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Research Article

Role of NDT in the Development of Production, Cost Reduction, and Enhancement Occupational Safety in the Oil and Gas Industry

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Abstract

Experience shows that in many cases of industrial decision making, proper knowledge of various aspects of a particular technology plays an important role. Therefore, if positive decisions are desired to be taken in favour of introducing NDT in industry in any country, its decision makers should be properly equipped with knowledge and information about this area of technology. The purpose of this paper is to review the following topics:Historical development of NDT and its relationship to destructive testing; The technology of NDT methods and its physics fundamental principles, comparison, and guide selection of NDT methods; The standards and its importance in NDT services; NDT requirements of key energy infrastructure; The economic importance of NDT in oil and gas industry- describe and statistics; The contribution of NDT to the enhancement occupational safety and environmental protection in oil and gas industry; The local experience in NDT and some other international experiences; Cooperation between competent International organizations and energy sector in NDT (IAEA as example);

Keywords: Economic Importance; Energy Infrastructure; NDT; Physics Fundamental Principles

Introduction

A wide variety of test schemes exist, some destructive and some non-destructive. Strictly speaking non-destructive testing has no clearly defined boundaries. Non-destructive testing (NDT) is the development and application of technical methods to examine material of components in ways that do not impair future usefulness and serviceability in order to detect, locate, measure and evaluate discontinuities, and other imperfections, to assess integrity, properties and composition; and to measure geometrical and physical characteristics [1].

Non-destructive testing (NDT) plays an important role in the quality control not only of the finished products, but also of half-finished products as well as the initial raw materials. NDT can be used at all stages of the production process. It can also be used during the process of establishing a new technology by product quality or when developing a new product.

In oil and gas industry Nondestructive testing (NDT) is the use of non-invasive analysis techniques to quantitatively inspect, measure and evaluate the safety and integrity of mission critical infrastructure and systems without interfering with the overall operation or future usefulness of those assets. This creates an interesting proposition for asset owners and operators within the oil and gas industry, who must balance increasingly stringent, non-discretionary regulatory and environmental compliance and safety requirements placed on energy drilling, production, transportation, storage and processing assets and systems [2].

Most of data, statistics and figures contained in this paper were taken from some reports and researches about NDT technology which have a relation to Oil and Gas industry in USA, such data can be circulated on global markets. Some aspects of the local experience have been reviewed in clause 8.1according to information provided byengineers from two production companies and one services company that work under National Oil Corporation.

Historical development of NDT and its relationship to destructive testing

Table 1 illustrates the evolution of the NDT industry in response to technological advancements and end market demands over the past two centuries in US.

Relationship to destructive testing

The approach of destructive testing renders the component useless for its intended use as against non-destructive testing which can be performed on the components and machines without, in any way, affecting their service performance. A comparison of destructive and nondestructive testing methods is given in (Table 2).

	1800s	1920s-1950s	1950s-1980s	1980s-present
Technological Innovation	"Oil and Whiting" and Visual Inspection methods	Magnetic Particle; Eddy Current; Industrial Radiography; Ultrasonic; Acoustic Emissions Testing developed		Digital Radiography, Automated Phased Array".
	1895:X-Rays discovered by Wilhelm Conrad Rontgen			Data management, risk-based analysis and predictive analytics services
End Market Developments	Emergence of NDT within the rail and automotive industry	Growth spurred by WWII and quality requirements across the transportation, maritime, aerospace and industrial sectors	Application of NDT across numerous end markets such as energy, healthcare, chemicals	Shale play proliferation
			Increased globalization of international standards and best practices	April 2010: BP Macondo oil spill –catalyst for heightened compliance requirements in the GOM September 2010: San Bruno pipeline explosion –triggered in US pipeline regulation movement
GOM: Gulf of Mexico				

Table 1: Historical development of NDT (US) [2].

Destructive Tests	Non-Destructive Tests
1. Tests usually simulate one or more service conditions. Consequently, they tend to measure serviceability directly and reliably.	1. Tests usually involve indirect measurements of properties of no direct significance in service. The correlation between these measurements and serviceability must be proved by other means.
2. Tests are usually quantitative measurements of load for failure, significant distortion or damage, or life to failure under given loading and environmental conditions. Consequently they may yield numerical data useful for design purposes or for establishing standards or specifications.	2. Tests are usually qualitative and rarely quantitative. They do not usually measure load for failure or life to failure, even indirectly. They may, however, reveal damage or expose the mechanisms of failure.
3. The correlation between most destructive test measurements and the material properties being measured (particularly under simulated service loading) is usually direct. Hence most observers may agree upon the results of the test and their significance with respect to the serviceability of the material or part.	3. Skilled judgement and test or service experience are usually required to interpret test indications. Where the essential correlation has not been proven, or where experience is limited, observers may disagree in evaluating the significance of test indications
4. Tests are not made on the objects actually used in service. Consequently the correlation or similarity between the objects tested and those used in service must be proven by other means.	4. Tests are made directly upon the objects to be used in service. Consequently there is no doubt that the tests were made on representative test objects.
5. Tests can be made on only a fraction of the production lot to be used in service. They may have little value when the properties vary unpredictably from unit to unit.	5. Tests can be made on every unit to be used in service, if economically justified. Consequently they may be used even when great differences from unit to unit occur in production lots
6. Tests often cannot be made on Complete production parts. The tests are often limited to test bars cut from production parts or from special material specimens processed to simulate the properties of the parts to be used in service.	6. Tests may be made on the entire production part or in all critical regions of it. Consequently the evaluation applies to the part as a whole. Many critical sections of the part may be examined simultaneously or sequentially as convenient and expedient.
7. A single destructive test may measure only one or a few of the properties that may be critical under service conditions.	7. Many non-destructive tests, each sensitive to different properties or regions of the material or part, may be applied simultaneously or in sequence. In this way it is feasible to measure as many different properties correlated with service performance as desired.
8. Destructive tests are not usually convenient to apply to parts in service. Generally, service must be interrupted and the part permanently removed from service.	8. Non-destructive tests may often be applied to in service parts or assemblies without interruption of service beyond normal maintenance or idle periods. They involve no loss of serviceable parts.

Table 2: Some differences between non-Destructive and destructive tests [1].

The technology of NDT methods and its physics fundamental principles, comparison, and guide selection of NDT methods.

Table 3 shows the basic information of most common traditional NDT methods:

Besides these traditional ways, technological advancements have led to the emergence of more advanced NDT capabilities. Advanced NDT methods include automated or remote ultrasonic testing, computerized radiography, acoustic emissions testing and

Method	Physics Fundamental Principles	Applications	Advantages	Limitations
Visual Testing (VT)	Visual testing is the first NDT method that should be considered before applying more sophisticated and expensive methods. In this method direct visual and optically aided inspection is applied to the surface of object to detect flaws and anomalies.	Surface discontinuities: cracks, porosity, slag,misalignment, warpage,incorrect size or number.	Inexpensive, fast, simple, apply during processing. Can eliminate need for other methods.	Surface only, variable and poor resolution, eyefatigue, distractions. Needs good illumination
Penetrant Testing (PT)	In this method a liquid penetrant is applied to the surface of the product for a certain predetermined time after which the excess penetrant is removed from the surface.The surface is then dried and a developer is applied to it. The penetrant which remains in the discontinuity is absorbed by the developer to indicate the presence aswell as the location, size and nature of the discontinuity	Surface discontinuities: cracks, porosity, seams,laps, leaks.	Inexpensive, easy to apply, more sensitivethan visual, materials,rapid, portable.	Surface only, not useful on hot, dirty', painted, or very rough surface. Requires some technique.
Magnetic Particle Testing (MT)	In this method the test specimen is first magnetized either by using a permanent magnet or an electric current through or around the specimen. Whenever there is a flaw which interrupts the flow of magnetic lines of force, some of these lines must exit and re-enter the specimen. These points of exit and re-entry form opposite magnetic poles and whenever minute magnetic particles are sprinkled onto the surface of the specimen, these particles are attracted by these magnetic poles to create a visual indication approximating the size and shape of the flaw	Surface and near surfacediscontinuities: cracks,voids, porosity,inclusions, seams, laps.	Low cost, fast, more sensitive to tight cracksthan PT, can do nearsurface, portable.	Material must be ferromagnetic, surface must be clean and goodcontact made, part mayneed demagnetization, alignment of field is important. Requires operator technique.
Eddv Current Testing (ET)	An alternating current of known frequency is applied to an electric coil placedadjacent to the material to be inspected. This current will produce its own magnetic field known as the excitation field and will also induce currents in the metal part known as eddy currents according to Faraday's law of electromagnetic induction. These eddy currents will produce their own magnetic field which will oppose theexcitation field. The resultant field is thus reduced which will change the coilimpedance.	Surface and near surface discontinuities: cracks.seams, composition, thickness, eccentricity, surface condition.	Extremely rapid, can beautomated, very sensitive, surface contact not necessary, permanent record.	Shallow penetration, conductive materials only, may require special equipment, sensitive to geometry, difficult interpretation sometimes
Ultrasonic Testing (UT)	Ultrasonic inspection is a non-destructive testing method in which high frequency sound waves are introduced into the material being inspected and the sound emerging out of the test specimen is detected and analysed.	Surface and deep subsurface and volumetric discontinuities: cracks,laminations, porosity,lack of fusion,inclusions, thickness.	Rapid if automated butmanual is slow,applicable to very thickspecimens, can givelocation and size ofdefects, good sensitivity, inspect from one side,portable.	Couplant required, thincomplex shapes aredifficult, orientation ofdefect important, very operator dependant

Radiographic Testing (RT)	The method of radiographic testing involves the use of a source of radiation from which the radiations hit the test specimen, pass through it and are detected by a suitable radiation detector placed on the side opposite to that of the source.	Subsurface discontinuities: cracks, voids, inclusions, lack of fusion, incomplete penetration, corrosion, missing components	Easily understood, permanent record, usually moderate cost, can be portable, applicable to wide range of materials.	Cannot detect laminations, radiation hazard and regulations, access to both sides, can be high cost, requires trained operators

Table 3: Common Methods of NDT "[1]".

guided wave testing, among other methods. All of these methods aim to detect defects or imperfections that could cause structures or equipment to break down. In U.S for example estimated that traditional NDT services accounted for 70% of NDT industry revenues in 2016[3]. However, this percentage expected to decrease slightly over the next five years due to growth in the advanced NDT methods market. While it expected an industry CAGR of 5.0% over the next five years [3], it believe that most this growth will come from the expansion of advanced NDT methods.

Method selection guide for some NDT of materials

The choice of the appropriate NDT method is an important part of the success of the detection and evaluation process, (Table 4) presents the selection guide of the proper NDT method to some materials and inspection tasks.

Material	Inspection Task	VT	PT	MT	ET	UT	PT
Metal.	Surface opening cracks	**	**	**	**		**
	Surface corrosion pits etc	**	**				**
	Severe corrosion thinning	**		**			**
	Internal cracks				*	**	**
	Porosity					**	**
	Lack-of -fusion defects					**	*
	Internal voids inclusions				*	*	**
	Defect sizing	*		*		**	*
	Thickness measurement				*	**	**
	Microstructure variation	*			**	*	
	Stress/strain measurement					*	*
Coated Mstalt	Coating thickness measurement				**	*	**
	Coating delamination	*			*	**	
	coating 'pin holes	*	**				
Composite Materials	Delaminationt and deisbonds	*			*	**	
	Fibre/matrix ration evaluation				*		
	Incomplete cure of resin					*	
	Internal porosity						*
Concrete	Concrete thickness measurement					*	**
	Reinforcing bar corrosion						*
Caramici	Surface cracks	*	**			*	*
	Internal cracks porosity					**	**
Any	Assembly verification	**					**
	Sorting				**		
** GOOD PROSPECTS							
*FEW PROSPECTS							

Table 4: The selection guide of the proper NDT method to some materials and inspection tasks [1].

The standards and their importance in NDT

Types and importance of standards in NDT In NDT services the standards types are: standards for terminology, equipment, testing methods, education, training and certification of NDT personnel, acceptance and rejection and accreditation standards. The proper use of appropriate standards has a direct effect on the quality of work environment and results of work. NDT services like any service needs standards, which can be summarized as following:

1. Clear communication: written standards to make communication clear and easy for the customer or user to communicate with the producer.
2. Economy of effort : If all of the possible parameters and variables are detailed in a document, it is mean economy of effort and time.
3. After the product has gone into service (sometimes years after) a life record of the standard used for production or inspection will likely be sufficient documentation of the process used to produce it.
4. Collective wisdom: Standard developed by the consensus process through discussion and debate, result in a document based on the collective wisdom of the participants.
5. International co-operation: standards can play an important role in international co-operation when their use is made in

negotiating international contracts and treaties for the supply of goods and services by one country to another, this standard is very important in all sectors specially in oil and gas industry [1].

The most important issuing bodies standards of NDT over the world

Table 5 presents (Table 5) Some standard issuing bodies.

The issuing body	Example of standard related to NDT
American Society for Testing and Materials (ASTM)	A 275/A275M-94 Test method for magnetic particle examination of steel forgings
International Organization for Standardization (ISO)	ISO/1027-86 Radiographic image quality indicators for non-destructive testing — Principles and identification
International Institute of Welding (IIW)	IIS/IIW-127-64 Behaviour of ultrasonic waves in the presence of various defects in welds.
British Standards Institution (BSI)	BS 2600 Radiographic examination of fusion welded butt joints in steel.
DeutschesInstitut fur Normen (DIN)	DIN 25450-90 Ultrasonic equipment for manual testing
Japanese Industrial Standards Committee (JISC)	JIS G 0568-93 Method of eddy-current testing for steel products.
Standards Association of Australia (SAA)	AS1101 3-87 Welding and non-destructive examination
The American Society of Mechanical Engineers (ASME)	Section VIII Pressure vessels.

Table 5: Some standard issuing bodies [1]

NDT requirements of key energy infrastructure

In US energy market, roughly 50% of NDT industry revenues come from oil and gas customers [5], like oil and gas exploration and production companies; offshore oil and gas structure fabrication contractors, offshore and onshore oil and gas pipeline owners, operators and contractors and oil and gas drilling and production equipment manufacturers.

In some oil countries such as Libya, this ratio exceeds 90% Ref [11], because the oil and gas sector as the end market has many stringent requirements, where NDT services have the ability to meet these requirements, in onshore, offshore fields, petrochemical factories and refineries, (Table 6) shows the NDT requirements associated with the primary infrastructure in the oil and gas sector.

The economic importance of NDT in oil and gas industry- describe and statistics

The economic importance of NDT

The cost of not doing NDT in many situations would be colossal and even unbearable. Let us imagine the consequences of failure occurring in chemical plant such as a refinery or a plant producing insecticides, a pipeline carrying oil or gas or other expensive fluids and many other similar situations in industry. The consequences in all these cases in terms of loss of costly machinery and equipment, lost production and even loss of human life would be colossal.

Most of these disasters can be prevented by timely use of NDT and therefore should be considered on the benefits side when calculating the cost-benefits ratio of NDT. Further, as industry becomes increasingly automated and the strength of the chain becomes even more dependent on its weakest link, where failure is not merely the failure of one piece of equipment, but the stoppage of a line where time is measured in thousands of dollars per minute, per hour or per day; so, providing the "expensive" nondestructive testing services will be true economy.

The cost reduction

What makes any technology acceptable and widespread is the economic value and the cost of applying it, the economic importance of the NDT technology in all industries and in the oil and gas industry particular can not be limited to a particular aspect, but its important role includes all stages from drilling, processing, and production to the export stage, it is mean from the underground to the tanker. This importance can be summarized in the following reasons:

Loss of product

In comparison to the cost of living with environmental damage or even dealing with clean up attempts, the value of the product lost through a component failure may be relatively small. The value of tanker full of crude oil would far exceed the cost of the NDT inspection that would have located the defect that caused it [1].

Lost time

Every operating plant has a figure for the cost of lost production due to unscheduled down time; preventive maintenance relies upon scheduled shutdowns during which all repairs, inspections and replacement can be carried out in an orderly manner. Timely detection of defects by an appropriate NDT method is a major factor in preventive maintenance, and can save many hours of downtime and a lot of money [1].

Critical Infrastructure		NDT Requirements
	• Onshore • Well Completion Equipment • Onshore Production Facilities	• Evaluation of potential wellhead sites and inspection of fabricated piping • Extensive drill pipe and tool inspection, utilizing bottom hole assembly inspection and full length ultrasonic inspection • Casing and coil tubing inspection using EMI equipment to evaluate well deterioration • Recurring evaluation of equipment and material integrity once well becomes productive due to increasingly harsh operating conditions of new drilling techniques
	• Offshore • Offshore Fabrication Yards • Oil and Natural Gas Production Platforms	• Inspection of fabricated piping and pressure vessel welds and valves • Ongoing inspections and maintenance of production platform piping systems and critical infrastructure • Mechanical integrity programs mandated for all production equipment • In-line inspection of risers, internal welds and other difficult to access platform infrastructure • Industry pressure mounting to increase inspection frequency
	• Onshore Oil and Natural Gas Pipelines • Offshore Oil and Natural Gas Pipelines	• Inspections for pipeline internal and external corrosion and cracking • Weld integrity testing • Point-to-point inspections and assessments of pipe wall thickness to detect leaks and localize deficiencies • Integrity management, fitness-for-purpose assessment and risk-based assessment required throughout the operating life of the pipeline • Certification of distribution pipeline safety, pursuant to regulatory standards
	• Petrochemical / Chemical Plants • Oil and Natural Gas Refineries	• High-temperature corrosion monitoring of critical plant equipment and piping systems • In-line assessments of rotating equipment to minimize downtime and improve utilization • Mechanical integrity and predictive maintenance to prolong the operability of rotating equipment and plant assets • Certification of asset installation, maintenance and repair • Repetitive service needs driven by perpetual operating schedules

Table 6: The NDT requirements associated with the primary infrastructure in the oil and gas sector [2] and [6].

Repair costs

Another expense easily defined, is the cost of replacement or repair necessitated by failure which could have been prevented by timely detection of a defect by NDT [1]. So the failure due to defects originating in construction or service, no matter how minor, may have far-reaching and serious consequences. The ability of properly applied NDT methods to detect these defects makes them in economy aspect invaluable tools.

NDT market

In general the NDT market represents a sub-segment of the broader testing, inspection and certification (TIC) industry, a $125 billion global market. The TIC industry spans a diverse range of primary end markets, including energy, manufacturing, transportation, aviation and healthcare. Driven by the perpetual and increasing demand for safety, quality and compliance. The NDT market has displayed considerable expansion recently as a result of secular growth driven by recurring maintenance spending and expansionary capital investment, resulting in an estimated $3.5 billion in annual spending in the industry across all end markets, for example in 2012 the global NDT industry had an estimated turnover about $5.6bn, including both products and services. The overall drivers were in maintaining and assuring the safety of key infrastructure, and although the financial crash of 2008 may have limited growth in other sectors, NDT maintained growth of about 3.2%, and growth is returning strongly [2,4,10].

The NDT universe is a highly fragmented market of service providers that includes small, locally operated companies, as well as a select group of larger, more diversified players. Within this market, few independent companies possess the size and scope (across both service lines and end markets) to operate as a one-stop shop for all end market customers, (Figure 5) shows the distribution of the top 183 companies specializing in NDT technology around the world.

Figure 1: Global distribution of 180 Key NDT supply companies [3].

In U.S for example, historically, demand for NDT services has predominately come from operators in the oil and gas industry as figure 5 illustrated. These businesses are asset-intensive and its adhere to strict infrastructural requirements mandated by regulatory agencies

Figure 2: Major NDT market segmentation in US in 2016 [4].

Contribution of NDT in the development of production

Primary customers for NDT services across the energy markets include: i) oil and gas exploration and production companies; ii) offshore oil and gas structure fabrication contractors; iii) offshore and onshore oil and gas pipeline owners, operators and contractors and iv) oil and gas drilling and production equipment manufacturer.

In addition to refineries, there are currently several hundred major petrochemical processing plants in the United States and internationally. Consequently, total capital and maintenance spending over the world in the hydrocarbon processing sector exceeded $225 billion in 2013, a 9.5% increase from 2010 levels. Furthermore, maintenance and repair expenditures and capital spending within the refining and petrochemical and gas processing segments have grown at a 4.3% and 2.0% CAGR (Compound Annual Growth Rate), respectively, since 2007 and exceeded $16.7 billion and $9.7 billion, respectively, in total for 2013 [4,10].

Therefore, large-scale refinery maintenance projects create significant demand for NDT service providers. on average, the refining industry spends a relatively stable amount on maintenance projects each year. Figure illustrate the maintenance and repair expenditures from 2007 to 2013 in US, this expenditures includes approximate percentage ranging between 1.2-2.8 % of spending on NDT services, which is an important contribution in the development of production of oil and gas [2].

Today, as well as in the near term, NDT service providers remain largely dependent on oil and gas firms for revenues, and NDT industry revenue growth is likely to come from strengthening oil markets and the subsequent rise in oil and gas production activity. Strength in oil markets drives asset utilization and, ultimately, the

Figure 3: Maintenance and repair expenditures in US 2007-2013 [2].

need for NDT services to monitor and maintain critical infrastructure. Therefore, any increase in oil prices in the near term should be beneficial for the NDT industry and its participants.

The contribution of NDT to the enhancement occupational safety and environmental protection in oil and gas industry

Enhancement of Occupational Safety

Oil and gas industry has higher standard of safety requirements, therefore safety is now front and center in the oil and gas industry. Thanks to a strong industrial culture of workplace safety and more advanced technologies to monitor and prevent injuries and accidents, the rate of injury was down to 1.8 per 100 workers in 2012, according to the American Petroleum Institute (API). And offshore, that rate dipped to 0.7 per 100 workers [6]. In the forefront of these used technologies is NDT technique, according to the same institute. Non-destructive testing is conducted to locate and characterize material conditions and flaws that if left overlooked could cause a lot of disasters. non-destructive testing as a preventative measure saves lives. It is also safe to both the tested product, and the tester. as well as, Increased awareness and concern for contamination of the plants, its water ways and its atmosphere have resulted in stringent regulatory controls for the manufacturing and installation of such projects as storage tanks, pipelines, offshore petroleum production installations, and chemical plants. In any of these, the failure of a simple valve or a seam weld could release large amounts of a damaging material onto the ground, into the air or into the water table. Dispersion is often so rapid that containment is impossible, and the results, even if not immediately toxic can be irreversible. NDT methods have a significant role to play in ensuring that flaws which could result in such a failure are eliminated before installation ref [9].

Pushing to new boundaries safely

According to the International Energy Agency, Roughly 64 million barrels per day of new oil capacity would have to come on stream between 2007 and 2030 to meet anticipated demand, Conventional exploration alone is unlikely to satisfy predicted worldwide demand, even as organizations are maximizing conventional methods, so the industry is rapidly investing in new technologies, such as hydraulic fracturing. These emerging technologies will require comprehensive analysis with proven safety leaders to ensure rigorous risk management and safety protocols are in place.

According to study by "Forbes magazine", more than half of executives interviewed in U.S cited regulations and environmental opposition as the biggest concerns facing the energy industry over the next 5 to 10 years as summarized in (Figure 4) As a result of the heightened public and regulatory focus on safety, asset owners and operators across the industry are continually faced with high economic and reputational costs of non-compliance [2].

Figure 4: Biggest Concerns Facing Energy Industry Over the Next 5 to 10 Yearsin US [2].

The information and data shown in Figure 4 show that safety and controls are the biggest concern of the oil and gas companies. Therefore, the search for all the means and techniques that will contribute to enhancing safety and protecting the environment is the most urgent task in the coming years, this gives NDT services the opportunity to be at the forefront of providing technical solutions to the producers to keep their production and development it, at the same time complying with the rules of safety and environmental controls.

The local experience in NDT and some other international experiences

The local experience in NDT

NDT in oil and gas industry in Libya is as old as establishment of oil industry itself, foreign companies of oil industry brought this technology as a required part for maintenance and assessment operations; overtime NDT has become full of Libyan cadres.

In the late 1980s and early 1990s foreign companies used this technology effectively in exploration and maintenance operations. Then had been established special departments for this technology in some national companies and oil service companies. At present, the contribution of local engineers in NDT services in oil and gas industry is more than 90%, and foreign experts are rarely invited [11].

In the absence of accurate figures and statistics at the local level, a mini opinion poll involving local engineers and experts in NDT technology was conducted from two NOC production and service companies for this paper. These experts confirmed that this field has locally the necessary elements of success, such as technical cadres and technical equipment, that includes almost all known traditional methods like UT, MT, RT, LT, ET and others, and even some modern advanced methods. In addition, there are local training cadres licensed and accredited by global centers [11].

The experts also concluded that this technique reduces the effort, time and money in the operations of detecting some faults and maintenance, which leads to a reduction of production and operating costs, as it is used in the works of assessment of faults and maintenance by 40% to 70% thanks to the reliability and speed of its results [11]. Experts also stressed the importance of this technique in avoiding accidents and protecting the environment.

On the other hand, some experts expressed dissatisfaction on the administrative side, where there are some problems such as the problem of licensing, as the license can be valid for work in a site and invalid at another site, lack of training especially in the last three years, lack of coordination or exchange of information between companies operating In this field at the national level, and the complete absence of government from all aspects of this technology.

Experts gave the following recommendations to support this technology and its staff:

- The need for a direct governmental role in the development and stimulation of the transfer of modern technology in the field of NDT.
- Continuous training internally and externally at all levels and the establishment of a database within the National Oil Corporation for this technology.
- Giving better definition of NDT value in risk reduction in all sectors.
- Standardize internationally approved standards and licenses for this technology locally, communicate with all concerned local parties, communicate with institutions that have experience in this field such as universities and the Libyan Atomic Energy Corporation, and formation of a local association that includes all those involved in this technique.
- Increase interest and shed more light on the welding department at the Petroleum training and Qualifying Institute (PTQI), which is the only place study this technique academically.

International experiences

UK Experience, Here we do not compare the advanced technology in a large industrial country verses to the local technology, but to take this experience as a great example for anyone who wants to the development in this field. The UK has traditionally been strong in NDT technology and innovation, The UK NDT industry and R and D (research to develop the new technology needed to meet the long term vision) base has an enviable track record of significant achievements. It is well positioned and has capable of delivering high value to the UK economy, where the UK follows many years ago the policy depends on:

Stimulating technology transfer for new inspection solutionsb) increasing business performance and growthc) recognition of the value of risk reduction through application of advanced NDT.d) development of widely understood capability statements and recognised standards for emerging (UK) technologiese) stimulate NDT R and D initiatives in applications where significant resource efficiency and sustainability benefits can be demonstrated.f) maintain and consolidate a funded R and D network to enable active involvement of all key players including centres of expertise, universities, government, industry and finance (insurance) [4].

According to the UK national institute (BINDT) there are 172 company covering the equipment supply, training, service and end user sectors. This constitutes the majority of the commercial organizations involved in NDT in the UK, as well as, the 24 key UK companies within the 183 biggest company over the world, contribute about 13% of the world market in the NDT services, and approximately the same percentage in global oil and gas market [4].

The best example of the success of NDT technology in UK was in the railway sector, where prior to the Hatfield disaster rail breaks were running at about 900/year on the UK network. When suitable NDT was applied, in this case an ultrasonic technique, the rate was reduced. Through progressive improvements in the NDT technique as shown in figure 5. further reductions have been achieved. This asset management system has now been exported to other national networks [4].

Malaysian experience

The success of Malaysia's NDT training programme can serve as a model and inspiration for other countries that wish to develop a domestic NDT certification programme. The Malaysian example illustrates that it is possible to build an internationally recognized testing system from scratch. Malaysia's training system and National NDT Certification Scheme have become a reference point for many countries. The beginning was in the 1980s With support from Malaysian Government and assistance from the IAEA, when was established the Malaysian National NDT Certification Board. Now days as a result of this longstanding partnership, over 50 companies in Malaysia, employing more than 2000 technicians, are certified to carry out NDT testing [7]. Companies in the oil and gas sector account for around 70 per cent of all NDT inspection business in Malaysia, Power plants, shipyards and the aviation industry are other important clients that benefit from this technology. The cost of local inspections is about one fifth of the cost of hiring inspectors and using technology from oversea [7].

Cooperation between competent International organizations and energy sector in NDT (IAEA as example).

The IAEA promotes industrial applications of radiation technology, including non-destructive testing (NDT), through activities such as Technical Cooperation Projects (national and regional) and Coordinated Research Projects. Through this cooperation, Member States have initiated national programmes for the training and certification of NDT personnel. National certifying bodies have also been established based on International Organization for Standardization (ISO) standards [8].

The activities of IAEA in NDT over 40 years can be summarized in the following table:

The year	The Activity
1981	IAEA incorporated an NDT project in its Regional Co-operation Agreement (RCA) for Asia and the Pacific which was looking at a much wider field of radiation technology which included radiotracers, radiation processing and nucleonic control systems
1982	with the support of UNDP, the United Nations Financing System for Science and Technology for Development (UNFSSTD), and the United Nations Industrial Development Organization (UNIDO), six countries started the Regional Non-Destructive Testing Project for Latin America and the Caribbean
1984	IAEA decided to support the work of ISO/TCI35/SC7 and to recommend its draft for use in all IAEA projects, closely monitoring developments and keeping open the option of developing its own document if progress appeared to be too slow. As another result of this meeting, the IAEA became an active member of ISO/ TC135/SC7 and contributed strongly to its work.
1987	TECDOC-407, Training Guidelines in Non-destructive Testing Techniques, was published then revised and expanded as IAEA-TECDOC-628 in 1991
2002 and 2008	Revised and expanded versions were issued . These latter versions included work conducted by the International Committee for Non-Destructive Testing (ICNDT) and many national NDT societies.

Table 7: IAEA cooperation activity over 40 years in NDT field [1].

Conclusion

NDT is an essential global engineering service that is used throughout the product lifecycle. Commercial success in many market sectors requires the deployment of effective inspection technologies by suitably qualified individuals. As the engineering infrastructure ages and more complex systems are built, the need for ever more capable NDT methods will grow.

NDT providers offer a critical service to asset owners and operators in the energy sector. NDT services improve the profitability of oil and gas operators by improving facility operation efficiency and reducing the incidence of machine failure and malfunction, while ensuring that equipment complies with the increasingly stringent environmental regulations in place. Locally, despite the difficult conditions in the country, there are many elements of success for this technology on which a thriving NDT industry can be built in the near and distant future.

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Bibliography

1. Training Course Series. Non-destructive Testing: A Guidebook for Industrial management and Quality Control Personnel, Iaea, Vienna, (1999).
2. Will Cooper and Drew Quart Pella, An Overview of Non-destructive Testing Energy Sector Report- Black Arch Partners.
3. IBISWorld Industry Report, Non-destructive Testing Services in the U.S.
4. A landscape for the future of NDT in the UK economy, Knowledge Transfer Networks, a Technology Strategy Board programme.

5. Sam Norman. Non-destructive Testing Services, Industrials – Engineering and Construction Services, The Henry Fund, Henry B. Tippie School of Management.

6. http://www.applus.com/en.

7. Brian Plonsky. IAEA Bulletin, September 2015 X-rays for industry: Non-destructive testing helps Malaysia's competitiveness.

8. Iaea Tecdoc Series Training Guidelines in Non-destructive Testing Techniques 2013 Edition, Vienna, (2014).

9. QI Fu-yuan and JIANG Zhong-ting. The Importance of Safety Production and Humanistic Management in Petroleum Project, Universe Scientific Publishing 6.1 (2017): 18686.

10. Salary Survey. Personnel for Quality and Non-destructive Testing, PQNDT, Inc (2011).

11. Mini opinion poll Information.

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