A history of non-destructive testing in Argentina

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For many years, Argentine governmental and private organisations have had the mission to approach and introduce in the country different aspects of non-destructive testing: research, development, services, training, certification and standardisation. In the present paper some highlights of this process are described.

1. Introduction

During much of the 20th century, Argentina's evolution from an agriculture and livestock-based country to an industrial one with technical capacities in many disciplines, prompted governmental and industrial organisations to promote and enhance the quality of domestic products, goods and services, fostering the presence of Argentine technological products on the export market. The stress was put on developing our own capacities to undertake research and development activities in support of our budding industry and looking forward to technological self-sufficiency.

Part of this process was the foundation in 1935 of the Argentine Institute of Standards (IRAM), a non-profit private civil association which is responsible for the national technical standards. In the regional order, it is part of the Panamerican Commission for Technical Standards (COPANT) and is also a member of the International Organization for Standardization (ISO).

A fundamental step was taken in the 50s, when activities in different fields of transformation metallurgy with a high scientific and technological commitment began. Inspection criteria were adapted and new organisations were created, such as the National Institute of Industrial Technology (INTI), the National Atomic Energy Commission (CNEA) and the Argentine Center for NDT (CAEND). The former two organisations were devoted to research, development and support of industry. The last one, a private Society, organised the first open courses for the training of NDT personnel.

Map of Argentina, showing the places where training courses on NDT have been offered within the framework of the NDT project. The continental territory, shown here, is 3,800 km long and is located between latitudes 22º and 55º South

The history of NDT in Argentina is actually strongly intertwined with the onsetting of the nuclear activities in the country and with the political decision made at that time, that many of the elements for the construction of the nuclear power plants were to be supplied by local industry[1]. At those early days it was clearly understood that 'the establishment of a national quality assurance/quality control (QA/QC) system is very important for safe, reliable and economic operation of the nuclear power plant.[…It] must be established also in the national industries….'[2].

In particular at the very beginning of nuclear activities in Argentina, a General Metallurgy Technical Group was formed in CNEA. This group was active in research and development on a wide range of problems related to systems and materials (such as solidification, corrosion, welding, phase transformations, diffusion, metal forming, material characterisation). In this context, plans

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were made towards the establishment of a highly skilled NDT team which was to devote itself to inspection problems in connection with research reactors, nuclear power reactors and associated nuclear facilities. In fact, the first NDT activities at CNEA in the early 60s were the X-ray inspection of the enriched uranium-aluminium plate fuel elements for the RA-1 (our first research nuclear reactor, constructed at the Constituyentes Atomic Center). It was always borne in mind, however, that these techniques had to be extended to other industrial fields in the country. Within this perspective, the Technical Assistance to Industry Service (SATI), a link between researchers, technologists and the metallurgical industry, was created in 1961 and postgraduate courses of metallurgy were dictated at CNEA on a yearly basis, within the framework of the Organisation of American States (OAS) through their Multinational Metallurgy Programme (MMP)[1].

2. Atucha I Nuclear Power Plant

A very important step forward was taken in 1965, when the country started considering the incorporation of nuclear electricity, under the 'natural uranium-heavy water' line. This step forward in national development, the production of energy from the fission of uranium atoms, spelled new technologies but also new risks, increasing inspection requirements from both qualitative and quantitative viewpoints, radiation hazards, etc. As prompted by the political views of the period, these strict requirements were handled in such a way as to assure maximum participation of national entities and industry. Particular emphasis was placed on encouraging national companies to produce many high-technology elements for the emerging nuclear industry, and this meant helping the metal and electromechanical industries acquire high-quality standards. CNEA and SATI provided much of the R&D support these companies needed to meet the requirements of the contractors[3,4]. Support was also given to IRAM to create or adapt industrial standards for nuclear grade products.

In 1968 the construction of the first Argentine nuclear power plant Atucha-I (CNA-I) began. This 300 MW pressure vessel, heavy water reactor (PHWR), a turnkey contract with German companies, started operation in 1974. NDT technologies had an important role in the assembling, start-up and in-service inspections of these complex installations, including the development of specially tailored equipment and procedures from the very first steps of the project.

3. The National Project of NDT

Basic points and the way domestic industries could accompany the insertion of nucleoelectricity in Argentina were both considered at the time. In 1969, within this spirit, and willing to accelerate this process, the Government of Argentina requested the assistance of the United Nations Development Program (UNDP) in the establishment of a National Centre for Non-Destructive Testing and Quality Control Methods (INEND) to support the country's rapid change from an agriculture-based economy to an industry-based economy, in particular to support the budding nuclear industry. UNDP and the International Atomic Energy Agency (IAEA) joined forces to conduct a survey mission in 1971, and in 1972, a project for the development of the centre was implemented[3,6].

When revisiting IAEA's history up to the present, it can be appreciated that the Argentine NDT National Project served as a reference for other projects, and that the important budget granted at that time was considerably higher than budgets similar projects are now granted. CNEA contributed with auxiliary equipment, laboratories, logistics and as counterpart an industrial gammagraphy laboratory and complementary laboratories were installed at the Constituyentes Atomic Center. Many years later, IAEA acknowledges the 'important pool of expertise [that] now exists within IAEA Member States' …. 'in the peaceful use of nuclear technology, such as NDT… '[7].

This was a true 'model project', as they are now called. The final user, so difficult to identify in the 'globalisation perspective' of the 90s and this early 21st century, was clearly defined on project postulation: the country itself. The whole country would actually benefit from the use of NDT of the highest scientific quality, and the multiplying effect of its future results would thus be ensured. We shall come back to these issues later.

A very important point in the project was the formation of human resources, because at that time Argentina lacked specialists in many scientific and technological fields related to nucleoelectricity. The project thus included a plan for training and fellowships abroad, for the purchase of modern and innovative equipment for the nuclear and the conventional fields, and for visits of foreign experts. In fact, through this project, some 15 international experts – most of them from UK (Harwell), France (COFREND), Spain (CENIM), Germany (Düsseldorf University) - visited Argentina, and 19 Argentine specialists studied in 10 different countries. INEND also began to offer training courses locally, and by 1979 had trained some 1300 individuals in NDT techniques[3,6]. The multiplying effect at the domestic order was thus achieved[4].

In that same period, the OAS had been sponsoring fellowships at CNEA through its Multinational Metallurgy Programme with the NDT portion being provided by INEND. Fellows from throughout Latin America returned to their home countries with an exposure to NDT and began to ask various UN agencies for assistance in developing their own NDT programmes[6].

In addition to providing inspection services, INEND pioneered the development of national standards of welding and NDT, including one for the qualification and certification of NDT personnel[5]. The public discussions on technical standards on NDT promoted by CNEA were carried on IRAM. At that time, the Bulletin 'INEND Informa' was edited and distributed in Argentina and the rest of Latin America. It was an excellent support to the technical activities and helped establish contacts throughout Latin America and the Caribbean.

In order to reach the most remote parts of the country, the acquisition of a mobile NDT training laboratory was also envisaged within the Project. It arrived in the country in 1976.

This mobile training laboratory, designed by INEND's personnel and fully equipped for many NDT methods, was at that time unique in the world. During the existence of the Project and later on, after it was incorporated to CNEA's patrimony, it proved to be very useful to the country and to neighboring countries as well. By the end of 1985, 50,000 km of national roadways had been covered, as shown in Figure 1. NDT Centres were established in different regions in the country, mostly in national or provincial institutions and Universities, such as INTI in Cordoba, Technical Assistance Direction (DAT) in Rosario, National Technological University (UTN) in Mendoza, Tucuman, Campana and Buenos Aires. Especialised centres were established, for example, at Aerolineas Argentinas Workshops in the Ministro Pistarini Airport in Ezeiza, Buenos Aires, and the Espora Aeronaval Base in Bahia Blanca in the south of the country, Figure 1.

Figure 1. Map of Argentina showing geographical regions and some of the cities mentioned in the article

4. Regional NDT Conferences

In 1979, by the time this Project which had started in 1971 was about to finish, the First Regional NDT Conference (I COREND) entirely devoted to NDT technologies was organised in Buenos Aires. The large number of Argentine and foreign participants vividly illustrated the wide interest in the subject. So much so that two years later, in 1981, the II COREND was held in Tucuman, with the support of the government of the Province of Tucuman and the National Technological University (UTN). A large number of participants from very important NDT centers in Latin America joined us. European experts were invited as guest lecturers. Roy Sharpe was invited to this Conference and visited INEND in October 1981.

After a long 16-year impasse, a new regional NDT meeting was held in 1997 in Mendoza under the name CORENDE (including Structural Testing and Condition Monitoring as well), which was followed by the CORENDE 2000 in Mar del Plata. We are now looking forward to a new CORENDE in 2005 and to holding PANNDT 2007 in Buenos Aires.

5. Embalse Nuclear Power Plant and Personnel Certification

In the meantime, the construction of a new nuclear power plant started in the 70s in Embalse, in the province of Cordoba. This plant, CNE, is a CANDU system 600 MW facility (natural uranium, heavy water, Zr-2.5%Nb pressure tubes, Canadian-Deuterium-Uranium plant). Argentine industry was to supply many parts, such as pumps, pipelines and heat exchangers, and to participate in the electromechanical and pipeline assembling of the CNE.

The principal contractor invited national tenders as well to perform the NDT inspections, in which the application of industrial radiography, ultrasound, liquid penetrants and magnetic particles was foreseen as part of a carefully settled working schedule. Argentina had so far no national inspector qualification and certification scheme, and consequently companies applying for the inspection tasks would need supervision from internationally recognised companies. Because the new nuclear power plant had to be licensed under the regulations of the country the applied technology came from, this presented us with a new problem and a new challenge.

There were some extra circumstances other than the inspection itself that prompted CNEA to create its own personnel certification procedure which, after approval by CNEA's authorities, was submitted to the contractor, who in turn approved it. In these conditions, we started working on inspection and assembly, and later on in a 'pre-service inspection' special program, under local leadership. 'The pioneering action of INEND' in this field 'made it possible that 20,000 tons of nuclear grade equipment and pipelines in CNE be mounted by Argentine companies, without the contractor requiring supervision by foreign specialists'[4]. CNE started operation in 1984.

From then on, INEND-ENDE was in charge of the periodical in-service inspections (ISI) and shutdown inspections of both nuclear power plants.

The NDT certification scheme for the four basic techniques, *ie*, industrial radiography, ultrasound, liquid penetrants and magnetic particles at levels 1, 2 and 3, is an invaluable result of the country's accepting such a challenge. Its importance can be fully appreciated now, 24 years after its implementation. Thanks to the experience acquired during CNE construction and through an IRAM-CNEA agreement, this procedure was publicly discussed until its acceptance as the IRAM-CNEA Y500-1003 standard. This standard was immediately put into force in Argentina and is applied in other countries as well.

The different public and private entities expanded due to the amazing variety of industrial requirements. Techniques became more and more popular and NDT methods were included in university curricula. Extension of personnel certification to other methods such as eddy currents and visual inspection was considered at that time. A national NDT personnel certification standard, IRAM-Y-9712, was approved in December 1993.

The National Registry of Qualified and Certified Personnel was created under IRAM assistance. Industries began to require their specialists were certified according to the mentioned standard. Argentina kept developing in a competitive frame and with the highest level of excellence. Personnel certification centers are working now in the country under the supervision of the Argentine NDT Certification Organisation (OACEND). At present there are five Certifying Centers, four of them in the Buenos Aires region and the fifth one in Mendoza, in the west region (Table 1 and Figure 1).

Table 1. NDT Certification centres in Argentina. Location of centres and methods certified. (BA: Buenos Aires), the UTN-Delta Center is in the city of Campana, 70 km North of Buenos Aires

Center	RT Radiographic testing	LP Liquid penetrant testing	MP Magnetic particle testing	UT Ultrasonic testing	ET Eddy current testing
CNEA-ENDE	X	X	X	X	X
INTI-BA	X	X	X	X	X
UTN-BA		X	X	X	
UTN-Delta					X
UTN Mendoza	X	X	X	X	

6. NDT Project for Latin America and the Caribbean

The INEND Project was about to finish. Time had come to share this experience with Latin America and the Caribbean. We did not even imagine, however, what the aftermath of our project could be. Indeed, the countries in the region showed great interest and gave their support in the light of Argentina's achievements. They accepted the challenge and each of them submitted a presentation to the international organisations.

In 1982, after two years evaluating the need for a regional project, the IAEA, the United Nations Financing System for Science and Technology for Development (UNFSSTD), and the United Nations Industrial Development Organization (UNIDO), joined forces and six countries started the Regional Nondestructive Testing Project for Latin America and the Caribbean (PREND). By 1985, an additional 11 countries had joined, and in early 1988, Costa Rica became the eighteenth country to participate. In this Project, cooperation from the governments of Germany, Canada and Italy have been particularly important[6].

Argentina's national authorities designated CNEA to represent the country and the Regional Coordinator established his headquarters at the Constituyentes Atomic Centre in Buenos Aires to undertake the organisation activities. CNEA invited all local entities related to NDT to join the National Committee. The scope of the activity in Argentina, as well as in the other 17 participating countries in Latin America and the Caribbean, was very wide.

This Project is over now. Latin America and the Caribbean face at present the need to harmonise the competence levels under the premise of human resource formation, to unify the certification schemes, to impulse the challenge of granting their personnel the responsibility to perform difficult and arduous tasks, and to recognise the importance of undertaking research and innovative activities.

7. The present, the future

Competence in different techniques has very particular characteristics according to their application areas: aircraft,

surgery, oil and gas pipelines, nuclear industry, large components of hydroelectric power plants, high-technology joint welding, etc. NDT is applied by many industries in their production processes, both for on-line and off-line inspection.

With regard to the international connections of our laboratories and societies, it is worth mentiong that in particular two NDT R&D laboratories are members of the World Federation of NDT Centers (WFCNDT), namely ENDE and FUDETEC (Foundation for the Technological Development, from the Techint Organization). The Argentine NDT Society (AAENDE) is a member of ICNDT, and many researchers and groups are members of different NDT societies as well as other professional associations abroad.

A nuclear power plant, CNA-II, a 600 MW PHWR, has been under construction since 1984 in Atucha. This project has been delayed by political and economical questions. If the decision to continue the project is finally made, the impact on industry and labour will be very strong and the NDT community will be faced with plenty of highly demanding work.

After a long period of unemployment and low industrial production, industry seems to be reactivating, with a trend towards exporting products with high value added. These products must meet high quality requirements, certified by NDT.

The papers in this issue of *Insight* give an indication of the scope of the applications of NDT in Argentina, many of which started in the '50s, fostered by the then budding nuclear industry, and by industry in general. Examples of them are discussed in this special issue of *Insight*, which is devoted to NDT in Argentina.

8. Founding fathers

Two people have been particularly important for the onset of these activities in Argentina and must be remembered here:

Prof Jorge Sabato, who had the vision of the technological development Argentina should be faced with and consequently introduced these subjects in CNEA and obtained international support for its expansion and development, which in turn extended to all the nation.

Dr Clifford K Beswick, Director of the INEND Project and of PREND, for making people conscious that organisation and technical work must be performed at a level of excellence.

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