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DEVELOPMENT OF NON –DESTRUCIVE TESTING (NDT) TECHNOLOGY IN PAKISTAN

ASGHAR ALI KHAN

NCNDT, SES Directorate, P.O. Box 1781, Islamabad, Pakistan

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Non-Destructive Testing (NDT) techniques are being extensively used to improve and maintain the quality of manufactured goods as well as for proper maintenance of industrial plants and equipment. Typical industries that benefit most include Aerospace, Chemical, Heavy Mechanical Fabrication, Conventional and Nuclear Power Generation, Automobiles, Oil and Gas, Shipbuilding, Foundries, and Armaments, etc. As the name implies, with these techniques an industrial product is inspected mostly for defects in its structure without destroying it. Among the most widely used NDT techniques for the detection of internal defects are Radiographic and Ultrasonic Testing. For surface and just below the surface defects Magnetic Particle Testing, Penetrant Testing and Eddy Current Testing are commonly used. In addition to these, there are some NDT methods which have specific applications. These include Acoustic Emission, Thermal and Infrared Testing, Microwave Testing, Computer Tomography, Strain Gauging, Leak Testing and Holography, etc. This paper describes various phases through which the development of NDT technology passed and its present state of the art. It started with the undertaking of a nuclear technology programme and has matured along with it. As it stands we are fully competent to undertake various essential activities related to this technology, namely,

(i) Training and certification of NDT personnel at various levels.

(ii) Provision of NDT services to various industrial sectors including nuclear power during manufacture, fabrication, pre-service inspection (PSI) and in-service inspection (ISI).

Keywords : Non-destructive testing, Development, History, Pakistan

1. Introduction

Non-Destructive Testing (NDT) techniques are being extensively used in the world to improve and maintain the quality of manufactured goods as well as for proper maintenance of industrial plants and equipment. Typical industries that benefit most include Aerospace, Chemical, Heavy Mechanical Fabrication, Conventional and Nuclear Power Generation, Automobiles, Oil and Gas, Shipbuilding, Foundries, and Armaments, etc. As the name implies, with these techniques an industrial product is inspected mostly for defects in its structure without destroying it. Among the most widely used NDT techniques for the detection of internal defects are Radiographic and Ultrasonic Testing. For surface and just-below-the-surface defects Magnetic Particle Testing, Penetrant Testing and Eddy Current Testing are commonly used. In addition to these, there are some NDT methods which have specific applications. These include Acoustic Emission, Thermal and Infrared Testing, Microwave Testing, Computer Tomography, Strain Gauging, Leak Testing and Holography, etc.

The National Centre for Non-Destructive Testing (NCNDT) was established by the Pakistan Atomic Energy Commission (PAEC) formally in 1995, but the NDT activities have been carried out in PAEC since the mid nineteen sixties. Establishment of the Centre has filled a long overdue need of the industrial sector of the country. It is quite timely as the country is picking up momentum to industrialize.

The NCNDT is fully equipped and well staffed for carrying out the following jobs:

i. Training and certification of NDT personnel at various levels.

ii. Providing NDT services to various industrial sectors of Pakistan during manufacture, fabrication, pre-service inspection (PSI) and in-service inspection (ISI).

This paper describes the role played by the

Corresponding author : ncndt@isb.comsats.net.pk

NCNDT for the provision of NDT services to the conventional and nuclear industry in Pakistan.

1. Early Years

At the time of independence in 1947, Pakistan had practically no industries; but during the late fifties and sixties intensive efforts, were made to establish various types of industries which included Chemical, Shipbuilding, Foundries, Armaments, Oil and Gas, Heavy Mechanical Fabrication, Automobiles, etc. Conventional and Nuclear Power Generation plants were also introduced. Most of these industrial plants were erected with the help of foreign companies. Consequently, foreign NDT companies-including the well known NDT company, Chicago Bridge alongwith their equipment and manpower were also involved in the erection of industrial plants. In 1960 a first Pakistani Company, Inspection and Reclamation Services Ltd., was established. A few years later, another Pakistani company, Industrial Inspection Consultants, was formed. In early 1960s, Pakistan Atomic Energy Commission had initiated its programme for the utilization of nuclear energy for power generation and other applications. It was visualized that Quality Control and Non-destructive Testing would be highly essential for the inspection of nuclear power plants and other facilities for their safe and reliable operation. Therefore, a number of bright young scientists were recruited and sent abroad for education and training in the field of general industrial applications of radiation technology, including industrial radiography. On return from abroad these persons established the radiography facilities as well as other NDT techniques at the Atomic Energy Centre, Lahore. Training materials were also developed and the first Industrial Radiography Course was organized in 1965. This course was regularly conducted at intervals of 1–2 years. This 8-weeks extensive training course included all the theoretical and practical aspects of radiography. Organisation of these courses introduced the NDT in general and radiography in particular in many government and industrial organizations. As a consequence, many organizations started to show interest in the development of NDT technology. Pakistan International Airlines requested for organizing a special course exclusively for its personnel, which was conducted in 1967. The NDT group at Atomic Energy Centre, Lahore, along with private NDT companies, also started providing some on-site NDT services. Some of these services included ultrasonic wall thickness measurements of chemical reactors at ICI Khewra, radiographic testing of oil storage tanks at Khanewal and Sihala, power houses at Shahdara and Guddu, gas and oil pipelines of ODGC and Pakistan Refinery Ltd., etc.

2. NDT During Seventies

In 1971 all the physical sciences activities at Atomic Energy Centre, Lahore, were shifted to the Pakistan Institute of Nuclear Science & Technology (PINSTECH). The NDT group expanded into Radiation and Isotope Applications Division (RIAD). The facilities of equipment and manpower were expanded and more persons were sent abroad for training in the field of NDT. In addition to industrial radiography courses, which continued to be held, others on ultrasonic testing were also initiated. Simultaneously, PAEC also established a Directorate of Industrial Liaison (DIL). The main functions of the directorate were to provide locally manufactured equipment and spare parts to various PAEC establishments, especially Karachi Nuclear Power Plant for which the Canadians had stopped to supply spare parts after the Indian nuclear test in 1974. The directorate established Quality Assurance Labs in the industrial area of Islamabad and actively started enhancing NDT facilities of equipment and manpower, and also organized seminars and training courses on the theme of quality assurance and control. NDT as an important tool for quality control remained an integral component for all these seminars and courses. This proved to be another good step in the direction of promoting awareness about NDT and quality control throughout the country.

In the early 1970s PAEC signed a bilateral cooperation agreement with Karlsruhe Nuclear Research Centre in Germany for the development of peaceful applications of nuclear energy. The programme of activities included training of persons in NDT technology, which helped to further improve the quality and capability of NDT personnel. The scope of NDT services to various industries in the country expanded during this period, and the number of private NDT companies increased significantly. Most of the NDT work was undertaken by these NDT companies with only limited help from abroad. The number of training courses increased and so did the NDT manpower in various industrial organizations. Towards the end of the seventies, International Atomic Energy Agency (IAEA) in collaboration with the United Nations Development Project (UNDP) sent a mission to the countries of East Asia and Pacific, including Pakistan. The mission was assigned the

task of assessing the level of industrial growth of the countries of the region and to look into the possibilities of introducing radiation technology for the improvement of industrial processes and quality of industrial products. The scope of the proposed radiation technology project included industrial radiography. However, due to the complementary nature of methods of NDT the whole range of NDT methods got included in the scope of the proposed IAEA/UNDP joint project. As a consequence of findings and recommendations of the mission a regional project was proposed, and for its execution a Regional Cooperation Agreement (RCA) was signed between 17 countries of East Asia and Pacific region including Pakistan. The scope of the work to be done included various aspects of radiation technology, radioisotope gauges, radiotracers, radiation processing, research reactors utilization and non-destructive testing.

3. NDT during the Eighties

In the 1980s, UNDP/IAEA/RCA project for the promotion of radiation technology in industries gained momentum, and NDT was included as one of the sub-projects. Many regional training courses were organized in which participants from member countries including Pakistan took part. Most of these regional training courses contained a part on "train the trainers", whereby the participants were instructed in the art of conducting training courses. The objectives of IAEA/RCA project were to develop core groups of personnel who would conduct training and certification of personnel and provide NDT services to industries. Thus the role of IAEA for promoting international harmonization for training and certification of NDT personnel through the use of ISO 9712 standard, and establishment of professional NDT societies and strengthening the International Committee for NDT (ICNDT), proved to be very effective. Simultaneously, efforts were made for the development of an international standard for qualification and certification of NDT personnel sponsored by ICNDT, International standards organization (ISO), and the IAEA. A draft, ISO/TC 135/SC7 N35-E, was issued in 1986 for Non-destructive testing: qualification and certification of personnel. A set of syllabi for various NDT methods was compiled by the IAEA as Training Guidelines in Non-destructive testing techniques (IAEA-TECDOC-407), and some training materials were also developed. These were used as text books for the regional training courses organized under UNDP/IAEA/RCA. The participants of such courses were guided and encouraged to organize similar training courses after return to their home countries. Consequently this group of trained persons started to organize additional training courses, this time in line with the guidelines of IAEA and the proposed draft ISO standard.

By the mid-eighties, the Directorate of Industrial Liaison was renamed and reorganized into the Directorate of Scientific & Engineering Services (SES). The scope of its activities was expanded manifold. It was envisaged that the facilities for NDT and QC (quality control) would be essentially needed in support of the manufacturing activities. Consequently the NDT group from RIAD, PINSTECH, was transferred to the SES Directorate and given the mandate of expanding the NDT activities including the training and certification of manpower and provision of NDT services to industries at large.

A document fulfilling the minimum requirements of the proposed ISO draft standard was approved by the PAEC. This document was entitled "Scheme for training and certification of NDT personnel" (PAEC/SES/NDT/001). It also included the constitution of a Board for training and certification of personnel to oversee the implementation of the above-mentioned PAEC document. Thus the training and certification of NDT personnel became more formalized. The training courses were now held in accordance with the standard documents. The certification examinations were properly conducted according to the ISO draft standard guidelines by an authorized examination committee. According to these guidelines a candidate for certification should obtain a minimum 70% marks in the individual papers with an aggregate minimum of 80%. This examination procedure started to gain more support from national industry during the last quarter of the 1980s. In view of the increased activities of the NDT laboratory, it was considered appropriate to upgrade it to the level of a national centre. Thus work was initiated for the design and construction of a national centre for non-destructive testing (NCNDT) in the industrial area of Islamabad. By this time numerous commercial and private NDT companies had been established, which were able to cope with the increasing NDT work in the country. In fact, some of the trained and certified manpower also went over to the Middle East countries where they got good jobs and good salaries.

4. NDT During the Nineties

The IAEA/RCA project for the promotion of NDT technology continued and many personnel from the NDT laboratory were trained and certified through various regional training courses organized under the project. The IAEA-TECDOC-407 “Training guidelines in non-destructive testing techniques” was updated and re-issued in 1991 as IAEA-TECDOC-628 with revised syllabi. Similarly the ISO draft standard was revised and re-issued as ISO-9712 (1992) and later as ISO-9712(FDIS) - 1999. The IAEA developed training manuals in accordance with the syllabi contained in TECDOC-628. Some of these training materials were the updated version of the lecture notes being used at the NDT laboratory. Therefore, in the light of international developments, training and certification process at the NDT laboratory of SES Directorate was also improved. More standard test pieces containing known flaws were fabricated and the number of training courses was enhanced. During this period many international experts were received through IAEA sponsorship, and many persons went abroad on fellowships. These further helped to improve the training and certification process.

By the mid nineties the NDT laboratory was up-graded into the National Centre for Non-destructive Testing (NCNDT) and housed in a newly constructed building. It was properly inaugurated by the-then Minister for Industries. Under the international technical assistance programme of IAEA a laboratory for NDT of concrete structures was added to the centre, which already had all the facilities for the basic five NDT methods as well as for destructive testing. Also, preliminary work was undertaken for the establishment of digital industrial radiography. Some more officers and equipment from PINSTECH and other PAEC establishments were transferred to the centre as well as additional manpower was recruited.

As the number of NDT companies and personnel increased, it was decided to undertake work for the formation of a Pakistan Society for Non-Destructive Testing (PASNT). A constitution was drawn and the Society got registered with the Registrar of Societies, Islamabad. In December 2000, during the 15th World Conference of NDT, PASNT was admitted as a full voting member of the International Committee for Non-Destructive Testing (ICNDT). The membership of PASNT continues to grow and is 170 at this stage.

The NCNDT started to publish a quarterly NDT Newsletter. The Newsletter contains important NDT news from home and abroad and is circulated to over 500 organizations in the country. During this time Pakistan Nuclear Regulatory Authority (PNRA) was established, which started to enforce the regulations for the use on radiation sources in all areas including industrial radiography. PNRA required that under their guidance a paper of radiation safety should be an essential and mandatory part of the training courses and examinations conducted by the PAEC certification board. This happened towards the end of decade of the 1990s. The author joined the IAEA as a Technical Officer (NDT). His presence in Vienna exposed him to a large number of international NDT bodies and provided a new vision to the NDT development programme in Pakistan. More personnel from NCNDT attended courses abroad, and also went to other countries as IAEA experts to share the experience of Pakistan with other developing countries.

5. Present Status of NDT Development

Non-Destructive Testing Technology is now well introduced in a large number of industries in the country. The number of industrial organizations which have sent their personnel for training to NCNDT is more than 100. Training and certification of NDT personnel is now a regular activity of the NCNDT. The NCNDT has conducted more than 155 courses and the number of participants to these courses is over 1700 to-date. Out of these, more than 1200 persons have been certified at various levels of competence. The NCNDT has faculty and equipment to conduct training courses up to level-3 in all the basic five NDT methods, namely liquid penetrant testing (PT), magnetic particle testing (MT), ultrasonic testing (UT), eddy current testing (ET)) and radiographic testing (RT). Some specialized courses such as ultrasonic flaw sizing, interpretation of radiographs, NDT and fracture mechanics, Introduction to NDT of concrete structures, and NDT appreciation course for management personnel have also been added to the list of NDT courses. The number of private and NDT companies capable of providing NDT services to various industries and projects has significantly increased. There are now about 20 such companies of various sizes providing such services. The NCNDT also provides specialized NDT services to industries. These are mostly in areas and for problems for which the private NDT companies have limited know-how and facilities. Some of the industries for which we have provided

NDT services include Power plants at Uch, Guddu, Shahdara, Multan, Warsak, Daragei, Faisalabad, Mangla, Tarbela; three refineries, namely Pakistan Refinery Limited, National Refinery Limited and Attock Oil Refinery Limited; gas processing plants of Oil and Gas Development Corporation Limited at Dakhani, Qadirpur, Uch and Tando Alam. In addition, NDT services have been provided to numerous other types of industries and the number of such industrial organizations is close to 70. In-service-inspection support is regularly provided to both nuclear power plants of PAEC, namely, KANUPP and CHASNUPP. At KANUPP, our involvement has been typically for inspection of main steam condenser tubes, inspection of heat exchanger tubes, fuel channel tubes, reactor outer concrete containment and the inspection of piping welds. The NCNDT has actively participated in all the both Reactor Fuel Outages (RFOs) carried out by CHASNUPP. As a first step we have performed all the NDT in the Conventional Island. The work involved inspection of main steam header piping, steam bypass piping, first-stage reheat steam piping, steam piping between high pressure (HP) cylinder and moisture separator and re-heater, main feed water piping, HP heater tubes, low pressure (LP) heater tubes, main condenser tubes, component cooling water heat-exchanger tubes, main steam piping etc. The team also acted as observers to the Chinese inspection company RINPO in the nuclear island, hoping that more active participation could be made in this area in the future. The NCNDT has started to undertake fracture mechanics based life- assessment studies for complete plant systems and components. Such studies are aimed at determining the fitness-for-purpose of the ageing equipment in the industrial plants. The NCNDT has plans to further expand NDT education to the Universities and polytechnic institutes of the country. NCNDT has started to undertake third- party inspection services with a view to improving the quality of NDT inspection in industry. The area of NDT of concrete structures presents a vast scope of applications, and is therefore being actively considered for establishment first at the NCNDT and later throughout the country. With the help of the IAEA, some of the needed equipment for this purpose has already been acquired and the first course on NDT of concrete structures successfully organized.

Mr. Asghar Ali Khan is former Director and presently Advisor, NCNDT, Islamabad.