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"THE TOTAL WEAPON SYSTEM"

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INDOOR AIR QUALITY - KOALA SYSTEM FOR AEROSOL REMOVAL

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SUMMARY

The basic concept is to avoid the accumulation of pollution scoriae inside any closed environment; osmosis with outdoor air to dilute the indoor pollution is really impossible in the case of climatized submarine's environments, (almost during the immersion), in an optimal way.

The system KOALA , which is used for such a purpose, can be configured itself like an ideal electronic window.

It is a group of apparatus particularly suitable for the depollution of dusts, gases, sub-micronic particulate and sterilization of bacterial, viral and fungal charge, contained in a box of modest dimensions and placeable in any corner near the walls of the environment to be treated.

AUTHORS' BIOGRAPHIES

Mr Salvatore Vanella is General Manager of VEC Srl, Pesaro, Italy. Since 1986 Mr Vanella has been dedicated to the study of air pollution and he has acquired remarkable specialised knowledge on the causes and consequences of air pollution on the human being. He has developed innovative technology for air depollution that presents optimal instrumental results for the human body. With his colleagues he directly participates in numerous congresses in Italy and abroad.

Mr Antonio Menghini is Marketing Manager, TAUARIA Environmental Division, VEC Srl, Pesaro, Italy. Since 1990, Mr Menghini has been studying the problem of air pollution, developing a notable expertise in this subject. He frequently takes part in congresses and conferences and writes articles for specialised magazines and newspapers.

Mr Antonio Tufano, Deputy Director Submarine Design Department, Fincantieri C.N.I., is qualified in (1) Global Approach to Submarines Signatures and Stealth, and (2) Indoor Air Quality KOALA System for the Submarine Design Department.

Mr Tufano graduated as a Naval Architect after a training period in the Italian Navy Design Department. He joined Fincantieri Offices carrying on the previous activities for both Surface Ships and Submarines. In the Surface Ships field, he has worked as a Staff Designer on the VITTORIO VENETO Cruiser project and the AUDAGE Destroyer, and as Chief Designer on the Helicopter Carrier GARIBALDI project. In the Submarines field, he has been involved in the SAURO Class design and, currently, is involved in the German-Italian Submarines Program.

1.0 INTRODUCTION

Indoor air quality (IAQ) problems can arise from many sources. The need to breathe pure air has already been defined as a very important aim by scientific assembly.

In recent testimony in connection with the now defunct Indoor Air Quality Bill (H.R. 1066) presented to the Congress by the U.S. E.P.A. it was recognized that dilution ventilation alone is not the solution to I.A.Q. problems; and it was stated that good indoor air quality can be achieved by following an integrated approach which combines dilution ventilation with source control, and the use of an effective localized air distribution and filtration system (A. Hedge - Cornell University - Health indoor air '94 - Anacapri - Naples). [1]

Pollution of the air in a submarine assumes four different physical states:

- **GASEOUS**
- **PARTICULATE**
- **MICROBIOLOGIC**
- **ELECTRIC**

apart from two peculiar physical states:

- Electromagnetic waves.
- Ionogenic radiations (natural and not).

There always exists a synergy between these physical entities, to be considered when the salubrity of an indoor environment is analyzed.

The air friction on a metallic isolated surface is enough, when the speed exceeds 2m/sec, to generate elecrosmog (cationic charge tied to the Azote atoms N+, about 80% in the air).

All this slows down the dust sedimentation, facilitating microbiologic and fungal transfer from the environment to the human body. Very sensitive subjects, for example asthmatics, have such immediate allergenic reactions, that they could be used as "environmental sensors".

The same kind of submicron dusts or liquid aerosol absorb gasses, "extending" their toxic action against the human lungs.

Contrary to what people generally think, the risk of contaminated air is as dangerous in this respect as water.

From studies published by Prof. Ziglio - Politechnic Institute of Milan - about the effects of the pollution in potable water on the human health, results that the oncogenic revealing (trichloroacetic acid) in the blood, is immediately manifested after a steam inhalation and not after drinking a glass of the same water. [2]

A further confirmation of this concept is given us thanks to the publication, from a group of E.P.A. researchers (Environmental Protection Agency-U.S.A.), about the potable water contamination caused by microscopic amiant fibres present in high quantity (between 200.000 and 3 millions/litre).

Since today, gastrointestinal tumours have not been considered to be caused by these fibres in the U.S.A..

The danger is in the air, for the respiratory apparatus, even when water is used for cleaning or cooking:

- pollutants, in their gaseous state, are toxic gasses mainly produced by fuels combustion for locomotion, cooking and heating, for example: CO, NOx, SO_2, C.O.V., O_3.

Added to these are other emissions from corroded materials and human activity:

- formaldehyde, radon, chloro, benzene, pentachloro-ethylene, pentachlorophenol.

The pollutants, when are in the state of particulate, are divided in two categories:

- dusts with dimension greater than 2 microns;
- particulate with dimension less than 2 microns.

After extensive research of indoor environments, it is evident that dusts constitute about 3% of the solid material suspended, and the particulate is about 97%. The main source of these kind of pollutants is from external air caused by wind actions, traffic, and dressing material's corrosion.

The microbiologic pollutants are divided into:

- bacteria, viruses, moulds, funguses, fungal spores.

The human body is considered one of the causes of this environmental contamination, added to animals and mechanical ventilation systems.

- The Electric pollution of the air (defined Electrosmog), is the electrostatic charge from the cations (positive ions), normally tied to the Azote atom in the air.

  Outside, the traffic produces high quantity of these ions, the same happens in an indoor environment caused by: air-conditioners, heating, TV screens, computers or people stepping on the carpets.

The Electromagnetic Wave pollution is caused by the electric current running through high voltage external lines and it is very dangerous for anybody who stands for long time near these electrodes. The same risk is present inside the environments closed to:

- electric installations;
- lighting systems;
- electronic apparatus.

Even radio transmission systems, radar or simply cellular phones generate electromagnetic fields; obviously proportionally to the intensity of the current used. Numerous research centres are trying to evaluate the danger for humans. For certain it is known, the potential risk as a synergy element add to the other pollutants. The worst effects are in the blood cells. This problem causes possible leukaemia, deformations of DNA in reproductive cells with consequent hereditary disease for unborn children. Exposure over a long time, it is thought, could generate tumours in cerebral tissues.

Air pollution is produced by ionizing radiations from radioactive substances, mainly natural ones for the Radon, generated when the Uranium comes in contact with air. It comes into living areas through potable water, building materials, gasses or winds. Artificial transmission is caused by all fuels, for locomotion. In burning, they produce a high percentage of Polonium 210. It is especially dangerous for those who travel by means of locomotion.

Other means of ionogenic contamination are radiologic apparata for hospital and ambulatory and the ones for nuclear medicine, responsible of the Iodine 131 pollution.

2.0 INDOOR AIR QUALITY IN A SUBMARINE

Space shuttles and submarines, distinguished by a very restricted environment, have supplied the reason to evaluate the I.A.Q. (indoor air quality), according to military methods normalized and derived from procedures of: A.C.G.I.H. (American Conference of Government Industrial Hygienists), N.A.S.A., U.S. Air Force and U.S. Federal Aviation Administration. The prolonged dives of "BEN FRANKLIN", P. Piccard's bathyscaphe (Abeles 1970), have supplied very effective methods for watching the I.A.Q., reported by BERTEL'S & Crump (1977), while NEFEDOV and others (1969) des-cribed an innovative method for exhaled air analyses. [3]

These innovations were activated in the working world by NIOSH (U.S. National Institute for Occupational Safety and Health) referring to the H.H.S. (U.S. Department of Health and Human Service).

In the civil area protocols were developed from A.S.H.R.A.E.(American Society of Heating, Refrigerating and Air Conditioning Engineers).

These methods were optimized to be effective at concentration levels ten times greater than those that are generally considered under the exposure prescribed by the low for the population occupying enclosed spaces.

Modern nuclear submarines and space shuttles need a wise management of metabolic aerodispersed products. Knowledge of their nature and their concentrations have been widely described by: Fomin (1965), Johnson & Sargent (1968), Nefedov, Savina & Sekolov (1972), Parker (1973), Shepelev and other (1974). They are mainly characterized by:

- exhaled air;
- human skin's scales;
- sudation and intestinal gases (Roth, 1968). [3]

Every day the human body loses from 15 to 30 millions of scales of 0,3 micron, each one carries statistically 4 or more bacteria. Its contribution to the daily dust generation in the environments is, in media, about 3gr./day for each man. Total bacterial charge loss by a human body in one day was calculated to be about 160mg.

These are the responses to the epidemic phenomena to which the crews are subjected overall for respiratory infections during some weeks (Morris 1972; Morris and Fallon 1973). [3]

On the walls, staphylococci and streptococci have been noted, and Russian astronauts have documented the need to spray on the instrumentation displays inside the shuttle abundant disinfectant to make reading the indicated values possible.

Such bio-effluence, forms a significant part of solid particle's suspension, measured in a closed environment in 0,4 mg./m^3, about twice that one can observe in a city atmosphere in a foggy day. [3]

Another aspect to take into consideration, is the strong perception of cutaneous secretions, normally the perception level is to 10^{12} molecules/milliliter (Yaglan 1936) [3] If there were 28 m^3 of air per person, it would needed 2,4 liters/sec. to gain such smelling perception; but in case of 11m^3 per person, the need of external ventilation passes to 19,2 liters/sec.

The preponderant part of the dusts (97%) in one environment has a corpuscular measure under 2 microns, and it can penetrate through the respiratory tract, reaching the alveolar membrane. [4]

Such a group of dusts is commonly named R.S.P. (Suspended Respirable Particles). The human lungs effective filtration is about 50%.

With respect to their biological, physical and chemical rating, they may be dissolved in the blood circulation, or be expelled through the mucus, or be captured by lymphatic gangli of the lungs.

Asbestos fibres, just oncogenic themselves, could adhere to biological material causing cruciate-contaminations. This type of action is typical of glass fibres, also, but their oncogenic rating is now under study.

Another pollutant, more dangerous because insidious for man, is Carbon Monoxide. It may be concentrated in a short time and exceed the T.W.A. (Time Weighted Average) of 10 p.p.m. by E.P.A. for 8 hours of exposure, also in presence of little combustions like cigarettes. [3]

Equally complex till today, is the recovery from micro-biologic pollution in environments with high density of occupants. That is proved by nosiocomial infection trends in intensive care units.

The EPIC study examined the prevalence of infections in I.C.U.s (Intensive Care Units) in Western Europe on a single day. Information was collected on 10.003 patients from 1417 I.C.U.s in 17 countries.

Overall, 45% of the surviving patients had, at least, one infection. Gram-positive and Gram-negative bacterial isolated were almost equally common.

The most common I.C.U.-acquired infection, was pneumonia, occurring in 46,9% of patients with one or more acquired infection and other ones of lower respiratory tract (17,8%). [5]

Since confirmation by SIPIO Project in Italy (CURTI, 1993) "... in the hospitals and, overall in the intensive care units, lung infections constitute the principal cause of death". [6]

Air pollution operates on the human body through its vital aspects:

- physical;
- mental;
- sexual.

At the physical level, it generates a debilitating situation reducing the defensive abilities, and now it has been seen the allergic syndrome in epidemics. Or, in the case of cancer, deaths by lung tumour are increasing of about 25% every year.

At the mental level, it reduces the performance of intellectual activities, increases stress or the ability to concentrate, as happens when the lead level in the blood exceeds 0,20 micro gr. [7]

At the sexual level (in man), it reduces potency, advances the andropause and increases the infecondity in newlyweds. [8]

Pollutants in air are not perceptible to the human sense of smell, only initially can an increased level be noted, but the human becomes accustomed after some minutes.

3.0 ENVIRONMENTAL ELEMENTS AND NERVOUS SYSTEM PATHOLOGIES

For subjects genetically susceptible, low concentration exposures to neurotoxic substances present in the environment, for a long period of time, could contribute to the pathologic evolution of the nerve-degeneration syndromes.

Nervous system cells, reduce in time for physiological reasons and in case of a pathological event. Contrary to other organs' cells, these cannot duplicate themselves.

Atmospheric and indoor pollution, almost always have high concentrations of toxic substances for the nervous system like: Lead, Mercury, Methylbenzene, Xylene, and a recent discovery, Aluminium. [9]

In Italy, every year, 5000 tons of lead and another 1.600.000 tons of C.O.V. (volatile organic compounds) are released in the atmosphere, like Xylene and Methylbenzene that are 30% of a car fuel's weight.

These two substances are in many chemical compounds in common use like polishers, paints, detergents, solvents, deodorizings or fuels, and their emissions are more concentrated in indoor environments.

The effects on the nervous system are well known:

- tiredness;
- drowsiness;
- equilibrium disease and short-memory.

A final confirmation has been given to us with three cases of Parkinson's disease in three subjects professionally exposed to N-Esano that is used as a substitute for all the Benzene and Formaldehyde, solvents for adhesives.

As happens for cancerous substances, with neurotoxins it is difficult to establish the level under which it is impossible to have a biological effect.

The most powerful toxic action against the nervous system is caused by Mercury. This element can destroy proteins in animals, vegetables and create permanent cerebral disease in human beings. [9] Mercury is used in batteries, paints, dental amalgams and as electrolitic in salty water to produce Chloro. It is always present in fossil fuels, that burn and create electric and thermal energies, so consequently releasing it in the air.

It is obligatory to organize preventative measures able to guarantee a strong limitation of Lead, C.O.V. and Mercury molecules, especially inside means of air flow where the toxic concentration can be from 3 to 18 times higher with respect to the already contaminated external air. [10]

Another aspect to consider is the abundant number of positive ions in the air as opposed to the scarce number of negative ones.

This causes tiredness, headaches and bad-performance; it is easy to lose concentration with drowsiness, irritability for no reason.

The ions are atoms that tend to unbalance, but they always have a chemical molecular fixed link. Generally atoms have the same number of electrons, each one is a negative charge, and protons, each one is a positive charge.

When inside an atom, positive and negative charges are balanced, the atom is neutral. It sometimes happens that the atom loses one electron, and it changes its nature into positive, it became a cation.

Alternatively, when the atom catches one more electron, its charge turns to negative and it is called an anion.

Positive and negative ions are the atomic gases constituting the atmospheric air: Azote, Oxigen, Carbonic Anhydride.

"SMALL IONS" are the result of the electric conductivity of the air.

Small ions are generated by electrons (free by radiations) and tending to create a link with Oxigen atoms if any kind of contaminant is present in the air.

They do not feel the effect of terrestrial gravity, as opposed, for example, to aerosol and fogs (with electrostatic charge), subject to gravitational attraction.

The relation between positive ions (+) and negative ions (-) is defined by their spatial charge and depends on environmental factors. [11]

For example, heavy traffic in town produces about 8 millions/cm3 of positive ions.

The phenomenon is natural: normally in town there are 500 ions/cm^3 of air (300 negative, 200 positive); in the countryside, or in high vegetation zones, is possible to find about 2000 ions, but the proportion of negative to positive is always the same, 3 to 2. [12]

Generally, a man breaths about 10.000 litres of air every day and 5 milliards of ions come into the lungs in a "clean", non-polluted, area.

A natural cause of positive ions increase are winds, like the Scirocco, the Foehn and the Sharav in Palestine. This is considered a calamity and brings headache, nausea, eye-sting and, in some subjects, cardiac, respiratory or circulatory disease.

The reason is not clear yet, but haemoglobin in blood tends to have a stronger affinity with the Oxigen negative atoms at a pulmonary alveolus level, much higher than with the positive ones.

Improving the air quality is possible in two ways: depuration and depollution.

To depurate means to remove the dusts (of dimension over 2 micron), depollution means to remove the pollutants in their physical states:

- toxic gases;
- particulate (dusts under 2 micron);
- micro-organisms;
- electric charge balance.

Depuration is effectuated through electrostatic filters and/or through ionizators. These apparata have limits in efficacy, maintenance, safety, aeraulic system applied.

The electrostatic filters are characterized by a minimal action threshold such as to exclude, as a matter of fact, the smallest particles (all gases, spores, viruses normally carried by host-particles). Maintenance is very difficult and not very practical. Safety is limited because it does not avoid bacterial reproduction in indoor environments and dangerous diseases can develop fast (pulmonia, mycosis etc.).

Moreover, the aeraulic system, not well designed, permits a depuration just near the machine; these apparata are often sold as depolluters but the technology doesn't allow appropriate results (actually they are forbidden in operating theatres).

Such limits have convinced people that air depuration is impossible.

Electric fields caused by the friction between synthetic dresses, shoes, carpets, hoover-cleaner, frictions to polish things or surfaces, removing dusts, ventilation system, air conditioners, could arrive also to 30.000 Volt/cm.

The static discharge under 1000 Volts are not usually reliable, but the discharge around 30.000 Volts are strong and considered troublesome for everyone [13].

In nature, even moon-phases modify the atom's charge, as tempests do when they occur. Before it happens, there is a massive quantity of positive ions in the air, after, during the quiet-phase, the negative ions increase. This is the explanation of animals' agitation before the onset of thunder and lightning.

In an indoor environment, all electric machines produce positive ions; even walking on a carpet with rubber shoes provokes the same effect. But the main cause is the air-conditioner that generates cations by engeens, ventilation pales and, especially, by Azote atoms friction of the air on the isolated surface of the plants that, having the air a speed more than 2 m/sec., charges in a cationic way (In ventilation systems, air circulates with a speed from 4 to 11 m/sec.).

The air even goes through synthetic filters, provoking positive ionization of Azote atoms; it is demonstrated by the fact that every friction between two bodies, when one is isolated, creates positive charges.

Then, even every kind of plastic material manufacture, produces electrostatic positive charges. Our philosophy in approaching the problem, based on the mathematics of OLF and DECIPOL, defined by Prof. Fanger in 1989, presents considerable advantages in comparison with the outdoor ventilation and it can be used in all the possible placements with unchanged achieve-ment of the final target: the control of indoor air quality, without waste of energy for the outdoor evacuation of the polluted air.

The KOALA is a group of apparata particularly suitable for the depollution of dusts, gases, sub-micron particules and sterilization of bacterial, viral and fungal charge, contained into a box of modest dimensions , and placeable in any corner near the walls of the environment to be treated.

After having stated the speed of air ventilation, it is suggested that KOALA be used in a continuous way, taking into account its low electrical adsorption.

Nothing prohibits the use of the apparatus in a discontinuous way. On the contrary, in comparison with other ventilation and conditioning systems, it does not release materials at the restarting time.

Moreover it has considerable advantages in comparison with traditional systems of electrostatic filtration or of air ionization, because:

- It does not need pre-polarization of the dusts for their capture.
- It does not use high tensions on the air and therefore it does not create Ozone.
- It does not use interception plates laid one upon the other and therefore it does not need controls and maintenance to avoid electrical discharges from short circuits due to the accumulation of stopped material.
- Also without maintenance it does not emit dusts and bacterial charge, even if it is used in a discontinuous way.
- Air ionization happens in a clean way, without provoking precipitation of dusts onto the environment surfaces.
- It can be used in the presence of other systems of thermic and/or climatic adjustment of the environment, because, for its kind of flow and air launching speed, it does not create interferences, or turbulence. In the case of absence of such apparata, anyway it respects the convective movement of the environment not mixing the air close to the ceiling with that close to the floor. It is of basic importance, in order to avoid the resuspension in the air of the particulate and bacterial charge.
- It avoids the "relapse" on the surface of dusts and bacterial charge or fungal associated one and allows the best working of scientific instruments and related control panel (usually invaded by bacteria and moulds in environments without change of outdoor air).

- The possibility to change the KIT-FILTER quickly and without maintenance, allows recovery from gases even for particular working requirements, using SPECIAL KIT-FILTERS, aimed at particular polluting gases.

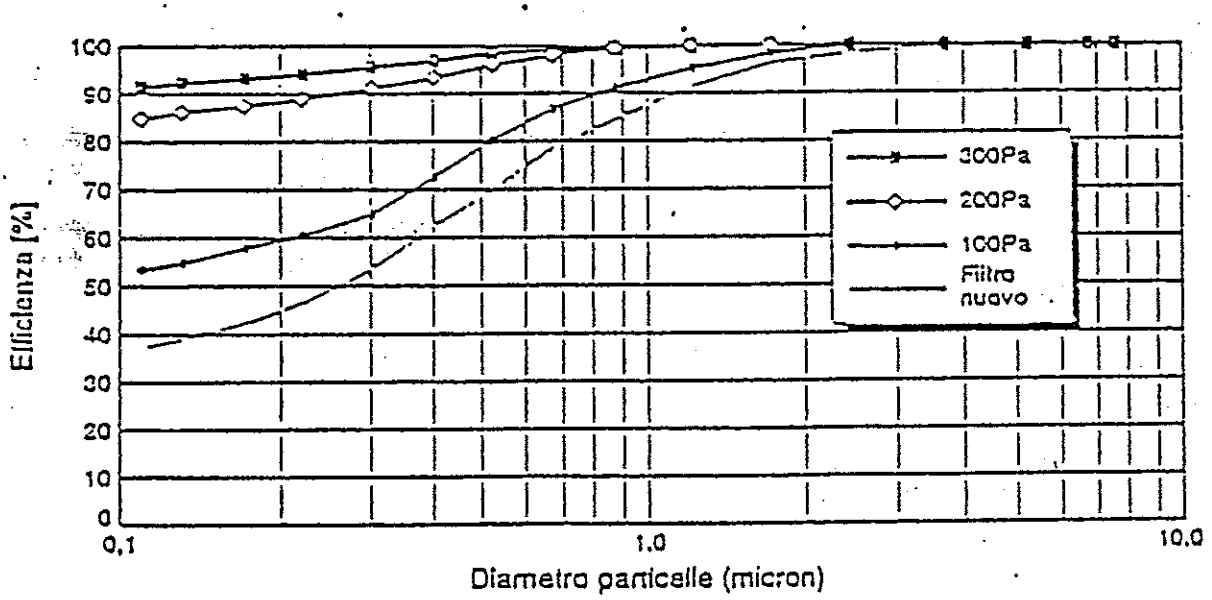
- It allows the control and the healing also from radioactive gases and dust in a continuous way, as already demonstrated on RADON and IODIUM 131 either in civil environment than in those sanitary ones.

It may seem excessive to define the KOALA system as the new frontier in air filtration for closed environments, but that, on the contrary, is really appropriate. In fact recent studies in hospital environments have ascertained that on average 97% of the dusts suspended in one room have dimensions less than 2 microns. No filtering system can guarantee IN A CONTINUOUS WAY, a standard of filtration at such a level of granulometry.

Certainly there are plants with absolute filters which, in industrial environments of microelectronics and pharmaceuticals, guarantee a cleaning class in the limit of 0,3 microns, but they need a control system and such maintenance as to make their use particularly difficult and expensive. However their use always provided that people are kept out of these environments or, otherwise that they are isolated from the air by means of masks and appropriate garments.

The diagram No. 1 shows a typical action of an hepa-filter, that's "only a little" absolute, comparing its indexes with the values read in standard conditions (with a new filter) its initial efficacy is referred to particles of about 5 microns. Subsequent filtered material raise hepa efficacy to particles having dimensions lower than one micron. But, being made up in a thin tissue it could be subjected to dangerous vibrations, that cause frequent losses of filtered materials. [14]

DIAGRAM NO. 1



For what concerns the electrostatic filtration, even if it normally presents the possibility of a standard of filtration down to one tenth of a micron, it changes quickly to 5 microns because of the oxidation of the plates for the dust's capture.

Therefore is justified the exclusive supremacy of KOALA in the filtering in continuous way at a standard of a thousandth of micron (0.001 micron), independently from the maintenance, for an extremely long time (in a standard civil environment, at least 3 months).

This premised the proposal to use the technology KOALA for the optimization of indoor air quality in a submarine, rises from the possibility of developing the product and to produce a "dedicated" version of it.

It is our aim that KOALA technology may represent an evolution factor of high strategic value, also for naval and submarine concept design, and a quality development in construction of submarine's interiors. There are a variety of benefits for all the crew:

- A better level of physical reactivity and ability, more resistance against intellectual fatigue, evident and conscious increase of concentration ability, more self-control, less emotional susceptibility and irascibility.

- At physical level it is expected an optimal standard, with a guarantee of prevention for all the syndromes and pathologies of the respiratory and pulmonary systems, one specific preventive action, impossible in other way, of cardio-vascular disorders.

While the capital benefit for the naval architect consists of relying on a new technology based on the concentration of pollutants instead of their dilution, that has just proved the ability to substitute 21 external ventilation rates per hour in an environment of 60 m^3. [15]

Our experimental proposal for the submarine adoption of the KOALA System is the installation of one machine in each environment (with a dedicated project), sufficient to cover all needs of I.A.Q. (Indoor Air Quality), and to choose the period of dive as long as possible to realize, with no doubts, a new clear, crew "performance".

These apparata will use KOALA technology to activate a strong depollution in every kind of environment against:

- dusts;
- gases;
- micro-organisms, and
- electrostatic charge.

The verification will be effected in two phases and through two enquiries:

a) A questionnaire followed by interview about the subject well-being to extend to the rest of the crew. Text will follow I.A.Q., International standards of enquiry.

b) Instrumental text to look into the main environmental parameters change, relative to I.A.Q. valuation.
   - First phase without KOALA system in use.
   - Second phase with KOALA system in use.

Thanks to this apposite plan we believe it would be possible to indicate:

- times;
- costs;
- modality of installation and use;
- protocols of environmental verification and the crew enquired composition of the testing specialist group.

All this effort we hope will be spent to obtain an assured environmental guarantee and, especially, to secure an optimal psychological and physical performance for all the crew.

It will lead to good results in every situation and a real possibility of achieving high aims whatever a naval operator demands.

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