation with 26 National NDT Societies.

In 2004 the web site http://www.rsnttd.ru was started. The Society regularly publishes new handbooks and technical books. In 2004 a new Handbook in English covering all NDT methods was published. RSNTTD publishes the following magazines: “Testing. Diagnostics”, "Defektoskopiya", "NDT World". A number of certification and training...
centers have been accredited within the framework of the RSNTTD. Eight volumes of handbook “Non-Destructive Testing” (all together - 17 books) were published during 2004 and 2005-2006.

The Society has held 17 conferences (both in the USSR and Russia). The 18th Russian NDT conference will be held in Nizhniy Novgorod 29 Sep.-04 Oct 2008. Since 1998 the Society has been providing active assistance at various conferences on NDT as “Pipeline Diagnostics”, “Security Technologies”, “Energy Diagnostics and Condition Monitoring”, “Computer Methods and Inverse Problems in NDT Diagnostics” and “Tomography”. 25 years ago, the former USSR Society was the host of the 10th NDT Conference in 1982 (see photo 1), which was very successful.

![Fig. 1. Team of participants of the 10th World NDT conference, Moscow, 1982](image)

In 2004 the RSNTTD celebrated the 20th anniversary of the EFNDT in Moscow. In 2005-2007 the international conferences and exhibitions “Non-destructive testing and Technical Diagnostics in industry” were held where scientists from Russia, Eastern Europe (Ukraine, Byelorussia, Moldova, Bulgaria) as well as England, Germany, USA, Canada, etc participated. They made reports on three principal directions: man-caused, ecological and anti-terrorist safety.

The RSNTTD unites 67 regional branches. The superior body of the RSNTTD is the Conference of authorized members. The governing bodies are the Board of Directors, the President, five Vice-Presidents, an Executive Director and Governing Bodies of regional branches.

The basic objectives of the RSNTTD are as follows:

- Join forces of specialists and organizations to provide the progress in the field of NDT (development of new advanced physical methods, multivariable signal processing techniques, design of monitor programs);
- Development of certification systems for personnel, laboratory means and technologies as well as their harmonization with European and American systems;
- Holding conferences and exhibitions as well as participation in international conferences and exhibitions;
- Publishing activities (monographs, textbooks, reference material, magazines).

The RSNTTD pays much attention to the problems of scientific and technological level of domestic developments, their competitiveness at the world market, the choice of advanced tendencies in NDT. Today the RSNTTD has developed into a powerful high-technology industry with the output of tens of billions of dollars. The design of modern NDT equipment is carried out by domestic companies with the multi-polar collaboration with national societies of leading countries, such as USA, China, Germany, England, Canada, India, France, Australia, etc.
There are hundreds of research and production companies and firms (“Promintro”, “Eho+”, “NIKIMPT”, “Luch”, “Kropus”, “Tvema”, “SintezNDT”, etc.) dealing with NDT and TD in Russia; large corporations have been founded (“Spektr-Group”, Moscow, “Unitest”, St. Petersburg). They all manufacture thousands of devices and inspection installations of different assignments: flaw detectors, structure analyzers, dimension gauges, tomographic scanners, vibrometers, and settings of complex applications.

Today Russia successfully develops all basic physical NDT methods: radiographic, acoustic emission, electromagnetic (magnetic and eddy-current), optical, thermal, fluorescence, visual, vibration testing methods, etc. Those methods and diagnostic techniques are widely used in all major industries: metallurgy, machine building, power, aerospace, oil and gas, railway and pipeline transportation. The most critical defects in machine building industry such as corrosion, ageing and fatigue stresses are under special monitoring due to their danger that results in annual losses of about $200 billions.

2. Basic Areas of NDT and TD applications

The operation principle of diagnostic systems is based on the monitoring of physical diagnostic parameters: kinematical, geometrical, statistical, dynamical, mechanical, molecular, thermal, acoustic, electrical, and magnetic and others, the number of which does not exceed 200 and can be processed systematically to assemble the necessary line for inspection.

The most essential measuring methods for physical parameters diagnostics are: electrometry, vibroacoustic, introscopy, measurement of mechanical properties, composition, dimensions, forces, deformations, pressure, temperature, time, weight, humidity, rate of throughput level, etc. It is natural that all diagnostic complexes are designed on the basis of recent achievements in information technology with the use of nanotechnology, new probes and area sensors, mathematical methods of multiparameter signals and images processing, monitoring programs, computers, global networks, banks and data bases. In Russia, all TD mainstreams are developing: man-caused, ecological and anti-terrorist that are discussed further.

2.1 Technogenic diagnostics

For tasks of technogenic diagnostics were designed a number of industrial equipment (portable, mobile, stationary) for operative inspection of parts of different application. Portable ultrasonic and electromagnetic flaw detectors, ultrasonic thickness gauges, magnetic thickness gauges for coatings, ultrasonic tomographs, magnetometers, continuous and pulse X-ray systems, stationary highly stable industrial cable X-ray systems with output voltage from 100 kV up to 450 kV, digital radiographs, industrial X-ray computerized tomographs, portable non-cooled IR imagers, humidity meters, vibrometers, etc.

A number of domestic companies manufacture mobile X-ray systems of continuous operation, gamma-flaw detectors, X-ray-TV systems, X-ray industrial tomographs.

There are first tomographs with betatrons designed in Tomsk Research Institute of Introscopy (NIIIN), and Moscow company “Promintro”.

On the basis of ultrasonic, wave guiding, holographic and tomographic methods and the methods of phased arrays, developed a number of ultrasonic tomographs, wave guiding flaw detectors, EMA thickness gauges, automotive motor-rail cars that are widely used in airspace, construction industry (inspection of concrete), nuclear, thermal power and iron industry, railway and pipeline transportation.

Optical methods have advanced in metallographic microscopes with automatic system of image processing as well as new types of flexible and rigid endoscopes.

Some examples of developed instruments and systems are presented on following photos 2-7.
Photo 2. X-ray Crawler for welds examination in the process of pipeline construction

Photo 3. Mobile complex laboratories for water leak detection, cable line tracing and failures detection, hidden pipelines location, evaluation of cathode protection quality

Photo 4. Intelligent magnetic tool for operating gas and pipelines inspections

Photo 5. X-ray computerized tomograph

Photo 6. Metallographic microscope

Photo 7. Ultrasonic tomograph for concrete structures quality evaluation

There are available new types of devices (receiver-analyzer) designed for vibration analysis. As well as number of various mobile laboratories based on different automobile chassis (UAZ, ZIL, GAZ, etc.) that are equipped with measuring instruments, power supply
modules, and used to detect cable line failures, water leaks location, underground pipelines traces, quality of welding joints and technical condition of cathode protection.

The methods of residual life evaluation and the evaluation of operational risk are the most developing ones. The residual life of an object is determined by a set of technical parameters, equation of condition, operation conditions and by the set of boundary technical parameters. The evaluation of residual life of highly important objects allows us to stop their operation in due time and arrange the proper maintenance.

2.2 Ecological diagnostics

The tasks of environment protection are the most urgent and important ones as well as most advanced, time-consuming and expensive taking into account the fact that the losses from ecological emergency cases are twofold higher than any others.

One of the most “bright” examples of the global problem of ecological diagnostics is the tsunami happened in Asia in December 2004 that took 300000 people lives. For earthquakes the methods and technologies of prediction are employed beginning from long-term calculations and ending up with magnetometric, geochemical, hydrodynamic, electrical, seismic, deformational and other sorts of measurements.

To predict an earthquake it is necessary to employ a number of devices: strain meters, hydro-geodetic levels, magnetometers, electric field and resistance meter, acoustic and electromagnetic emission. The geometric, hydro geological and biological measuring methods are also applied.

An urgent problem is the detection of nuclear wastes: gamma, alpha and beta radioactive nuclides, products of nuclear explosions. The measurement of radon, cesium, strontium and other elements activity is of great importance.

For this purpose Russia uses more than 100 types of radiometers, gamma-alpha-beta spectrometers, different dose meters and other technical means.

Many optical devices are also used in ecological diagnostics of atmosphere, water, soil and biotics including different types of lidars, spectrometers, CCD cameras, reflectometers, light meters, brightness meters and others.

More than 150 types of thermal imagers, radiometers, pyrometers, thermometers, line scanners and others are used for gas blow-out monitoring, heat leakage, fires, geothermal activity and all that.

Many tasks on the determination of humidity, rain precipitation, water-salt mode, water reserves, coats of snow and ice, etc are solved by the radio wave methods of diagnostics such as radiometric, radiolocation, TV, polarization, radio holographic, resonance, geometrical and time-domain ones. The terahertz frequency range for radio-wave testing methods has been actively developing for last years. At present there are more than 50 types of MVF diagnostic devices – radiometers, radio detectors, microwave scanners, radio altimeter, meteorological parameter gauges, ground penetration radars and others.

There are more than 700 methods and technologies of chemical analyses of atmospheric air and aerosols, atmospheric precipitation, industrial emissions, drinking and sea water.

Tens of gas chromatography methods are used for this purpose such as electrochemical, photometric, fluorescent, IR, ultra-violet, atomic emission, nuclear magnetic resonance, weight, conductometric and others that are also used in hundreds of different types mobile laboratories and instruments.

Taking into account the fact that more than 250 types of gas analyzers of atmospheric air, soil and hydrosphere are used, the chemical analytical branch of ecological diagnostics is still important and knowledge-intensive.

All together in the field of ecological diagnostics used are more than 1200 types of devices and instrument channels, more than 2000 methods and technologies, with the turnover in Russia being not less than $2 billion.

2.3 Anti-terrorist diagnostics
To provide public safety and security the means and methods for the detection of weapons, explosives, radioactive and radionuclide emission as well as for verification of documents and security papers authenticity based on NDT methods are used. The devices and technical means for patrolling, surveillance and search of criminal elements comprise a big family as well (some examples are presented in photos 8,9).

Photo 8. Explosives gas analyzer  Photo 9. Non-cooled IR imager

For above mentioned purposes used are the X-ray, magnetic, thermal and eddy-current methods that held to arrange the inspection of airline passenger luggage and people at the entrance to the objects of high risk. The optical television and endoscope systems for technical vision used are widely used in banks, security services, apartment buildings and transportation systems security, etc.

In Russia in lots designed and manufactured is forensic equipment that provides detection with high reliability of fake products and counterfeits. This is a wide range of instruments from simple and cheap ultrasonic devices and IR illuminators up to special imaging spectrometer installations; the instruments for documents and security papers examination in ultraviolet and reflected IR radiation, IR magnifying glass operating in reflected IR radiation, imaging spectrometer comparator that reveals purposely done changes in the originals, forensic systems for detailed documents examination in ultraviolet and visual light ranges.

The sampling probes used to control soft and discrete material, technical endoscopes, non-cooled thermal (IR) imagers, night vision devices and X-ray fluoroscopes are manufactured.

The separate range of developed and manufactured optic electrical is used for detection and visualization of portable systems of covert observation at the distance up to 15. For example, the multi-spectrum detection system “Zond” is designed for visual detection of hidden and camouflaged objects in a wide range of wavelengths and consists of 3 receiving channels with different spectral ranges from 400 nm up to 13 µm that allows detection of a man and covert observation at distance up to 1000 m.

3. The NDT personnel certification system

3.1 Certification schemes used in Russia

The activity in the field of NDT personnel certification in NDT in Russia is conducted by several Bodies: The Federal Service for Environmental, Industrial and Nuclear supervision (ROSTEKhNADZOR), Independent Centers on NDT personnel certification, Training and Examination Centers. Personnel are certified for three qualification levels (1, 2, 3).

Currently in Russia there are 34 Independent Certification Bodies (CB) and 100 examination centers. Annually relevant Bodies of Russia certify for: 1-level – 1100; 2-level – 16000; 3-level – 220 specialists.

Due to absence of legally appointed by the Russian Government Accreditation Body some Russian Certification Bodies had and have to apply for accreditation from International Accreditation Bodies while CB “SPEKTRCert” of JSC “MSIA “Spectrum” supported by the
RSNTTD decided to become a pioneer on the way proposed by the EFNDT for countries where legally established Accreditation Body is not present.

For CB “SPEKTRCert” it was very important to have an international recognition to become a part of the Multilateral Recognition Agreement (MRA) administrated by the CEC of EFNDT and, as soon as possible, to use the Question Banks developed by BINDT (UK), DGZIP (Germany) and Cofrend (France).

The approval procedure was split in two stages.

At the first stage (in July, 2006) the EFNDT auditors evaluated the readiness of CB “SPEKTRCert” to perform the certification in accordance with the requirements of ISO/IEC 1704:2003, EN473:2000 and IAF CD 24:2004. They followed the procedure developed by the CEC EFNDT. Assessors visited examination center where practical exams are conducted, checked examination specimens and made several recommendations.

In March, 2007 the follow-up audit was arranged during which the results achieved by “SPEKTRCert” to the moment were revised. The general impression of the assessors was positive and final report was prepared where some minor comments and observations were made.

After two audits were performed the CB “SPEKTRCert” was approved as complying with the requirements of ISO/IEC 1724:2003, EN473:2000 and IAF CD 24:2004 and Certificate on Approval and of Certificate of Registration and MRA were issued. The approval is valid for three years.

Audit of Certification Body “SPEKTRCert” seeking EFNDT approval was the first after all documents for approval were set by CEC EFNDT.

The work done by teams of EFNDT assessors and specialists from certification body together is of great importance for all participants and EFNDT as institution.

3.2 Harmonized Question Banks

The extension of economic ties of the Russian Federation in the world market, cooperation with the USA and other countries requires the harmonization of certification procedures implemented by the ASNT and the EFNDT as well as criteria for specialists training in the field of NDT.

In year 2002, the ROSTEKhNADZOR established the system based on the normative-legal “Rules of NDT personnel certification (PC 03-440-02)” and covering 12 NDT methods: ultrasonic, acoustic-emission, radiographic, magnetic, eddy-current, liquid penetrant, leak testing, visual and measuring, vibration analysis, electrical, thermal, and optical. Established system is in good compliance with international and European standards implemented in this area but takes into account specific Russian requirements.

In its turn the RSNTTD developed a bank of examination questions for I, II and III levels of NDT personnel certification covering 10 NDT methods (ultrasonic, acoustic-emission, radiographic, vibration analysis, magnetic, eddy-current, liquid penetrant, thermal, visual and instrumental). Approximately at the same time were formulated the minimal requirements imposed on the process of NDT personnel training and the requirements for the level of knowledge in the field of material technology, material science, product defects, knowledge of certification systems established by EN473:2000 and by PC 03-440-02 (basic exam for III-rd level). It should be noticed that basic difference of NDT personnel certification schemes is in the determination of types of Certification Bodies providing certification.

According to the document SNT-TC-1A– the Certification Body is employer based, i.e. Second part certification.

While according to the standards EN 473 and ISO 9712 and rules PC 03-440-02, the Certification Body shall be independent, i.e. the Third party certification.

At the same time the question banks prepared by the EFNDT, RSNTTD and ASNT are very similar and meet basic requirements of the relevant European and international Standards.
For example, the RSNTTD question bank covers 10 NDT methods, while the EFNDT question bank covers 6 and the ASNT question bank covers 13 NDT methods (in last one 4 methods are leak testing methods).

The total number of questions in various the question banks as follows – 5354 (RSNTTD); – 7205 questions (EFNDT) and question bank and 2830 questions (ASNT)

The RSNTTD question bank for the basic exam, Part A, for level III contains 140 questions on material science, manufacturing technology of welding and castings made of iron, thermal treatment, appearing defects and their influence onto the product quality. Less number of questions of ASNT and RSNTTD can be explained by their limited application and the elimination of repeated and identical questions.

The comparison analysis of the RSNTTD, EFNDT and ASNT question banks shows that each of them has advantages and disadvantages, and the effectiveness of NDT personnel certification will significantly improve if examination questions of the above societies and others would be combined.

By our opinion, it is wise to take the examination questions of the RSNTTD, EFNDT and ASNT banks for the following 16 basic testing methods:

1. Ultrasonic testing – (EFNDT, RSNTTD, ASNT);
2. Radio wave testing – (EFNDT, RSNTTD, ASNT);
3. Radiographic testing – (EFNDT);
4. Neutron Radiography testing – (ASNT);
5. Magnetic testing – (EFNDT, RSNTTD, ASNT)
6. Magnetic Particle testing – (EFNDT, RSNTTD, ASNT);
7. Liquid Penetrant testing – (EFNDT, RSNTTD, ASNT);
8. Leak testing – (RSNTTD, ASNT);
9. Visual and Measurement testing – (EFNDT, RSNTTD, ASNT);
10. Visual Optical testing – (RSNTTD, ASNT);
11. Eddy-Current testing – (EFNDT, RSNTTD, ASNT);
12. Radiation testing and Safety Precautions – (EFNDT);
13. Acoustic Emission testing – (RSNTTD, ASNT);
14. Vibration analysis – (RSNTTD, ASNT);
15. Electrical testing – (RSNTTD, ASNT);
16. Thermal testing – (RSNTTD, ASNT)

To bring together the requirements and methods for NDT personnel certification it is also wise to align at the most the examination questions of the RSNTTD, EFNDT and ASNT question banks.

3.3. Certification of NDT and TD instruments and devices

The RSNTTD together with interested authorities and parties in addition to the NDT personnel certification system has built up a certification system of NDT and TD technical instruments and devices.

The NDT equipment for measurements is certified by the Federal Service “ROSTEKhREGULIROVANIE”, the certificate is issued based on the results of trials and tests performed by the relevant Service and instruments are registered in the Register.

Other types of NDT equipment are certified by either the State Services or the Services of RSNTTD. Availability of certificate means permission to use certified products for the industrial applications.

4. Conclusions

Russia is carrying out a large innovative work in the field of NDT and TD. About 400 patents are issued annually. The development prospects for NDT and TD in Russia are very
promising and the NDT role in the development of the state industrial potential will definitely be rising continuously.

Great influence of Russian NDT Society and community is confirmed by the fact that it was awarded to host the 10th European NDT conference on 7-10 June, 2010.