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Means and Techniques Used in Creating Breaches within the Underwater Environment Structures

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Abstract: This paper study special means and techniques used for the types of tests required by the groups of river raid divers, combat divers and the Deep Diving Intervention Squad, tests which were performed in the "SCF 0" District.
The first part of the study defines the specific terms used. **The choice of means** (by means of: explosives - respectively the type, quantity and, quality of the substance or mixture used, Special Explosive Devices or flexible explosive charges with cumulative effect - respectively the type and diameter of the charge, means of initiation used for each type of experiment, etc.) **and the specific techniques** follow, which are to be used depending on: constructive features, type of mission/action, available time, location of the objective where the opening is to be made, arrangements, importance of the objective, working environment (terrestrial, underwater, lagoon, seaside, river, dams, natural lakes, delta, swamps, etc.).
Finally, the study presents some of the experiments performed in the polygon and the conclusions/lessons learned.

1. General considerations on the particularities of the diving missions (combat divers)

There are crisis situations whose solution involves quick access through doors, windows or even through the walls of some buildings. This is often not possible by using mechanical means or the time required is too long, even if there are special devices for breaking doors, windows or other structures made of inhomogeneous materials. This leads to the option of using special explosive devices (DES) in a much shorter time, which can help save the lives of people taken hostage or limit the risks to personnel in the intervention forces for special operations or groups of combat divers (SSLI).

The selection of explosive devices and specific intervention techniques will be made permanently according to the specific missions of the raid divers, namely:

- the operational situations faced over the years by military divers – on the ground (SSLI), underwater (SISMA, SSLI, EOD) etc.
- the constructive particularities of the objectives in which they must enter the underwater environment, respectively wrecks of civil / military ships, submarines, planes, etc.
- layout and importance of objectives – buildings with metal or wooden doors, wooden structures, BCA, brick, concrete or reinforced concrete, railway track as a resistance element, etc.
- detachment – of drifting mines, left undetected from world confrontations, –in / from anchoring systems (fast, safe and precise sectioning of anchor chains, large diameter metal or textile ropes, connecting keys) etc.
- the available time (for combat divers group) is another very important factor – it can be very short, short or slong;
- particularities of the operative situation such as anti-terrorist or counter-terrorist interventions (with or without hostage-taking);
- protection of intervening personnel or those in the immediate vicinity;

- explosive devices and loads used inside port, sea, river berths involve the protection of objectives (buildings, archaeological monuments, etc.) located on the shore, on the coast, underwater in the port or in the open sea (where environmental protection is required);
- the river requires the protection of fauna, ecosystems and shores, the intervention in natural or artificial lakes (dams) requires environmental protection measures, etc.

In conclusion, in order to protect the environment and bystanders, it is necessary to use as small quantities of good quality explosives as possible (e.g.: plastic explosives orflexible, explosive BLADE-type loads) instead of large quantities of conventional explosives (dynamite, TNT) or large-caliber ammunition used to create ground breaches.

The study of the means and techniques useful for creating breaches, as well as the tests and experiments performed in order to train divers was done at their request and depending on the situations encountered over time by groups of military divers.

2. Structures in which breaches can be created

The missions of raiding divers may involve the need to quickly enter very different objectives. In certain situations, it is necessary to create breaches or force entrances in different premises / buildings / terrestrial or underwater spaces.

This creates the need to develop breaches.

Ammunition or special explosive devices (DES) are used to create breaches. In order to obtain a maximum breaking effect, according to the requirements imposed for the creation of the breach, it is necessary to know the properties of the DES or the ammunition to be used. In most cases, during the creation of the breach, the effects of DES on obstacles are determined either by the manufacturer (during development or reception operations on standard targets) or by the practical experience of the groups using the respective devices (in training, applications or operational situations especially created in polygons).

Due to the complexity of the phenomena and events associated with the process of creating the breaches, the “side” effects of using these types of ammunition have been less studied and therefore known, respectively to the effects of the creation of the breach on the possible “targets” behind the objective that requires the intervention of “achievement of the breach”.

Therefore, this chapter proposes the study of the targets behavior in which breaches will be created, respectively the knowledge of the structures and of the structural elements that will be intervened.

It should be noted from the beginning that in addition to the theoretical strength of the walls and the structure of the ship, the plane, the building, etc. as a whole, during the assessment of the effects of the explosion of a DES one must also take into account the causes that may lead to the amplification of the destructive effects, namely:

- improper design / execution of the structure, exhaustion of the exploitation duration;
- premature aging or due to the environmental conditions of the component materials;
- the small / special dimensions of the space in which the explosion takes place;
- the configuration of the walls / buildings / environment in the immediate vicinity (which can favor the composition of shock waves);
- the presence of electric cables or gas pipes, etc.

In a metal structure, taken as a system, the following subsystems are considered:

- basic structure – having as basic function the safety in operation for the actions that will require it. This subsystem includes resistance walls (diaphragms), columns and beams, floor slabs, structural elements, stairs;
- the cover or the closing assembly – having as basic function the separation of the environment-built spaces (sometimes it can be part, partially or totally, of the structural system);
- compartmentalization – which defines and delimits the interior spaces of the ship by functions (sometimes it can be partially replaced by the structural subsystem);
- equipment that includes installations, equipment, etc., elements necessary for the operation of the structure.

The constructive peculiarities of the objectives in which the groups of incursion divers (**various combat**) must enter – respectively civil or military ships, shipwrecks, planes, etc., buildings that they must release or subordinate require: **responsible choice of means and the specific techniques to be used**, the study and finally **the knowledge of the constructive particularities**, the arrangement and the importance of the objectives where the interventions / incursions will be carried out, **the available time**– is a very important parameter, according to which the procedures used differ greatly. on a case-by-case basis and are most often chosen, depending on the particularities of the real situation at the place of the mission / intervention for which divers are requested.

Special explosive devices (DES) will be made and used, when the operative situations require their use, with all the measures of protection of the persons involved and of the environment.

BLADE flexible cumulative explosive loads will be used when a precise cut on a certain contour is required (**"cut" type effect**), taking into account **the minimum radii of curvature** they can have, **the amount of explosive per linear meter** with which they are loaded, the place and size of the pipe, bar, chain, rope, type "I" profile, etc.

In case of dismantling or creating breaches in doors, walls, etc. DES with **blast effect** – destruction (by blowing the explosive mass), **strip** (FD[1] fixed on solid rubber), **push** (FD fixed on smaller or larger 0.5l bottles filled with water) or **cut** – cutting (flexible blades with BLADE cumulative effect).

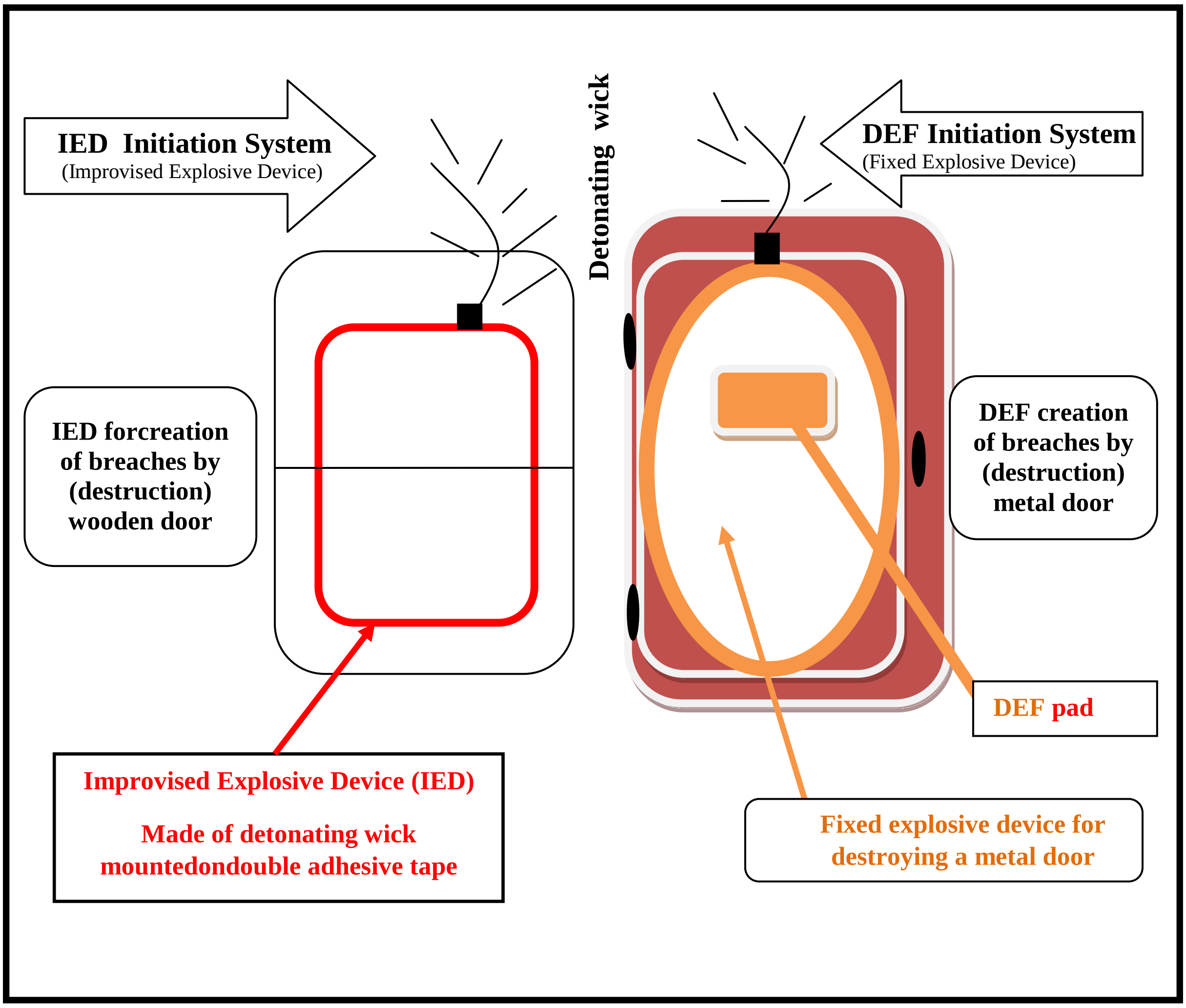


Figure 1. Breach creating in wooden and metal doors on a certain contour – "cut" type effect.

[1] Detonating wick

a) b) c)

Figure 2. a) & b) Creation of breach in a wooden door with an explosive load made of a detonating wick and an double adhesive tape and c) the effect obtained

a) b) c)

Figure 3. a), b), c) Creation of breach in metal door with flexible load with BLADE type cumulative jet

a) b) c)

Figure 4. a), b), The explosion and c) the effect obtained on the ground

a) b)

Figure 5. a) Underwater breach creation in metal plates (doors) with flexible cutting blade with cumulative jet, b) transport means, c) divers carrying the initiation device, d) the underwater explosion and, **e**) the effect obtained underwater, f) measuring and noting of the effect obtained under water.

c) d) e) f)

In general there were mounted NONEL staples (which will be presented in the next chapter) with reophors having a length of L = 10m and with the firing system by pushing (syringe type) and pulling; experiments were performed for all necessary and desired DES, at that time, by this type of operationalized groups of divers. For divers of SISMA groups, CEDs were used (see figs. 6 and 10 a) with (fig. 6 a) and without delay (fig. 6 b), also presented in the next chapter.

a) b)

Figure 6. a) Detonating electrical staples (CED) with delay and b) without delay

The followings are used for the creation of breaches in buildings: ammunition against bunkers caliber 60mm BDM 60, SMAW-D weapons systems, Wallbuster(which uses an explosive quantity of ~1kg, with a maximum load diameter of 174mm, and a total mass of about 2,5kg), fixed explosive devices (DEF) for creating breaches in walls with dimensions of: ~1m length (height) and ~0.8m width, based on BLADE type blades and water as a targeting / pushing agent of the cumulative effect etc. and for the demolition, an explosive placed in mine or well holes will be used.

The constructions of the different structures present varied characteristics in terms of the type of materials used, the structure, the thickness, etc.

In order to design explosive means of creating breaches, respectively DES, these characteristics must be known in order to achieve a good sizing of special explosive loads.

In certain situations, the ammunition used or the type and quantities of explosive required are the result of a long practical experience.

a [7] **b** [7] **c**

Figure 7. –**a)** constructive versions of DES, **b)** existing intervention sets worldwide, **c)** fighter involved in the process of making breaches with the fixed explosive device (DEF)

Figure 8. Underwater cutting on the contour of a 10mm thick naval sheet with DES made of jet flexible load / ICTRM 10 cumulative effect type (made at UPS Dragomirești) combined at the corners with HITEX type explosive (produced at UPSD) and the effect obtained

3. Types and evolution of detonation systems used for experiments

The rapid assessment of imminent hazards in the target area (where a mission is to be carried out) by a group of scouts must inevitably be followed by a mission especially prepared and carried out by rapid incursiongroups. These are especially trained combat forces that establish, on the basis of minimal information, how the mission should proceed, to list the obstacles that may arise during the orderly mission, what steps the fighters have to follow, the risk reduction controls to be performed on different sectors –where there will be interventions, the minimum number of people that are necessary for the respective activity, etc.

Figre 9. Different types of explosives and the explosive used in the tests in the “SCF 0” District.

After assessing the risks, the mission leader decides what each fighter should do, whether it is safe to continue the mission or whether additional checks are needed, and finally establish the types and minimum mandatory number and types of DES that are needed for fighters to carry outthe mission.

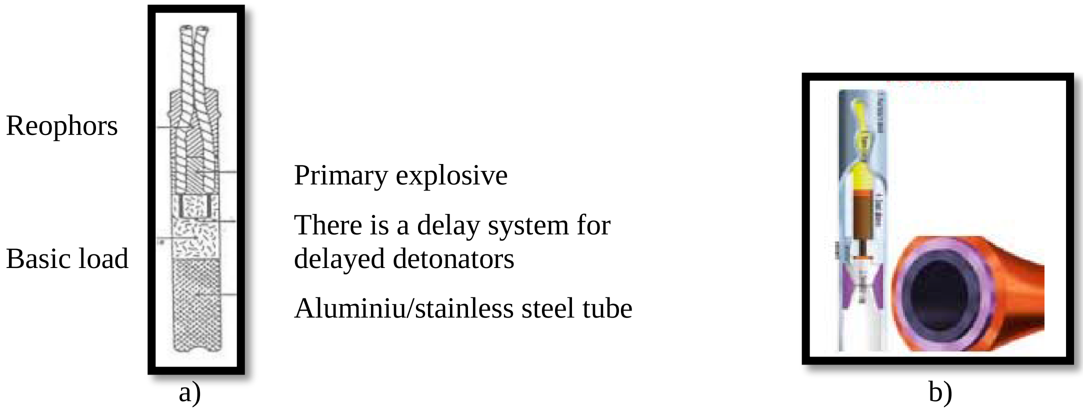


Figure 10. a) Simple electrical holder cross section (instantaneous/without Olofssondelay–1880) [9, 13] b) NONEL electric detonator (system developed in the '60s) [9, 13]

The advantages of the electric detonator without delay are:

- a high degree of safety;
- total control of the start time (initially the circuit test must be done);
- good results regardless of the weather and good operational safety;
- reduction of air explosions and ground vibrations.

There are also delayed staples - the **delayed electric detonator** is formed in the same way as the instantaneous one, except for the inclusion inside the CED of the delayed powder train.

The delay time is based on the length and composition of the delay powder.

It evolved as follows: a half-second delay in the early 1900s, and from 1943 the delay time could be set to milliseconds.

- copper was replaced with aluminum, the circuit was tested;
- good results with delays – used in specific applications (ditch, tunnel, etc.).

The disadvantages of delayed detonating electric staples are: the risk of premature detonation, the need to research and find, for these cases, an alternative initiation system and external sources of electricity - such as: lightning, static currents and radio frequency energy which can initiate them.

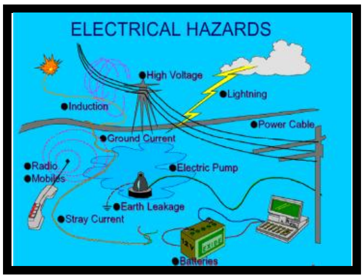


Figure 11. External sources of electricity-possible risks/causes of premature detonation of the CED[10]

Due to the numerous risks present in the handling and use of explosive loads (electrical loads due to accumulations of static electricity, electromagnetic waves generated by radio stations, radio locations, etc., stray currents generated by low and high voltage electrical networks and atmospheric electricity, external actions of a mechanical or thermal nature), it was necessary to introduce a priming system without starting explosives.

The Swedish company Dyno Nobel was the first to develop detonation systems without primary priming explosives by designing a non-electric priming system called the **NONEL (NON-ELECTRIC) set**, designed to trigger the detonation of explosive loads.

The NONEL starter is a simple and extremely useful and efficient tool to handle, robustly made of metal alloys (stainless steel). It is a set that no longer requires other equipment (explosive, etc.) to initiate the NONEL tube. [13]

The NONEL set consists of:

- ✓ NONEL detonating tube;
- ✓ NONEL type millisecond detonating caps;
- ✓ NONEL detonating distributors;
- ✓ NONEL detonation device.

The evolution of the initiation system (non-electric detonating staples provided with a short pull or push detonation cable – syringe type), which entered the market in 1973, offering multiple advantages,comes up with some advantages to the initiation of explosives compared to CED:

- ✓ Total non-electric initiation system developed in the 1960s by Dyno Nobel;
- ✓ There are NONEL delayed detonators (NONEL EZTL). They can have the following values: 9, 17, 25, 33, 42, 67, 100, or 109 milliseconds and differ by cable of different colors (green, yellow, red, white, blue, black) depending on the delay time;
- ✓ Detonators that include non-electrical staples connected to the “NONEL” tube havedifferent sizes, relatively short,surface connectors (**3.5m, 6m, 9m, 12m, 15m, 18m**), which allow different distances – depending on needs – related to the DES type and the place where the DES is mounted.

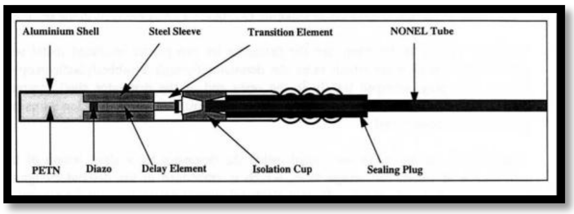
The NONEL tube consists of:

a) 

b) 

Figure 12. a) Cross section through a push-driven NONEL detonator tube [13] and, b) such a NONEL test tube.

- The NONEL type shock tube is resistant to oil, abrasion, ultraviolet, elongation and has a good tensile strength, it transmits the shock wave to the NONEL type detonator / staple;
- The shock wave results from filling the tube with reactive powders with an area speed of 2100m/s;
- The noise emitted during operation is minimal and the speed of transmitting the cable signal is very high.




a) b) c)

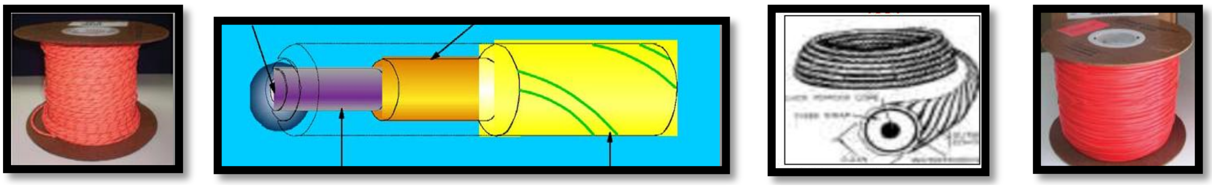
Figure 13. a) Section through the NONEL - triggered detonator tube [10] and, such a NONEL tube used for testing in “SCF 0” District b) and c).

The detonating wick:

- Powerful, flexible, continuous detonator;
- Developed in 1907 in France and called wick;
- It consists of the lead tube that surrounds TNT, combustion at 4900m/s;
- Nowadays, PETN core surrounded by various cotton textiles, combinations and plastics and waterproof;

- Burning speed is higher than 7000m/s.

DETONATING WICKPETN coreplastic fabric



PrimaCord®5 plastic fabric plastic packaging [13] PrimaLine®10

Figure14. Section through the detonating wick. It consists of: PETN type explosive core wrapped in cotton, nylon fibers (synthetic polymer textile fibers) woven in a certain direction, plastic fibers woven in the opposite direction to those in the previous layer, plastic cover.

Name **Impact resistance**	DETONATING WICK	**The amount of m explosive / linear**
Uniflex σ_t= 100KgF		3,6 g/m
Powerflex σ_t= 100		5 g/m
Trunkcordσ_t= 100		5 g/m
Redcord σ_t= 95		10 g/m
Shearcord		
Ftrunkcord σ_t= 95		70 g/m

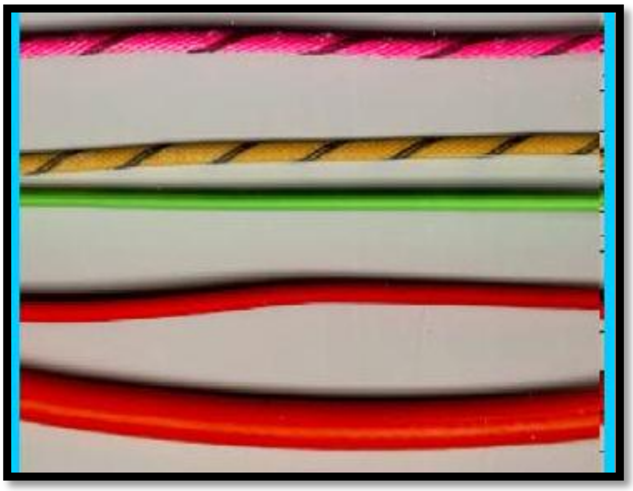


Figure 17. Detonating wick type, name and quantity of PETN type explosive in the FD core [11].

The advantages of the detonating wick are:

- versatil, safe for use in external environments with electricity sources, firing simultaneously without detonators, without limit of openings, completely consumed, cheap;
- the incorporation of the delay connector in 1950, allowed sequential blasting of larger models than the electric ones.

The disadvantages of the detonating wick are: noisy initiation, FD moves easily, the possibility of interrupting the part of the FD that comes out of the opening.

5. Conclusions

The hereby study has pointed out that DES consists of a blasting or buster explosive, a means of initiation and a propellant mass, which in this case is water, metal strips with cumulative effect or solid rubber. The detonation of the explosive load results in a significant amount of energy that determines strong shock waves based on which a destructive mechanical work is performed (breaking the shell in which the explosive is inserted) and the propulsion of fragments, splinters and jets, with applications in military and civilian field.

From the analysis of the few existing data in the literature three main typesof explosive loads used to create breaches have resulted:

- push loads;
- cutting loads (cut type);
- destruction loads (blast type)

Of these types of loads, the most commonly used for creating breaches in doors, especially when hostages are possible, is the push load, due to the small amount of explosive used and the reduced destructive effects. The present theoretical and applied studies developed on this topic or related topics as a field and intended for raid divers have constantly sought to use explosive as little as possible not only to protect the terrestrial and / or submarine environment and existing underwater ecosystems but also to be easily and conveniently transported while the safety distance should be as short as possible.

The purpose of this study is to conduct research specific to the missions of military and civilian divers of small, medium or deep depth, on the use of explosive detonation – resulting from the initiation of DES – in order to propel the jet / water jets to create breaches in light obstacles encountered in their missions on board ships / land or submerged. We insisted on the propulsion speed of the water jet, given the quality and quantity of the explosive (which we have always sought to reduce), as one of the most important parameters in this process.

LIST OF ABBREVIATIONS AND ACRONYMS

AT = anti-terrorism;
CPSA = Underwater Research Center of the Diving Center;
CD = research **-** development;
CED = detonating electrical staples;
CT = counterterrorism;
DEF = fixed explosive device with length (height) of ~ 0.8 ÷ 1m and width of ~ 0.6 ÷ 0.8m – creates a breach in the wall for the dimensions of a soldier with combat equipment;
DES = special explosive device;
DGPCT = General Directorate for Preventing and Combating Terrorism;
EO = Explosive Ordnance = explosive ammunition;
EOD = Explosive Ordnance Disposal = demining or removing explosive devices;
FD = detonating wick;
HMX = octogen;
IED = Improvised Explosive Device = Improvised Explosive Device (DEI);
ÎEx = explosive load,
LCD = research-development work;
PENT = Pentaerythritol tetranitrate;
RDX = hexogen;
SISMA = Deep Diving Intervention Squad;
SSLI = Incursion Combat Diving Squad;
SSP = Special Pyrotechnic Service;
SSP-DGPCT = Bomb Squad within Antiterrorist Brigade or Special Pyrotechnic Service of the General Directorate for Preventing and Combating Terrorism
TNT = trotyl cast, pressed, etc.;
UPS Dragomirești = Special Products Plant Dragomirești;
UXO = Unexploded Explosive Ordnance = unexploded ordnance.

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