Nondestructive Testing Of The Immerse Structures Within The Romanian Oil Fild In The Black Sea Using Deep Divers

Stefan GEORGESCU*
Maritime University, Constanta, Romania,
stefan102001@yahoo.com

***Abstract*—The paper sets out to present the main aspects resulting from the execution of nondestructive testing with deep divers within the Romanian oil field in the Black Sea. The paper start with visual control, photographic control and finished with ultrasonic control. In all this steeps are presented conclusion from practical activity done by the author in Oil field. Also the paper present practical aspect in modality to organized a underwater yards.**

Keywords—NDT, Visual examination of the immerse structures, ultrasounds. divers, maritime oil field.

PERFORMING NON-DESTRUCTIVE TESTING ON IMMERSE STRUCTURES WITH DIVERS

Performing non-destructive testing with specialized divers on different elements of various immerse structures involves primarily visual inspection of immerse structural elements subject to testing, their photographing and filming, and ultimately, their ultrasound examination. The results of the visual inspection, the film records and the ultrasound examinations are analyzed by specialists in strength of materials and immerse structural behavior, aiming to detect any remediable flaws. [1]

1. VISUAL INSPECTION OF IMMERSE STRUCTURES

In order to maintain in safety conditions the functioning of immerse structures, they must be constantly monitored and controlled. Underwater inspection is a traditional activity of divers which relies exclusively on visual methods, such as: the divers' eyes, photography, videography and underwater television.

Taking into account the purpose of visual inspection, its immediate use should not be underestimated. It is extremely important that a diver should be able to descend under water to the level previously determined of the structure, to examine it and be able to describe what he has seen. This initial or preliminary report may be supported by photos, film or video. The diver can see the object in stereoscopic image and in its own color, both of these elements cannot be highlighted when the object is represented at the surface in photos, film, video images and underwater television. [2]

Visual inspection should be considered as the first means of investigation or immediately non-destructive testing. Therefore, all divers used for visual inspection are required to perform at any time visual inspection training, and when an inspection is necessary, it will be used a typical inspection program together with a summary of the main methods used for each activity carried out. Once these methods, required by various inspections, are understood, they can be addressed the most effective programs and methods of inspection.

Thus, in addition to traditional methods of inspection, there can also be mentioned: non-destructive testing, inspection of damage by corrosion, control and removal of seaweed deposits, and cleansing and stability control. The primary reason for inspection is to help maintain the integrity of structures over time.

1.1. Naked eye inspection

Direct visual observation of an underwater object ensures the obtaining of raw data that can be provided to specialists in relation to the observed object's characteristics. For this type of inspection the human eye is extremely valuable when characterizing and identifying underwater objects and phenomena, but only to a certain, limited, level of evaluation. Thus, such an observation cannot determine the degree of corrosion and cannot detect the cracks and defects that cannot be perceived by the eye of the diver. So that the value of visual observation carried by divers reaches high rates, verbal comments must be recorded for their subsequent correlation with data obtained by other methods of transmitting images at the surface.

In order to understand the usefulness and value of visual inspection, it is necessary to imagine such an activity in its typical context. First, the inspection's beneficiary requirements may fall into the following: the object of inspection will consist of verifying the extent of protection of the platform and pipeline to the distance of 20 m from the base of the underwater structure, and in order to achieve this objective visual inspection will be performed on anodes and their way of fixing, on all cables from the anodes and their way of fixing, on raisers and their way of fixing, on legs and their way of mounting, and on the bottom area to the distance of 20 m to verify the pipes, waste or other materials existing on the platform area. Based on the above mentioned example, a diving plan is prepared which initially covers the inspection and the reporting of the results, and then it specifies the parties which are subject to non-destructive testing.[3]

Before entering the water, the diver must memorize the position and the exact configuration of the component he is about to inspect. This activity is based on proper preparation and realistic planning. First, the structure plans will be examined in order to identify the section that will be inspected. Then, divers will be briefed. To eliminate confusion, sketches and plans will be simplified or scale models will be used whenever possible. Familiar with the mental image of the working area, the diver will be able to dive in the set point and select the correct section for inspection. An extra support is that for a certain number of steel structures, the legs or some branches or ties which intersect, have identification markings on the most important points. Thus, the diver may seek a position "on the leg B crossed with tie 36" and he can check his position by examining the markings on the structure. The diver can begin work under water, and the information on the inspected surface section may be available immediately. Further on, special equipment is really necessary because his initial visual inspection is important in order to specify the type of equipment to be used. The diver who performs visual inspection should distinguish characteristic aspects of the marine fouling, the welds, damage, anodes, coating, waste (materials thrown or dropped into the water) and the appearance of the bottom of the water.

1.2. Theoretical and practical training of visual inspection.Tools and methods for cleaning immerse structures.

Currently there is no specific method of training for divers who perform direct inspection. However, there are ways of training the divers who perform non-destructive testing, taking into account a certain visual technique. A control plan must be preceded by a preliminary visual inspection. Planning a non-destructive testing exercise will require, ultimately, a visual inspection to recognize objects and gather information in order to elaborate a detailed plan. For this reason, visual research remains one of the basic techniques of the diver that performs the underwater inspection.

Non-destructive testing cannot be implemented without a thorough preparation of the surface to be inspected. The most accurate results are obtained on metallic luster. There are a variety of tools and instruments available for this activity, out of which there can be mentioned: *hand tools* (scrapers, wire brushes, hammers, chisels, etc.), *pneumatic tools* (tools for drilling, grinding, etc.), *hydraulic tools* have the advantage that they work at any depth, *water jetting* at high pressure which are effective in removing underwater gravel and sand. [4]

1.3. Underwater lighting

There cannot be performed a thorough inspection to underwater structures and facilities without taking into consideration the visibility conditions. Such inspection requires an assessment of the lighting conditions in the water and the need for underwater lighting. There are four main methods of visual inspection, namely: naked eye inspection, photographic inspection, inspection using television images, and video inspection. All methods are affected by the way in which light penetrates the water. Under water, light decreases as depth increases. In clear water, at a 5 m depth, the light energy is reduced to ¼ of the value at the surface of the water, at a 15 m depth it is reduced to 1/8 of the initial value, and at a 40 m depth the light energy value is reduced to 1/30. Due to several phenomena governed by physical laws, light penetrates differently the water than the air. Hence, it results the following effects corresponding to the phenomena which govern the penetration of light in water: water color absorption, reduced contrast, decrease in light intensity due to its water absorption, reflection and refraction of light at the air/ water interface, and absorption and scattering of light by solid particles suspended in water.

a. **Water color absorption.** Light, for photographic applications, is called white light. It may be decomposed into a spectrum of basic colors, which are: red, orange, yellow, green, indigo blue and violet. Light is not absorbed by the water itself, thus the number of colors in the spectrum is reduced. Clean sea water absorbs primarily the red color from the spectrum, and as depth increases, more and more colors are retained. Thus, red and orange are the first colors which disappear, then yellow, while green and blue persist longer. The absorption of a part of the color spectrum raises a lot of problems when taking photographs underwater. Color absorption with a higher wavelength gives light a blue-green hue when it is penetrated to over 20 m depth. This means that monochromatic photographs reduce the effect of contrast and polychromatic photographs give pictures a green hue. There are two ways to balance the phenomenon. The first way consists in applying a red filter on the lens. This solution is not used too often because the filter actually reduces all available light that could still reach the photosensitive film, even if the color balance is restored. The second way is to use artificial light. This way, contrast is recovered for monochrome film and the greenish hue is reduced in polychromatic photographs.

b. **Reduced contrast in water.** When looking at an object, its shape and structure become apparent to the eye due to various intensities of light that is reflected on the surface of the object. If light intensity differences are striking, the contrast is photographically good. If intensity differences are less striking or absent, the subject has poor contrast and the image is blurred. The contrast itself does not solve entirely the problem because it should also be taken into consideration the resolution of the picture.

c. **Decrease in light intensity under water.** The decrease in light intensity under water is the most well known phenomenon. In fact, the more the diver descends deeper into the water, the more the intensity of light decreases. The problem of decreasing light intensity is quite complicated, which is why it is necessary a presentation of all the involved factors including the behavior of the light ray at the air/ water interface, light attenuation, its scattering, etc. At the boundary between air and water, sunlight encounters water barrier. Rays penetrate water only vertical or almost vertical, while those with very large angle of incidence will be reflected. So, in the morning and in the afternoon, very little light penetrates the water. If the surface of the water is wavy, then it means that there will be more surfaces which will reflect light and thus the quantity of light penetrating the water decreases. Snell's Law refers to this particular aspect of physics.

As light comes through the water, it is attenuated, reducing the quantity of light available to a certain depth. Light attenuation is not constantly proportional to the depth. As a certain quantity of light is entering the water, a part of this light encounters particles in suspension and is reflected by them, and thus the light is scattered. The dispersion phenomenon affects also the artificial light.

d. **The importance of underwater lighting.** The technical quality of a photo taken under water is directly proportional to the quality of underwater lighting, in other words, more light means quality. However, the light source must be well located. Before defining the importance of proper lighting, it should be reminded that a detail can be seen both in the lighting section and in the lower lighting section. A photograph is not good for technicians if details cannot be observed. The use of multiple light sources allows a better capturing of details but it requires an additional effort. In some cases, it is preferable the use of a single light source within the required technical conditions. In order to provide underwater lighting for underwater photography or filming, there can be used two types of light source: fixed lamps and electronic flashes. Fixed lamps are usually accessible for divers or underwater vehicles, and they may have a mixed spectrum, some with tendency to yellow, others to green. Some of these may be suitable for video processing, but not for photography. Fixed lamps are heavy and bulky, they require the use of the brightness meter, and their power is small, which is why they do not offer major advantages in underwater photography, except for some special applications. Electronic flashes are more often used because they provide the necessary power to obtain adequate photographs; they show the color spectrum of the film produced for daylight; they are compact and easy to carry and they are cheap.

The location of additional light is important but it cannot eliminate the compromise between ideal lighting and feasible lighting. For that purpose one can make two speculations presented as follows.

The first speculation is to reduce the volume of water between the subject and the lenses. The diver should approach the subject as much as possible in order to photograph it.

The second speculation is that when there is not enough light and thus the area is unclear more illumination is gained from the camera axis. Unfortunately, in this case, the subject tends to be lighted on one side. It is recommended that the disposition of lights consider certain rules of locating lighting lamps, as presented in the following:

- For all works: the offset of the electronic flash on the axis of lenses is kept lest it should reduce the dispersion, and to ensure an adequate angle lamp to the size of the subject, respectively the position of the flash and the angle of the photo camera or video camera.
- For works in confined places (the subject reaches dimensions of 5 … 50 cm): lighting is maintained in a part of the subject when using a single flash; lighting is placed at a reasonable distance to the subject while two flashes are located at equal distances, and divers must be sure that their shadow is not on the subject.
- For remote works (the subject reaches dimensions of 50 … 150 cm): the flash is maintained in front of the camera (at about 25 … 30 cm) wherever possible, and it is ensured that the device for the electronic flash be placed in the visual field of the camera.

Lighting is of great importance not only for photography or television transmission of images but also for other methods of inspection where visibility is poor or does not exist.[5]

2. UNDERWATER PHOTOGRAPHY

Capturing an underwater image bears the accomplishment of a series of actions that can be grouped into two stages as follows. The first stage is photographing using the camera lens whereby it is obtained an image that is recorded in the sensitive emulsion of the negative photographic material, and the second stage is the stage where it takes place the image processing. This is the stage in which the recorded image is fixed and transposed on the positive material under the guise of photography or slide. This section will address questions that belong to the first stage, making also mentions of certain technical references to underwater filming and underwater video recordings, especially to those that are also common to underwater photography.

Underwater photography (or perhaps a more accurate name would be photographing "in water" to distinguish it from the usual "in air") consists in capturing and recording the image on film of subjects found in seas and oceans, rivers, lakes, pools or aquariums. In order to practice this kind of photography, which is very special considering the properties of the working environment, two problems must be solved: ensuring the safety of the diver and the integrity of his photographic materials and equipment and adapting his photographic technique to the conditions imposed by the optical properties of the environment in which the pictures are taken.

It should be kept in mind that for this kind of photos water is an undesired natural filter whose less than mediocre qualities affect essentially the quality of image. Within this context, it may be emphasized that what is even worse is the fact that the "harmful" effects of the water filter are accumulated, and thus it is simultaneously placed both between the light source and the subject, and between the subject and the photographic lens.

For rational choice of action in this "anti-filter" fight, it is necessary to know the major changes that light suffers when it penetrates the water and when it crosses this environment. When taking underwater pictures, in addition to the technical knowledge, the operator plays an important role because he must constantly adapt to the way of achieving his purpose in the environmental conditions.

2.1. Conclusions regarding underwater photography

Any underwater photographing and filming activity is determined by the hydro-weather conditions of the place, the characteristics of the used material, the available technique, and the possibilities and practical skills of the diver.

The main factors that influence the quality of underwater photography are dominated by three particular phenomena of the aquatic environment, namely refraction, scattering and absorption, which generate deformations and distortions of photographic images, chromatic aberrations and tones of the photo. Basically, the changes produced by the above mentioned factors are: a visual field reduced to 1/3, an apparent distance of ¾ from the real distance, poor clarity, a decrease of field depth, a rapid absorption of light and special effects due to the existing suspensions in water.

The main methods to counter these drawbacks, most of them depending on the skill of the photographer diver are: choosing a minimum distance from the subject, the use of short focal length lenses, adjusting light according to the apparent distance to the lens, choosing a suitable light source and use of artificial adjustment to restore color.[5,6]

3. UNDERWATER VIDEOGRAPHY

Underwater filming is a film recording technique of various plants and immersed structures and of the structures' elements and immersed plants in order to subsequently perform visual inspection on their condition to identify any possible defects arose during their operation.

Underwater video cameras may be usual cameras, underwater case video cameras, with control functions on the outside of the case, or they may be underwater sealed video cameras, specially designed for underwater videography and thus they have zero buoyancy. These underwater cameras are equipped with lenses that have special lighting, field and setting options qualities.

Underwater videography, with industrial and military purposes, involves special film materials and equipments consisting of specialized cameras, a wide range of accessories, suitable photosensitive materials, and specific photo developer devices, as well as proper lighting equipment. Due to its high complexity, industrial and military underwater videography requires also the use of highly trained divers with a rich professional experience in the field.

It is recommended that the distance between the underwater camera and the displayed object be as small as possible. This thing can be achieved by using common lenses with short focal lengths or specially designed lenses for underwater filming.

In order to decrease the effect of light scattering, it is recommended that the angle between the optical axis of the lens and the axis of the light beam be more than 25 … 30°. Therefore, the artificial light source shall not be placed near the lens. Thus, it will be used an underwater illumination device with projectors, equipped with adjustable arms so that there is the possibility that the projectors be optimally closed or distanced from the lens. To increase visibility and enhance contrast there can be used polarizing filters.

Image stability can be improved by filming at a slightly higher frequency than normal, namely at a frequency of 28 … 30 images per second both for a 16 mm film and a 35 mm film.

It is recommended that during underwater videography the videographer be accompanied by another experienced diver who plays the role of the safety diver and ensures the underwater safety of the first diver.

When using ordinary cameras placed in watertight sealed cases, it is required to check the tightness of the equipment by immersing it at a depth of 9 m, and then raised to the surface for water infiltrations checking.

While performing underwater videography, the camera must be firmly kept and moved with a relatively low and uniform speed.

When filming with the purpose of expertise, it is recommended that each sequence should be filmed at different distances and angles in relation to the pursued objective, as well as at different exposures so that important details should not be missed within subsequent visual inspection of images recorded on film. For a proper maintenance, the camera is washed with clean fresh water.[7]

4. THE USE OF UNDERWATER TELEVISION

Underwater television has recently become an important working method for underwater activities related to visual inspection of many underwater works, especially of offshore works from submarine oil and gas industry.

Today, underwater television cameras are used extensively by divers for underwater works, such as: inspection of platforms to determine the degree of damage, inspection of marine pipelines, ship salvage, the positioning of various submerged structures, performing various photographing or burying works of pipes, etc. Along with taking underwater pictures using photo cameras and video cameras, it is used increasingly more the TV technique with video recording at the surface, using black-and-white systems or color systems.

Underwater television cameras must meet the requirements not only in terms of optical quality but also in terms of design, such as: weight, size, shape, maximum depth for use, functional capacity, cost, portability, technical support necessary at the surface, operational aspects, handiness, ability to penetrate narrow spaces, lighting, security systems, connectivity options. Currently, underwater TV cameras are frequently used in industrial and military diving activities. The television camera system allows extended inspections on areas which have defects in order to fully clarify the specialized technical personnel on them. These TV cameras can be handled by the diver, and can be placed on a submersible device or it can be installed permanently on the seabed or on a fixed immerse structure in which case they are handled through a remote manipulator.

Underwater television cameras can be worn by divers either by using the handle or attached to the rigid helmet.

Most underwater television cameras are completely autonomous electronically, requiring low voltage of direct current. This leads to the elimination of many cables increasing the operational reliability. Underwater television cameras may be used in a wide range of lighting conditions. Much of the electricity necessary to an underwater camera system is consumed through lighting. Depending on the application, there are used sodium iodide lamps, mercury vapors or incandescent lamps. Special attention should be paid to the tightness of underwater connectors with O-ring type fittings, which should always be checked or replaced.

The equipment used at the surface of the water consists of a monitor, a video recorder, a power source for lighting, etc.

There are also today ultrasound underwater television cameras that do not require the video electric cable to be connected to the monitor.

As regarding the handling of underwater television cameras, it should be mounted in such a way that it is always kept in an upright position in order to avoid any confusion from the technical staff at the surface, concerning the horizontal or vertical position of objects.

The underwater television camera is unable to transmit rapid movements. Therefore, panoramic movement should be performed slowly, paying attention to the focus range that can permanently change.

Both the technical staff at the surface and the diver must coordinate their activities due to problems that arise, such as: the moving of the boat, the tangling of the string of the diver or camera, problems with the diving equipment, cold, fatigue, marine life, etc.

There should be continuously maintained radio communications between the surface and the diver using a specific language, such as: “Panorama on the left”, “More to the left”, “Stop”, “Still”, “Stop right there”, “Change focus”, “More”, “Closer”, etc. The technical assistance may ask the diver close-ups of various objects or their different angles.[8]

5. UNDERWATER ULTRASOUND EXAMINATION

Complementary to non-destructive testing by ultrasound examination, and before it, there are carried out measurements of the structure’s potential cathodic protection. The value of this potential, as well as its deviation from the standard potential, is a size measurement of the reactivity of metal in regard to the surrounding environment and to the rate of reaction on the metal surface. Comparing the value of the potential measured metal with the values given by the current-potential polarization curve, it can be determined whether the metal is dissolved (corrosion) or protected. Since the metal-electrolyte system is a single electrode of a cell and thus it cannot, by any means, determine the absolute potential of an electrode, it is necessary to insert a second electrode in the system in order to achieve a cell, and thus to determine the electrochemical potential between these two electrodes, using a voltmeter with high impedance input. In order to not complicate the interpretation of results, this second electrode must be stable and less influenced by the working conditions, representing the reference electrode up against which it is measured the variation of the working electrode (metallic structure). The reference electrode used was a Cu/CuSO4. The diver moves the electrode in specific points of the structure, while its values are read at the surface. The equipment consists mainly of two parts: the surface equipment and the underwater equipment.

The surface equipment includes an ultrasonic fault detector equipped with some features out of which the most important is that it can be connected to an underwater repeater, an intercom system, a closed circuit television installation and possibly a VCR.

The underwater equipment includes an underwater repeater through which the diver is transmitted the image displayed on the fault detector screen at the surface and to which probes are cable connected in underwater construction, an intercom system, projectors, and a television camera.

As regarding the working methods used in underwater ultrasonic measuring, these are: the multi-echo method, the emission-reception method, and the digital display of thickness method.[9]

5.1. The multi-echo method

Generally used for parallel laminated surfaces, the multiple-echo method has a limited applicability due to its imprecision for rough surfaces.

This method is based on multiple reflections that occur between the areas of the object. Thickness is determined by evaluating the position of the n^{th} echo . Thickness is given by: $t = En / n$, where En is the n echo.

The higher the value of n is the accuracy of the thickness is even greater. Ultrasonic frequencies have 2 … 10 MHz (high frequency for smaller thicknesses). Initially, the device is calibrated using a type AI calibration block on areas of 100 mm and 25 mm (punctuated echo), based on the thickness to be determined (there were used 100 mm dial).

5.2. The emission-reception method

The emission-reception method is recommended to measure small thicknesses and corroded surfaces. A double crystal probe emits an ultrasonic beam which reflects on the other sides of the object, being received and converted into an indication for the cathode tube. In this case, calibration is done on two calibration blocks with thicknesses chosen so that it should fit in the range of thicknesses to be measured.

5.3. The digital display of thickness method

The digital display of thickness method is derived from the previous method; the difference is that it uses a special construction meter. It is equipped with a double crystal probe and allows local reading (at the diver) of thicknesses directly in millimeters and tenths of millimeters.

5.3.1 Fault detector control

Fault detector control aims at discovering possible cracks both in the component elements of the structure and in their welding areas; it is also important both for their position and size. Control is usually done through direct contact using probes, for transverse waves sloped under angles and chosen according to the thickness of material and ultrasonic frequencies between 2 and 10 MHz. There are special techniques of examination, using longitudinal waves beam, which do not require that the probe-element direct contact to be controlled and, therefore, it does not require a pretentious cleaning of the area examined.

Immerse structures consisting of piping components joined by welding, usually have complicated shapes. Therefore, their welding cords are also curved in space and for their own control the probes are moved on the cylindrical sides corresponding to the exterior surfaces of the piping components

The bottom of the probe must meet a geometric condition in such situations. The beam's orientation will have, if possible, a longitudinal direction from the axis. Examination, in all cases, will be preceded by a simulation of sides' directions and areas screened by ultrasonic beam. This examination is done on 1:1 scale drawings of the welded joints on which the trajectory of the ultrasonic beam is materialized. The ultrasonic beam covers different angles of probes reflected on transparencies. Complicated sections will be applied to computer graphics systems (CAD). Thus, the best probing solutions will be identified so that no area should be left unexplored. Evaluation of cracks' sizes is performed, generally, the same way as for a land examination: the method of equivalent defect, the method of amplifying 6 dB and 12 dB with restrictions imposed by the fact that the examination cannot be done usually on the same side. The best results are obtained by building calibration blocks of the same material and using the same geometry, with artificial defects in different positions.

Underwater fault detector control uses a series of special methods for assessing cracks. Thus, transverse cracks use the method of knife-edge diffraction and the method of drain wave, while longitudinal cracks use the method of zigzag beam and the cleavage cracks use the method of partial repeated reflections.

The method of knife-edge diffraction is based on the physical effect produced on the ultrasonic beam at the incidence with a boundary between two media with different acoustic impedance. In this case, on the boundary, beside the reflection and refraction phenomena, will also appear surface waves and on the surface edges will be formed diffraction waves.

The method of drain wave is a technique that, unlike the previous one, is useful in identifying discontinuities placed just under the examined surface. It is also difficult to be used in checking the area under the opposite surface.

The method of zigzag beam is used to examine the pipes suspected of longitudinal cracks. It is performed with probes either for longitudinal waves or transverse waves.

A special advantage of this method is that the examination is performed without direct contact between the probe and the object to be examined, thus eliminating the need for a pretentious cleaning of the surface.

The method of partial repeated reflections is also an unconventional technique of underwater examination, without direct contact between the probe and the object, used mainly to identify the discontinuities which are parallel to the surface of the object.

When performing such an examination, the probe must be perpendicular to the pipe surface lest the reflected echoes should be picked up. Orientation is achieved, in this case, using a suitable device. Thus, the examination represents a completely different oscillogram than the one by direct contact. Both water-object interfaces and object-water interfaces multiply the echoes, resulting, thus, a series of interface echoes evenly distanced, which represent the ultrasonic water trajectory and respectively a series of echoes corresponding to the water course, following their echoes interface.

This method can also be used for measuring the thicknesses of underwater structures; it is a particular case of the multi-echo method, taking advantage of eliminating a lengthy cleaning of the examined areas.

General observations regarding the methods of underwater examination:

- all of these methods can be used for an ultrasonic examination performed within a land, through immersion, if the object to be examined is completely submerged in water or only in the control area it is created a layer of water;
- actual examination should be preceded by a period of training in real conditions;
- the evaluation of defects is only made by comparison to the calibration blocks fitted with artificial defects, and to blocks of the same material and geometry with the object to be examined.[9]

5.4. Interpretation of results on computer

After the structure's elements are measured, they are first compared to the initial thicknesses (if there is any information about them) or to the thicknesses from drawings.

Then, the structure's elements are analyzed (with their actual thicknesses) in terms of consistent efforts and strains included in the most favorable demanding conditions: maximum static load, the parameters of wave = centenary wave, the parameters of maximum wind, earthquake, etc. After mathematical modeling, the structure's elements determined by consistent effort, is subjected to a second type of processing that aims at: analyzing tensile strength, studying the appearance and development of cracks due to fatigue, determining the frequency, volume and subsequent testing methods based on the likelihood detection.A compatible graphic workstation IBM-PC, AT-386 was used in this purpose. Data processing was done by running programs with high degree of accuracy. Worldwide, offshore structures have the same rigors as nuclear power plants, and thus there were chosen two software packages with the permit of U.S. Atomic Energy Commission, namely: ALGOR for calculating forces and strains and FRACTURESEARCH for calculating fatigue, cracks and frequency control.

References

[1] Degeratu, M., Georgescu, S. and Ionita, S., *Travaux en immersion réalisés à l'aide des scaphandriers. Le Contrôle non destructif et les outillages d'explosion sous- marine. Des Travaux techniques subaquatiques*. Lucrari subacvatice realizate cu scafandri. **Nondestructive Control and Underwater Destructive Equipment. Technical, underwater operations.**Controlul nedistructiv si utilaje de explozie sub apa. Lucrari tehnice subacvatice. IIe Vol. Bucuresti : Ed. Matrix-Rom, 2005. Bibliographie. ISBN : 973-685-956-8 ; 214p. [B.ANMB. II 16103].

[2] Degeratu, M., Petru, A., and Georgescu, S., *Aparate de respirat sub apa. / Dispositifs pour respirer en immersion. /* **Underwater Breathing Equipment.**Bucuresti : Ed. MATRIX ROM, 2003. ISBN : 973-685-558-9.

[3] Georgescu, S., ********* Executarea controlului nedistructiv la structurile imerse. / *L'Exécution du controle NDT aux structures immergées./ Non-destructive examination of the submerged structures.* In: Buletinul Petromar, Nr. 1,2,3, / 1993

[4] Georgescu, S., Fotografia subacvatica. / *La Photographie subaquatique*./ Underwater photography. A XVI-a Sesiune de Comunicari Stiintifice a cadrelor didactice. Constanta, 1993

[5] Georgescu, *S,. Executarea controlului NDT la structurile imerse. / L'exécution du contrôle NDT à structures immergées./ NDT* inspection for submerged structures. A 6-a Sesiune de Comunicari Stiintifice a Centrului de Scafandri. Constanta, 1993.

[6] Georgescu, S., ***Fotografia subacvatica. / La Photographie subaquatique./ Underwater photography. A XVI-a Sesiune de Comunicari Stiintifice a cadrelor didactice. Constanta, 3-5 iunie 1994

[7] Georgescu, S., *La Photographie subaquatique*. / U***nderwater photography.***[Notes de cours]. Ed. Centrului de Scafandri. Constanta ; 1993.

[8] Georgescu, S., (si colectiv). Controlul nedistructiv la structurile imerse. / *Le Contrôle non destructif aux structures immergées.* ***Nondestructive Control of the Submerged Structures.x***[Notes de cours]. Constanta : Ed. Centrului de Scafandri, 1994. (Usage interne).

[9] Georgescu, S., Degeratu, M., and Ionita, S., *Travaux en immersion réalisées à l'aide des scaphandriers. Outils, ustensiles et outillages pour le travail sous-marin. Tranchage et soudure subaquatiques*. Ire vol. Bucuresti: Ed. Matrix Rom, 2004.172p. ISBN: 973-685-816-2. [B.ANMB. (II 15.670)].