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Study of fire safety measures for an existing sports facility in accordance with current building regulations.

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Vull donar les gràcies de tot cor a les meves tutores, la Pilar i la Nuria, per la seva paciència, guia i suport incondicional durant tot el procés. Sense elles, aquest projecte no hauria estat possible. També vull agrair al meu marit i al meu fill per la seva comprensió i per haver-me donat l'espai que necessitava per poder estudiar aquest grau i realitzar el TFG

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SUMMARY

This study has assessed the fire safety measures of a sports facility constructed in phases over three decades, with the first phase built in 1984 and the last in 2002.

The primary objective is to ensure the protection of users of the facility and to minimize the risk associated with a potential fire. To achieve this, it has been analyzed whether the facility complies with the fire safety regulations applicable in Barcelona, namely: *"El Real Decreto 314/2006* [(1)]*, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación (CTE)"* and the *" l'Ordenança*[(2)] *Reguladora de Condicions de Protecció (ORCPI/08)".*

To carry out this study, all available information on the building has been gathered, both from the Contemporary Archive of Barcelona City Council [(3)] and the archive of the Barcelona Sports Institute, in addition to the information provided by the sports center manager.

The documents and plans have been reviewed to identify the construction systems, materials used, and installations implemented, as well as the regulations applied at each stage of construction. Subsequently, various inspections have been carried out on the facility to verify whether the actual construction coincided with what was described in the projects.

A comprehensive assessment of compliance with fire safety regulations was conducted, identifying several areas of non-compliance. One of the most significant deficiencies is the lack of fire compartmentation between the sports hall and the corridor leading to the fitness studios, specifically at two points: the connecting door and a window located on the same wall.

As a corrective measure, it is proposed to replace the door and window with ones that offer superior thermal insulation and fire resistance. According to the price database of the Catalan Institute for Construction Technology (ITEC)[(4)], the approximate cost of this intervention would be €22,230. 57 including VAT.

Another significant non-compliance it has been identified is that the existing fire protection installations do not cover the entire area of the center. When measuring the distances that the fire hydrants, extinguishers, and call points should cover according to the plans, it has been

found that approximately 8 fire hydrants, 20 extinguishers, and 7 call points are missing. Additionally, all detectors have expired and need to be replaced. This corrective measure would have an approximate cost in the market, according to the ITEC price database, of € 47,489.17 including VAT.

In conclusion, despite being constructed in different phases, the sports facility exhibits an acceptable level of fire safety in terms of passive protection. This includes compartmentation, fire resistance and stability of the structure, as well as the adequate number and arrangement of exits and evacuation routes.

However, the active fire protection systems need to be significantly improved. Actions to correct the identified deficiencies in compartmentation and to expand the active fire protection systems will ensure an optimal level of safety for the center's users and full compliance with current regulations.

Key terms: fire safety, assessment, inspection, regulations, deficiencies, corrective measures, building.

RESUM

El present estudi ha avaluat les mesures de seguretat de protecció contra incendis d'una instal·lació esportiva construïda en diferents fases al llarg de tres dècades, la primera fase es va construir l'any 1984 i l'última el 2002.

L'objectiu és millorar, les mesures de seguretat dels usuaris que utilitzen el centre esportiu i reduir a límits acceptables el risc de danys derivats d'un incendi accidental, tenint en compte les característiques constructives de l'edifici, els usos que es fan en cada espai, les seves instal·lacions i el manteniment tant de l'edifici com de les instal·lacions.

Per fer-ho s'ha analitzat si l'equipament compleix amb la normativa de protecció contra incendis en vigor a Barcelona que és: *"El Real Decreto 314/2006* (1)*, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación (CTE)"* i l'Ordenança(2) Reguladora de Condicions de Protecció Contra Incendis de Barcelona (ORCPI/08).

Per a dur a terme aquest estudi, s'ha recopilat tota la informació disponible sobre l'edifici, tant a l'Arxiu Contemporani de l'Ajuntament de Barcelona(3) com a l'arxiu de l'Institut Barcelona Esports, a més de la informació proporcionada pel gestor de centre esportiu.

S'ha revisat els documents i els plànols per identificar els sistemes constructius, els materials utilitzats i les instal·lacions executades, així com la normativa aplicada en cada etapa de la construcció. Posteriorment, s'ha realitzat diverses inspeccions a l'equipament per verificar si la construcció real coincideix amb el que estava descrit en els projectes.

A continuació, s'ha dut a terme una avaluació integral del compliment de la normativa de protecció contra incendis, detectant diversos incompliments. Un dels més importats és la manca de sectorització contra incendis entre el pavelló i el passadís d'accés a les sales d'activitats dirigides en dos punts concrets: la porta de comunicació i una finestra situada a la mateixa paret

Com a mesura correctora, es proposa substituir la porta i la finestra per unes que ofereixin un aïllament tèrmic i una resistència al pas de les flames superior a les actuals. Segons el banc

de preus de l'Institut de la Tecnologia de la Construcció de Catalunya en (ITEC[4]), el cost d'aquesta intervenció seria de 2.230,57 € IVA inclòs.

Un altre incompliment important que s'ha detecta és que les instal·lacions de protecció contra incendis existents no cobreixen la totalitat de la superfície del centre. En mesurar les distàncies que havien de cobrir les boques d'incendis equipades, els extintors i els polsadors, s'ha constatat que falten aproximadament vuit boques d'incendis equipades, vint extintors, set polsadors d'alarma. També s'ha detectat que tots els detectors, menys els dels vestuaris que es van reformar el 2020, estan caducat i cal canviar-los. Aquesta mesura correctora tindria un cost, segons el banc de preus de l'ITEC(4) 47.489,17 € IVA inclòs.

Com a conclusió, tot i haver estat construït en diferents etapes, l'equipament esportiu presenta un nivell de seguretat contra incendis acceptable en quant a protecció passiva. Això inclou la compartimentació, la resistència i l'estabilitat al foc de l'estructura, així com el nombre i la disposició adequades de les sortides i els recorreguts d'evacuació.

No obstant això, cal millora significativament els sistemes de protecció activa contra incendis (boques d'incendis equipades, extintors, polsadors d'alarma i detectors).

Les actuacions per corregir les deficiències detectades en la sectorització i ampliar els sistemes de protecció activa permetran garantir un nivell de seguretat òptim per als usuaris del centre i el compliment integral de la normativa vigent.

Paraules clau: seguretat contra incendis, avaluació, inspecció, normativa, deficiències, mesures correctores, edifici.

SUSTAINABLE DEVELOPMENT GOALS

The study of fire safety conditions in a sports center fits within a broader global context, closely tied to the United Nations' 2030 Agenda. Specifically, it aligns with Sustainable Development Goal 11, which promotes the creation of sustainable, inclusive, safe, and resilient cities and communities. In this regard, the prevention and management of risks such as fires are crucial to ensuring the safety of people and the protection of public and private assets, thereby contributing to the development of cities that are more resilient to the effects of climate change and other emergencies.

1. INTRODUCTION

In any building, there is a risk that users may suffer harm resulting from an accidental fire, due to the building's construction characteristics, its usage, and the maintenance carried out on the building and its installations.

In sports facilities, the combination of high foot traffic, flammable materials such as curtains, wall coverings, and furniture, along with the presence of electrical systems and technical equipment (boilers, climate control systems, etc.), creates an environment with a significant fire risk.

Factors such as short circuits, boiler failures, or accidents during maintenance tasks, such as welding, further increase this risk. For this reason, it is necessary to adopt specific safety measures, taking into account the uses and activities conducted within the facility.

This project aims to assess to what extent an existing sports facility, operational since 1984 and constructed in multiple phases over 30 years, complies with current fire safety regulations. The study seeks to identify potential deficiencies, propose corrective actions, and evaluate their associated costs.

1.1. DESCRIPTION OF THE SPORTS FACILITY

The construction of the sports facility originated from the need to provide recreational and sports spaces in a neighborhood of Barcelona.

The first building, completed in 1984, was an outdoor summer swimming pool. The following year, the pool was covered, locker rooms were built, and a second outdoor summer swimming pool was added.

Later, in 1987, an uncovered multi-sports court was constructed. Years later, this court was covered, expanding its usage possibilities and transforming it into a sports hall with locker rooms. This sports hall hosted the men's and women's volleyball training sessions during the 1992 Barcelona Olympics.

The most significant expansion occurred in 2002 with the construction of fitness rooms and spaces for organized activities.

Figure 1, an aerial image obtained from the urban information web portal [5] of the Barcelona City Council, clearly shows the different buildings that comprise the sports facility, highlighting its phased construction through the distinct roofing structures visible in the image.

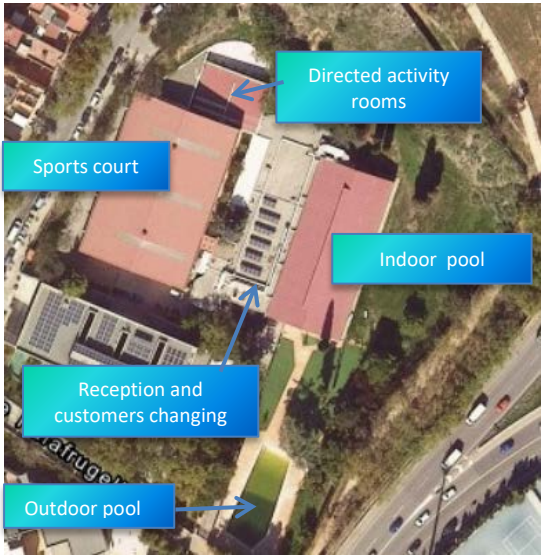

Figure 1 An aerial view of the current sports facility

In recent years, rehabilitation and renovation works have been carried out in various areas of the facility, including the reception area, some locker rooms, and the outdoor summer swimming pool.

In Figure 2, an image shows the results of the latest renovation performed in the group locker rooms. The user locker rooms were renovated simultaneously and featured the same finishes.

Figure 2 Image of the new group locker and changing rooms

In Figure 3, you can see the outdoor pool after the renovation carried out during the winter of 2023-24.

Figure 3 Image of the new outdoor pool

Currently, the sports facility is located on a 10,472 m² plot of urban land designated for sports facilities. Its built area is 4,478 m², which is clearly divided into two main blocks constructed during different phases: one corresponding to the multi-sports court and the other to

the swimming pool. These two spaces are connected through a central area dedicated to circulation and services.

The facility offers a variety of services to the neighborhood, such as organized activities, personalized training plans, ongoing fitness and pool support, small group training sessions, family recreational activities, basketball and swimming clubs, and the Olímpia Campus during school holidays for children.

The center's operating hours are Monday to Friday from 7:00 AM to 11:00 PM and weekends from 8:00 AM to 8:00 PM.

This variety of activities and extended hours results in high occupancy levels at the facility.

1.2. DIAGNOSIS OF THE CURRENT STATE

Currently, the city has several sports facilities built around the 1980s and 1990s. Over the years, expansion and renovation works have significantly altered the original configuration of uses, spaces, and services. This situation has impacted the safety conditions for users of these centers, prompting the need for a study to evaluate compliance with current fire safety regulations in a specific sports facility.

In this particular case, the facility was constructed in different phases between 1984 and 2002. Renovation works were carried out on the locker rooms in 2020 and on the outdoor pool in 2023.

The successive modifications, renovations, expansions, and changes in the use of spaces have resulted in a current configuration that may not fully comply with current fire safety regulations.

Fire safety regulations are constantly evolving, adapting to new technical knowledge and lessons learned from past incidents. Standards for safety, fire detection and extinguishing systems, as well as evacuation requirements, have undergone significant changes over the past decades.

In the case of sports facilities, safety is of particular importance due to the high density of people often present in these spaces, especially during events or competitions.

Therefore, it is essential to conduct a thorough assessment of sports facilities to verify compliance with current regulations and to ensure that the implemented safety measures are

adequate to protect people and property in the event of a fire. This evaluation will help identify potential deficiencies, establish an improvement plan, and ensure that sports facilities are safe spaces for all users. .

1.3. REGULATORY FRAMEWORK

1.3.1. Regulatory Framework in Effect During Construction

The sports facility was constructed in different phases over the years. The first structure, built in 1984, was an outdoor swimming pool. The following year, the pool was covered, and the facility was expanded with locker rooms for the indoor pool and an additional outdoor summer pool. In 1987, the multi-sports court was constructed, which was later covered, and locker rooms for the sports court were added in the summer of 1991. Finally, in 2002, fitness and activity rooms were built. In recent years, renovations and rehabilitation works have been carried out in various areas, including the pool locker rooms, reception, administration area, and outdoor pool. These works were completed in different stages between 2020 and 2023.

During the construction phases of each building, different fire protection regulations were in effect. These regulations had to be adhered to at the time of construction, regardless of whether the building was publicly or privately owned. The mandatory regulations always varied depending on the intended use of the building. For instance, buildings primarily used for industrial purposes were governed by regulations distinct from those applicable to buildings used for administrative, educational, healthcare, residential, or public access purposes.

Sports facilities have always been regulated under the fire protection standards for public access buildings, never under industrial-use regulations.

Below, it has been summarized in four tables the fire protection regulations that were complied with during each phase of the construction of the sports facility.

Table 1 Fire Protection Regulations Applicable in the First Construction Phase

1984 – 1985	Construction of an Outdoor Pool, Later Covered and Expanded with Locker Rooms
State Regulations	*"Real Decreto 2059/1981[6] , de 10 de abril, por el que se aprueba la Norma Básica de la Edificación «Condiciones de protección contra incendio en los edificios".* *"Real Decreto 2816/1982[7], de 27 de agosto, por el que se aprueba el Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativas"*
Municipal Regulations	*"Ordenanza [8] sobre Normas constructives para· la prevencion de incendios"*

Table 2 Fire protection regulations applicable in the second construction phase

1987 – 1991	Construction of a sports court, later covered and expanded with locker rooms.
State Regulations	*"Real Decret 279/1991 [9], de 1 de marzo, por el que se aprueba la Norma Bàsica de la Edificiación "NBE-CPI/91: Condiciones de protección contra incendios en los edificios".* *"Real Decreto 2816/1982, de 27 de agosto, por el que se aprueba el Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativas"*
Municipal Regulations	*"Ordenança[10] sobre Normes Constructives per a la Prevenció d'Incendis, de 30 de novembre del 1990"*

Table 3 Fire protection regulations applicable in the third construction phase

2002	Construction of activity rooms
State Regulations	*"Real Decreto 2177/1996 [11], de 4 de octubre, por el que se aprueba la Norma Bàsica de la Edificación NBE-CPI/96: Condiciones de protección contra incendios de los edificios"* *"Real Decreto 1942/1993 [12], de 5 de novembre por el que se aprueba el Reglamento de instalaciones de protección contra incendios"* *"Real Decreto 2816/1982, de 27 de agosto, por el que se aprueba el Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativas"*
Municipal Regulations	*"Ordenança [13] municipal de condicions de protecció contra incendis, de 27 de juny de 1997. (OMCPI/96)"*

Table 4 Fire protection regulations applicable during the renovations

2020-2023	Renovation of pool locker rooms, reception, administration area, and outdoor pool.
State Regulations	*"El Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación (CTE)"*
	"Real Decreto 513/2017 [14], de 22 de mayo, por el que se aprueba el Reglamento de instalaciones de protección contra incendios"
	"Real Decreto 2816/1982, de 27 de agosto, por el que se aprueba el Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativas"
Regional Regulations	*"LLEI 3/2010 [15], del 18 de febrer, de prevenció i seguretat en matèria d'incendis en establiments, activitats, infraestructures i edificis."*
Municipal Regulations	*"Ordenança[16] reguladora de les condicions de protecció contra incendis a Barcelona, publicada el 5/4/2008 (ORCPI/08)"*

1.3.2. Current Regulatory Framework

This study involves identifying the fire protection regulations applicable to buildings with a sports use in Barcelona and reviewing whether the selected facility complies with these regulations. For areas of non-compliance, corrective measures with estimated costs will be proposed to ensure compliance with the regulations. The fire protection regulations currently applicable to newly constructed buildings in Barcelona intended for sports use are listed in Table 5.

Table 5 Fire protection regulations applicable in 2024

2024	Regulations currently applicable if the building were newly constructed
State Regulations	*"El Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación (CTE)"*
	"Real Decreto 513/2017, de 22 de mayo, por el que se aprueba el Reglamento de instalaciones de protección contra incendios (RIPCI)"
	"Real Decreto 2816/1982, de 27 de agosto, por el que se aprueba el Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativas". Només aquells articles que no ha derogat el CTE

Regional Regulations	"*LLEI 3/2010, del 18 de febrer, de prevenció i seguretat en matèria d'incendis en establiments, activitats, infraestructures i edificis".*
Municipal Regulations	"*Ordenança reguladora de les condicions de protecció contra incendis a Barcelona, publicada el 5/4/2008 (ORCPI/08)"*

In the annexes of the "*Código Técnico de la Edificación"* CTE and RIPCI, a list of all mandatory UNE regulations can be found.

Although the "*Código Técnico de la Edificación*" (CTE) has repealed parts of the *"Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativas"*, the remaining sections of the regulation are still in effect. Specifically, the section concerning seating arrangements in stands applies, detailing the required number of stairs per seating area, seating spaces, and the spacing between stairs.

As previously mentioned, the regulations applied to sports centers are characterized by the need to first define the use of the center and its various spaces. Based on this use, the requirements for compartmentation, evacuation, fire resistance, and structural stability are determined, as well as the type and distribution of fire protection installations.

Other regulations, such as those applied to industrial establishments, require the calculation of the fire load for the different areas of the factory or warehouse as a first step. Based on this calculation, the requirements for compartmentation, evacuation, fire resistance, and structural stability are determined, as well as the necessary fire protection installations for each fire sector.

Among all the cited regulations, the one that carries the most weight in determining the fire protection conditions for buildings with public access use is the *"Código Técnico de la Edificación"* (hereafter referred to as CTE). The entire study conducted in Sections 4 and 5 of this project has been carried out according to the guidelines of this regulation. Below is a brief summary of the CTE.

Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación level subsection (CTE)

The Código Técnico de la Edificación (CTE) aims to improve the quality of construction and promote innovation and sustainability. It serves as a regulatory framework that establishes the

basic quality requirements for buildings and their installations. Through this regulation, compliance with essential building requirements related to the safety and well-being of people is ensured, covering aspects such as structural safety, fire protection, health, noise protection, energy efficiency, and accessibility for people with reduced mobility.

The CTE seeks to harmonize national building regulations with current European Union provisions, such as Directive 89/106/EEC on the free circulation of construction products within the European market and Directive 2002/91/EC on the energy efficiency of buildings.

To facilitate understanding, development, application, and updating, the CTE is organized into two parts:

a) The first part contains general provisions and conditions of application (the main text) and the basic requirements that buildings must meet.

b) The second part consists of the so-called basic documents, which provide the technical specifications necessary to ensure that buildings comply with the basic requirements.

The CTE is divided into six basic documents (DB). A brief summary of these six basic documents is provided in Table 6.

Table 6 Basic document of the CTE

D. B	Title of each basic document (DB) and brief description
DB-SE	Structural Safety SE. Ensures the resistance and stability of buildings.
DB-SI	Fire Safety SI. Establishes measures to prevent and control fires and facilitate evacuation.
DB-SUA	Safety in Use and Accessibility. Prevents accident risks during building use and ensures hygiene, health, and environmental protection.
DB-HS	Health. Ensures appropriate conditions of hygiene and comfort.
DB-HR	Noise Protection. Reduces noise transmission between different spaces.
DB-HE	Energy Saving. Improves the energy efficiency of buildings.

Each document addresses a specific aspect of construction and provides guidelines to meet the basic requirements established by the CTE.

In my study, since I am evaluating whether the sports facility is fire-safe for its users, I will focus primarily on the basic document on fire safety (DB-SI).

I will also review a couple of sections from the basic document on safety in use and accessibility (DB-SUA) that are related to occupant evacuations.

The basic document on fire safety (DB-SI) from the "*Código Técnico de la Edificación*"(CTE) is divided into six sections, each addressing a specific aspect of fire safety, and seven annexes, each with a specific focus to ensure fire safety.

In Table 7, it has been provided a brief summary of the six sections of DB-SI.

Table 7 Seccions del document bàsic SI del CTE.

D. B	Titles of the sections of the CTE Basic Fire Safety Document (BD-FS) and brief descriptions
DB-SI-1	Interior Propagation: Establishes measures to limit the spread of fire within the building, such as compartmentation and the use of fire-resistant materials.
DB-SI-2	Exterior Propagation: Defines measures to prevent the spread of fire to other buildings or outdoor areas, including building separation and the use of fire-resistant façades.
DB-SI-3	Occupant Evacuation: Provides guidelines to ensure the safe evacuation of occupants in case of fire, such as the arrangement of emergency stairs, exits, and signage.
DB-SI-4	Fire Detection, Control, and Extinction: Includes fire detection systems, alarms, and extinguishing equipment such as extinguishers and sprinkler systems.
DB-SI-5	Firefighter Intervention: Establishes necessary conditions to facilitate firefighter intervention, such as adequate access points and water supply locations.
DB-SI-6	Structural Fire Resistance: Defines fire resistance requirements for building structures, ensuring they maintain their integrity for a specified period during a fire.

The basic document on safety in use and accessibility (DB-SUA) from the "*Código Técnico de la Edificación*" (CTE) is divided into seven sections, each with a specific focus to ensure the safety of building use and accessibility, along with two annexes.

In Table 8, it shows a brief summary of the seven sections of DB-SUA.

Table 8 Seccions del document bàsic SUA del CTE

D. B	Titles of the sections of DB-SUA of the CTE and brief description
DB-SUA-1	Safety Against Risk of Falls: Establishes measures to prevent falls in various situations, such as stairs, ramps, corridors, and other transit areas.
DB- SUA -2	Safety Against Risk of Impact or Entrapment: Defines measures to prevent impacts or entrapments with building elements, such as doors, windows, and other movable components.
DB- SUA -3	Safety Against Risk of Confinement: Defines safety measures to prevent people from becoming trapped in confined spaces or enclosures.
DB- SUA -4	Safety Against Risk Caused by Inadequate Lighting: Specifies measures to ensure adequate lighting in all building spaces, with special attention to evacuation routes.
DB- SUA -5	Safety Against Risk Caused by High Occupancy: Defines safety measures to ensure the safe evacuation of people in case of emergency, particularly in high-occupancy spaces.
DB- SUA -6	Safety Against Risk of Drowning: Applies to buildings with swimming pools or water areas, outlining safety measures to prevent drowning accidents.
DB- SUA -7	Safety Against Risk Caused by Moving Vehicles: Applies to buildings with parking or vehicle circulation areas, detailing safety measures to prevent accidents involving vehicles.
DB- SUA -8	Safety Against Risk Caused by Lightning: Defines protective measures for buildings against lightning strikes.
DB- SUA -9	Accessibility: Refers to the conditions that buildings must meet to be accessible to all individuals.

1.3.3. Comparison Between the Current Regulatory Framework and the Previous One

The current regulatory framework for constructing, expanding, or rehabilitating a building with a sports use today includes the "*Código Técnico de la Edificación"* (CTE), specifically the basic document on fire safety (DB-SI), and the "*Ordenança Reguladora de Condicions de Protecció Contra Incendis de Barcelona"* from 2008 (ORCPI/08). The previous mandatory framework included the *"Norma Bàsica de l'Edificació - Condicions de Protecció Contra Incendis*" from 1996 (NBE-CPI/96) and the 1997 *"Ordenança Reguladora de Condicions de Protecció Contra Incendis de Barcelona* "(OMCPI/96).

Although the two frameworks (CTE and NBE-CPI/96) are different, they have very similar safety requirements for building users. This is because the regulatory change was not intended

to make the new framework more restrictive but to introduce a shift in approach. The NBE-CPI/96 was primarily based on prescriptive requirements, defining specific solutions that had to be implemented. In contrast, the DB-SI adopts a performance-based approach, establishing safety objectives to be achieved and allowing for greater flexibility in construction solutions, provided that the objectives are met.

The regulatory change also brought updates to material classifications. The NBE-CPI/96 used a national classification system for fire reaction of materials (M0, M1, M2, etc.), whereas the DB-SI adopts the European classification (Euroclasses: A1, A2, B, C, D, E, F), which is more comprehensive, precise, and allows for European-wide comparisons. This classification is based on standardized European tests (UNE EN standards).

The same applies to the fire resistance of construction elements. The DB-SI adopts European criteria for fire resistance (R, EI, REI), defined by resistance times in minutes (e.g., REI 60 means resistance for 60 minutes). These criteria are also based on European test standards (UNE EN).

Lastly, the basic documents of the CTE are periodically reviewed and updated to adapt to technical advancements and new societal demands. In contrast, the NBE-CPI/96 was more static and did not undergo modifications.

The update of the Ordenança Reguladora de Condicions de Protecció Contra Incendis de Barcelona was necessary to harmonize it with the CTE.

The motivation for conducting this study on the building's fire safety measures was to verify whether users were engaging in activities safely. The concern was not about regulatory changes rendering the building unsafe but rather about the dynamic nature of sports facilities. Over the years, small modifications in the use of spaces—such as converting an activity room into a gym or a storage area into an activity room—often result in unauthorized changes, such as opening doors where they shouldn't be or removing fire extinguishers and fire hose reels (BIE) that are considered obstructive. Such changes inadvertently reduce the center's safety measures.

The primary aim was to determine if the building was safe for its users and whether the findings could be extrapolated to other sports facilities in the city.

2. OBJECTIVES

The objective is to improve, if necessary, the safety measures for users of the sports center and to reduce the risk of harm from an accidental fire to acceptable limits, considering the building's construction characteristics, the uses of each space, its installations, and the maintenance of both the building and its installations.

The building under study was constructed between 1980 and 1992. Over the years, modifications, expansions, and renovations have altered the initial configuration of uses, spaces, and services, which may have reduced the safety measures of the building and, consequently, for its users, increasing the risk of an accidental fire.

The objective of the study is to determine to what extent safety measures for users may have diminished and, if necessary, to establish a periodic procedure for fire safety audits in sports facilities to prevent this decline.

To achieve this objective, it will examine whether the current building complies with all sections of the basic document on fire safety from the *CTE* and some sections of the basic document on safety in use. It will also review whether any articles from *ORCPI/08* apply.

If non-compliances are identified, I will propose corrective measures and assess their cost.

Currently, there is no regulation requiring a comprehensive study of the fire protection conditions of the building, as no rehabilitation, expansion, or renovation is being carried out. The center has a maximum occupancy of less than one thousand people, so it is not obligated to review its emergency plan every four years.

As explained previously, this study is conducted to determine whether an older sports facility, subject to multiple modifications, continues to ensure user safety forty years after its construction.

3. METHODOLOGY

3.1. PHASES OF THE STUDY ON FIRE SAFETY MEASURES FOR AN EXISTING SPORTS FACILITY

The first phase of the study involved defining its objectives and scope. Subsequently, it has been conducted a thorough collection of available information about the building, utilizing resources from the "*Arxiu Contemporani de l'Ajuntament de Barcelona"*, the archive of the "*Institut Barcelona Esports"*, and information provided by the sports center manager.

At the "*Arxiu Contemporani de l'Ajuntament de Barcelona"*, it has been searched for all construction and activity licenses related to the sports center, including those for the initial construction, expansions, and renovations conducted over the years. It was expected to find the construction projects for each phase, detailing the architectural solutions designed and the justification for the applied regulations. While some projects were found, not all were available.

In the archive of the "*Institut Barcelona Esports"*, it looked for projects from interventions carried out in the last five years and graphical documentation of the center.

The manager provided the most recent documentation, including periodic reviews of the fire protection systems, the certificate for fireproofing the lightweight pavilion roof structure, and the most updated plans in AutoCAD format.

It has been reviewed the documents and plans to identify construction systems, materials used, and installations implemented, as well as the regulations applied during each construction phase. Subsequently, several inspections of the facility has been conducted to verify whether the actual construction matched the descriptions in the projects and plans. The location of all installations has been checked too.

It has been updated the plans to reflect all distributions, uses, and installations that did not match the actual conditions.

After analyzing the construction projects, licenses, and other relevant documents obtained, it has been observed that while compliance with fire protection regulations was justified for each modification, expansion, and renovation, there is no comprehensive study evaluating the entire facility to provide an overall view of regulatory compliance.

In Sections 4, 5, and 6, as well as in the graphical documentation in appendix 1 of this study, it has been detailed the analysis of compliance with current regulations, including the identification of existing deficiencies and proposed corrective measures necessary to ensure the safety of users in potential emergency situations.

3.2. GRAPHIC DOCUMENTATION

As previously explained, although the facility manager provided with plans of the center, certain door distributions has been modified, uses, and fire protection installations to establish a solid and accurate base for starting the study.

Once it had been updated plans reflecting the actual layout of the center, it has worked on them to determine how to compartmentalize the building into fire sectors with a surface area of less than 2,500 m² (to comply with regulations) while minimizing sectorization non-compliances. In the end, three fire sectors have been defined, which are detailed and explained in Section 4.1.1, as well as in Plan 1 of sectorization found in appendix 1 and Figure 6.

After defining the fire sectors, it has been measured the usable surface areas of each zone with a distinct use within the center. This surface data was necessary for calculating occupancy in Table 13. The results of these occupancy calculations were illustrated in Plan 2 of evacuation. Using these calculations, it has been measured evacuation routes from every evacuation origin to a floor or building exit to verify compliance with the *CTE* (this analysis is explained in Section 4.3 of this project).

Once all of this was completed, possible blockage scenarios has been considered on the plans to measure evacuation routes and calculated occupancy to verify compliance with regulations.

Figure 4 presents a detail of Plan 2 of evacuation, located in appendix1. In this plan, it is included: the surface area of each space with a distinct use, the maximum occupancy of each space, evacuation origins, evacuation routes, alternative evacuation routes, blockage

hypotheses, the maximum capacities of building exits, the capacity for a normal evacuation, and the capacity in case of a blockage at one of the exits of the same enclosure.

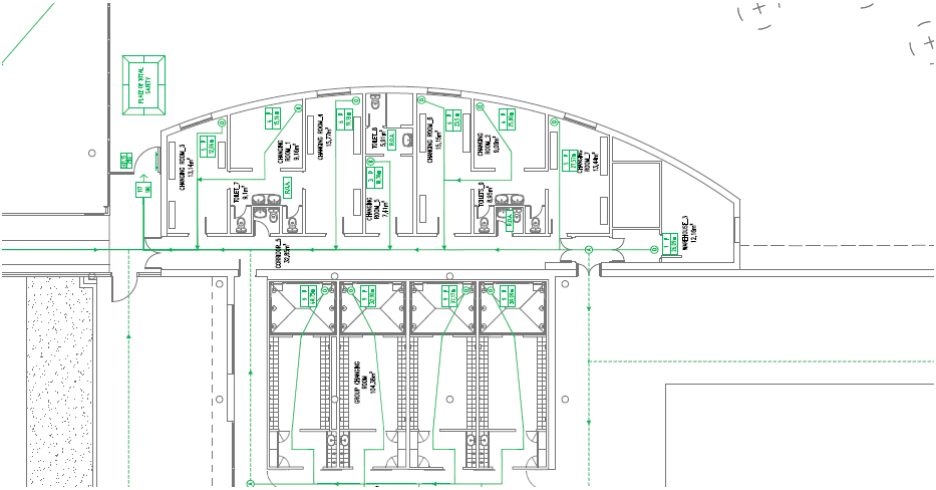

Figure 4. Details of plan 2

To create plan 3 of the installations, visual inspections of the location of existing fire protection installations has been conducted, comparing them with the graphical documentation archived. Once their locations were confirmed, the distances covered by each extinguisher and each fire hose reel (BIE) has been measured.

For the extinguishers, it has been drawn a circle with a 15-meter radius centered on each extinguisher and repeated this process for all existing extinguishers. The installation is considered covered if all the circles touch or overlap. In areas where this condition was not met, the location for a new extinguisher has been marked. Figure 5 provides an example of this procedure, where the larger semi-circle represents the coverage area of the extinguisher.

For the BIEs, it has been followed a similar approach but measured a distance of 20 meters from the BIE (represented as an initial 20-meter radius circle, not drawn), which corresponds to the hose length, followed by an additional 5-meter circle from that point, representing the nozzle reach of the BIE. The total area covered by a BIE is the combined area of these circles. This

process to all existing BIEs has been applied, and in areas not covered, it has been proposed to install a new BIE. Figure 5 shows an example of this process.

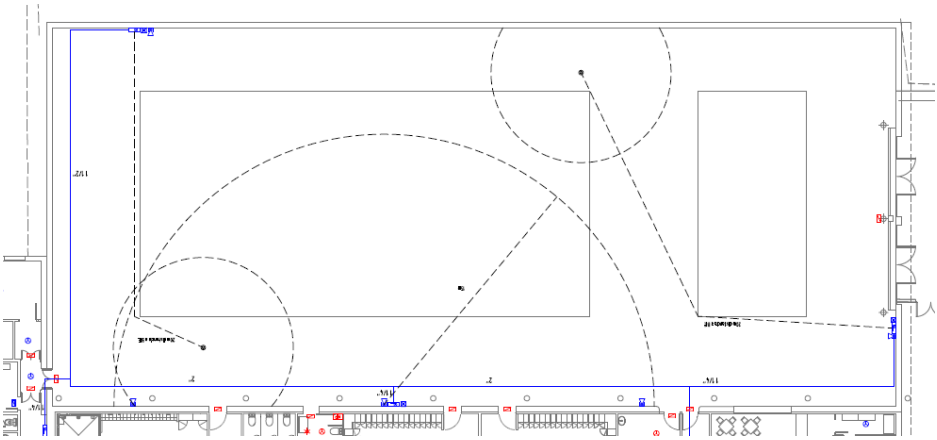

Figure 5. Details of plan 3

The same process has been done with the detectors that needed replacement because they were expired, as well as with the fire alarms.

It has been mapped the missing emergency lights along the evacuation routes.

3.3. CALCULATIONS PERFORMED

In this study, two types of calculations have been done: one to determine the maximum allowed occupancy in each space, each building exit, and the facility as a whole, and the other to economically assess the corrective measures proposed.

3.3.1. Occupancy Capacity Calculations

To calculate the occupancy capacity of each space, it been used the occupancy densities that must be met according to the regulations and measured the usable surfaces of each space on the plans. The calculation is straightforward: the regulations specify the maximum number of people per square meter based on the use of each space. Table 9 provides the calculation for some spaces as an example.

Table 9. Example calculation of capacity table

Description	Usable Area	Occupancy Density [m2/person]	Maximum Capacity
Reception	3,40	2,0	2
Administration	14,89	10	2
Leisure Area	8,66	5	2
Stands	147,50	0,5	295

It has been calculated the maximum number of people who can evacuate through the exits based on the actual width, which it has been verified through measurement, and the CTE formula that relates the door width (A) to the maximum evacuation capacity (P). This formula also specifies that the minimum width of any door must be 0.80 m.

For example, if evacuation exit 1, which is the main access to the center, has a width of 1.95 m, applying the formula gives an evacuation capacity of 390. Table 10 provides examples of the evacuation capacities for some of the building's exits.

Table 10. What the evacuation exit calculations indicate

$A \geq P/200 \geq 0{,}80$ m

Exit Number	Width (m)	Evacuation capacity (people)
1	1,95	390
2	0,80	160
4	2,00	400
5	2,00	400

To verify whether the corridors have sufficient evacuation width, the calculation is performed using the same formula as for doors, but the minimum width of a corridor is 1 m. If we perform the calculation for a corridor with a width of 1 m, it can evacuate 200 people.

Once the three results were obtained, it has been simulated emergency situations in spaces with multiple exits to verify whether, in the event of one exit being blocked, users could safely evacuate through the other and reach a secure outdoor area. To carry out these verifications, it has been calculated and ensured that all doors and corridors leading to the outdoor space had

dimensions sufficient for the number of people to be evacuated. This calculation is referred to as the "blockage hypothesis calculation."

3.3.2. Economic Assessment of Corrective Measures

To carry out this economic assessment, I used a software program called "*Temps, Cost, Qualitat* "(TCQ). *TCQ* is a computer system designed to support the drafting, monitoring, and control of construction projects and works. It has been used it because it is associated with the ITEC price database and includes the composition of the construction elements of a project.

The software works in a tree structure where you first select the chapter of the work and then the activities within the chapter. For example, the first non-compliance that was identified it was to replace a door connecting two fire sectors with one that provides fire tightness (E) and thermal insulation (I) for 60 minutes (EI_2-60 C5).

I started by searching for the sectorization chapter, then closures and partitions, followed by fire doors, and then swing fire doors. From the list provided, I searched for one with the characteristics I needed: metal, EI_2-60 C5, dimensions 100x210 cm, and whether installation was required. I could also specify if construction work was needed. Once all selections were made, the program detailed the "*preu d'execució material*"(PEM) and all the activities necessary to complete the door replacement.

Table 11 provides an example of the activities and expenses evaluated by TCQ when selecting to replace a metal fire door, EI2-60 C5, single-leaf swing, with dimensions 100x210 cm, high price, with a window, installed.

Table 11. Valued Activities: Metal Fire Door, EI2-60 C5, single-leaf swing, for an opening of 100x210 cm, high price, with a window, installed.PAS2-5REM € 602.05"

Code	Description	Preu		Quantitat		Import
A012F000 A0F-000P	First-Class Locksmith	29.06 €/ h	x	0.375 h	=	€ 10.90
BASA71L7 BAS1-0IFI	Metal Fire Door, EI2-C 60, single-leaf swing, for an opening of 100x210 cm, high price, with a window	590.88 € / u	x	1 u	=	€ 590.88
A%AUX001 A%AUX001	Overhead cost	10.90 €	x	0.025	=	€ 0.27

To determine the final value of an item, the "*preu d'execució material*"(PEM) must be increased by 13% for general expenses, 6% for industrial profit, and 21% VAT. Typically, this calculation is performed at the end of the entire budget, not item by item.

In appendix 2, detailed budgets for the identified non-compliances have been included.

4. ANALYSIS OF COMPLIANCE WITH THE BASIC DOCUMENT ON FIRE SAFETY OF THE CTE.

This section aims to thoroughly evaluate whether the sports facility complies with the technical fire safety specifications outlined in the six sections of the "*document bàsic SI"* of the CTE.

To achieve this objective, detailed inspections of the installations were conducted, the available technical documentation was analyzed, and the results obtained were compared with the requirements established in the current regulations. Through this analysis, the strengths and weaknesses of the existing fire protection system were identified, and corrective measures were proposed to ensure the safety of people and property. .

4.1. SECTION 1: INTERIOR PROPAGATION

Section 1 of the "*document basic"* from the "*Código Técnico de la Edificación"* establishes the minimum safety conditions that the sports facility must meet to prevent the risk of fire propagation within its interior.

To mitigate this risk, the building must be compartmentalized into fire sectors based on its use and surface area. Additionally, areas of special risk, such as the electrical panel room and the machine room, must be separated from the rest of the fire sectors. This compartmentalization must also be maintained in concealed spaces such as false ceilings.

4.1.1. Compartmentalization into Fire Sectors

When establishing the conditions for compartmentalization into fire sectors, according to the *CTE*, sports use falls under the category of public access use. Our building conducts all its activities on the ground floor. Consequently, the fire sectors of the building must meet the following conditions:

- The total constructed area of each sector must not exceed 2,500 m².
- The fire resistance of the walls and ceilings delimiting the fire sector must maintain smoke tightness (E) and thermal insulation (I) for 90 minutes (*EI90*).

Following this criterion, our building is divided into three fire sectors, which we will name:

- Sector 1: Comprising the reception area, locker rooms, activity rooms, and indoor pool.
- Sector 2: Comprising the pavilion.
- Sector 3: Comprising the technical room.

In Figure 6, the considered fire sectors can be seen The plan is included in Appendix 1.

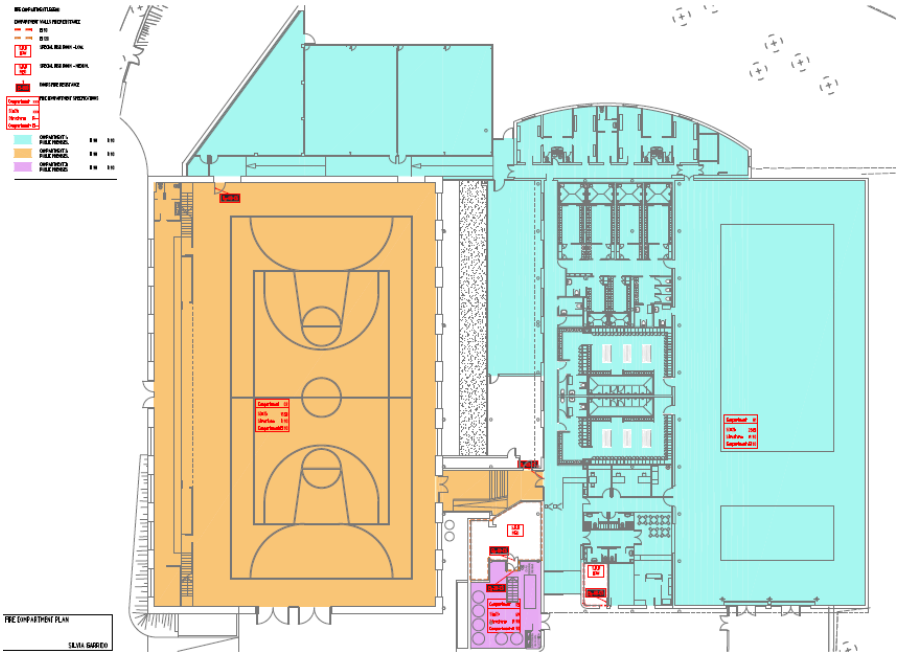

Figure 6 Considered Fire Sectors

Table 12 summarizes the building's fire sectors, as well as their load-bearing resistance (R), thermal insulation (I), and smoke tightness (E) as specified by the CTE for a public access activity conducted on the ground floor. I have also included the actual R and EI values of the defined sectors based on the characteristics of the construction materials. Lastly, a column indicates whether the sector complies with the regulations.

Table 12. Fire sectors of the Sports Center

Name	Regulatory			Current Setup			Compliance SI 1
	Maximum Surface[m^2]	R	EI	Surface [m^2]	R	EI	
Sector 1	2.500	90	90	2.383	180	180	YES
Sector 2	2.500	90	90	1.533	180	180	YES
Sector 3	2.500	90	90	69	180	180	YES

According to the technical documentation reviewed and the site visits conducted, it has been verified that the partition walls for fire sectors 1, 2, and 3 are made of perforated brick with a thickness of 140 mm and a 15 mm mortar render on both sides. According to the *CTE*, with these characteristics, the walls have an *EI-180 minutes* rating, exceeding the *EI-90* requirement set by the *CTE*. Therefore, they comply.

The columns that are part of these fire compartmentalization walls are made of reinforced concrete, with a minimum column dimension of 350 mm and a minimum covering of 50 mm. According to the *CTE*, a column with a dimension of 350 mm and a minimum covering of 40 mm achieves an *R-180 minutes* rating. Therefore, they also comply.

Despite the above, there are two communication points between Sector 1 and Sector 2 where the compartmentalization is breached. These points are the door that connects the pavilion with the corridor leading to the activity room and a window located on the same wall. These two locations are highlighted in Figure 7.

All the documentation available has been reviewed and found no document justifying the *EI* rating of the door or the window. Additionally, neither the door nor the window has any technical specification plate indicating their level of thermal insulation (*I*) or smoke tightness (*E*). Therefore, to comply with the *CTE*, these elements must be replaced with ones that meet the required *EI* rating and can be verified.

Specifically, a glass window with an *EI-90* rating and a door with an *EI2 45-C5* rating (flame and gas tightness and thermal insulation for 45 minutes) must be installed.

In Figure 7, the elements that need to be replaces are in a red box.

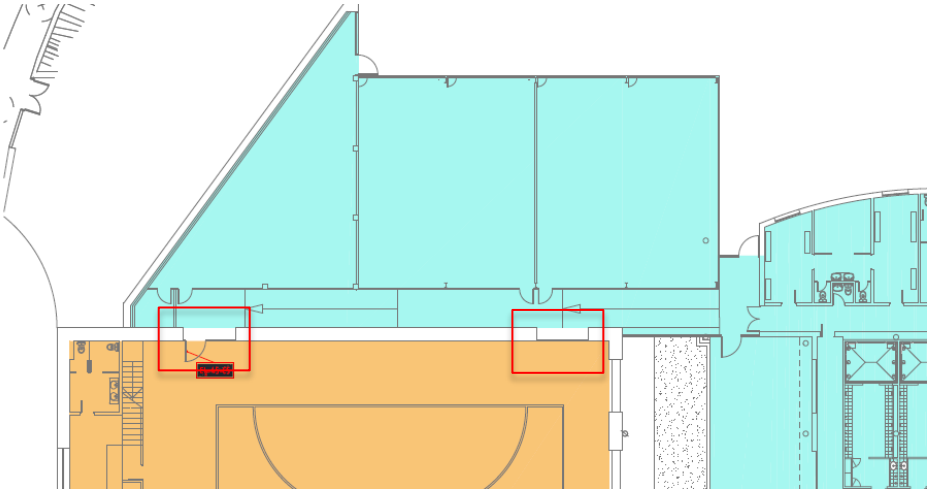

Figure 7. Identification of Elements to be replaced

Work Execution Procedure

1. Dismantling the Existing Elements

The first step is to carefully dismantle the two frames to be replaced using manual tools, ensuring that the surrounding walls are not damaged.

2. Preparing the Openings

After removing the frames, the openings will be adjusted as needed. For the door, the opening will be reduced by constructing a ceramic masonry wall with one visible face, using bricks of the same characteristics as the existing ones. The side of the wall facing the interior of the pavilion will be plastered and painted in the same color as the existing wall.

Note: It has been decided to make the door smaller to standardize its dimensions, allowing for a more economical replacement.

3. Installing the New Frames

Once the preparation work is completed, the new frames will be installed. The metal fire door will have a fire resistance rating of *EI_2-60-C5*, and the window will have a rating of *EI-90*.

4. Final Cleaning

A final cleaning of the affected area will be carried out to complete the work.

Economic estimate of the work

As explained in the methodology, it has been prepared a budget using the TCQ software, based on the price database of the "*Institut de la Tecnologia de la Construcció de Catalunya" (ITEC)*, to economically assess the cost of the work.

In appendix 2, there is a table with the prices for each item, broken down by chapter. The total cost of this intervention is €22,230.57, VAT included.

4.1.2. Special Risk Areas

According to the CTE, it is considered that the sports facility has the following special risk rooms or areas:

- Main electrical panel room: It will be considered a low-risk special area.
- Boiler room: It will be considered a medium-risk special area, as the installed power is greater than 200 kW but less than 600 kW.

In Figure 6, their location is indicated.

Therefore, the main electrical panel room, as a low-risk special area, must have a load-bearing structure with fire resistance of 90 minutes (R90), walls and ceilings with smoke tightness and thermal insulation for 90 minutes (EI90), and doors with a classification of at least EI_2 45-C5 (flame and gas tightness and thermal insulation for 45 minutes).

The boiler room, as a medium-risk special area, must have a load-bearing structure with fire resistance of 120 minutes (R120), walls and ceilings with smoke tightness and thermal insulation for 120 minutes (EI120), and it must also have an independent vestibule connecting it to the rest of the building, with both doors having a classification of at least EI_2 30-C5 (flame and gas tightness and thermal insulation for 30 minutes).

According to the technical documentation reviewed and the site visits conducted, I verified that the partition walls of both special risk rooms are also made of perforated brick with a thickness of 40 mm and a 15 mm mortar coating on both sides, which, according to the CTE, has an EI 180 minutes rating. Therefore, they comply.

The columns are also made of reinforced concrete with a minimum column dimension (support) of 350 mm and a minimum covering of 50 mm. According to the CTE, a column of 350 mm with a minimum covering of 45 mm achieves an R 180 minutes rating (R180). Therefore, they comply.

Below, Table 13 provides a summary of the regulatory characteristics required for the two special risk rooms, the actual characteristics based on the construction materials, and whether or not they comply with the CTE.

Table 13. Summary of the Regulatory Compliance for Special Risk Rooms.

Name	Risk Area	Risk Class	Surface (m^2)	Regulatory		Current Setup		Compliance
				R	EI	R	EI	
LR 1	Boiler Room	LRE mig	49	120	120	180	180	YES
LR 2	Electrical Panel Room	LRE Baix	13	90	90	180	180	YES

4.1.3. Concealed Spaces

The fire compartmentalization of occupiable spaces will continue into concealed spaces, such as false ceilings, cavities, raised floors, etc.

The required fire resistance of fire compartmentalization elements will also be maintained at points where these elements are penetrated by installation components such as cables, pipes, conduits, ventilation ducts, etc.

In this sports facility, I verified during the site visit that compartmentalization in concealed spaces is ensured through the following systems:

- Electrical Trays: The passage holes for electrical and telecommunications trays that connect rooms, electrical panels, and the rest of the building are sealed with intumescent bags or mortar to maintain the required thermal insulation (I) and smoke tightness (E).

- Ventilation Ducts: There are no ventilation ducts crossing fire sectors.

4.2. SECTION 2: EXTERIOR PROPAGATION

This section establishes the minimum safety conditions that the facility must meet to prevent the risk of fire spreading to neighboring buildings from a fire originating within the facility.

To mitigate this risk, the separating wall between the two activities must have specific *EI* characteristics, and there must also be a separation distance between the openings of our building and those of neighboring buildings. This distance depends on the angle formed by the two façades. This exterior propagation must also be considered between two fire sectors within the same building.

4.2.1. Facades and party walls

It has been verified that, at the façade level, the minimum regulatory separations are met, which are as follows:

To limit the risk of horizontal exterior fire propagation through the façade between two fire sectors, the points on their façade that are not at least *EI 60* must be separated by the distance *d* in horizontal projection, depending on the angle of the intersection between the two fire sectors. The Figure 8 illustrates the distance requirement based on the angle.

α	0º(1)	45º	60º	90º	135º	180º
d (m)	3,00	2,75	2,50	2,00	1,25	0,50

(1) Refleja el caso de fachadas enfrentadas paralelas

Figure 8: Required Separation Distance Between Two Openings of Two Fire Sectors.

The sports center has an irregular shape and is not adjacent to any neighboring building; therefore, it complies with this section on exterior propagation concerning neighboring buildings.

4.3. SECTION 3: EVACUATION OF OCCUPANTS

This section justifies compliance with the conditions that the general design of the sports center must meet to ensure the proper evacuation of all its occupants in the event of a fire.

4.3.1. Compatibility of Evacuation Elements

The sports center is classified as a public access facility and is not integrated into a building with another use. Therefore, it does not share any evacuation elements with other activities.

Its evacuation elements are independent of those in nearby buildings, and in the methodology section, I explained how I calculated that they have the minimum dimensions necessary to evacuate the facility's users in the event of an emergency.

4.3.2. Occupancy Calculation

Occupancy of Spaces

According to the CTE, the projected occupancy for each room in the building is indicated in Table 13 of appendix 3. It should be noted that the occupancy of alternative occupancy rooms (*ROA*) and zero occupancy rooms (*RON*) is not counted for calculation purposes, meaning they will not have occupancy unless it originates from another room. Thus, even if occupancy shifts between rooms, the overall building occupancy remains unchanged.

Circulation spaces, subscriber locker rooms, restrooms, and the pool deck are considered alternative occupancy rooms, as they will be used by individuals already counted in other areas of the building.

For group locker rooms, a density of 1 person per 3 m² has been applied due to their high occupancy, particularly during peak times when children using them are not counted in other areas of the building.

In the directed activities room, a density of 1 person per 5 m² has been applied, as the activities conducted there have a capacity limit.

For the seating area in the stands, where people may be seated, the occupancy density for spectator spaces without defined seating of 1 person per 0.5 m² has been applied, as established by the *CTE*.

The results of the calculations, including the total occupancy of the building, can be found in Table 14 in appendix 3. Below is a fragment of the table as an example:

Table 14. Calculation of occupancy for the Sports Center

Name of Zone	Usable Area	Density (m2/person)	Occupancy
General Access and Pavilion Access	100,9	-	ROA
Reception	3,40	2,0	2
Hallways_1, 2, 3, 4, and 5	193,05	-	ROA
Pool Deck	596,35	-	ROA
Multipurpose Court	1297,39	5	260
Directed Activities Room_1	126,39	5	25
Directed Activities Room_2	97,32	5	20
Fitness Room_1	180,82	5	37
Fitness Room_2	126,07	5	26
Service_1, 2, 3, 4, 5, 6, 7, 8 & 9	75,83		ROA
Pool Basin_1	75	2	38
Pool Basin_2	312,50	2	157
Locker Room_7	13,44	3	5
Subscriber Locker Rooms_1 & 2	186,8	.	ROA
Group Locker Rooms	104,38	3	36
Family Locker Rooms	25,81	3	9
Adapted WC_1 and 2	9,9	-	ROA
Total Occupancy			963

Regardless of the location of the building's occupants and always considering possible alternative occupancies, the total projected occupancy of the building will be 963 people.

Evacuation Origin

According to the *CTE*, any occupiable point in the building is considered an evacuation origin (including occupiable points in special risk rooms and zero occupancy rooms, although these are not included in the calculation of evacuation height or occupancy). Exceptions are spaces where the occupancy density does not exceed 1 person/5 m² and the area is less than 50 m²; in these cases, the evacuation origin will be located at the door of the room.

As explained in the methodology, I identified all evacuation origins on the plans and measured the distances from these points to the building and floor exits to verify compliance with this requirement. It has been also ensured that if the evacuation route to the exit exceeded 25 m, an alternative evacuation route was available that complies with the *CTE*, with the total route being less than 50 m.

All these calculated routes are shown in the plans 2 in appendix 1. As a result, it can be stated that the building complies.

Number of Exits and Evacuation Route Lengths

Regarding the exits of the various rooms, it has been considered the intended use of the occupied spaces and the number of occupants to determine whether one or more exits are required.

In rooms or floors with a single exit, no evacuation route to a floor exit exceeds 25 m. In rooms or floors with more than one exit, no evacuation route to a floor exit exceeds 50 m, and no route from an evacuation origin to a point where at least two alternative routes are available exceeds the maximum permissible length for a single exit. Therefore, compliance with the *CTE* is ensured.

As explained in the previous section, the calculations performed and the justification for compliance are illustrated in the plans attached in appendix 1.

4.3.3. Sizing of the Evacuation Means

According to the *CTE*, the sizing of exits must allow for the evacuation of an entire floor, even if one of the exits is blocked (in cases where more than one exit is required). Thus, each floor exit must accommodate the evacuation of the people normally assigned to it, plus the additional people who would need to evacuate through these exits if one of the other exits were blocked.

Regarding the sizing and capacity of doors, passageways, corridors, and ramps, they must comply with the following:

Table 15. Sizing and Capacity of Doors, Corridors, Ramps, and Stairs

Types of General Elements	Size
Doors and Passageways	$A^a \geq P^b/200 \geq 0.80$ m Minimum door leaf width: 0.6 m - 1.23 m
Corridors and Ramps	$A^a \geq P^b/200 \geq 1.00$ m

(a) A= A = width (in meters) of the element.
(b) P= Total number of people expected to pass through the point where the width is being sized

Thus, the capacity of the doors, passageways, etc., will ensure the proper evacuation of the building, even under the hypothesis of a blockage of one of the other exits.

After measuring all doors and passageways on-site and mapping or correcting these measurements in the plans included in appendix 1, it can be concluded that the evacuation elements of the facility are correctly sized and therefore comply with the *CTE*.

Room/Building Exits

To verify compliance with this section, I first numbered all the floor (building) exits in our facility. Then, I measured their widths and calculated the evacuation capacity of each exit based on Table 14. Subsequently, using the occupancy calculations for each space, as listed in Table 13, it has been assigned the occupants who would use each exit in the event of a fire (planned evacuation). The assignment of occupants, according to the *CTE*, is based on proximity.

Once the normal evacuation scenarios were established, it has been conducting blockage hypotheses, which involve studying what would happen if one of the exits were blocked by the fire. In this case, the occupants who would have used the blocked exit would need to proceed to the next closest exit. It must then be verified whether this alternate exit has the capacity to

handle the planned evacuation plus the additional occupants redirected from the blocked exit. As in the previous case, assignments are always made based on proximity.

This entire analysis is documented in the plan 2 in appendix 1, where each floor exit is marked with its dimensions, evacuation capacity based on its size, planned evacuation, and evacuation under the blockage hypothesis. Table 16 provides a summary of all these calculations. As can be observed, all exits comply with the *CTE*.

Table 16. Number and Sizing of Exits Applying Blockage Hypotheses:

Exit No.	Width [m]	Planned Evacuation [person]	Evacuation with Blockage Hypothesis [person]	Evacuation Capacity [person]	Compliance
1	1.95	100	186	390	YES
2	0.80	2	Not applicable	160	YES
3	0.80	2	Not applicable	160	YES
4	2.00	99	198	400	YES
5	2.00	99	198	400	YES
6	1.15	86	189	230	YES
7	1.15	20	Not applicable	230	YES
8	1.20	148	148	240	YES
9	1.20	147	147	240	YES
10	3.35	130	278	670	YES
11	3.35	130	277	670	YES
Total Occupation		963			

Safe Outdoor Area

In the sports center, the outdoor spaces are those located in front of the building exits marked on the evacuation plan, as they comply with the *CTE* requirements, which are:

- In front of each building exit connecting to the safe outdoor area, there must be a space with a surface area not less than $0.5 \cdot P$ m² within a zone defined by a radius of $0.1 \cdot P$ from the building exit, where *P* is the number of people expected to evacuate through that exit.
- It allows access for firefighting services and assistance for occupants as needed.

- The building exits to this space are less than 60 meters from an intervention street.
- The minimum width of the passage from the intervention street is greater than 3.0 m (for the highest accessible roof more than 8 meters above ground level).

4.3.4. Staircase Protection

The only evacuation stairs in the building are the descending stairs connecting the stands with the court. Since the evacuation height is less than 10 m, according to the *CTE*, they do not require protection (compartmentalization). This means they can remain open stairs, as they are currently configured. Therefore, they comply with the current regulations.

4.3.5. Doors Located on Evacuation Routes

According to the *CTE*, doors designated as floor or building exits, as well as those intended for the evacuation of more than 50 people, must be swing doors with a vertical pivot axis. Their locking mechanism must either remain inactive while the areas to be evacuated are in use or consist of a device that can be easily and quickly opened from the evacuation side without the need for a key and without requiring action on more than one mechanism.

Any exit door must open in the direction of evacuation if:

- It is intended for the passage of more than 100 people.
- It serves more than 50 occupants in the room or space where it is located.

After calculating the occupancy of each space in the center, I inspected the entire facility and verified that all doors in spaces intended for the evacuation of more than 50 people, or more than 100 sequentially, open in the correct evacuation direction.

Together with the facility manager, we activated the alarm system to verify the operation of the center's only automatic door and found that it remained closed, which does not comply with the regulations.

Considering that this non-compliance occurred at the main access door, through which most people would attempt to exit in an emergency, it was deemed critical to address this deficiency promptly. With the manager's permission, it has been contacted BERINI, the company responsible for maintaining the facility's fire protection systems, and arranged a joint visit to recheck the door's operation.

During the visit, we reactivated the alarm and confirmed that the automatic door closed. Alfonso, a BERINI technician, explained that the issue was likely due to a misconfiguration of the control panel. Fortunately, this repair was covered under the maintenance contract and could be resolved within two weeks at no additional cost to the center.

The repair was completed as agreed, and the center now complies with the regulations

4.3.6. Signage of Evacuation Routes

It has been verified that the current signage in the center complies with the *CTE* and uses the evacuation signs defined in the UNE 23034:1988 standard.

4.3.7. Smoke Control in Case of Fire

The sports center, classified as a public access facility with a maximum projected occupancy of 963 people (less than 1,000), does not require a smoke control system in case of fire according to the *CTE*. The center does not have such a system and therefore complies with current regulations.

4.4. SECTION 4: INSTALLATION OF FIRE PROTECTION SYSTEMS

According to the *CTE* and given that the building is classified as a public access facility, it must have the following fire protection equipment and systems: hydrants, extinguishers, BIEs, fire detectors and alarms, fire water systems, emergency lighting, and signage.

During various inspections, it has been verified the existing installations, their locations, and their condition. Subsequently, the regulatory inspections carried out and the installation certificates has been verified.

During the document review process, it has been found that the fire detectors were expired. According to the Fire Protection Systems Regulation (*RIPCI(14)*), these detectors must be replaced every 10 years. However, the system is functioning correctly and has a valid certificate from the last maintenance inspection.

In appendix 2, I included the detailed budget for all the missing fire protection systems. The budget is based on the price database of the "*Institut de la Tecnologia de la Construcció de Catalunya" (ITEC)*. The total cost for all items is €47,489.17 VAT included.

4.4.1. Exterior Hydrants

The facility has an exterior hydrant with a minimum flow rate of 1,000 l/min and an outlet pressure for each hydrant nozzle exceeding 102 kPa, as required by the regulations. It complies.

4.4.2. Portable Fire Extinguishers

According to the *CTE*, there must be a 21A-113B fire extinguisher *("The letter A indicates the extinguisher's effectiveness in extinguishing fires of solid materials, such as wood, paper, textiles, etc. The higher the number, the more intense the fire it can extinguish. The letter B indicates the extinguisher's effectiveness in extinguishing fires of flammable liquids, such as gasoline, oil, paint, etc. The number 113, as with the previous case, indicates the extinguisher's higher capacity to extinguish such fires*") every 15 meters along the evacuation route from any evacuation origin.

After verifying on-site the location of the existing extinguishers, I measured on the plans to see if they cover the entire surface area of the center. In section 3.2 of the methodology, I explained how I did this.

The conclusion is that 19 21A-113B powder extinguishers are missing to cover the entire surface of the center; therefore, it does not comply with the *CTE*.

In Appendix 2, I included the detailed budget for all the missing fire protection installations. The material execution price (PEM) for each 6 kg 21A-113B powder extinguisher is €48.73.

Additionally, a 5 kg CO2 extinguisher needs to be installed next to the facility's installation room where the main protection panel is located. The PEM for this extinguisher is €82.48.

4.4.3. Equipped Fire Hose Reels

After verifying the location of the existing BIEs on-site, and based on measurements on the plans, they do not cover the entire surface area of the center. In section 3.2 of the methodology

is well explained but, to summarize, the maximum distance between each equipped fire hose reel (BIE) and the next closest one must be no more than 50 meters. The distance from any point in the center to the nearest BIE cannot exceed 25 meters.

The conclusion of the study is that 8 BIEs are missing to cover the entire surface of the center; therefore, it does not comply with the *CTE*.

It will be necessary to install 3 BIEs in plastic cabinets with plastic doors in the covered pool area, as it consideres they offer greater resistance in this humid environment. Each 25 mm diameter BIE (BIE-25), consisting of a plastic cabinet and door, a 20 m hose for surface mounting, including the proportional part of accessories and all small auxiliary connection and assembly materials, has a material execution price (PEM) of €430.60 each.

In the other areas where 5 more BIEs are needed, it proposes installing the same BIEs but in stainless steel cabinets and doors, with a material execution price (PEM) of €425.90 each.

To install a BIE, in addition to the cost of the BIE and its cabinet, the cost of the fire water distribution network from the nearest BIE to the new location must be added. As shown in the figure, to install the BIEs in the pool area, it is necessary to extend the distribution network passing through the reception area. This existing network has a general diameter of 2 inches and is reduced to 1.25 inches when it branches off to a BIE. Figure 9 shows a detailed view of the network expansion that would be necessary.

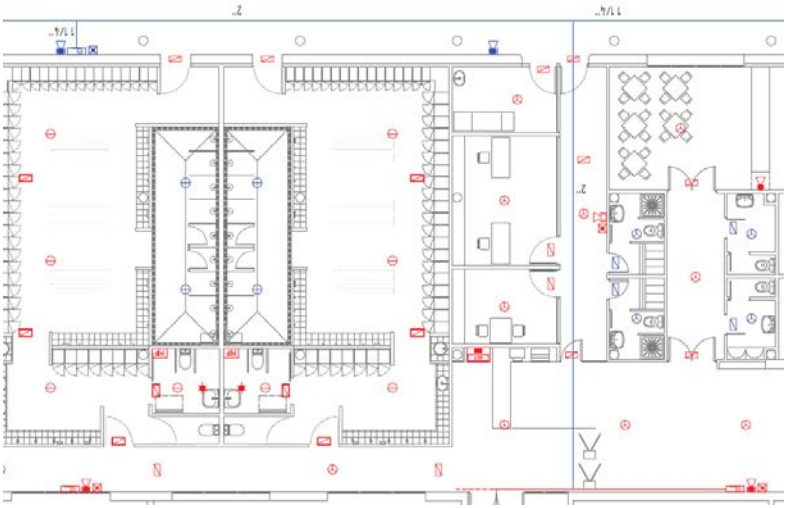

Figure 9 Detail of the Network Expansion for BIEs

The plans for the expansion of the fire water distribution network and the corresponding diameters are graphed. In appendix 2, within the budget, there are 3 entries for the distribution network, one for each water pipe with different diameters.

4.4.4. Fire Water Supply

The fire water supply system of the center is provided through the public network with a specific supply. It complies with the *CTE*.

4.4.5. Fire Detection and Alarm System

According to the *CTE*, the installation of a fire detection and alarm system is required for the center.

The center currently has acoustic and visual alarm devices, as well as a detection panel and fire detectors. However, upon reviewing the system's documentation, I found that it was installed more than ten years ago. According to the Fire Protection Systems Regulation (*RIPCI*), the detectors have expired (they expire every 10 years) and need to be replaced, even though they

are functioning correctly and have passed regulatory inspections. Therefore, it does not comply with the current regulations.

It is essential to install new detectors throughout the facility, except in the locker rooms that were renovated in 2020. I propose installing optical smoke detectors in most areas, except in the locker rooms, where I recommend installing thermovelocimetric detectors, as optical ones could be falsely triggered by hot water vapor. In the pavilion, due to the large area and height, linear optical beam detectors need to be installed.

In the installation plan (Plan 3), you can consult the proposed locations for the detectors. This proposal was created by measuring the areas covered by each detector on the plans, following the recommendations of the UNE 23007 standard.

Regarding the pool area, I have not included fire detection systems, according to an exception in the *CTE*, which allows the omission of this installation in areas where there is no significant fire load. In these cases, it is only mandatory to have extinguishers every 15 meters.

Regarding the installation of alarm call points, they must be placed in such a way that the maximum distance to be traveled from any evacuation origin to a call point does not exceed 25 meters. After reviewing the current installation, I found that this requirement is not met, as there are 10 missing alarm call points. In Plan 3, I have included a proposed location for these call points, with the aim of complying with the *CTE*.

In the event of a fire detection or activation of an alarm call point, the panel will emit an acoustic and visual alarm signal to facilitate the evacuation of the building.

The material execution prices (PEM) for the detectors are:

- Optical smoke detectors: €57.91 each, with 40 units missing.
- Thermovelocimetric detectors: €52.64 each, with 14 units missing.
- Linear optical beam detectors: €1,151.46 each, with 3 units missing to cover the entire pavilion.

To install the detectors, in addition to the cost of the detectors themselves, the cost of extending the electrical installation to the detectors and the fire panel must be added. During the visit with BERINI, we confirmed that the panel did not need to be expanded, so only the cost of the wiring to the detectors and the necessary auxiliary means for installation, such as an

elevator for the detectors in the pavilion, need to be included. All of this is detailed in the budget in appendix 2.

4.4.6. Signage of Fire Protection Installations

It has been verified on-site that the signage for the manual fire protection installations complies with the requirements established in the Fire Protection Systems Regulation (RIPCI).

It will be necessary to signal the new equipment to be installed with different types of signs:

- Square 210x210 mm: For BIEs (equipped fire hose reels) and extinguishers.
- Rectangular 445x148 mm: To signal evacuation routes to emergency exits.
- Rectangular 297x148 mm: For emergency exits.

All models will be made of PVC panels, photoluminescent, and comply with the UNE 23035-4 standard.

The material execution price (PEM) for installing all the signs is €725.80. In appendix 2, you will find the breakdown of the three items. .

4.5. SECTION 5: FIREFIGHTERS INTERVENTION

In this section, it has been verified that the dimensions of the access roads and entryways to the facility are sufficient for a fire truck to reach the building. It has been checked that the surrounding area allows the fire truck to park.

4.5.1. Access Conditions to Buildings

The access road for firefighters must meet the following requirements, according to section 5 DB-SI of the *CTE*:

- Minimum free width: 3.5 m
- Minimum free height or clearance: 4.5 m
- Load-bearing capacity of the road: 20 kN/m²

In curved sections, the roadway will be delineated by the trace of a circular arc with minimum radii of 5.30 meters and 12.50 meters, with a free circulation width of 7.20 meters.

The sport facility complies it.

4.5.2. Surroundings and Accessibility Conditions for the Facade

Buildings with an evacuation height of less than 9 meters, like ours, are not required to meet the surrounding conditions or have openings on the facades.

The intervention can be carried out on flat ground through the building's doors.

4.6. SECTION 6: FIRE RESISTANCE OF THE STRUCTURE

According to the *CTE*, and given that it is a public access building with an evacuation height of less than 15 meters, the required fire resistance is as follows: for structural elements above ground level, at least R-90; for medium-risk special areas, R-120; and for low-risk special areas, R-90. In Table 17, I have summarized the fire resistance required by the *CTE* for each structural element of the sports center and the actual fire resistance of the structural element. It can be verified that all elements comply.

Table 17. Verification of the Fire Resistance of the Structure Required by the Regulations and the Actual Fire Resistance of the Sports Center

Name	Regulatory	Current Setup	Compliance
	R	R	
Sector 1	90	180	YES
Sector 2	90	180	YES
Sector 3	90	180	YES
LRE mig	120	180	YES
LRE Baix	90	180	YES

The main structural elements of all fire sectors are made of reinforced concrete with a minimum dimension of 350 mm and a minimum cover of 50 mm. According to the *CTE*, reinforced concrete structural elements with a minimum dimension of 350 mm and a minimum cover of 45 mm achieve an R-180 rating. Therefore, in the case of this study, we are above the regulatory requirement.

Regarding the lightweight roof structure of the pavilion, it is made of IPE360 metal profiles placed every 5.2 meters, and the roof cladding consists of galvanized corrugated sheets. Thus, it can be considered a lightweight roof (with a weight of less than 1 kN/m²).

According to the *CTE*, the main structures of lightweight roofs, which are not intended to be used in the evacuation of occupants and are located at a height of no more than 28 meters above the exterior ground level, can achieve an R-30 rating. In the case of this study, an R-30 rating has been achieved through the fireproofing of the lightweight roof structure with a fire-resistant coating. Therefore, **it complies** with the *CTE*.

5. ANALYSIS OF COMPLIANCE WITH THE BASIC DOCUMENT ON SAFETY IN USE AND ACCESSIBILITY OF THE CTE.

In this section, we will only verify compliance with the sections of the Basic Document on Safety in Use and Accessibility (SUA) that relate to fire safety.

5.1. SECTION 1: DISCONTINUITIES IN THE PAVEMENT

Here, it has been reviewed the compliance with this section because the continuity of the pavement is very important in case of an emergency during evacuation routes. In the event of an emergency, if the pavement has any discontinuity, it could delay the evacuations.

The *CTE* states:

"Except in restricted use areas, the pavement must meet the following requirements:

- *It must not have joints with a height difference of more than 4 mm. Protruding elements from the pavement level, small and localized (e.g., door thresholds), must not protrude more than 12 mm, and any protruding element that exceeds 6 mm in its faces facing the direction of circulation must not form an angle with the pavement greater than 45º.*
- *Unevenness not exceeding 5 cm must be resolved with a slope not exceeding 25%.*
- *In areas for pedestrian circulation, the floor must not have holes or gaps large enough for a sphere of 1.5 cm in diameter to pass through.*

When barriers are used to delimit circulation areas, they must be at least 80 cm high. In circulation areas, a single step or two consecutive steps are not allowed, except in the following cases:

- *In restricted use areas.*
- *In access and exit points of buildings."*

After checking, all the pavements are continuous and comply with this section.

5.2. SECTION 2: SAFETY AGAINST THE RISK OF IMPACT OR ENTRAPMENT

In this section, it has been verified that the users of the sports facility are not at risk of impact from fixed elements such as pipes, ventilation ducts, or operable elements like doors. And also, the possibility of entrapment with the manual sliding doors of the locker rooms.

5.2.1. Impacts

- Fixed Elements

The *CTE* states:

"The clear height of passage in traffic areas shall be at least 2.10 meters in restricted use areas and 2.20 meters in other areas. At door thresholds, the minimum height must be 2 meters clear.

Fixed elements protruding from the front part and positioned above traffic areas must be placed at a height of at least 2.20 meters.

In circulation areas, the walls will not have outstanding elements starting from the ground, which protrude more than 0.15 meters in the height area between 150 mm and 2200 mm, measured from the ground, and present a risk of impact."

After checking, the sports center complies with this section.

- Operable Elements

The *CTE* states:

"Doors located at the sides of corridors with a width of less than 2.50 meters must be installed in such a way that the door swing does not invade the circulation area."

Figure 10 shows the placement of the lateral doors as outlined by the *CTE*.

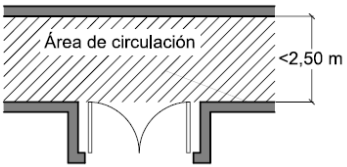

Figure 10. Placement of Lateral Doors in Evacuation Routes

In the inspections conducted at the facility, it has been verified that the center follows the law.

5.2.2. Entrapment

To prevent the risk of entrapment caused by a manual sliding door, including its opening and closing devices, the distance to the nearest fixed object must be at least 20 cm.

Automatic opening and closing devices must have appropriate protection devices based on the type of operation and must comply with the relevant technical specifications.

It has been verified that these doors are located in the group locker rooms and user locker rooms that were renovated in 2020. All the installed doors comply with the *CTE*.

5.3. SECTION 4: EMERGENCY LIGHTING

According to the *CTE*, the installation must have an emergency lighting system that, in case of failure of the normal lighting system, will provide the necessary illumination to ensure visibility for the occupants, allowing them to see the location of safety equipment, fire protection systems, and the evacuation routes to the exits.

The *CTE* states:

"The fixed emergency lighting installation must be equipped with its own energy source and will automatically activate in the event of a failure in the normal lighting supply.
A failure in the normal lighting supply is considered when the voltage drops below 70% of the nominal value.

The system will guarantee service for a minimum time of one hour from the moment of the failure of the normal lighting system.

During this time, the emergency lighting system will ensure:

- *At the locations of safety equipment, manual fire protection installations, and distribution panels, the minimum luminance will be 5 lux. The lighting of the indicative signs for manual fire protection systems and first aid will ensure:*
- *The ratio of maximum luminance to minimum luminance within white or safety colors will not exceed 10:1, and significant variations between adjacent points will be avoided.*
- *The ratio between white luminance (Lwhite) and color luminance (Lcolor) will be >10:1 and will not be less than 5:1 nor greater than 15:1. The safety signs will be illuminated at least 50% of the required value after 5 seconds and at 100% after 60 seconds."*

The center has an emergency supply through a double power supply from the electricity company. With the help of the maintenance staff and BERINI, we cut the normal power supply to the center to test the operation of the emergency lights. We detected that some lights were not working, so the installation does not comply with the regulations.

Specifically, 22 emergency lights were not working and need to be replaced.

The material execution cost (PEM) for each emergency light is €72.32. The TCQ corresponding to the replacement of these lights is included in the installation budget in Appendix 2. The locations of the lights that need to be replaced are marked in blue on the plan in Appendix 1.

6. ANALYSIS OF COMPLIANCE WITH THE REGULATING ORDINANCE ON FIRE PROTECTION CONDITIONS IN BARCELONA

The purpose of the ordinance is to establish the fire protection conditions that buildings and their installations must meet in Barcelona and to facilitate the intervention of the Fire Prevention, Extinction, and Rescue Service.

The ordinance complements the Technical Building Code and sets specific requirements for the city of Barcelona.

In this project, it will analyze whether it also complies with the municipal ordinance. To carry out this study, the characteristics of the building must first be defined:

- Use: Sports center with public attendance according to the CTE (Technical Building Code).
- Floor: All activities are on the ground floor.

According to these characteristics, Annex I of the ordinance applies, not Annex II, which is intended for industrial establishments.

Our building must comply with the following articles from Annex I:

- Article 7: Occupancy density.
- Article 8: Characteristics of evacuation routes.
- Article 13: Fire protection installations.

6.1. OCCUPANCY DENSITIES

In this article, the ordinance states:

"The occupancy densities regulated by the Technical Building Code in section 3 must be considered as minimum values for the sizing of evacuation system elements. These values cannot be exceeded to establish the maximum authorized capacity in establishments intended for public attendance."

The sports facility has an authorized maximum capacity of 963 people, calculated as indicated in the Technical Building Code, and the evacuation elements have also been sized according to these calculations, so it complies with the ordinance.

6.2. CHARACTERISTICS OF THE EVACUATION ROUTES.

In this article, the ordinance states:

- *"The start of any type of non-compartmentalized staircase according to fire sectors is not considered a floor exit. Therefore, the actual evacuation route length through the staircase to the building's exit on the access floor must be measured. The route must comply with the maximum lengths allowed by the current regulations."*

In the sports center, the only stairs that could be used as alternative evacuation routes are those starting at the stands and ending at the court. I have measured the evacuation route through the staircase as specified by the ordinance, and this can be seen in Figure 11.

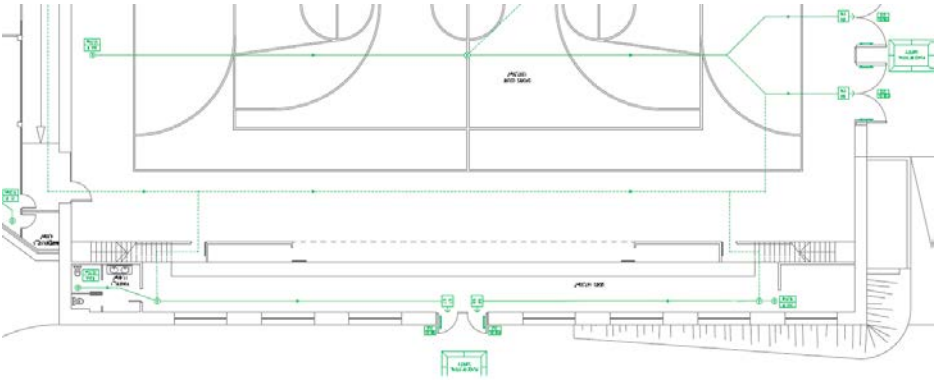

Figure 11 Expansion of plan 2 where the alternative evacuation from the stands is located.

- *"For the evacuation routes to be counted in the evacuation calculation, they must be continuous up to the access floor of the building".*

It has been verified that all the evacuation routes in the center are continuous from every evacuation origin to the exit, so it complies the ordinance.

6.3. FIRE PROTECTION INSTALLATIONS.

In this article, the ordinance states:

- "*The control point of the fire protection installations must be located near the access points, free of obstacles, and clearly visible to the intervention services.*"

In the sports center, the control panel for the fire protection installations is located behind the reception desk, as shown in plan 3 of appendix 1, **so it complies** the ordinance.

In Figure 12, it is marked with a green rectangle where the control panel is located.

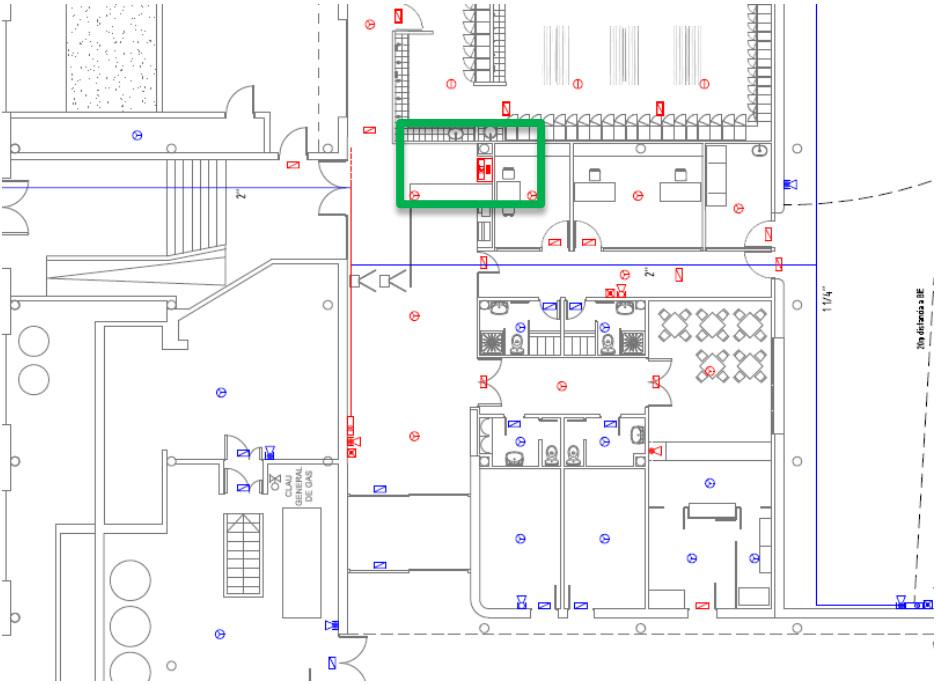

Figure 12 Details of the location of the fire control panel.

- *"Detection and alarm: When this installation is mandatory, the suitability and number of detectors must be justified, as well as the type, based on the existing risk in the activity."*

It complies, in the justification of compliance with the Technical Building Code, in section 4.4.5 of this project, the suitability, number of detectors, and type are specified:

- 14 thermal detectors in the changing rooms
- 3 linear optical beam detectors in the pavilion
- 40 optical smoke detectors throughout the rest of the center.
- *"Emergency lighting: the minimum intensity of this installation is 3 lux."*

The CTE indicates that 5 lux are required, so since the center complies with the CTE, it also complies with this section of the ordinance.

N. CONCLUSIONS

El This study has evaluated the fire protection conditions of a sports facility built in several phases over three decades. The main objective was to determine if it complies with the regulations in force in Barcelona, specifically Royal Decree 314/2006, of March 17, which approves the Technical Building Code (CTE) and the Fire Protection Conditions Ordinance, to ensure the protection of users and minimize the risk of fire.

The conclusion is that although the sports facility presents an acceptable level of fire safety in terms of passive protection systems (compartmentalization, fire resistance, and structural stability, and occupant evacuation), it is necessary to expand the active protection systems. These systems include extinguishers, BIEs, fire detection and alarm systems, and emergency lighting. These measures will ensure an optimal level of safety for users and compliance with the regulations.

To improve the sectorization of the center, an investment of €22,230 (including VAT) is required. This investment is necessary to replace the door and window that connect the pavilion (sector 2) and the corridor of the activity rooms (sector 1) with a door and window that provide smoke-tightness and superior thermal insulation (EI) and comply with the regulations. The other fire sectors and special risk rooms comply with the regulations. The external compartmentalization with neighboring buildings is also compliant.

The sports center has a maximum capacity of 963 people, with sufficient exits that are well distributed. In addition, the corridors and doors have the appropriate dimensions that allow for a safe evacuation in case of an emergency.

For the fire protection installations to comply with the regulations, an investment of €47,489.17 (including VAT) is required. This investment will increase the number of extinguishers, fire hydrants, emergency lights, replace almost all fire detectors, and adequately signal all new installations.

The center has good accessibility for firefighting intervention, as it is an isolated building with independent access from the public road.

Therefore, to ensure an optimal level of safety for all users of the center and comply with the current regulations, it is essential to implement the corrective measures proposed in this project. After presenting this study to the facility manager and the Institut Barcelona Esports, a joint commitment has been made to carry out the necessary works, prioritizing the most urgent actions, such as replacing the emergency lights and detectors, and installing the missing fire alarms, extinguishers, and fire hydrants. These actions have already been carried out.

Once all actions have been completed, the emergency plan will need to be updated with the new installations.

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ACRONYMS

- CTE: “Codigo Tècnico de l’Edificació”
- DB: Basic Document
- ITEC Catalan Institute of Construction Technology
- RIPCI "General Regulations for Public Spectacles and Recreational Activities"
- SE: Structural Safety
- SI: Fire Safety
- SUA: Safety in Use and Accessibility
- HS: Hygiene, Health, and Environmental Protection
- HR: Noise Protection
- HE: Energy Saving and Thermal Insulation
- CTE-DB-SI-1: Technical Building Code, basic document of fire safety, section 1 – Interior Propagation
- CTE-DB-SI-2: Technical Building Code, basic document of fire safety, section 2 – Exterior Propagation
- CTE-DB-SI-3: Technical Building Code, basic document of fire safety, section 3 – Evacuation of Occupants
- CTE-DB-SI-4: Technical Building Code, basic document of fire safety, section 4 – Fire Protection Systems
- CTE-DB-SI-5: Technical Building Code, basic document of fire safety, section 5 – Firefighters' Intervention
- CTE-DB-SI-6: Technical Building Code, basic document of fire safety, section 6 – Fire Resistance of the Structure.
- NBE-CPI/96 Basic Building Regulation - Fire Protection Conditions of 1996
- OMCPI/96 Barcelona Regulatory Ordinance on Fire Protection Conditions of 1997
- ORCPI/08 Regulatory Ordinance on Fire Protection Conditions of 2008
- TCQ Time, Cost, Quality
- R: Load-bearing resistance

- I: Thermal insulation
- E: resistance
- EI: Smoke permeability and thermal insulation
- PEM: Material Execution Price
- R90: For structural elements, fire resistance of 90 minutes
- EI90: For walls and ceilings, smoke permeability and thermal insulation for 90 minutes.
- EI_2 45 C5: For doors, flame and gas tightness and thermal insulation for 45 minutes. The sub-index 2 indicates the testing method used to determine thermal insulation for 45 minutes, and C5 indicates resistance to impact and durability of the door at 200,000 cycles.
- EI_2 30-C5: Flame and gas tightness and thermal insulation for 30 minutes. The sub-index 2 indicates the testing method used to determine thermal insulation for 45 minutes, and C5 indicates resistance to impact and durability of the door at 200,000 cycles.
- Extinguisher 21A-113B: A: Indicates the effectiveness of the extinguisher to put out fires involving solid materials such as wood, paper, textiles, etc. The number, the higher it is, represents that the extinguisher can put out a larger and more intense fire of this type. B: Indicates the effectiveness of the extinguisher to put out fires involving flammable liquids such as gasoline, oil, paint, etc. The number 113, like in the previous case, the higher the value, the greater the extinguishing capacity.
- cd/m^2: This is the unit of measurement for luminance, representing the amount of light emitted by a surface per unit area in a specific direction. In this case, it refers to the intensity of light emitted by the safety signs.
- Lbanca: Refers to the luminance of the white color in the safety sign
- Lcolor: Refers to the luminance of the safety color (e.g., red, green) in the sign.

APPENDIX

APPENDIX 1: GRAPHIC DOCUMENTATION

FIRE COMPARTMENT LEGEND

COMPARTMENT WALLS FIRE RESISTANCE

EI 90

EI 120

S.R.R LOW — SPECIAL RISK ROOM - LOW.

S.R.R MED — SPECIAL RISK ROOM - MEDIUM.

EI-60C — DOORS FIRE RESISTANCE

Compartment xxx
S(m2): xxx
Structure: R--
Compartment: EI-- — FIRE COMPARTMENT SPECIFICATIONS

COMPARTMENT 1: PUBLIC PREMISES.	EI 90	R 90
COMPARTMENT 2: PUBLIC PREMISES.	EI 90	R 90
COMPARTMENT 3: PUBLIC PREMISES	EI 90	R 90

EI-45-C5

Compartment 02
S(m2): 1533
Structure: R 90
Compartment: EI 90

EI-45-C5

S.R.R MED

EI-30-C5

EI-30-C5

Compartment 03
S(m2): 69
Structure: R 90
Compartment: EI 90

CUADRO GENERAL BT-MT

Compartment 01
S(m2): 2383
Structure: R 90
Compartment: EI 90

S.R.R LOW

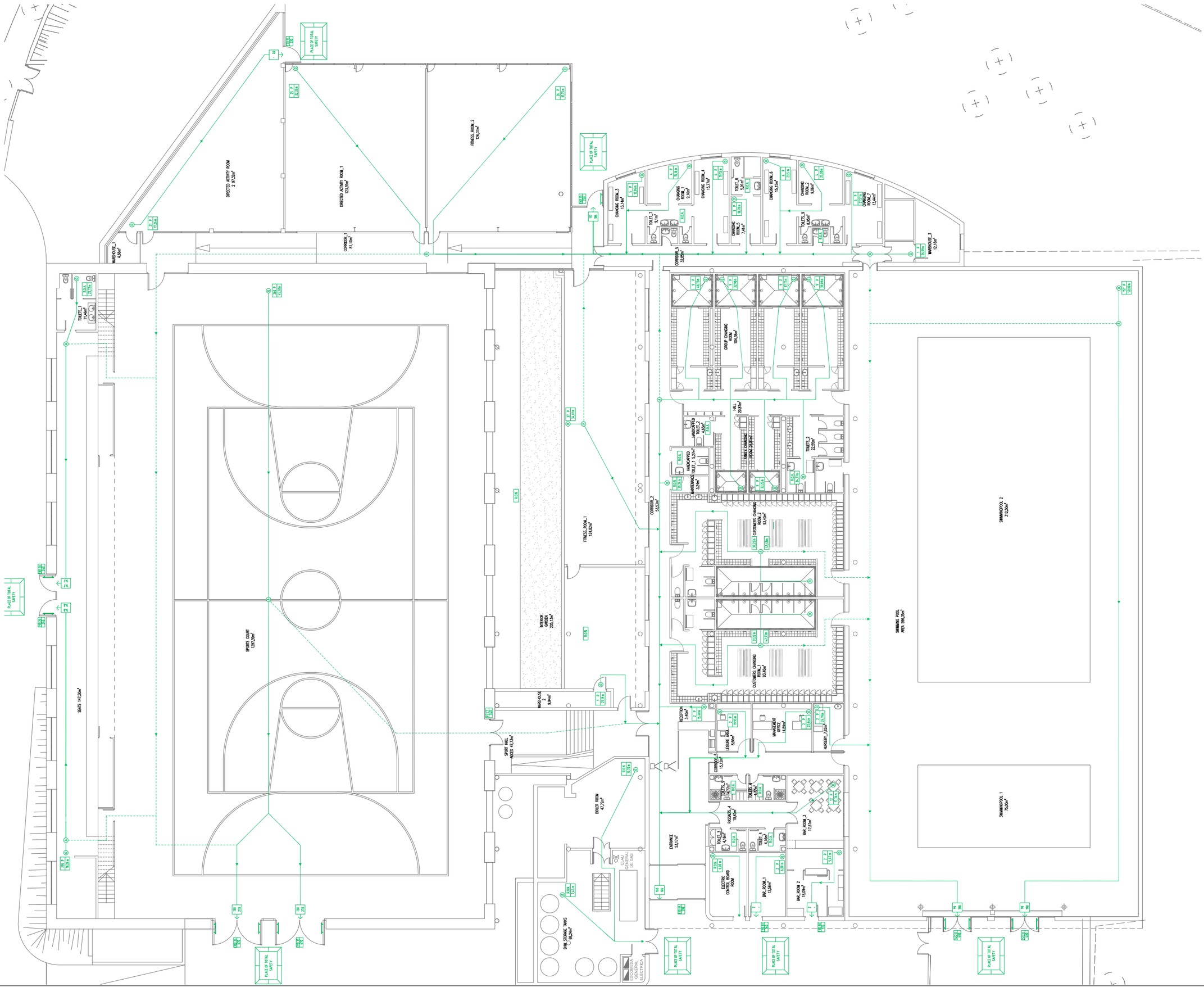
EI-60-C5

1- FIRE COMPARTMENT PLAN

SILVIA GARRIDO

EVACUATION LEGEND

- ESCAPE ROUTE
- ALTERNATIVE ESCAPE ROUTE
- ESCAPE ROUTE DIRECTION
- DOORS
  - P: NAME
  - m: WIDTH
  - p: CAPACITY
- BUILDING EXIT
  - X: PEOPLE TO EVACUATE
  - Y: PEOPLE TO EVACUATE WITH LOCK SCENARIO
- ORIGIN OF EVACUATION
- POINT WITH ALTERNATIVE ROUTES
- R.O.A. ALTERNATIVE OCCUPANCY ROOM
- R.O.N. NULL OCCUPANCY ROOM
- 000 P NUMBER OF PEOPLE ADDED TO THE ESTIMATED FOR THE ROUTE.
- 000 m ESCAPE ROUTE FROM "X" m TO NEAREST EXIT



2- EVACUATION AND OCCUPANCY PLAN

SILVIA GARRIDO

FIRE PROTECTION SYSTEMS LEGEND

EXISTING ELEMENTS.

NEW ELEMENTS.

DRY POWDER FIRE EXTINGUISHER 6 KG.
21A-113BC EFFICACY. INCLUDING PICTOGRAM SIGNAGE

CO2 FIRE EXTINGUISHER, 5 KG. 89B. EFFICACY, INCLUDING PICTOGRAM SIGNAGE

DRY POWDER FIRE EXTINGUISHER, 6 KG.
21A-113BC. EFFICACY, INSIDE CUPBOARD
DIMENSIONS 66 X 27 X 21 CM
INCLUDING PICTOGRAM SIGNAGE

CO2 FIRE EXTINGUISHER, 5 KG, 89B EFFICACY. INSIDE CUPBOARD, DIMENSIONS 68 X 27 X 21,5 CM INCLUDING PICTOGRAM SIGNAGE

DET
8888
CENTRAL OF FIRE WARNING SYSTEM.

Zx Bx
FIRE WARNING BUTTON.

Zx Bx
OPTICAL DETECTOR

HEAT DETECTOR

XX
EXISTING FIRE HYDRANT FEEDING NETWORK

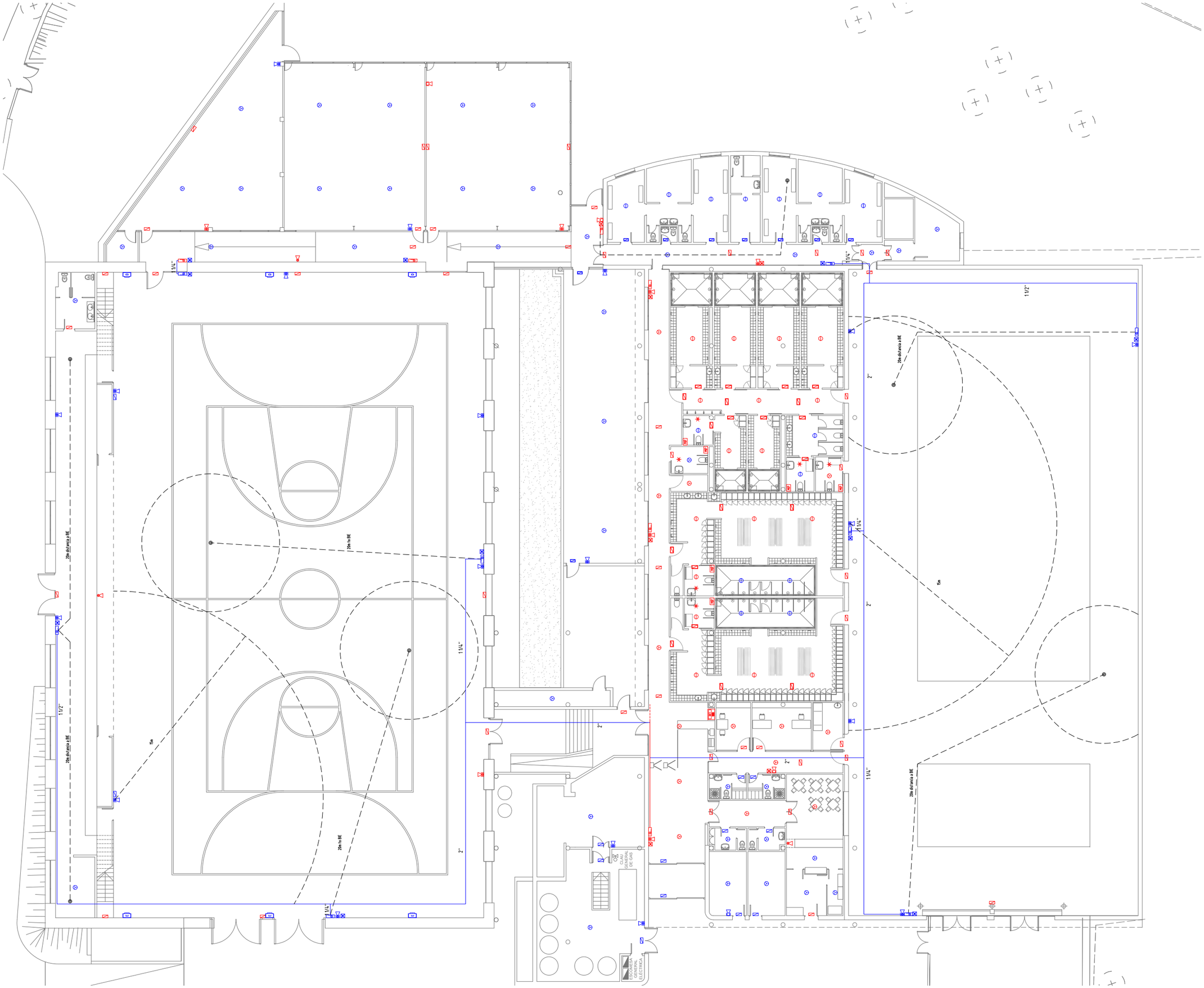
FIRE HYDRANT-25 INSIDE CUPBOARD (66 X 60 X 21 CM) WITH 20 METRES HOSE. INCLUDING PICTOGRAM SIGNAGE

Zx Bx
OCULAR WARNING DEVICE.

MIP
MÒDUL MONITOR

EMREGENCY LIGHT WITH LED OF 400 lm, 3 W, NO PERMANENT.

SEALED EMERGENCY LIGHT WITH LED OF 400 lm, 3 W, NO PERMANENT.



3- FIRE PROTECTION SYSTEMS PLAN

SILVIA GARRIDO

APPENDIX 2: ECONOMIC ASSESMENT

BUDGET FIRE SECTORIZATION

BUDGET					
			Price	Measurement Units	Import
Project	01	Budget			
Capitol	01	Fire sectorization			
P2140-M701		Removal of the panel and frame of a window measuring 4 m in height by 3 m in width, using manual means and manual loading onto a truck or container.	217.33	2 u	434.66
P6123-7BPH		Partition wall supported on one visible face, 14 cm thick, made of water-repellent hollow brick, 290x140x50 mm with exposed faces, category I, HD, according to UNE-EN 771-1 standard, installed with industrialized masonry mortar M 7.5 (7.5 N/mm²), designation (G) according to UNE-EN 998-2 standard.	94.96	8 m^2	759.68
P811-3EZW		Smooth plastering on the interior vertical surface above 3.00 m in height, using 1:4 cement mortar, floated and troweled with Portland cement with limestone filler 32.5 R.	45.83	8 m^2	366.64
P89H-4V7C		Painting of the interior vertical cement surface with silicate paint with a smooth finish, including one primer coat and two finish coats.	14.51	8 m^2	116.08
PAJ2-M701		Supply and installation of a fixed PVC window, dimensions 3000x4000 mm, standard finish on both sides, white color, with EI-90 fire protection classification, and base frame. The price includes all necessary work and materials for the proper completion of the item.	1,493.27	1 u	1,493.27
PC1J-6Y9C		Fire protection glass with EI-90 classification, installed with glass beading on wood, steel, or aluminum.	943.83	12 m^2	11,325.96
PAS2-5REM		Metal fire door, EI2-C 60, single-leaf swing door, for an opening of 100x210 cm, with a high price including a window, installed.	602,05	1 u	602,05
P874-M701		Cleaning, preparation, and adjustment of flooring and coverings in the area affected by the intervention, as directed by project management. Includes all necessary work and materials for the proper completion of the item.	274.85	1 u	274.85
		TOTAL			15,373.19
Project	01	Budget			
Capitol	02	Waste Management			
P2R6-4I5D		Loading with mechanical means and transport of inert or non-special waste to an authorized waste management facility, using a 12-ton transport truck, with a distance of up to 5 km.	6.32	2 m^3	12.64
P2RA-EU6C		Controlled disposal in an authorized landfill, including the levy for the controlled disposal of construction waste, according to LAW 8/2008, for mixed inert waste with a density of 1 t/m³, originating from construction or demolition, with code 17 01 07 as per the European Waste List.	26.57	2 m^3	53.14
		TOTAL			65.78
		MATERIAL EXECUTION COST			15,438.97
		13 % GENERAL EXPENSES OVER 15.438,97€			2,007.07
		6 % INDUSTRIAL BENEFIT OVER 15.438,97€			926.34
					18,372.37
		21 % IVA OVER 18.372,37€			3,858.20
		TOTAL BUDGET :			22,230.57

BUDGET FIRE EXTINGUISHING, FIRE DETECTION AND SIGNAGE

BUDGET						
			Price	Measurement	Units	Import
Project	01	Budget				
Capitol	01	Fire extinguishing				
PM20-DGBD		25 mm diameter fire hose reel, BIE-25, consisting of a stainless steel cabinet and stainless steel door, including BIE (foldable axial feed reel, 20 m hose, and nozzle), for surface mounting, including a proportional part of accessories and all auxiliary connection and assembly materials.	425.9	5	u	2,129.50
PM20-M701		25 mm diameter fire hose reel, BIE-25, consisting of a plastic cabinet and plastic door, including BIE (foldable axial feed reel, 20 m hose, and nozzle), for surface mounting, including a proportional part of accessories and all auxiliary connection and assembly materials.	430.6	3	u	1,291.80
PM32-DZ53		Manual multipurpose dry powder fire extinguisher, 6 kg charge, with built-in pressure, painted, with wall mount.	48.73	19	u	925.87
PM32-DZ5C		Manual carbon dioxide fire extinguisher, 5 kg charge, with built-in pressure, painted, with wall mount.	82.48	1	u	82.48
EY00-M701		Masonry assistance for creating wall penetrations between rooms, including sealing.	323.76	1	u	323.76
P129-M701		Daily rental of an articulated arm aerial basket, electric motor, with a maximum working height of 15 m. The price includes maintenance and civil liability insurance.	117.7	10	u	1,177.00
P129-M702		Transport to site and removal of articulated arm aerial basket, electric motor, with a maximum working height of 15 m.	112.35	1	u	112.35
EY00-M702		Connection to existing pipeline, draining, and filling of the installation.	534.95	1	u	534.95
PF21-EUQW		Galvanized steel pipe with welding, made of S195 T steel, 1" and 1/4" thread size (specified outer diameter = 42.4 mm and DN = 32 mm), series M according to UNE-EN 10255, threaded, with medium difficulty level, and surface-mounted.	25.66	70	m	1,796.20
PF21-EUQX		Galvanized steel pipe with welding, made of S195 T steel, 1" and 1/2" thread size (specified outer diameter = 48.3 mm and DN = 40 mm), series M according to UNE-EN 10255, threaded, with medium difficulty level, and surface-mounted.	31.38	63	m	1,976.94
PF21-EUQY		Galvanized steel pipe with welding, made of S195 T steel, 2" thread size (specified outer diameter = 60.3 mm and DN = 50 mm), series M according to UNE-EN 10255, threaded, with medium difficulty level, and surface-mounted.	44.05	96	m	4,228.80
		TOTAL				14,579.65
Project	01	Budget				
Capitol	02	Fire detection				
PM16-8D37		Linear smoke detector for an analog fire protection system, with a longitudinal range between 3 and 300, according to UNE-EN 54-12 standard, surface-mounted.	1,151.46	3	u	3,454.38
PM15-4IDC		Optical smoke sensor for an analog fire protection system, according to UNE-EN 54-7 standard, with surface base, surface-mounted.	57.91	40	u	2,316.40
PM15-4ICY		Thermal rate-of-rise sensor for an analog fire protection system, according to UNE-EN 54-5 standard, with surface base, surface-mounted.	52.64	14	u	736.96
PM17-M701		Alarm button for an analog fire protection system, manually operated by repositioning a fragile element (resettable), addressable, according to UNE-EN 54-11 standard, surface-mounted. The price includes all necessary work and materials for proper completion of the item.	53.3	7	u	373.10

PM17-M702		Alarm button for an analog fire protection system, manually operated by repositioning a fragile element (resettable), addressable, according to UNE-EN 54-11 standard, surface-mounted, with IP-67 protection rating. The price includes all necessary work and materials for proper completion of the item.	163.3	3 u	489.90
PM18-M701		Indoor alarm siren for an analog fire protection system, addressable, according to UNE-EN 54-11 standard, surface-mounted. The price includes all necessary work and materials for proper completion of the item.	73.61	7 u	515.27
PM18-M702		Indoor alarm siren for an analog fire protection system, addressable, according to UNE-EN 54-11 standard, surface-mounted, with IP-67 protection rating. The price includes all necessary work and materials for proper completion of the item.	178.61	3 u	535.83
PG34-4IA0		Cable with 300/500 V rated voltage copper conductor, designation S0Z1-K (AS+), bipolar, with a cross-section of 2 x 1.5 mm², metallic screen with drainage, and low smoke emission polyolefin cable sheath, installed in a tube.	2.72	1042 m	2,834.24
PG2P-6SZM		Rigid halogen-free plastic tube with 16 mm nominal diameter, insulating and flame retardant, with an impact resistance of 2 J, compression resistance of 1250 N, and dielectric rigidity of 2000 V, threaded joint, surface-mounted.	5.31	681 m	3,616.11
PG2N-EUK5		Flexible corrugated halogen-free plastic tube with 16 mm nominal diameter, insulating and flame retardant, low smoke emission, and no toxic or corrosive gas emission, impact resistance of 2 J, compression resistance of 320 N, and dielectric rigidity of 2000 V, installed above suspended ceilings.	1.76	65 m	114.40
PM11-M701		Adaptation of an existing fire control panel, with loop extension to increase the number of elements to be installed, including power supplies and necessary modules for the existing panel. The price includes all necessary work and materials for proper completion of the item.	1,097.8	1 u	1,097.8
		TOTAL			16,084.39
Project	01	Budget			
Capitol	03	Signage			
PMS0-6Z5B		Fire protection installation signage, square, 210x210 mm panel made of 1 mm thick PVC, photoluminescent category A according to UNE 23035-4, adhered to a vertical surface.	10.24	20 u	204.80
PMS0-6Z5G		Evacuation route signage to emergency exit, rectangular, 445x148 mm panel made of 1 mm thick PVC, photoluminescent category A according to UNE 23035-4, adhered to a vertical surface.	15.81	20 u	316.20
PMS0-6Z5A		Emergency exit signage, rectangular, 297x148 mm panel made of 1 mm thick PVC, photoluminescent category A according to UNE 23035-4, adhered to a vertical surface.	10.24	20 u	204.80
PH11-M796		SUPPLY AND INSTALLATION OF EMERGENCY LIGHTING. Supply and installation of emergency lighting, model identical to the existing one, with the possibility of recessed or surface mounting. Includes all necessary work and auxiliary materials for the proper completion of the installation.	22.00	72 u	1,591.04
		TOTAL			2,316.84
		MATERIAL EXECUTION COST			32,980.88
		13 % GENERAL EXPENSES OVER 32,980.88 €			4,287.51
		6 % INDUSTRIAL BENEFIT OVER 32,980.88 €			1,978,85
					39,247.25
		21 % IVA OVER 39,247.25 €			8,241,92
		TOTAL BUDGET			47,489.17

APPENDIX 3: CAPACITY CALCULATION TABLE

Table 14. Calculation of occupancy for the Sports Center

Name of Zone	Usable Area	Density (m2/person)	Occupancy
General Access and Pavilion Access	100,9	-	ROA
Reception	3,40	2,0	2
Bar_Room 1 (storage)	12,56	10	2
Bar_Room 2 (bar)	18,09	10	2
Bar_Room 3 (dining area)	17,61	1,5	12
Electrical Panel Room, Boiler Room, and ACS Accumulation Room	128,5	-	RON
Administration	14,89	10	2
Leisure Space	8,66	5	2
Stands	147,50	0,5	295
Infirmary	7,62	5	2
Storage_1	4,66	40	1
Storage_2	9,94	40	1
Storage_3	12,16	40	1
Maintenance	3,24	-	RON
Hallways_1, 2, 3, 4, and 5	193,05	-	ROA
Pool Deck	596,35	-	ROA
Multipurpose Court	1297,39	5	260
Directed Activities Room_1	126,39	5	25
Directed Activities Room_2	97,32	5	20
Fitness Room_1	180,82	5	37
Fitness Room_2	126,07	5	26
Interior Garden	149,13	-	RON
Service_1, 2, 3, 4, 5, 6, 7, 8 & 9	75,83		ROA
Pool Basin_1	75	2	38
Pool Basin_2	312,50	2	157
Lobby	20,87	-	ROA
Locker Room_1	9,16	3	4
Locker Room_2	9,06	3	4
Locker Room_3	13,14	3	5
Locker Room_4	15,77	3	6
Locker Room_5	7,41	3	3
Locker Room_6	15,15	3	6
Locker Room_7	13,44	3	5
Subscriber Locker Rooms_1 & 2	186,8	.	ROA
Group Locker Rooms	104,38	3	36
Family Locker Rooms	25,81	3	9
Adapted WC_1 and 2	9,9	-	ROA
Total Occupancy			963