9th International Conference on NDT of Art, Jerusalem Israel, 25-30 May 2008
For more papers of this publication click: www.ndt.net/search/docs.php3?MainSource=65

THE HELLENIC SOCIETY OF NDT, THE NON-DESTRUCTIVE TESTING IN GREECE IN NOWADAYS AND THE WAY THAT THE ANCIENT GREEKS USED THE NDT FOR THEIR MATERIALS TESTING IN FAR ANTIQUITY

Ioannis N. Prassianakis
National Technical University of Athens (NTUA)
5 Heroes of Polytechnion Avenue, Gr. 157 73 Zografou, Athens, Greece

ABSTRACT

This paper introduces in the present situation of NDT in Greece and provides also the activities of the Hellenic Society of Non Destructive Testing (HSNT) as well as its contribution to the development of the National System of Nondestructive Testing.

Also by this paper some ancient inscriptions that the archaeologists have found in various areas in Greece, which prove that the ancient Greeks in far antiquity 25 centuries ago knew and applied the NDT for testing their materials, using the human senses (smell, sight, hearing, taste and touch) are presented. The result of this way of testing is that ancient Greeks have created a lot of famous monuments and temples well known round the world, many of which survived in perfect condition until today, as the Parthenon of Acropolis of Athens etc.

INTRODUCTION

Nondestructive testing (NDT) has been defined as comprising those test methods used to examine an object, material or system without impairing its future usefulness and has been widely used for studding of structural materials, Krautkramer[3], and Prassianakis[10].

NDT is a branch of the materials sciences, which incorporates all the technology for detection, and measurement of significant properties, including discontinuities, in items ranging from research specimens to finished hardware and products. NDT has become an increasingly vital factor in the effective conduct of research, development, design and manufacturing programs.

The international community on nondestructive testing adopted a system that classifies the NDT methods into six major categories: visual, penetrating, radiation, magnetic-electrical, mechanical vibration, thermal and chemical-electrochemical.

From these NDT methods the most important and well-known used worldwide, for the materials and constructions testing, are the Visual Testing (VT), the Ultrasonic Testing (UT), the Radiographic Testing (RT), the Liquid Penetrant Testing (LT), the Magnetic Particle Testing (MT), the Eddy Current Testing (ET), the Acoustic Emission Testing (AT) and the Thermography Testing (TT). The objective aim of each NDT method is to provide information about the following material parameters, Krautkramer[3], Prassianakis[6-8,10-12] Popovics[5]:

1. Discontinuities (such as cracks, voids, inclusions, delaminations);
2. Structure or malstructure (including crystalline structure, grain size, segregation, misalignment);
3. Dimensions and metrology (thickness, diameter, gap size, discontinuity size);
4. Physical and mechanical properties (reflectivity, conductivity, elastic moduli, hardness, damage, sonic velocity);

5. Composition and chemical analysis (alloy identification, impurities, elemental distributions);
6. Stress and dynamic response (residual stress, crack growth, wear, vibration); and
7. Signature analysis (image content, frequency spectrum, field configuration).

An application of NDT methods of great importance is the testing of monuments and various archeological objectives where the destructive way for testing these materials is absolutely forbidden.

Modern NDT is used by manufacturers: (1) to ensure product integrity, and in turn, reliability; (2) to avoid failures, prevent accidents and save human life; (3) to make a profit for the user; (4) to ensure customer satisfaction and maintain the manufacturer's reputation; (5) to aid in better product design; (6) to control manufacturing processes; (7) to lower manufacturing costs; (8) to maintain uniform quality level; and (9) to ensure operational readiness.

The critical conditions under which the failure of real materials takes place, which begins always from regions of discontinuities where stress concentration exists, are examined by the well-known discipline of Fracture Mechanics (FM). These microscopic or macroscopic discontinuities of the materials can be located and determined in time, by the aid of NDT methods, and furthermore can be studied in more detail by the aid of FM, Prassianakis[7,13].

Thus, using NDT methods the failure of the materials and constructions can be anticipated or even avoided. The importance of NDT is mainly owed at the reason that they do not influence the material properties, they can be applied even when the materials are in work and yet in all of their area.

NDT IN GREECE

Formal training on NDT in Greece began about 40 years ago in 1970, when the first Greek radiographers had to be trained and certified mainly for safety reasons, by "Demokritos", the National Center for Scientific Research that first offered this training and issued the relevant certificates in Greece, Prassianakis[9]. Later and mainly since 1980 many training, education and examination centers and companies offer certification of NDT personnel according to SNT-TC-1A and EN473 using foreign instructors and examiners.

Prassianakis in 1985, introduced the NDT on National Technical University of Athens (NTUA), Kotouzas[2], first in undergraduate courses and later in postgraduate and also in the form of seminars under the authority of the university Continuing Education Committee, NTUA[4]. These seminars occupied all NDT methods and were accompanied by examinations according to EN 473 and ISO 9712 standards, using experience staff of NTUA and Greeks holders of Level III coming from industry. All these contemporary NDT methods introduced later from the rest, mainly, technological universities and institutes of the country, in the education programs as well as in the research field.

In 1987 was founded HSNT which from very early started to offer training and certification in various NDT methods using Greek ASNT's Level III holders as examiners. In 1994 was founded the Hellenic Accreditation System (ESYD) who has signed agreements of mutual recognition with many other relative European bodies and organizations and is full member of the European Collaboration for Accreditation (EAC), of the International Accreditation Committee of Laboratories (ILAC) and of International Accreditation Forum (IAF). In January 1999 a new training and examination center was founded in Volos, the KETEPE who

on the beginning of 2005 was approved by HSNT according to ISO-EN/17024 standard and starts to be used as HSNT examination center in compliance with the EN 473 and ISO 9712 standards, using Greek staff as trainers and HSNT members as examiners, HSNT[1].

The certification of NDT personnel in Greece until 2005 was also offered by various certified examination centers in collaboration with foreign accredited bodies. More than 80 Greek industries, companies and organizations use NDT, with approximately more than 1000 NDT certified inspectors.

THE HELLENIC SOCIETY OF NON-DESTRUCTIVE TESTING (HSNT)

HSNT was founded in 1987, Prassianakis[9], HSNT [1] by approval of the city court of Athens under Resolution No 2861/15-9-1987. Today, HSNT encompasses more than 400 members, who come from the universities, research centers and industries of the country. There are three categories of membership in the Society: Honorary, Full Members and Associate or Student Members. Among them, almost all ASNT level III certificate holders in Greece are members of HSNT. Many famous on NDT persons, members of other NDT sister societies around the world have been accepted also as honorary members of the society also.

HSNT has been fortunate to have as founding and active members University Professors, experienced industry Engineers of all disciplines and experienced NDT inspectors of Hellenic Accreditation System (ESYD), Hellenic Organization for Standardization (ELOT), Olympic Airways (OA), Hellenic Aerospace Industry (HAI), State Factory of Weapons (EBO), Hellenic Air Force and Navy, Hellenic Railways (OSE), State Aircraft Factory (KEA), State Airforce Laboratory (KETA), Shipyards, Refineries, Hellenic Electricity Power Plant (HPPC), Hellenic Air force Research Centre (HARC), Hellas Lab Association, Civil and Military Aviation and Hellenic Petrol's and others. According to HSNT statutes, the purposes of the association are as follows:

- To promote the technology of NDT in Greece.
- To organize lectures and educational seminars in NDT.
- To promote theoretical and practical research in NDT and publish the results.
- To provide advice on NDT quality control.
- To continually keep members up-to-date in NDT matters.
- To make available and publish magazines, pamphlets and books on NDT.
- To promote the interests of its members.

The society is governed by a seven-member Board of Directors, which is elected for a two-year period by the General Assembly in a secret balloting.

The Main Activities of HSNT, From its Establishment Until Today

From its establishment, Prassianakis[9], HSNT[1], was quickly recognized internationally as the national non-profit association for NDT in Greece. It was a member of ECNDT, from 1987 (London 15-9-1987) to 1998 and a founding and full member of the new EFNDT, from 1998 (Copenhagen 25-5-1998). Also, HSNT is a member of ICNDT, from 1989 (Amsterdam 22-4-1989). The society has signed agreements of mutual cooperation, with other NDT societies, as: ASNT (1991), BInstNDT, ABENDE (1992), DGZfP (1998), BUSNDT (2000) and SSNDT (2004). It has also signed the agreement of multilateral mutual recognition of NDT – Personnel certification schemes with other European countries (EU/EFTA), during a special meeting in Nice/France in 1994. HSNT is a founding member of Balkan Peninsula Society of NDT (BP S NDT), (2001) and of the East European and East Mediterranean Society of NDT (SEEEM NDT), (2002).

Members of HSNT participate in various national NDT committees and councils including:

- The NDT Technical Committee of ELOT, TC 70 "Nondestructive testing of materials", which was established in 1992 and which main purpose is the elaboration of European NDT standards, as well as the cooperation with CEN/TC 138.
- The Hellenic National Accreditation System (ESYD), and
- The Hellenic Association of Laboratories, which is member of Euro Lab, since 1998.

The article written in the scientific magazine 'Insight' in June 1999 with the title "NDT in Greece" was important for the international recognition of HSNT, Prassianakis[9].

HSNT co-organized with BANT, the 1st Hellenic-Belgian International Conference on NDT in Patras, Greece, on May 22-23, 1995. HSNT organized a one-day conference on NDT on November 23, 1998 at NTUA, on the Zographou University Campus. Furthermore, HSNT with BANT, AlPnD, University of Patras and the Vrije Universiteit Brussels, organized the 2nd International Conference, in Athens, on May 24-26, 1999. The HSNT 2nd National Conference on NDT took place in University of Volos on June 17, 2000, and the 3rd National Conference on NDT of HSNT took place in Thessaloniki, on June 9, 2001. Also HSNT organized its 4th annual National Conference on NDT, which was held, together with the 2nd NDT Conference of the Balkan Peninsula Society of NDT (BPSNDT), on November 2, 2002 in the Zografou University Campus of the NTUA. HSNT organized its 3rd International Conference on NDT, in Chania Crete-Greece, on October 15-17, 2003. HSNT organized also its 5th annual National Conference on NDT on November 18-19, 2005 in the Zografou University Campus of NTUA. Finally HSNT organized its 4th International Conference on NDT, in Chania Crete, on October 17-19, 2007. The society and some of its certificated members have organized training seminars on various NDT methods and have also certified (at level II) NDT personnel, according to ASNT and EN 473 standards.

The main purpose of HSNT was its accreditation as an independent certifying body, in order to run examination centers for qualification and certification of NDT personnel in Greece, carefully and after strict procedure was succeeded according to ELOT-EN-ISO/IEC 17024 standard in March of 2005 by ESYD (certification No. 198/2005). After its accreditation HSNT submitted all the necessary documents for the approval by EFNDT, so it was accepted (27-5-05) for recognition and registration within the terms of the Multilateral Recognition Agreement (MRA) and received the corresponding Registration Certificate on June 2005. HSNT is the unique national non-profit body accreted by ESYD in Greece, internationally recognized, for the qualification and certification of NDT personnel, Prassianakis[9], HSNT [1].

Accreditation of HSNT includes five methods: Radiographic Testing (RT), Ultrasonic Testing (UT), Visual Testing (VT), Magnetic Particle Testing (MT) and Liquid Penetrant Testing (PT). Each method contains three levels (I-II-III). The education, training and certification of NDT personnel is provided by the examination centre KETEPE, located in Volos Greece, certified by HSNT according to EN 473 and ISO 9712 standards and the eventual certificates of successful examinees are edited by HSNT directly.

Today HSNT is preparing in order to extend, as soon as possible, its accreditation in all the rest NDT methods and industrial NDT fields. On the other hand HSNT examines the expressed interest from other candidate examination centers and the procedure now is in progress in order that they will be soon certified, thus occupying all the rest NDT education and training NDT fields.

EDUCATION AND TRAINING ON NDT METHODS IN GREEK UNIVERSITIES

Simultaneously from 1985 the education and training in formal way on the contemporary NDT methods were introduced mainly in the technological universities and institutes of the country so in the undergraduate and postgraduate education programs as well as in the research field. It started mainly from the first technological university of the country, the NTUA that was founded in 1836, a few years after independence of country and the formation of the New Hellenic State (1821) and from its department of Mechanics, Prassianakis[9].

The systematic development of NDT methods in Greece started after 1970 with the application of visual NDT examination (Holography, Moiré, Photoelasticity and Caustics) methods, in NTUA. In 1985 was established the NDT laboratory in the department of Mechanics of the School of Mathematical and Physical Sciences (SEMFE). Thus, from 1985 all NDT methods were taught to the university students in undergraduate and postgraduate level. Later, NDT introduced in the rest schools of NTUA and other universities so that in nowadays almost all technical universities and institutes provide education, training and research in all NDT methods. From 1990 a lot of special seminars for all NDT methods have been organized by Prassianakis in the Continuing Education Centre of NTUA, NTUA[4], for post-graduate students, as well as considerable research also has been accomplished concerning mainly the ultrasonic method. Finally in 1996 Prassianakis introduced NDT officially in the postgraduate programs of the department of Mechanics of the School of Mathematical and Physical Sciences (SEMFE) of NTUA, Kotouzas[2].

NDT IN ANCIENT TIMES

All the marvelous technological achievements of the human spirit are based on the rapid evolution of the science, the technology and the quality control of materials. The humanity has to show many big and ultra structures from the distant antiquity. Although the science of Mechanics was not known, were made tough structures many of which survive until today. It was happened because there was known the NDT, as many archeological findings confirm it.

Although the start of the NDT can be considered the 19th century, which however was developed and was established as scientific method much later in the middle of the last century, the currently way of testing using NDT methods was introduced in last decades for industrial applications, NDT was known and used for testing materials and constructions from far antiquity in Greece. Ancient Greeks e.g., Prassianakis[9,11-14], Varoufakis[15-18] used strict specifications in their orders and also a well-organized quality control system, based on NDT methods with the help of human senses. It was applied to almost all products in those times for the protection of the consumer as well as the state from the illegitimacy and bad quality. All these specifications belong to the same century, the 4th B.C. century, the time period in which in ancient Greece a high development of Greek civilization took place.

Non-Destructive Testing in Distant Antiquity by Ancient Greeks

The ancient Greeks were "technological" population. They considered, as it is reported in their Mythology, the Technology and the Energy as gifts of divine forces to the human gender, immediately afterwards the Creation. For each marketable good, as for the technological products of ancient Greeks, the production followed the qualitative control.

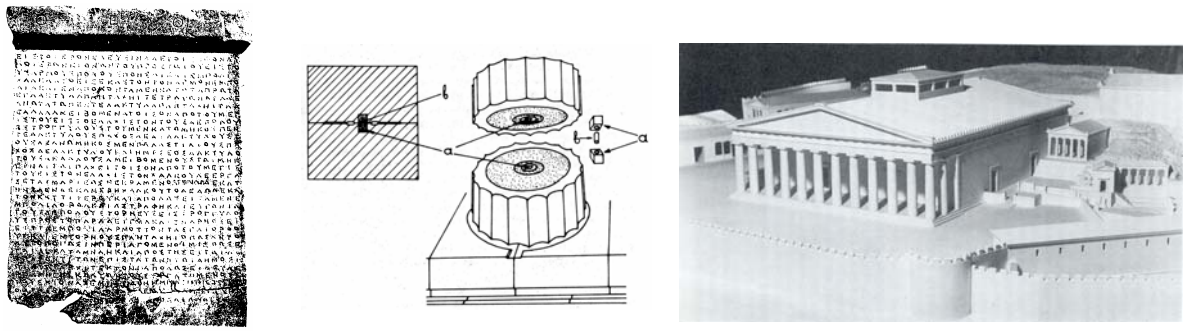
Based on historical and scientific information that the archaeological spade and the scientific research have brought in the light, we are led to the conclusion that the ancient Greeks, 25 centuries ago, knew and also applied the qualitative control in the materials that they used.

In the antiquity the destructive testing was not known. On the other hand, as it is also confirmed by many ancient Greek inscriptions, Prassianakis[11-14], Varoufakis[15-18], the NDT must would be applied by subjective way, that is to say with the help of the five human senses (sight, hearing, touch, smell and taste). These inscriptions were engraved, mainly, in marble plates and they have been found in excavations that have been carried out in regions where the ancient Greek culture was developed. The most important from these inscriptions are:

1. The inscription of Eleusis, of the 4th century B.C.,
2. The Athenian law on silver coinage of the 4th century B.C,
3. The laws of Thasos, of the 5th century B.C., and
4. The inscription of Oropou, of the 3rd B.C. century

The Inscription of Eleusis

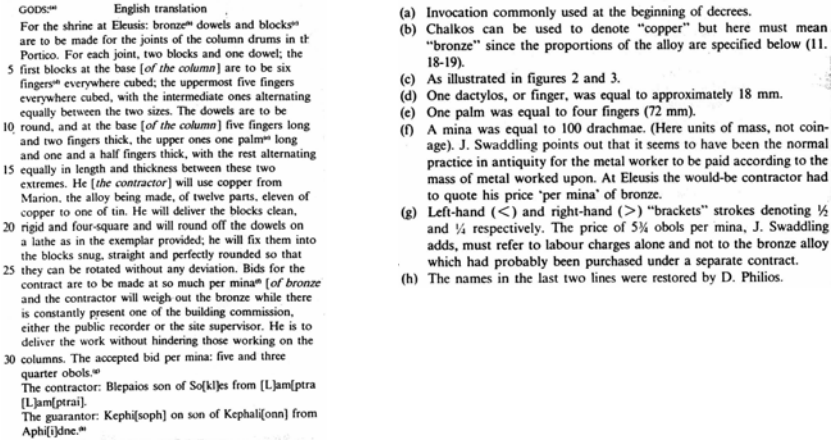
The inscription of the Eleusis, Figure 1(a), was found by D. Philios on 1893 in the small town of Eleusis, which located 15 Km west of Athens city and is inscribed on a white marble stele around 360 B.C. The text of it, Figure 2 (in English translation (a), in original ancient Hellenic (b) and its translation to new Hellenic (c)), constituted a standard with very strict technical specifications. It concerns the manufacture of bronze fittings known as empolia and poloi, Figure 1(b), to be used in the erection of the columns of the Philonian Stoa, a portico placed in front of the much older temple of Eleusis, Figure 1(c), the well known Telestirion, Varoufakis[15].



(a) (b) (c)

Figure 1. The marble inscription of Eleusis (a) and the bronze fittings (b) (empolia b(a) and poloi b(b)) and the Temple the Telestirion and the Philonian Stoa, of Eleusis (c).

It is worth noting that it was given the contractor of the project specific instructions about the origin and the chemical composition of the copper-tin alloy, which was to be used and also the shape and exact sizes of the required fittings were specified. At that time this inscription is considered as the oldest ancient European standard discovered so far. It reports that the bronze and the fittings should be produced in the Marion of Cyprus (today named Arsinoi) and that the 12 parts contain 11 copper and 1 tin.



GODS:[a] English translation

For the shrine at Eleusis: bronze[b] dowels and blocks[c] are to be made for the joints of the column drums in th Portico. For each joint, two blocks and one dowel; the first blocks at the base [*of the column*] are to be six fingers[d] everywhere cubed; the uppermost five fingers everywhere cubed, with the intermediate ones alternating equally between the two sizes. The dowels are to be round, and at the base [*of the column*] five fingers long and two fingers thick, the upper ones one palm[e] long and one and a half fingers thick, with the rest alternating equally in length and thickness between these two extremes. He [*the contractor*] will use copper from Marion, the alloy being made, of twelve parts, eleven of copper to one of tin. He will deliver the blocks clean, rigid and four-square and will round off the dowels on a lathe as in the exemplar provided; he will fix them into the blocks snug, straight and perfectly rounded so that they can be rotated without any deviation. Bids for the contract are to be made at so much per mina[f] [*of bronze*] and the contractor will weigh out the bronze while there is constantly present one of the building commission, either the public recorder or the site supervisor. He is to deliver the work without hindering those working on the columns. The accepted bid per mina: five and three quarter obols.[g]

The contractor: Blepaios son of So[kl]es from [L]am[ptra [L]am[ptrai].

The guarantor: Kephi[soph] on son of Kephali[onn] from Aphi[i]dne.[h]

(a) Invocation commonly used at the beginning of decrees.
(b) Chalkos can be used to denote "copper" but here must mean "bronze" since the proportions of the alloy are specified below (11. 18-19).
(c) As illustrated in figures 2 and 3.
(d) One dactylos, or finger, was equal to approximately 18 mm.
(e) One palm was equal to four fingers (72 mm).
(f) A mina was equal to 100 drachmae. (Here units of mass, not coinage). J. Swaddling points out that it seems to have been the normal practice in antiquity for the metal worker to be paid according to the mass of metal worked upon. At Eleusis the would-be contractor had to quote his price 'per mina' of bronze.
(g) Left-hand (<) and right-hand (>) "brackets" strokes denoting ½ and ¼ respectively. The price of 5¼ obols per mina, J. Swaddling adds, must refer to labour charges alone and not to the bronze alloy which had probably been purchased under a separate contract.
(h) The names in the last two lines were restored by D. Philios.

(a)

(b)

(c)

Figure 2. The English translation (a) of the original in ancient Hellenics (b) and in the new Hellenics (c) of the Eleusis inscription.

The Athenian Law on Silver Coinage

The stele of Figure 3(a) of dimensions $(1.268 \times 0.457 \times 0.126)m^3$, regard the Athenian law on silver coinage belongs to the beginning of the 4th century B.C. and constitutes a "directive" regarding the quality control of silver in general, and more specifically the Athenian silver currency. It was discovered during the ancient Agora excavations on 1970.

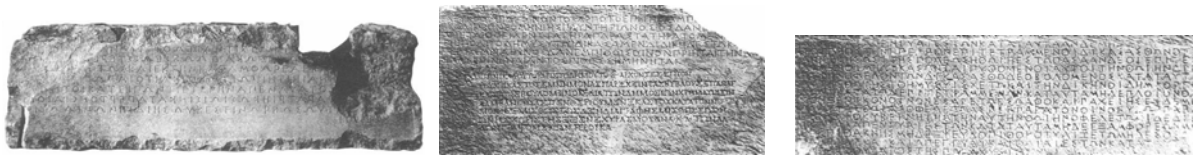
In this inscription the following important points are noted: a) The law required that the silver currency should be tested by a skilled public officer. This means the existence of empirical quality control, which was carried out on silver coins by skilled tester. b) The testers and the sellers of goods were to be severely punished in case the former were reluctant to test the silver coins brought them, and the latter if then did not accept coins certified to be genuine. c) The law states that a tester existed in the city of Athens, and one was newly installed in Peiraeus. d) The new law in force cancels and replaces existing previous decrees. In Figure 3(b) there is a pure silver Athenian coin of 5th century B.C., in Figure 3(c) there is a counterfeit coin of the late archaic period cut across, strengthens this view, while Figure 3(d) shows a case of counterfeit coin of the end of the 5th century (406 B.C.).

(a) *(b)* *(c)* *(d)*

Figure 3. The Athenian law (a), a pure silver Athenian coin of 5th century B.C. (b), a counterfeit Athenian coin of the archaic period cut across of the 6th century B.C. (c) and a copper silver plated Athenian coin of 5th century B.C. (d).

The Three Laws of Thasos Concerning the Testing of Wine and Vinegar

Important are also the three inscriptions of Thassos, of the 5th century B.C. Their text mentions three very important directives, concerning the quality control of wine. These three inscriptions, Figure 4, are kept at the small museum of the Thasos, a small island of the north Aegean. Their text mentions three very important directives: a) The purchase of wine would have been valid, only, if the large jars (pithos) of wine had been sealed with a quality mark, b) A heavy penalty should be imposed on those importing foreign wine in the area of the island of Thassos, and c) The penalties would have been equivalent to those imposed in the case of "watering the wine". The latter is extremely important since it reveals the existence of another law, unfortunately not yet found, which would have specified the quality control of wine, Prassianakis[11-14], Varoufakis[15-18]. The conclusion is that the testers in ancient Greek must have used their senses sight, smell and taste for testing the wine.



(a) *(b)* *(c)*

Figure 4. The three laws of Thassos concern: The first inscription (a) of the 5th B.C. century the testing of wine and vinegar, and the second (b) and third (c) of 420-400 B.C. century the commerce of the pure wine and the testing of the illegitimacy with water of the wine.

Figure 5. The inscription of Oropou, of the 3rd B.C. century, concerns the testing of the damaged gold and silver objects of the holy temple of Amfiaraou of Oropou.

The Inscription of Oropou
The inscription of Oropou, Figure 5, is of the 3rd B.C. century and concerns the testing of the damaged gold and silver objects of the holy temple of Amfiaraou of Oropou.

Possible Quality Control Procedures of Testing Metals in Ancient Greece
The quality control procedures of testing pure metals and metals alloys in antiquity should be based on the NDT methods, using reference specimens with different contents in the various metals. The tester with the help of NDT methods, that is to say the sight, touch, hearing and with engraving, comparing the unknown content of alloy with the standard reference blocks would realize easily the composition of the unknown alloy and consequently the existence of illegitimacy.

First, they observe the coin carefully, then they touch it with their very sensitive fingers, they feel the weight when keeping it in their first, and finally they let it drop on a hard surface and hear the sound of its ringing.

Regarding gold, it is well known that its purity or its composition was determined by the common test of the touchstone (Lydian stone). It is the oldest colorimetric non-destructive assaying in use since the antiquity. The test is based on the comparison of rubbing a gold object of unknown composition and those left by a series of gold standards of certified composition. “Lydia Lithos", was a black hard stone and constituted one from the objects with which ancient Greeks by engraving checked the cleanliness of the golden and silver currencies, jewels, alloys and other objects.

The testing of bronze composition must be done in a similar way. A color comparison between the bronze supplied by the contractor and a series of standards of copper and copper-tin alloys of know composition would have been a possible testing procedure. Experimental work, executed by Varoufakis[16], proved that latter could work successfully. The testers in ancient Greek using their senses sight, smell and taste for testing the wine must follow similar procedure.

The message from the distant antiquity is that the ancient Greeks used strict specifications in their orders and also strict control of quality, because, if there is not a control, the specifications would not have any value and the danger for illegitimacy would be serious.

CONCLUSIONS
During the last years, the whole situation in the field of quality control using NDT methods and the certification of NDT personnel in Greece has changed significantly. Industry is better organized, a lot of NDT training and certification centers have been established and the certification of NDT personnel can be offered by the Greek national accredited body, the Hellenic Society of NDT.

On the other hand from the previous mentioned investigations comes out the high level of knowledge and experiences of ancient Greeks in the field of standardization, testing and certification of materials, goods and products. A well organized quality control, based on Non-Destructive Testing methods, was applied to almost all products in those times, such metals, alloys, coins, wine and other goods and objects, using the five human senses: sight, touch hearing, smell and taste as well the use of the touchstone (the Lydian stone).

This confirms the opinion that as at the antiquity as well as at nowadays in well organized with developed culture societies is observed also developed technology. Culture and technology that is to say keep pace. It would not be possible becomes big work of humanity at the antiquity, which up to today we admire, if the engineers of that period not used standards and technical specifications, as on the other hand happens in nowadays.

REFERENCES

1. HSNT, Web Site: www.hsnt.gr.
2. Kotouzas, M. K., NDT Training and Certification in Greece, Materials Evaluation, pp. 1182 -1183, October 1996.
3. Krautkramer, J. and H., Ultrasonic Testing of Materials, Springer - Verlag, Berlin (1977).
4. NTUA, Postgraduate Programme of Continue Education, National Technical University of Athens, Continuing Education Committee, Athens Greece, 1990-2000.
5. Popovics, S., Analysis of the Concrete Strength Versus Ultrasonic Pulse Velocity Relationship, Materials Evaluation, pp. 123-130, February 2001.
6. Prassianakis, I. N. and Theotokoglou, E. N., The Attenuation Evolution Near Notch Tips in Polymers by the NDT Method of Ultrasounds, Engineering Fracture Mechanics, Vol. 43, No 1, pp. 117-121, 1992.
7. Prassianakis, I. N., An Experimental Approach to Damage Evaluation Using Ultrasounds, European J. of NDT, Vol. 3, No 3, pp. 93-96, January 1994.
8. Prassianakis, I. N., Moduli of Elasticity Evaluation Using Ultrasounds, INSIGHT, Vol. 39, No 6, pp. 425-429, June 1997.
9. Prassianakis, I. N., NDT in Greece, INSIGHT, Non-Destructive Testing and Condition Monitoring, European Issue, Vol. 41, No 6, June 1999, pp. 350-371.
10. Prassianakis, I. N., NDT of Materials - the Ultrasonic Method, Edited by National Technical University of Athens (NTUA), Athens-Greece, 2002.
11. Prassianakis, I. N., Non Destructive Testing and the Hellenic Society of Non Destructive Testing, Proceedings of the 3rd ICNDT of HSNT, Non-Destructive Testing in Antiquity and Nowadays, - Skills - Applications - Innovations, Chania, Greece, October 15-18, 2003: pp. 3-7.
12. Prassianakis, I. N. and Prassianakis N. I., The Ultrasonic Testing of the Non Metallic Materials: Concrete and Marble, Journal of Theoretical and Applied Fracture Mechanics, Vol. 42, pp. 191-198, 2004.
13. Prassianakis, I. N., The Contribution of NDT for the Development and Survival of a Society from the Antiquity to Nowadays, the 8th ICSS NDT, "Application of Contemporary NDT in Engineering", September 1-3, 2005, Portoroz Slovenia, Proceedings of the Conference Published by SS for NDT, pp.139-150, Portoroz - Slovenia, September 2005.
14. Prassianakis, I. N., The Scheme of Certification of NDT Personnel in Greece, Proceedings- Abstracts Pert 1, Th. 3.6.3, 9th ICNDT of EFNDT, Berlin 25-29 September 2006, and NDT-NET Database, www.ndt.net/search, ECNDT 2006- Berlin- Certification, Qualification, Training, Personnel, 2006.
15. Varoufakis, G. I., The Ancient Greece and the Quality, Edited by AIOLOS, ISBN 960-7267-99-0, Athens, 1966.
16. Varoufakis, G. I., Non-destructive Tests of Attic Silver Coins in Antiquity, 1st ICNDT of HSNT, Patras 1966, Proc. Balkema, Rotterdam, ISBN 90-5410-595x.
17. Varoufakis, G. I., Materials Testing in Classical Greece, Hellenic Organization for Standardization, Athens, 1987.
18. Varoufakis, G. I., The NDT of products in Antiquity, 1st NCNDT of HSNT, proc., Athens, Greece, November 23, 1998.

Back to Top