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Door Fan Test in Data Processing Center at Portopalo Test Site

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***Abstract*—**The door fan test is a verification procedure on the tightness of a room, necessary following the installation of saturation extinguishing systems and made mandatory according to the UNI 15004-1: 2019 standard whenever a gas extinguishing system is designed and installed. The door fan test was carried out at the Portopalo di Capo Passero headquarters of the Southern National Laboratories and highlighted how the Data Processing Center (CED) is perfectly up to standard, passing the door fan test in an excellent way. The Southern National Laboratories constitute a solid research reality, well established in the international scientific panorama. The CED in the Portopalo site has been expanded, so the extinguishing system has been expanded according to a detailed design. After checking the correctness of the design to verify the absence of air leaks, we carried out the door fan test. The activities of the Laboratori Nazionali del Sud (LNS) are mainly aimed at basic research in the field of Nuclear Physics, Nuclear and Particle Astrophysics. The Portopalo site will host some of the largest submarine wired scientific research infrastructures built in Europe and in the world, such as KM3NeT and EMSO ERIC; in particular, the site research laboratory in Portopalo will host the power supply and data acquisition systems of the underwater infrastructures, and a technological backbone will be created, unique in the Mediterranean, capable of allowing the connection, at abyssal depths, of dozens of real-time surveying and research structures of the marine environment deep.

***Keywords*—**KM3Net, fire protection, door fan test, CED.

I. Introduction

KM3NET is a research infrastructure housing the next generation neutrino telescopes. When finished, the telescopes will have detector volumes between a megaton and several cubic kilometers of clear sea water at Mediterranean Sea. KM3Net will be positioned in the deepest part of the Mediterranean Sea and will allow us to open a window into our universe, contributing to the search for the characteristics of one of the most elusive particles we know: the neutrino. Thanks to the KM3Net telescope, the INFN (National Institute of Nuclear Physics) scientific community will search for neutrinos from the most remote parts of the Universe such as supernovae, gamma-ray bursts or colliding stars. Thousands of optical sensors will be able to detect the very faint light that reaches the depths of the sea, coming from the charged particles created by the collisions of neutrinos with the Earth. The marine infrastructure will be multidisciplinary, in fact it will not only deal with physics, but will also house the instrumentation for Earth and Sea sciences for long-term and on-line monitoring of the deep-sea bottom at depth of several kilometers [1].

The KM3NeT-It deep-sea installation site is located at 36°16' N 16° about 100 km off-shore Portopalo di Capo Passero, Sicily, Italy, where the shore station is located (see Fig. 1). The shore infrastructure comprises facilities to power the subsea detectors and a shore station with a control room managed by INFN and INGV [1].

II. KN3Net CED

A data processing center (CED) is an organizational unit that coordinates and maintains data management equipment and services, i.e., the IT infrastructure necessary for the operation of the structure. The CED serves to coordinate and manage the dissemination of information within the reality in which it operates, it must provide both generic and specific IT support for organizational and administrative management and surveillance activities. It also provides technical-scientific advice to the various structures in the field of processing systems, computer networks and information systems as well as evaluating the needs and objectives to be achieved for the functionality of the computerized services. The entire data processing is managed by the CED present within the structure.

The servers are normally arranged in rack cabinets to allow quick access and easy replacement and to facilitate the connection of the various cables for communications and power supply.

The room, for fire prevention, is equipped with both a fire detection system and an automatic saturation extinguishing system that work in a double cross-consent assisted way to avoid unnecessary discharges of extinguishers and guarantee the maximum of safety for people and equipment, both subject to protection. It was necessary to expand the CED room from a total volume of 349.5 m^3 to a total volume of 641.52 m^3, to expand the calculation needs of the KM3Net experiment and due to the collaboration initiated in the INFN-LNS Portopalo headquarters with INGV.

A. Saturation Extinguishing System

The saturation extinguishing system is particularly suitable for the protection of all environments where it is not possible to use water (data centers, archives, electrical substations, libraries, warehouses and technical areas with the presence of personnel).

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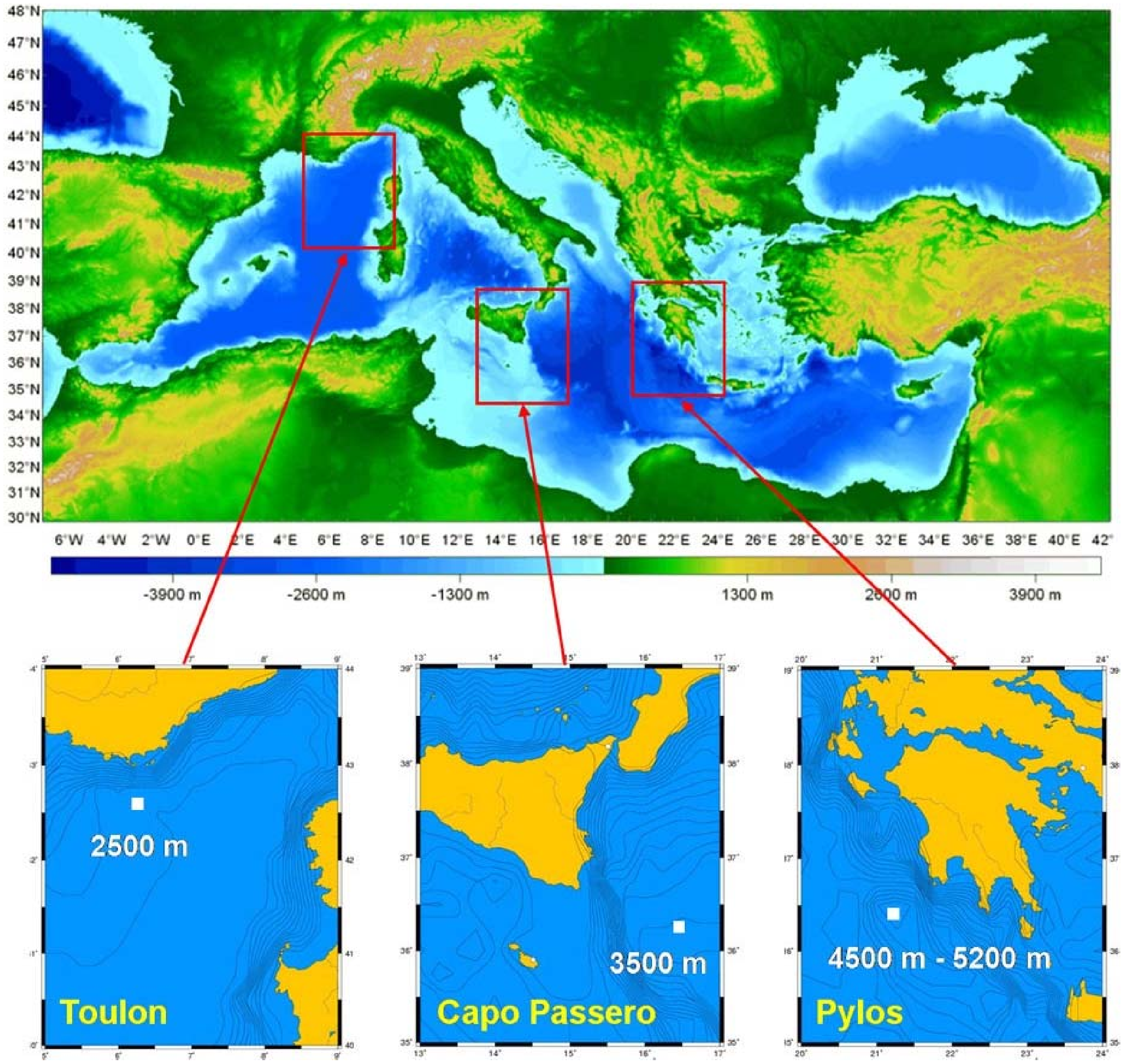

Fig. 1 Locations of the sites of the three Mediterranean neutrino telescope projects

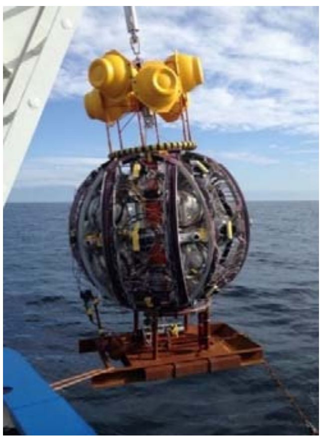

Fig. 2 Launching vehicle at the start of deployment

Inert gas fire extinguishing systems use argon and nitrogen gases and related mixtures as extinguishing agents, by the technique of total saturation of the environment "total flooding": they act by reducing the level of oxygen in the environment up to the point where combustion cannot be obtained. Argon and nitrogen are natural gases present in the air and their extinguishing action is mainly based on the lowering of the oxygen content present in the environment up to a value between 10% and 12%, below this value the combustion process cannot happen and, in any case, it does not constitute a risk for any person.

B. Dimensions

The characteristics of the room and the automatic extinguishing system at INERGEN (IG-541) present in

Portopalo di Capo Passero are:

- Local Data CED
  - Room Volume: 598.75 m^3
  - Underfloor volume: 42.77 m^3
  - Total volume: 641.52 m^3
  - Risk class: Class A High risk
- Necessary System Data
  - Project concentration used: 45.7%
  - Gas used: IG-541
  - Specific gas volume at T = 20 °C and p = 1 atm: 0.706 m^3/kg
  - Cylinder capacity: 80 l
  - Cylinder pressure: 300 bar
  - Cylinder charge: 33.1 kg/each.
  - Quantity of extinguishing agent required: 554.8 kg
  - Quantity of cylinders required: 16.76 → 17

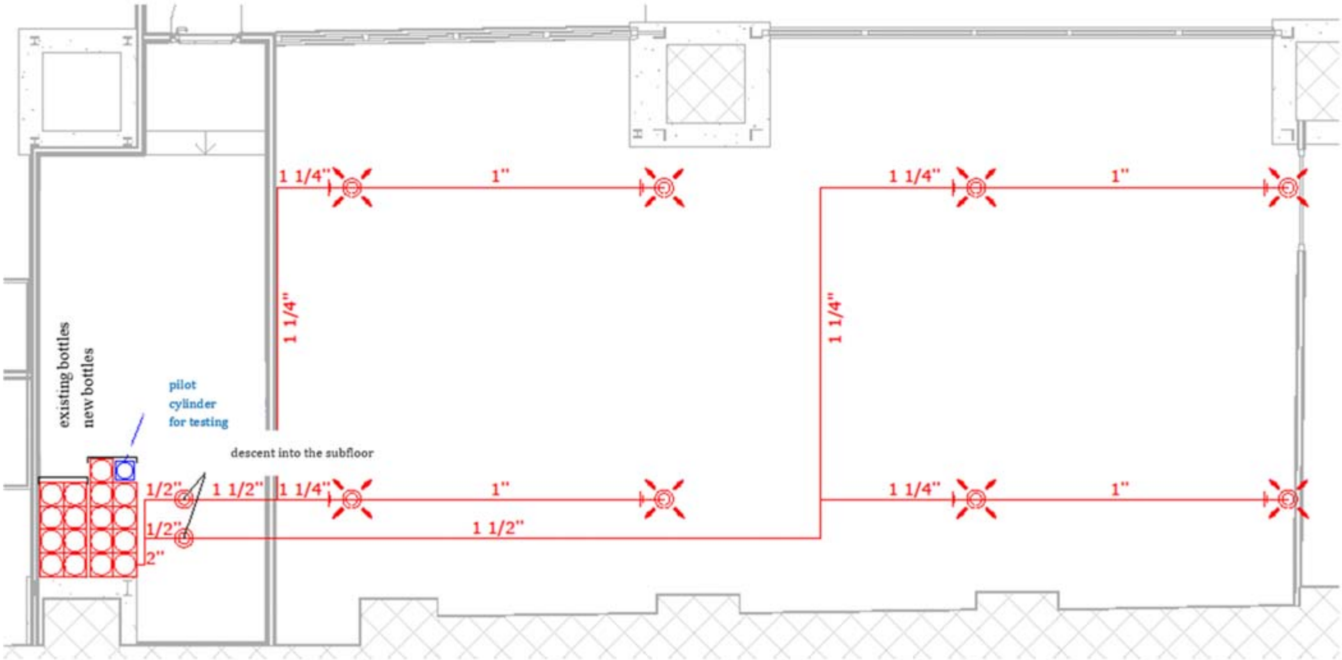

Fig. 3 Environment distribution network

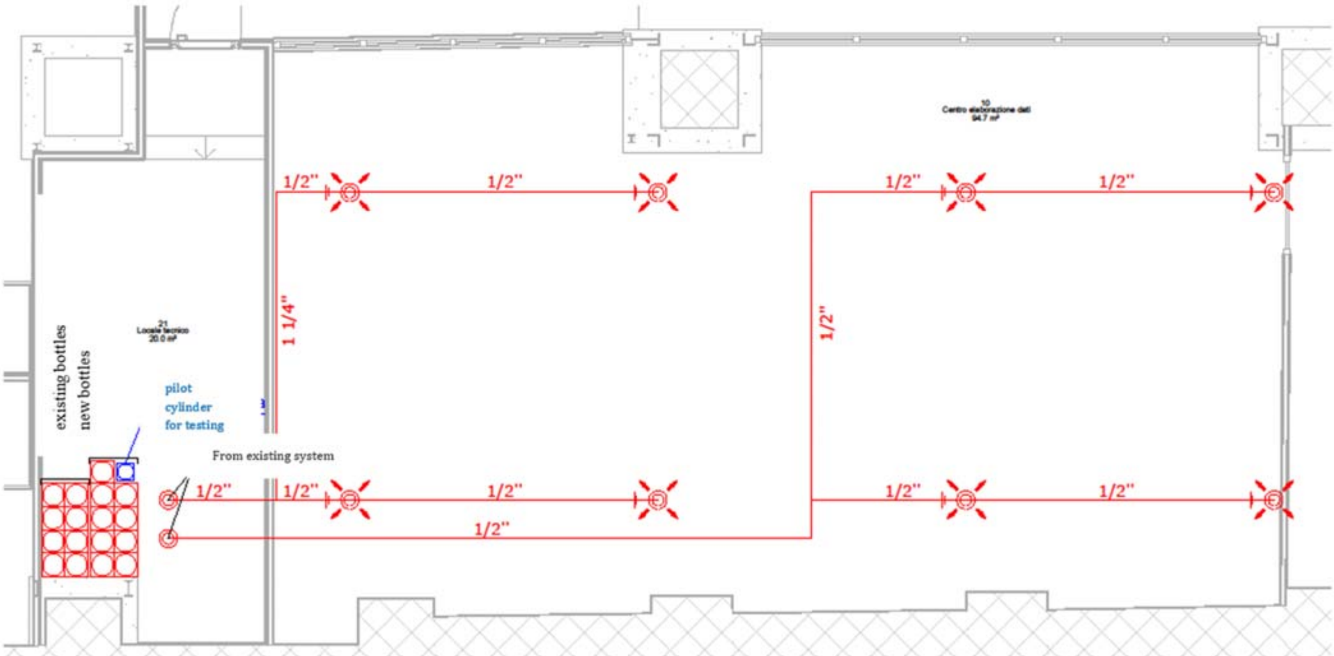

Fig. 4 Underfloor distribution network

The IG-541 System can be activated in the following ways:

- Automatic activation: It takes place through the detection system located in the protected area. When the fire occurs, the control unit of the detection system activates the solenoid valve on the pilot cylinder, consequently the discharge of the inert gas cylinders through the pneumatic line is activated.
- Electro/manual activation: The activation command takes place via a button located outside the protected area. The operation is then the same as already described in the previous point.
- Manual emergency activation: The system can be activated through the manual control with the handwheel located on the pilot cylinder.

The discharge of the extinguishing agent in the protected volume causes an overpressure which is balanced using one or more overpressure dampers. The overpressure damper is an indispensable component in a protected room with a gas extinguishing system.

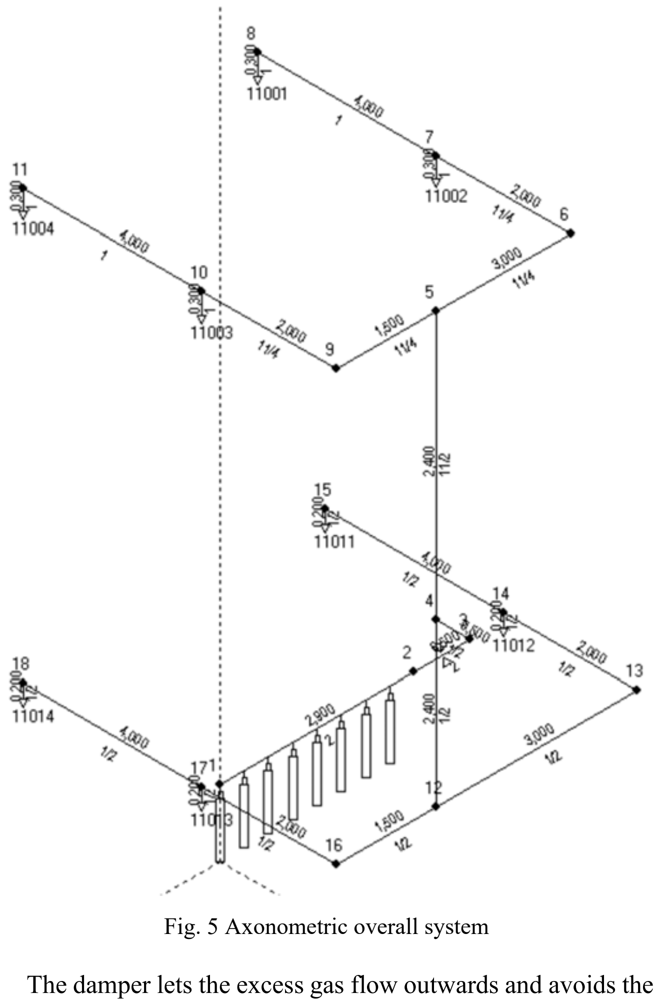

Fig. 5 Axonometric overall system

The damper lets the excess gas flow outwards and avoids the formation of dangerous overpressures. An installation failure of the overpressure dampers could cause, in case of the extinguishing agent discharge, serious structural damage to the walls and fixtures of the protected volume. Consequently, the functionality of the extinguishing system would also be compromised.

III. The Door Fan Test

The door fan test is a verification procedure on the tightness of a room, necessary following the installation of saturation extinguishing systems (present within the CED) and made mandatory according to the UNI 15004-1:2019 standard every time designed and installed a gas extinguishing system [2].

Subsequently at the end of the 80s it was developed and regulated, within the fire protection, as a verification tool for the control of the premises that have a gas saturation extinguishing system. The Door Fan Test (DFT) test protocol was officially formalized in the 1989 edition of the standard: NFPA 12A: "Halon 1301 Fire Extinguishing Systems", Appendix B and taken up in 1994 by NFPA 2001: “Clean Agent Fire Extinguishing Systems”, Appendix B [3].

The homologous ISO standard was also defined later, which is reported in Annex E of the published standard in 2000: ISO 14520-1: 2000: “Gaseous fire-extinguishing systems - Physical properties and system design - Part 1: General requirements”. The DFT is a procedure for analyzing and verifying the sealing characteristics of a specific room; that is to say of its capacity to prevent that in the presence of a pressure gradient between inside and outside an air flow through the walls that compartmentalize it [4]. The DFT provides a method to evaluate the extent of losses in a room and its capacity to retain inside the gas emitted by a total saturation extinguishing system (Total Flooding Discharge). It provides a procedure for the research and precise identification of areas with leaks on the surfaces that delimit the room. The procedure consists of pressurizing and depressurizing the environment and at the same time measuring the necessary air flow rates with the aid of equipment consisting of:

- A panel to be adapted to the opening of a doorway of the room to be examined.
- N ° 1 or 2 fans with adjustable speed, to be installed on the aforementioned panel, to enter and extract air from the room.
- A control console with instruments for measuring the pressures inside and outside the room, air flow generated to obtain them, internal and external temperatures.
- A calculation unit (PC) for processing the measured values and extrapolating the characteristics sealing of the room [5].

A. The Test Execution Stages

DFT conceptually develops in three stages:

- Measurement: The amount of air flow introduced/extracted into/from the room is measured for generate a certain overpressure/depression value inside.
- Calculation: From the measured values, it is possible to calculate the equivalent loss area (ELA: Equivalent Leakage Area), i.e., the total area of all leaks, cracks, seams and porous surfaces that allow leaks from the surfaces of subdivision of the room in question.
- Prediction: Once the value of the Equivalent Leakage Area is known, an estimate can be made of the gas retention time

inside the room.

The DFT is performed as an alternative to a complete gas discharge test which would certainly be much more expensive.

In particular, in the case of fire extinguishing systems with gas extinguishers, this test allows to analyze the behavior of a room when a pressure variation (caused by the discharge of the extinguishing gas) occurs, with the aim of highlighting any possible construction differences of the room that could generate air flows to the outside that would led to a not adequate concentration of gas inside the room for the required period of time, defined as the residence time, (current legislation requires that this time must not be less 10 minutes).

The test consists in putting the volume of the protected room under pressure and vacuum, by means of a fan operated by a control and measurement instrument. The measurements of the pressure and the air flow, detected by the manometer, allow to establish the losses of the room (ELA) and, consequently, the residence time of the extinguishing agent inside it, the quantity of which was established during the project phase, depending on the volume of the room and the type of extinguishing gas used.

The result of the door fan test is a part of the certification that the installer is required to provide to the user. It is also essential not only in the initial phase of commissioning and acceptance of the system, but this test must also be repeated in the case in which it is ascertained, during the periodic inspection (six-monthly or annual), a possible change in the integrity of the room due to wall crossings or possible changes in volume.

Fig. 6 Door FanTest in Portopalo CED

Carrying out the test is also required in the event of loss of its documentation and in the planned (10-year) overhaul of the system.

IV. Design and Door Fan Test: Portopalo Site

From the experience gained in the integrity analysis of numerous premises characterized by different locations, construction types and intended uses, it is clear that too often the design of the total gas saturation fire extinguishing system regardless of the physical characteristics of the protected volume and therefore its sealing requirements.

Frequently, the design process, even if carried out in compliance with the adopted legislation, focuses attention above all: on the relationship between protected risk, chosen extinguishing agent and concentration request; on the consequent determination of the quantity of extinguishing agent required; on the correct calculation hydraulic distribution piping; in a certain sense taking the permanence of the gas for granted within the protected volume. Therefore, when constructing a new system, attention is paid to the sealing characteristics of the room; it is very often entrusted by the client to the company that carries out the civil works. On the other hand, the installer is not particularly interested in the interventions on the compartments, to the point that it is not infrequently neglected the supply of suitably sized overpressure dampers. For this reason, there must be coordination by a qualified subject that can be identified in:

- Engineering company that issues the plant specifications, possibly after the DFT;
- Authority Having Jurisdiction (the Anglo-Saxon Authority Having Jurisdiction), typically the entity insurance;
- Testing body appointed by the client.

Performing the DFT, before having developed the gas extinguishing project, allows to ascertain the feasibility of the system itself, and also allows to carry out a cost benefit analysis with any alternative solutions. The DFT also guarantees information regarding the definition of any Project Factors, also linked to the presence of personnel. In the following we will describe the aspects that have the greatest impact on the sealing characteristics of the protected volume will be described below [2].

In order to facilitate the understanding of this report, the following definitions are provided:

- *Volume of the room "V"* - It is the volume measured in cubic meters of the room that will be protected by the total saturation gas extinguishing system.
- *Maximum protection height "H"* - Expressed in m, it coincides with the position of the dispensing nozzle with respect to the floor of the room.
- *Minimum height to protect "h"* - It is the height of the highest combustible good to be protected inside the room.
- *Extinguishing Concentration* - It is the minimum concentration of extinguishing substance required to extinguish the flame of a particular fuel under defined experimental conditions
- *Design concentration* - It is the concentration of the extinguishing substance, including a safety factor, required to extinguish a fire of a particular fuel.
- *Equivalent area of losses "ELA"* - It represents the sum of all losses in the room as if they were concentrated in a single opening.
- *Retention time of the extinguishing gas* - It is important to reach an effective concentration of the extinguishing substance and keep it above the extinguishing concentration for a sufficient period (current legislation requires that this time must not be less than 10 minutes) to

prevent any re-ignition due to an ignition source (e.g., a trigger, smoldering fire, etc.). It is therefore essential to determine the probable period during which the extinguishing concentration around the hazard will be maintained, known as the residence time, determined by the DFT.

TABLE I
PASS/FAIL ENCLOSURE INTEGRITY REPORT

Depressurization	Range for room pressure: -10 to -60.0		
Blower Range		Ring A	
Room Pressure	Auto Corrected RP	Flow Pressure	Auto corrected FP
-13.2	-13.2	47.3	47.9
-20	*-19.9*	*81.8*	*82.4*
-33	*-33.1*	*146*	*146.6*
-40.4	*-41*	*180*	*180.6*
-42.4	*-43*	*191*	*191.6*

Losses inside the room due to the presence of cracks on the walls of the room or the presence of channels (aeration or electrical) that cross the same walls will affect the dispersion speed of the extinguishing gas.

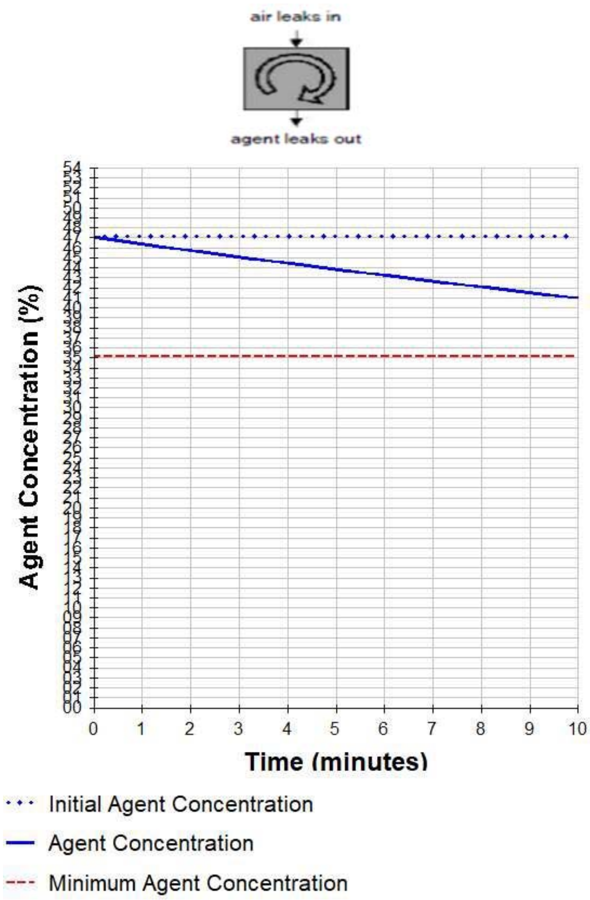

Fig. 7 Below celling leakage defaulting to worst case

This enclosure was tested in compliance with ISO 14520.1 Annex E. Assuming continual mixing during the retention period, enclosure leakage could allow sufficient agent to be lost to cause the agent concentration to drop from the initial concentration of 47.05% to the minimum specified concentration of 35.15%. The retention time would then be 22.0 minutes which exceeds the minimum retention time of 10 minutes. The enclosure therefore passes this acceptance procedure.

TABLE II
TOTAL ROOM LEAKAGE DATA

Test date/time	2021/02/19 10:00	Net protected volume Vg Max	642 m^3
Tester Certified to	No enclose certification	Protected Height HO Min	5.70 m
Level:		Protected Height H	5.70 m
		Static during discharge PSH	0.0 Pa
Elevation above sea level	20 m	Operating temperature	25°C
Correction method	NFPA 2001 (2000) Formula A-3-5.3.3	Initial concentration. C	47.05%
Correction factor	0.99	Mixing during retention	Yes
Agent	INERGEN by Volume (IG-541)	Agent quantity	398 m^3
Actual total leakage. At	0.2604 m^2	Minimum concentration	Cmin 35.15%
Actual lower leakage. A_l	0.1302 m^2	Minimum retention time	10.0 minutes

V. CONCLUSION

The analysis ascertained the class A high-risk (Fig. 3) establishing a project concentration of 45.7% as prescribed by Table 4 of UNI EN 15004-10/2018 as well as the extinguishing concentration of 35.15%, as specified in point 7.5.1.3 of UNI 15004-1/2019, which prescribes a value of 95% of the 37% heptane extinguishing concentration, obtainable from Table 2 of UNI EN 15004-10 (37 x 0.95 = 35.15%). It can therefore be concluded that an effective total gas saturation extinguishing system cannot be regardless of the knowledge and adaptation of the characteristics of the protected volume from the stage of design.

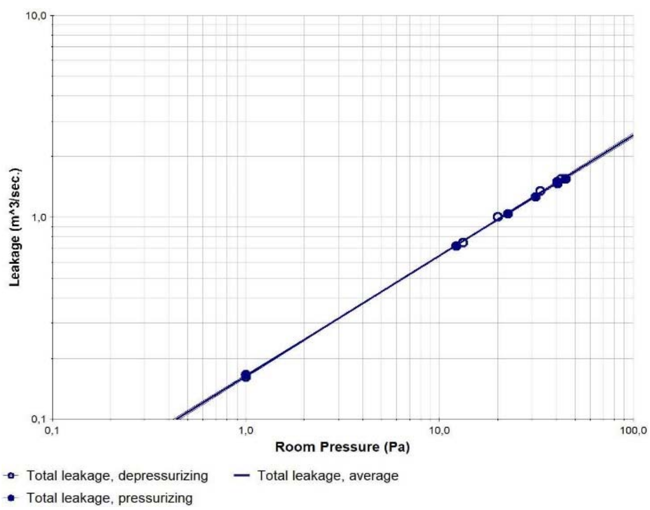

Fig. 8 Lower leakage – Below celling leakage of 0.1302 @ 10 Pa

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Since 2003 he started to work at the INFN – Catania's Section, as a fellow to the CMS experiment at CERN in Geneva. For this experiment has served as a mechanical designer and subsequently responsible for the mechanical testing experiment called "Cosmic Magnet Test Challenge" at CERN. In 2007 moved to Alice experiment, with a check for technological research at the University of Catania, serving as head of the mechanical integration EMCAL detector at CERN. In 2009 he began to collaborate with the experiment JLAB12 with the role of mechanical mananger for the GEM particles tracker. From 2012 he collaborated with the experiment ICARUS and later with the WA104 experiment to CERN in Geneva, where he served as a mechanical designer with a PJAS contract at CERN. From 2014 he was as mechanical mananger design for the experiment AISHA at the LNS.

From 2010 he served as an adjunct professor for the Catania's University, teaching physics and materials science.

He collaborated with the ICCM conference which is a member of the Scientific Committee. Author of numerous publications including:

- F. Noto et al - Structural Mechanics Optimization of the AISHa Ion Source - Proceedings of the International Conference on Computational Methods (Vol.2, 2015) ISSN 2374-3948.
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