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UMA VISÃO SOBRE ENSAIOS NÃO DESTRUTIVOS E SUAS APLICAÇÕES NA INDÚSTRIA AERONÁUTICA

AN OVERVIEW ABOUT NON DESTRUCTIVE TESTING AND ITS APPLICATIONS IN THE AERONAUTICAL INDUSTRY

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Finalidade: Apresentar uma visão geral sobre os ensaios não destrutivos (NDT) e sua aplicação na indústria aeronáutica.
Duração: 7 meses

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Palavras chave: Ensaios não destrutivos (ENDs), aplicações de ENDs, métodos e técnicas de ENDs, aplicação aeronáutica de ENDs.

Resumo. Este trabalho apresenta uma visão geral sobre os ensaios não destrutivos (NDT) e sua aplicação na indústria aeronáutica. Este trabalho é apresentado em um caráter exploratório e generalista de pesquisa e baseia-se na literatura e na web sobre o tema. Destina-se a dar uma ideia geral sobre o que é NDT, por que e quando usamos esta metodologia, a fim de tirar ao máximo benefício da mesma. Além disso, há uma breve explicação sobre os principais métodos e técnicas de NDT, além de vários exemplos de suas aplicações. Contudo, ele traz uma descrição da terminologia usada na zona de base de END. Desta forma, espera-se que este trabalho traga alguma contribuição para a comunidade acadêmica, levando o conhecimento de uma forma simples e objetiva, a fim de motivar mais em pesquisas mais detalhadas sobre este importante método de teste, o que com certeza economizar tempo e dinheiro na maioria dos processos de fabricação, quando utilizado na ocasião correta.

1. INTRODUCTION

According to ABENDE (Associação Brasileira de Ensaios Não Destrutivos), NDT are defined as the techniques used in the materials and products quality control without prejudicing the further use of it, contributing to increase quality, reliability and cost saving. It consists in one of the main tools used in quality control and is used in product inspection of welded, cast, forged, rolled, among others.

Nondestructive testing or Non-destructive testing (NDT) is a wide group of analysis techniques used in science and industry to evaluate the properties of a material, component or system without causing damage. In other words it is a way of testing without destroying. This means that the component- the casting, weld or forging, can continue to be used and that the nondestructive testing method has done no harm. The terms Nondestructive examination (NDE), Nondestructive inspection (NDI), and Nondestructive evaluation (NDE) are also commonly used to describe this technology. Because NDT does not permanently alter the article being inspected, it is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research. Common NDT methods include ultrasonic, magnetic-particle, liquid penetrant, radiographic, remote visual inspection (RVI), eddy-current testing, and low coherence interferometry. NDT is commonly used in forensic engineering, mechanical engineering, electrical engineering, civil engineering, systems engineering, aeronautical engineering, medicine, and art. (WIKIPEDIA,2014)

According to (NON DESTRUCTIVE , 2011), while destructive testing can be an effective and economical solution for high-volume, low-cost components, it’s clearly undesirable for larger, more expensive systems. If you want to test the limits of a multi-million-pound jet engine, destroying it is a pretty drastic way to advance your knowledge. Fortunately, there is an alternative. And a range of so-called non-destructive testing (NDT) techniques - which can be used to probe structures and materials either before they enter use or as part of a maintenance programme - are now widely used across a range of engineering sectors.

In today's world where new materials are being developed, older materials and bonding methods are being subjected to higher pressures and loads, NDT ensures that materials can continue to operate to their highest capacity with the assurance that they will not fail within predetermined time limits. NDT can be used to ensure the quality right from raw material stage through fabrication and processing to pre-service and in-service inspection. NDT finds extensive applications for condition monitoring, residual life assessment, energy audit, etc. (“WHAT IS NDT?”, 2013)

The importance of the NDT in several industrial sectors and currently even more in R&D (Research and development) has been growing significantly over time.

2. HISTORY OF NDT

In ancient times, the sound of the blade of the sword of Damascus would be a strong indication of how the metal would be in combat. This approach was also used by bell's makers. Hearing the sound of the bell, the sound of metal could be established in a very general way. This same "sonic" technique has been used for decades by blacksmiths as they heard the sound of different metals that were being formed. (SOUZA, 2010)

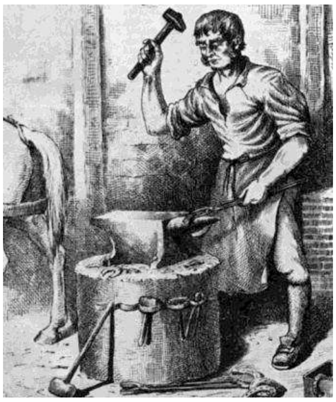

Fig. 1 – Early Blacksmith

The roots of non-destructive testing began to take shape before the '20s. The most recent developments have appeared due to tremendous activity during World War II. Since the '50s, END has been having great growth, lots of innovations, with new tools and materials. Before World War II engineers had no concern in projects with high safety factors, such as pressure vessels and other complex components. After some catastrophic failures and other accidents, this concept has changed. Some of the improvements in manufacturing and inspection practices can be attributed to boilers and some of its catastrophic failure. (SOUZA, 2010)

According to (WIKIPEDIA, 2014), the notable events in history in early industrial NDT are the following:

- 1854 Hartford, Connecticut: a boiler at the Fales and Gray Car works explodes, killing 21 people and seriously injuring 50. Within a decade, the State of Connecticut passes a law requiring annual inspection (in this case visual) of boilers. This serious accident was a point of major change in the progress of the inspection and NDT. Ten years later, in 1864, the State of Connecticut adopted the "Boiler Inspection Law". (SOUZA, 2010)

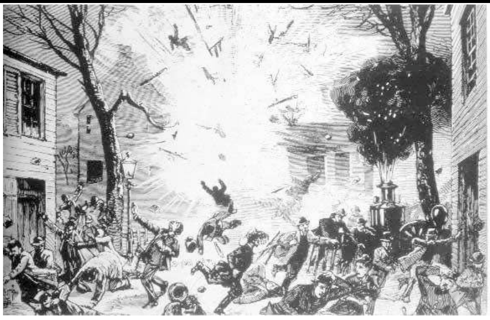

Fig. 2 – March of 1854 - Hartford, Connecticut

- The next key development in the history of non-destructive testing was also due to a disaster - a major train derailment. This resulted in a detection of magnetic / electrical current induction field that was developed by Dr. Elmer Sperry and H. C. Drake. (SOUZA, 2010)

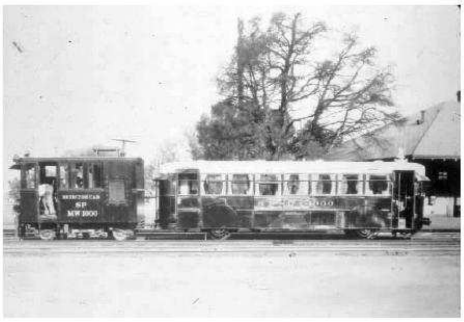

Fig. 3 – Train derailment

- 1880 - 1920 The "Oil and Whiting" method of crack detection is used in the railroad industry to find cracks in heavy steel parts. (A part is soaked in thinned oil, then painted with a white coating that dries to a powder. Oil seeping out from cracks turns the white powder brown, allowing the cracks to be detected.) This was the precursor to modern liquid penetrant tests.
- 1895 Wilhelm Conrad Röntgen discovers what are now known as X-rays. In his first paper he discusses the possibility of flaw detection.
- 1920 Dr. H. H. Lester begins development of industrial radiography for metals.
- 1924 — Lester uses radiography to examine castings to be installed in a Boston Edison Company steam pressure power plant.
- 1926 The first electromagnetic eddy current instrument is available to measure material thicknesses.
- 1927 - 1928 Magnetic induction system to detect flaws in railroad track developed by Dr. Elmer Sperry and H.C. Drake.
- 1929 Magnetic particle methods and equipment pioneered (A.V. DeForest and F.B. Doane.)
- 1930s Robert F. Mehl demonstrates radiographic imaging using gamma radiation from Radium, which can examine thicker components than the low-energy X-ray machines available at the time.
- 1935 - 1940 Liquid penetrant tests developed (Betz, Doane, and DeForest)
- 1935 - 1940s Eddy current instruments developed (H.C. Knerr, C. Farrow, Theo Zuschlag, and Fr. F. Foerster).
- 1940 - 1944 Ultrasonic test method developed in USA by Dr. Floyd Firestone, who applies for a U.S. invention patent for same on May 27, 1940 and is issued the U.S. patent as grant no. 2,280,226 on April 21, 1942. Extracts from the first two paragraphs of this seminal patent

for a nondestructive testing method succinctly describe the basics of ultrasonic testing. "My invention pertains to a device for detecting the presence of inhomogeneities of density or elasticity in materials. For instance if a casting has a whole or a crack within it, my device allows the presence of the flaw to be detected and its position located, even though the flaw lies entirely within the casting and no portion of it extends out to the surface. ... The general principle of my device consists of sending high frequency vibrations into the part to be inspected, and the determination of the time intervals of arrival of the direct and reflected vibrations at one or more stations on the surface of the part."

- 1950 The Schmidt Hammer (also known as "Swiss Hammer") is invented. The instrument uses the world's first patented non-destructive testing method for concrete.
- 1950 J. Kaiser introduces acoustic emission as an NDT method.
  (Basic Source for above: Hellier, 2001) Note the number of advancements made during the WWII era, a time when industrial quality control was growing in importance.
- 1963 Frederick G. Weighart's and James F. McNulty's co-invention of Digital radiography is an off shoot of the pairs development of nondestructive test equipment at Automation Industries, Inc., then, in El Segundo, California. See James F. McNulty also at article Ultrasonic testing.

3. NDT METHODS AND TECHNIQUES

According to (WIKIPEDIA,2014), NDT is divided into various methods of nondestructive testing, each based on a particular scientific principle. These methods may be further subdivided into various techniques. The various methods and techniques, due to their particular natures, may lend themselves especially well to certain applications and be of little or no value at all in other applications. Therefore choosing the right method and technique is an important part of the performance of NDT.

- Acoustic emission testing (AE or AT)
- Blue Etch Anodize (BEA)
- Dye penetrant inspection Liquid penetrant testing (PT or LPI)
- Electromagnetic testing (ET)
  - Alternating current field measurement (ACFM)
  - Alternating current potential drop measurement (ACPD)
  - Barkhausen testing
  - Direct current potential drop measurement (DCPD)
  - Eddy-current testing (ECT)
  - Magnetic flux leakage testing (MFL) for pipelines, tank floors, and wire rope
  - Magnetic-particle inspection (MT or MPI)
  - Remote field testing (RFT)

- Ellipsometry
- Guided wave testing (GWT)
- Hardness testing
- Impulse excitation technique (IET)
- Infrared and thermal testing (IR)
  - Thermographic inspection
  - Infrared thermal microscopy
- Laser testing
  - Electronic speckle pattern interferometry
  - Holographic interferometry
  - Low coherence interferometry
  - Profilometry
  - Shearography
- Leak testing (LT) or Leak detection
  - Absolute pressure leak testing (pressure change)
  - Bubble testing
  - Halogen diode leak testing
  - Hydrogen leak testing
  - Mass spectrometer leak testing
  - Tracer-gas leak testing method Helium, Hydrogen and refrigerant gases
- Magnetic resonance imaging (MRI) and NMR spectroscopy
- Metallographic replicas
- Near-infrared spectroscopy (NIRS)
- Optical microscopy
- Positive Material Identification (PMI)
- Radiographic testing (RT) (see also Industrial radiography and Radiography)
  - Computed radiography
  - Digital radiography (real-time)

    - Neutron radiographic testing (NR)
    - SCAR (Small Controlled Area Radiography)
    - X-ray computed tomography (CT)
- Scanning electron microscopy
- Surface Temper Etch (Nital Etch)
- Ultrasonic testing (UT)
    - ART (Acoustic Resonance Technology)
    - Electro Magnetic Acoustic Transducer (EMAT) (non-contact)
    - Laser ultrasonics (LUT)
    - Internal rotary inspection system (IRIS) ultrasonics for tubes
    - Phased array ultrasonics
    - Time of flight diffraction ultrasonics (TOFD)
    - Time of Flight Ultrasonic Determination of 3D Elastic Constants (TOF)
- Vibration Analysis
- Visual inspection (VT)
    - Pipeline video inspection
- Corroscan/C-scan
- IRIS - Internal Rotary Inspection System
- 3D Computed Tomography
    - Industrial CT Scanning
- Heat Exchanger Life Assessment System
- RTJ Flange Special Ultrasonic Testing

As noted above, there is a huge variety of methods and techniques of NDT and the choice for each type of it must be very careful, once it depends on four main criteria:

- Material Type
- Defect Type
- Defect Size
- Defect Location

The most common methods used nowadays in general are visual, dye penetrant, ultrasonic, Eddy current, and radiography being used only in special circumstances. Magnetic particle, acoustic emission and the other methods mentioned are being used only in special circumstances (METSO, 2010). The followings subchapters will present a general view about each of the main methods/techniques.

3.1 VISUAL INSPECTION

According to (METSO, 2010), this type of inspection are done by experts who are trained to visually check for many types of problems including surface rust, scaling (paint lifting away, showing a rough not-clean surface), and signs of cladding buckling (bumps when looking down a straight line or putting a straight edge up to the headbox apron). Testing is needed not just on cast iron surfaces but also on stainless steel. If a stainless part is not kept clean there will eventually be some visible surface corrosion and pitting. Fortunately corroded stainless only requires surface cleaning and conditioning to be renewed.

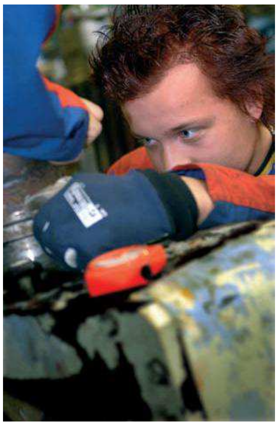

Fig. 4 – Expert doing a visual inspection.

Other important aspects to notice during a visual inspection include missing or corroded-away washers (Fig. 4), and the condition of bolts. Bolts made of mild steel will delaminate over time. Attention must also be paid to those parts of the machine that are only used in special circumstances, such as changing machine clothing. Removable block finished surfaces may not mate properly when installed, resulting in vibration. Cantilever beams have rods going to supports. These rods are typically mild steel and may become corroded. This can be disastrous because when changing a fabric, these rods are all that hold up the section.

Fig. 5 - In this mill there were lock washers which had corroded away. Any fasteners that have failed should be replaced with stainless steel lubricated if they were mild steel standard fasteners.

Fig. 6 - The end of this walkway support is entirely corroded through and much of the material is completely gone. There is also delamination in process on other parts of the support. This part will need to be replaced.

Special tools like caliper micrometer, hand grinders and others are used to support the professional of visual inspection to optimize his work, saving time and reducing the error probabilities.

3.2 DYE PENETRANT (LIQUID PENETRANT TESTING)

According to (METSO, 2010), this method uses capillary action to detect discontinuities, and is commonly used in fatigue testing to find cracks in roll shells. Liquid penetrant has been used at least as far back as the late 1800s, for things such as detecting cracks in pottery and railway locomotive wheels. Since that time, advances in liquid penetrant materials have been made which make the results easier to see. Essentially, a liquid is applied to the surface and penetrates into the flaws in the surface. After a dwell time to ensure sufficient penetration, the excess penetrant is removed. Then a developer is applied to the surface in order to draw the remaining penetrant from the cracks up to the surface. The penetrant is typically either a high contrast color, such as red, or is a UV fluorescent dye that will show up under black light (Fig. 7). While this method is slower to perform than the ultrasonic method, the results are very clearly visible to the technician.

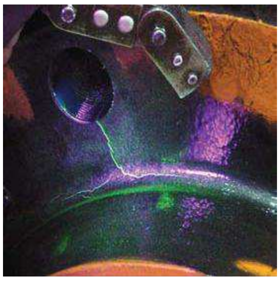

Fig. 7 - Some liquid penetrants fluoresce under ultraviolet light, making cracks easier to see.

3.3 ULTRASSONIC TESTING

According to (METSO, 2010), the ultrasonic method uses equipment (Fig. 8) that produces an electrical pulse which sends a high frequency sound pulse into the structure. If this sound pulse hits a crack or void in the structure - or the other side of a wall, when used to measure thickness - part of the pulse will be reflected. These reflections are transformed back into an electrical signal by a transducer, and the results displayed on screen. The results are instantaneous, and the technician only needs access to one side of the structure.

Fig. 8 - When only one structural side is available, an ultrasonic wall thickness gauge is used.

3.4 RADIOGRAPHY

According to ("WHAT IS NDT?"., 2013), Radiography uses an x-ray device or radioactive isotope as a source of radiation which passes through the material and is captured on film or digital device. After processing the film an image of varying density is obtained. Possible imperfections are identified through density changes.

3.5 EDDY CURRENT (ELETROMAGNETIC)

According to ("WHAT IS NDT?"., 2013), in eddy current testing electrical currents are generated in a conductive material by an induced magnetic field. Distortions in the flow of the electric current (eddy currents) caused by imperfections or changes in a material's conductive properties will cause changes in the induced magnetic field. These changes, when detected, indicate the presence of the imperfection or change in the test material.

3.6 MAGNETIC PARTICLE

According to (METSO, 2010), this method of determining surface discontinuities has been around since 1868 when it was used to inspect cannon barrels using a compass needle. It is only usable on ferromagnetic compounds, and uses magnetic fields and iron filings to detect component flaws. Magnetic particle testing is commonly used to inspect castings, forgings and weldments for fitness. The ferrous structure is magnetized and iron particles are spread on the structure. The particles would normally only cluster at the magnetic North and South poles of the structure. If they cluster elsewhere, there is a discontinuity in the magnetic field that may indicate a crack in the structure.

3.7 ACOUSTIC EMISSIONS

According to ("WHAT IS NDT?"., 2013), when a solid material is stressed, growing imperfections, if any within the material emit short bursts of acoustic energy called "emissions". As in ultrasonic testing, acoustic emissions can be detected by special receivers. Emission sources can be evaluated through the study of their intensity, rate and other characteristics. The growing defects can be located by triangulation technique (similar to earthquake epicenter location).

4. APPLICATIONS

Non-Destructive Testing and Evaluation (NDT&E) is one of the most critical aspects within the field of aerospace structural design. A wide range of NDT procedures ensure that not a single manufactured component reaches service without first passing a series of stringent tests. In fact, today, NDT is trusted as a guarantee for safety in the aerospace arena, making new research in the field a matter of strategic and essential attention.

NDT is used in a variety of settings that covers a wide range of industrial activity, with new NDT methods and applications, being continuously developed. NDT services are not only integrated with Asset Integrity Management (AIM) solutions, but also with Material Testing laboratories and seamlessly fit into Supply Chain services. (WIKIPEDIA,2014)

- Rehabilitation
- Automotive
  - Engine parts
  - Frame
- Aviation maintenance companies use Nondestructive Testing (NDT) to inspect or detect cracks, flaws or imperfections in engine parts.
  - Aerospace
  - Airframes
    - Spaceframes
  - Powerplants
    - Propellers
    - Reciprocating Engines
    - Gas turbine engines
  - Rocketry
- Construction
  - Structures
  - Bridges
  - Cover Meter
- Maintenance, repair and operations
  - Bridges
- Manufacturing
  - Machine parts
  - Castings and Forgings
  - Fabrication Inspection
- Industrial plants such as Nuclear, Petrochemical, Power, Refineries, Pulp and Paper, Fabrication shops, Mine processing and their Risk Based Inspection programmes.
  - Pressure vessels
  - Storage tanks
  - Welds
  - Boilers
  - Heat exchangers
  - Turbine bores
  - In-plant Piping
  - Full Storage tank Assessment
  - Shutdown Inspections
  - In-service Equipment Inspections
- Miscellaneous
  - Pipelines
    - In-line Inspection using "pigs"
    - Pipeline integrity management
    - Leak Detection

    - Pipeline Open Data Standard
    - ASME Pressure Vessel and Piping as-built Inspections
    - Piping and Pressure Vessel Corrosion Monitoring
- Railways
    - Rail Inspection
    - Wheel Inspection
- Tubular NDT, for Tubing material
- Corrosion Under Insulation (CUI)
- Amusement park rides
- Submarines and other Naval warships
- Wire Rope Testing for, Crane Wires, Mooring Wires, Rope-way Wires
- Medical imaging applications

NDT techniques are particularly useful for monitoring and testing the kind of high-value, safety-critical components used in the aerospace industry. Indeed, according to Peter Milligan, compliance manager with the British Institute of Non Destructive Testing (BINDT), NDT is now compulsory for many aerospace firms. “Most, if not all, aerospace manufactures have to have some form of NDT carried out on their products (in particular, rotating parts) as it is a safety-critical part of the production process,” he told The Engineer. “NDT is a vital part of the production process from a quality-assurance point of view, as it gives confidence that the parts being tested won’t have defects in them that could cause problems in future life cycles.”

Fig. 9 - NDT is an essential tool in the aerospace industry (NON DESTRUCTIVE, 2011)

The variety of techniques available can be roughly broken down into two areas: surface techniques, which are used to identify surface defects such as cracks and surface porosity, and sub-surface techniques - such as ultrasonic testing or radiography - that can be used to detect defects that lie under the material’s surface.

One of the most widely used NDT methods is penetrant testing, a technique in which a visible dye solution is used to reveal surface defects, especially in the composite components for the aerospace industry. Another technique much used is the Ultrasonic testing to locate voids, cracks and laminations, as well as inspect welds and carry out thickness measurements. Beyond these two techniques, we have the Magnetic Particle, Radiography, Eddy Current are very well established techniques in the aeronautic sector (NON DESTRUCTIVE, 2011).

One method showing increasing promise in the aerospace industry, according (NON DESTRUCTIVE, 2011) is pulsed thermography, in which infrared cameras can be used to detect sub-surface damage. This technique holds particular promise for detecting flaws in sections of composite materials.

There is an emerging technique called guided-wave testing - a form of long-range ultrasonic inspection. It is mostly used on long stretches of pipes that could be used to carry liquids or gases, the main purpose for this method is to detect internal defects such as corrosion and liner defects. This method also allows tests to be carried in areas that are often inaccessible.

Another non-destructive testing technique based on resonant frequency response is showing great promise in the aerospace industry. Originally commercialized by US firm Vibrant, but refined for use in the aerospace industry through a partnership at Sheffield's Advanced Manufacturing Research Centre (AMRC), process compensated resonance testing (PCRT) is said to detect hidden flaws more effectively than other NDT processes. This technology works by subjecting a part to a range of resonant frequencies and recording its response. By comparing these results with known standard patterns, it's possible to identify defective parts. One of the most compelling uses of the technique is in turbine blade inspection. Also, it is used to probe aircraft wheels, fasteners and engine components.

5. TERMINOLOGY

The standard US terminology for Nondestructive testing is defined in standard ASTM E-1316 (ASTM E-1316,1997). Some definitions may be different in European standard EN 1330.

Indication: The response or evidence from an examination, such as a blip on the screen of an instrument. Indications are classified as true or false. False indications are those caused by factors not related to the principles of the testing method or by improper implementation of the method, like film damage in radiography, electrical interference in ultrasonic testing etc. True indications are further classified as relevant and non-relevant. Relevant indications are those caused by flaws. Non relevant indications are those caused by known features of the tested object, like gaps, threads, case hardening etc.

Interpretation: Determining if an indication is of a type to be investigated. For example, in electromagnetic testing, indications from metal loss are considered flaws because they should usually be investigated, but indications due to variations in the material properties may be harmless and non-relevant.

Flaw: A type of discontinuity that must be investigated to see if it is rejectable. For example, porosity in a weld or metal loss.

Evaluation: Determining if a flaw is rejectable. For example, is porosity in a weld larger than acceptable by code?

Defect: A flaw that is rejectable — i.e. does not meet acceptance criteria. Defects are generally removed or repaired.

6. BRAZILIAN APPLICABLE STANDARDS

The Brazilian Technical Standard Association (ABNT - Associação Brasileira de Normas Técnicas) keeps in its catalog several NDT standard, according to (CAMPOS, A., 2012). Some of them are listed below:

- ABNT NBR NM 327/2011: Non-Destructive Testing – Liquid Penetrant - Terminology
- ABNT NBR NM 328/2011: Non-Destructive Testing - Magnetic Particle - Terminology
- ABNT NBR NM 329/2011: Non-Destructive Testing - Visual Inspection - Terminology
- ABNT NBR NM ISO 9712/2010: Nondestructive Testing - Qualification and Certification of Personnel

- ABNT NBR 15194/2005: Non-Destructive Testing - Acoustic Emission potted metal pressure during the pressure test - Procedure
- ABNT NBR 15519/2007: Non-Destructive Testing - Acoustic Emission - Secondary Sensor Calibration
- ABNT NBR 15691/2009: Nondestructive Testing – Liquid Penetrant - Standardized Practice
- ABNT NBR 15824/2010: Nondestructive Testing - Ultrasound - Thickness Measurement
- ABNT NBR 15955/2011: Nondestructive Testing - Ultrasound - Ultrasound Instruments Verification

According to (CAMPOS, A., 2012) , the ABNT pointed Brazilian Association in Non-Destructive Testing and Inspection (ABENDI – Associação Brasileira de Ensaios Não Destrutivos e Inspeção) to represent Brazil MERCOSUL Committee for Standardization in Non-Destructive Testing - CSM 24. Moreover ABENDI granted the right to development standards of Nondestructive Testing and for this standardization structure was given the name of "Standardization Organization Sector - ONS-58. (Organismo de Normalização Setorial)".

Moreover, ABENDI keeps several paper publications available for download about NDT. Another branch of ABENDI is about certification, standardization, information center and a library which can be consulted, with training and study commission.

NDT is present in four Regulatory Standards, which are NR 12 (machinery and equipment), "NR 13 (Boilers and Pressure Vessels), NR18 (Construction industry) and NR 34 (Marine)". According to (COMISSÃO TRIPARTITE, 2014), in Brazil, these NR's regulate and provide guidance on mandatory procedures related to safety and occupational health. These standards are cited in Chapter V, Title II, of the Consolidation of Labor Laws (CLT). Were approved by Ordinance No. 3214, June 8, 1978, are obligatory for all Brazilian corporations governed by the Labor Code and are periodically reviewed by the Ministry of Labour and Employment. Are developed and modified by specific tripartite commission composed of representatives of government, employers and employees.

7. CONCLUSION

Day after day we are compelled to do our activities in a better way, with lower cost and in shorter period of time. These three demands are considered as basic guidelines of any design or process engineering, especially in the aeronautical industry where the costs are extremely high. Like all preventive maintenance, there are times when NDT is appropriate and times it is not the best solution. Non-destructive testing can help to solve chronic process problems, as well as avoid catastrophic equipment failures and unsafe operating conditions.

There is no question that the success of the airplane industry is dependent on NDT. Without NDT, the cost of maintaining and flying in airplanes would increase dramatically, while the safety of flying would decrease. When people step into an airplane they trust that it will get them to their destination with as little turbulence as possible. NDT plays a vital role in keeping air travel one of the safest modes of transportation.

Nowadays we have been seeing several new methods being developed in order to enhance quality and reduce cost and time. The NDT is fundamental for inspection / maintenance of machinery and equipment.

NDT can only be perform by an experienced personnel to assure the correct use of the methodology and to mitigate errors possibilities, once it plays a very important role in terms of safety. Many lives can be taken away in case there is negligence or lack of qualification. That's why in Brazil, for instance, it has a strict certification process. It needs qualified and certified personnel, calibrated equipment and the use of national technical bases (ABNT) or international ones.

Non-destructive testing is currently performed in modern industry, in several different kind of applications, especially in aeronautic ones. When experience is combined with process know-how and access to original drawings and all information about the element being inspected, it is an unbeatable solution to keep processes up and running.

8. REFERENCES

ASTM E-1316: "Standard Terminology for Nondestructive Examinations", The American Society for Testing and Materials, in Volume 03.03 NDT, 1997. (ASTM E-1316,1997)

CAMPOS, A., "Ensaios não destrutivos" (END). Disponível em <http://segurancailimitada.blogspot.com.br/2012/07/ensaios-nao-destrutivos-end.html>. Julho/2012. Acessado em 15/01/14. (CAMPOS, A., 2012)

METSO, Technical paper series. "Non-Destructive Testing: Why, When, What and How?". Metso. July, 2010. < http://www.metso.com/pulpandpaper/mpwgeneral.nsf/webwid/wtb-111019-2256f-eb3fd/$file/ndt.pdf >. Julho/2010 (METSO, 2010)

NON DESTRUCTIVE testing in the aerospace industry. Disponível em <http://www.theengineer.co.uk/channels/production-engineering/non-destructive-testing-in-the-aerospace-industry/1007190.article>. Janeiro de 2011. Acessado em 17/01/14. (NON DESTRUCTIVE , 2011)

"NONDESTRUCTIVE TESTING In The Aerospace Industry" NDT Resource Center. Disponível em <http://www.ndt-ed.org/AboutNDT/SelectedApplications/AircraftInspection/Aircraft%20Inspection.htm>. Acessado em 10/01/14. (NONDESTRUCTIVE TESTING, 2014)

COMISSÃO TRIPARTITE de Saúde e Segurança no Trabalho (CTSST) (em português). Ministério do Trabalho e Emprego. República Federativa do Brasil – MTE. Disponível em <http://portal.mte.gov.br/seg_sau/comissao-tripartite-de-saude-e-seguranca-no-trabalho-ctsst.htm>. Acessado em 15/01/14. (COMISSÃO TRIPARTITE, 2014)

SOUZA, R. R.; "Ensaios não-destrutivos: Controle de Qualidade e END; Estanqueidade". Disponível em ,<www-gmap.mecanica.ufrgs.br/html/sumulas/.../Aula%202%20END.ppt> Acessado em 13/12/13. (SOUZA, 2010)

"WHAT IS NDT ?". Disponível em <http://isnt.org/NDT_Methods.pdf> . Acessado em 02/12/13. ("WHAT IS NDT?"., 2013)

Wikipedia contributors. Nondestructive testing. Wikipedia, The Free Encyclopedia. January 27, 2014, 17:28 UTC. Disponível em <http://en.wikipedia.org/w/index.php?title=Nondestructive_testing&oldid=592662828>. Acessado em: 27/01/14. (WIKIPEDIA,2014)

9. RESPONSIBILITY NOTICE

The authors are the only ones responsible for the printed material included in this paper.

Abstract. This work presents an overview about the nondestructive testing (NDT) and its application in the aeronautical industry. This work is presented in an exploratory and generalist character and is based in literature and web research on the topic. It aims to give a general idea about what is NDT, why and when we use this methodology in order to take the most benefit of it. Also, there is a brief explanation about the main methods and techniques of NDT, besides several examples of its applications. Moreover, it brings a description of the basic terminology used in NDT area. This way, it is hoped that this work brings some contribution to the academic community in bringing the knowledge in a simple and objective way, in order to motivate further and more detailed research about this very important method of testing, which for sure save time and money in most manufacturing processes when used in the right occasion.