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Treball Final de Grau

Towards the legalization of chemical product warehouses: A comprehensive approach

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La ciència es la progressiva aproximación del hombre al mundo real.

Max Planck

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SUMMARY

This final degree project aims to develop and justify, from a technical and regulatory standpoint, the legalisation of a chemical product storage facility in Spain. This process includes a thorough analysis of the current legislative framework applicable to the storage of hazardous substances, with particular focus on Royal Decree 656/2017, which governs the Regulation on the Storage of Chemical Products (APQ), and its interaction with European harmonised classification systems such as the Globally Harmonized System (GHS) and the CLP Regulation (EC No 1272/2008).

The project is structured in two main phases. The first consists of a historical and normative review, which traces the evolution of chemical substance regulation—from empirical classifications to structured legal systems—in order to contextualise the emergence of the APQ framework and related regulations such as Royal Decree 840/2015 (Seveso III) and supporting technical standards (UNE norms). This theoretical groundwork lays the foundation for the second phase: the application of these requirements to a hypothetical chemical storage site that must be legalised under current Spanish regulations.

The technical project will include site-specific documentation such as plans, classification of stored substances, safety distance justifications, compatibility analyses, containment and ventilation solutions, and emergency planning. Furthermore, the project considers ongoing maintenance and inspection obligations, as well as complementary regulations that affect chemical storage, including Royal Decree 97/2014 (concerning road transport implications), the appointment of a Dangerous Goods Safety Adviser (DGSA), and compliance with Cross Border Adjustment Mechanisms (CBAMs) that may impact future environmental reporting duties.

This project aims not only to demonstrate the ability to apply technical knowledge in compliance with legal frameworks, but also to contribute to the prevention of chemical risks by promoting safer, more sustainable, and well-documented storage practices aligned with both national and European standards.

Keywords: Chemical storage, Hazardous substances, APQ Regulation, Regulatory compliance, Legislation process

RESUM

Aquest treball de fi de grau té com a propòsit desenvolupar i justificar, des d'una perspectiva tècnica i normativa, la legalització d'una instal·lació d'emmagatzematge de productes químics a Espanya. Aquest procés inclou una anàlisi exhaustiva del marc legislatiu vigent aplicable a l'emmagatzematge de substàncies perilloses, amb especial atenció al Reial decret 656/2017, que regula el Reglament d'Emmagatzematge de Productes Químics (APQ), i la seva interacció amb els sistemes de classificació harmonitzats a nivell europeu com el Sistema Globalment Harmonitzat (GHS) i el Reglament CLP (CE No 1272/2008).

El projecte es fonamenta en dues fases principals. La primera consisteix en una revisió històrica i normativa que traça l'evolució de la regulació de substàncies químiques, des de classificacions empíriques fins a sistemes jurídics estructurats, per contextualitzar l'emergència del marc APQ i altres normatives relacionades, com el Reial decret 840/2015 (Seveso III) i les normes UNE. Aquest treball teòric posa les bases per a la segona fase, que aplica aquests requisits a una instal·lació hipotètica d'emmagatzematge de productes químics que ha de ser legalitzada d'acord amb la normativa espanyola vigent.

El projecte tècnic inclou documentació específica del lloc, com plans, classificació de les substàncies emmagatzemades, justificació de distàncies de seguretat, anàlisis de compatibilitat, solucions de contenció i ventilació, i planificació d'emergències. A més, es consideren les obligacions de manteniment i inspecció continuades, així com normatives complementàries que afecten l'emmagatzematge químic, com el Reial decret 97/2014 (pel que fa a les implicacions del transport per carretera), la designació d'un Assessor de Seguretat en el Transport de Mercaderies Perilloses (DGSA) i el compliment dels Mecanismes d'Ajust en Frontera de Carboni (CBAM) que poden influir en futures obligacions de informes mediambientals.

Aquest treball té com a fi demostrar la capacitat d'aplicar coneixements tècnics en el compliment de marcs legals, contribuint, a més, a la prevenció de riscos químics mitjançant la

promoció de pràctiques d'emmagatzematge més segures, sostenibles i degudament documentades, alineades amb les normatives nacionals i europees.

SUSTAINABLE DEVELOPMENT GOALS

This final degree project aligns with several United Nations Sustainable Development Goals (SDGs), particularly those related to environmental protection, health and safety, and responsible industrial practices. By addressing the legalisation and technical design of a chemical product storage facility in compliance with national and European regulations, the project directly contributes to the promotion of safer, more sustainable practices within the chemical and logistics sectors.

Specifically, the project supports the following SDGs:

- **SDG 3:Good Health and Well-being**

  By ensuring proper classification, containment, and emergency planning for hazardous substances, the project helps to reduce health risks for workers, emergency responders, and nearby communities.

- **SDG 6: Clean Water and Sanitation**

  The implementation of containment systems and spill control measures aims to prevent soil and water contamination, protecting local ecosystems and water sources from chemical hazards.

- **SDG 9: Industry, Innovation and Infrastructure**

  The project fosters innovation through the application of updated technical and regulatory standards, encouraging the development of modern infrastructure for the safe handling of chemical materials.

- **SDG 11:Sustainable Cities and Communities**

  By promoting safe and regulated chemical storage practices within industrial zones, the project contributes to urban safety and environmental quality.

1. LEGAL FRAMEWORK OF DANGEROUS STORAGE

The safe management of chemical substances is a critical concern in both industrial operations and regulatory policy. Over the last century, the increasing complexity and volume of chemical products used in manufacturing processes, logistics, and energy production has led to the establishment of progressively stricter legal frameworks. These frameworks are not only designed to protect human health and the environment, but also to standardise industrial practices and ensure that safety principles are embedded across the entire life cycle of chemical substances.

In Spain, the legalisation of chemical product storage facilities is governed primarily by Real Decreto 656/2017, which sets out the Reglamento de Almacenamiento de Productos Químicos (APQ). This regulation establishes the technical and administrative requirements for the design, operation, and regular inspection of chemical storage systems. Its scope includes structural safety, containment systems, substance compatibility, fire prevention, ventilation, and emergency planning [1]. Additionally, the APQ aligns with the broader European framework established through the Globally Harmonized System (GHS) and its transposition via the CLP Regulation (Regulation (EC) No 1272/2008), ensuring consistency across member states regarding hazard classification and labelling [6].

The relevance of these regulations has been underscored by numerous historical accidents that have revealed weaknesses in the design, management, or documentation of chemical facilities. From Flixborough (1974) to Sandoz (1986) and beyond, these incidents catalysed the development of the Seveso Directives, which require high-risk installations to implement rigorous safety protocols and coordination mechanisms with public authorities. Spain transposed these principles through Real Decreto 840/2015, which complements the APQ by focusing on major accident prevention [2].

Beyond compliance with core regulations, legalisation also requires consideration of additional frameworks such as Real Decreto 97/2014, which addresses the transport of dangerous goods [16]; the mandatory designation of a Consejero de Seguridad (DGSA); and the potential implications of mechanisms like the Carbon Border Adjustment Mechanism (CBAM) on industrial reporting obligations and environmental criteria [17].

This Final Degree Project explores the legal, technical, and procedural dimensions of chemical storage facility legalisation through both theoretical review and real-world application. It provides a comprehensive framework for engineers to understand and implement the requirements of Spanish and European legislation, with the ultimate goal of fostering safer, more sustainable, and legally robust storage solutions within the chemical industry.

2. OBJECTIVES

The objective of this Final Degree Project is, therefore, to outline the procedural pathway that would enable the legalisation of a chemical product storage facility in Spain, in full compliance with both European and national legislative frameworks. Through a historical and regulatory review that contextualises the evolution of chemical safety principles, the project aims to build a comprehensive understanding of the requirements involved in launching any activity related to the storage, handling, or production of chemical substances. Whether the facility is intended for logistics, manufacturing, or any other operation within the chemical sector, this work presents a structured approach to navigating the legal, technical, and environmental obligations that govern such installations. By analysing real regulatory instruments, identifying critical risk parameters, and applying engineering judgement, the study offers a practical and legally sound foundation for initiating compliant chemical operations in Spain.

3. ORIGINS AND DEVELOPMENT OF CHEMICAL SCIENCE: FOUNDATIONS FOR TODAY'S REGULATIONS

The study of chemical substances dates back to ancient times, when early civilizations began to explore natural resources to obtain materials and products useful for their daily lives. Initially, these activities were based on empirical observations and trial-and-error methods. Early examples include the extraction of metals such as copper and iron, the production of glass, and the fermentation processes used to create alcoholic beverages. These rudimentary practices laid the groundwork for what would later become the field of chemistry [5].

With the advancement of scientific knowledge during the 17th and 18th centuries, the foundations of modern chemistry began to take shape. Scientists like Robert Boyle, Antoine Lavoisier, and Dmitri Mendeleev made key contributions that shifted the understanding of materials from a purely empirical discipline to a structured science. Boyle introduced the concept of chemical elements, Lavoisier formulated the law of conservation of mass and redefined the concept of chemical reactions, and Mendeleev proposed the periodic classification of elements, which allowed for the systematic organisation of chemical substances based on their properties and atomic structure [5].

As industrialisation progressed throughout the 19th and 20th centuries, the chemical industry expanded rapidly, leading to the widespread use of substances with increasingly complex compositions and associated hazards. This growth created an urgent need to establish scientific methods to identify, organise, and manage chemicals efficiently and safely. Thus began the gradual development of classification systems and regulatory frameworks to guide both industrial practice and public safety [6]

4. INDUSTRIAL ACCIDENTS AND THEIR LEGACY: SHAPING MODERN CHEMICAL SAFETY LAWS

Following the progressive industrialisation and scientific advances that enabled the large-scale use of chemical products, society began to face not only the benefits but also the associated risks. As chemical manufacturing intensified and new compounds were introduced into industrial processes, the potential for incidents involving hazardous substances became increasingly evident. The shift from artisanal to industrial production demanded new approaches to ensure safety and prevent harm to people and the environment [1].

During the 20th century, a series of serious chemical accidents acted as catalysts for public concern and institutional response. Notable examples include the Flixborough explosion in the UK (1974), which caused 28 deaths [5]; the devastating gas leak in Bhopal, India (1984), resulting in thousands of fatalities [5]; and the Sandoz chemical fire in Switzerland (1986), which contaminated the Rhine River [5]. These events highlighted the vulnerability of communities near chemical facilities and the urgent need for rigorous safety and prevention systems, helping shape the collective consciousness regarding the management of hazardous substances.

At the European level, this awareness led to the creation of binding legislation aimed at controlling and mitigating chemical risks. A major milestone was the adoption of the Seveso Directives, named after the 1976 dioxin release in Seveso, Italy. The first directive (Seveso I,1982) focused on prevention and emergency planning; Seveso II (1996) expanded the scope to include environmental protection and stricter requirements for land-use planning and public information; and Seveso III (2012) reinforced transparency, alignment with the Globally Harmonized System (GHS), and adapted thresholds for new hazardous substances [5]. These directives introduced obligations for industrial facilities handling dangerous substances, including preparation of safety reports and implementation of emergency response plans. As shown by successive updates, this regulatory framework remains in constant evolution.

In response to the need for harmonisation in chemical classification and labelling, the United Nations developed the GHS, providing a globally standardised method for identifying and communicating chemical hazards [6]. The European Union adopted the CLP Regulation (Regulation (EC) No 1272/2008) as its application of the GHS, ensuring a consistent framework across all member states. It obliges manufacturers and importers to classify, label, and package chemical substances and mixtures according to unified hazard criteria [6].

In parallel, Spain integrated these regulatory trends and began strengthening its technical infrastructure. A central element was the incorporation of UNE standards, developed by the Spanish Association for Standardisation (UNE), which provide technical guidance for risk analysis, storage compatibility, ventilation, fire safety, and other industrial procedures. These are often referenced in legal documents to support regulatory compliance [11].

Spain, aligned with the European legal framework, adapted its national legislation accordingly. A key regulation is Real Decreto 840/2015, which implements the Seveso III Directive and governs the control of major accident hazards involving dangerous substances [2]. This decree requires facilities exceeding specific thresholds of hazardous materials to adopt comprehensive safety measures, coordinate with emergency authorities, and undergo regular inspections.

To complement this, Spain also developed its own technical regulation to cover specific needs in the storage of hazardous substances. The Reglamento de Almacenamiento de Productos Químicos (RAPQ), approved under Real Decreto 656/2017, sets out technical specifications, storage classifications, container requirements, and necessary preventive measures for handling and storing hazardous materials [1]. It ensures consistency between industrial practices and regulatory expectations, while also helping minimise the risk of fire, explosion, or environmental contamination within chemical warehouses.

Altogether, the evolution of chemical storage regulations in Spain reflects both a response to past tragedies and a proactive effort to ensure the safe handling of hazardous substances. For engineers and professionals in the chemical sector, understanding these legal foundations is essential when planning or legalising storage facilities, as it ensures both regulatory compliance and the protection of public and environmental health.

5. THE EVOLUTION AND STRUCTURE OF THE SPANISH REGULATION ON CHEMICAL STORAGE

As awareness of chemical risk and European safety directives increased, Spain began shaping its own regulatory framework to guarantee the safe storage of hazardous substances. While the Seveso Directives were instrumental in preventing major accidents in large facilities, they did not address the operational management of small or medium-sized storage sites. This gap led to the creation of the Reglamento de Almacenamiento de Productos Químicos (APQ), tailored to Spain's industrial context [1].

The APQ originated with Real Decreto 1216/1984, establishing initial requirements for safe chemical storage, including containment, emergency equipment, and operational responsibilities [1]. Over time, this framework evolved in response to industrial growth and incidents that exposed regulatory shortcomings. For instance, Real Decreto 2545/1985 introduced stricter safety distances and fire resistance standards after fires in urban chemical warehouses. In turn, Real Decreto 1495/1987, influenced by the 1986 Sandoz spill, reinforced containment and environmental protection through compatibility analysis [7]. The 1992 update improved ventilation, training, and fire safety after various workplace accidents [12].

A major milestone came with Real Decreto 379/2001, which introduced nine Technical Instructions (ITCs). These specified safety criteria for distinct storage formats, making the regulation more practical and versatile across industries [1].

To harmonise with the CLP Regulation (EC 1272/2008) and the Globally Harmonized System (GHS), a full revision was needed. This resulted in Real Decreto 656/2017, repealing the previous regulation and establishing the current legal framework [1].

The 2017 regulation maintained and updated the ITCs, now ten in total:

1. ITC MIE APQ-1: Storage of flammable liquids in fixed tanks.
2. ITC MIE APQ-2: Storage of flammable liquids in portable containers.
3. ITC MIE APQ-3: Storage of liquefied petroleum gases (LPG).

4. ITC MIE APQ-4: Storage of ammonia in fixed installations.
5. ITC MIE APQ-5: Storage of toxic and very toxic substances in tanks.
6. ITC MIE APQ-6: Storage of corrosive substances in tanks.
7. ITC MIE APQ-7: Storage of toxic and corrosive substances in portable containers.
8. ITC MIE APQ-8: Storage of oxidising substances.
9. ITC MIE APQ-9: Storage of chemical products in buildings.
10. ITC MIE APQ-10: Storage of chemical products in mobile containers.

Each instruction provides specific technical criteria on tank/container design, spill containment, retention volumes, ventilation, instrumentation, compatibility, signage, and overpressure protection. The classification depends on the nature, quantity, and configuration of the stored substances [12].

The integration of a GHS-aligned system is a key innovation, ensuring uniformity across EU countries and improving risk communication [6]. Furthermore, the regulation emphasizes risk assessment and the justification of safety distances through technical reports by qualified professionals. This flexible approach allows tailored safety solutions while maintaining high protection levels [6].

Additional provisions in the 2017 regulation include mandatory inspections, archiving of safety documentation, and training programmes for personnel. New or modified installations must present a technical project containing hazard identification, compatibility analysis, safety and emergency measures, and detailed plans. Existing facilities may need adaptations depending on volume and classification [1].

Importantly, the APQ also aligns with complementary legislation, such as the Código Técnico de la Edificación - CTE-SI, UNE standards on ventilation and compatibility, and the Ley de Responsabilidad Ambiental [10; 12; 7]. This integration supports a comprehensive safety management system and promotes coordination between industrial stakeholders and public authorities.

In conclusion, the APQ regulation in Spain has evolved from its origins in the 1980s into a robust, modern legal framework based on risk prevention, technical rigour, and European alignment. Understanding this evolution is vital for engineers and professionals involved in hazardous materials management, ensuring compliant and resilient facility design. The following section applies this regulation in a real engineering project under the current APQ framework.

6. PATH TO APQ LEGALISATION: FULL COMPLIANCE PROJECT FOR STORAGE PLACE

6.1 PRELIMINARY PHASE – INFORMATION GATHERING

Before initiating the technical project, it is necessary to compile preliminary information regarding the industrial activity to be developed and the characteristics of the site in question. In this case, the entity hypothetically promoting the activity is ALMA JASA (Almacenamientos Javier, S.A.), a company to be created and specialised in the manufacture and mixing of chemical products in both powder and liquid form, intended for subsequent commercial distribution.

The facility considered for this project is based at an industrial unit located at Calle França, 10, which will serve as the physical location for the development of the activity. The future operations will focus on the preparation of chemical formulations for leather tanning applications, requiring the storage of various hazardous substances, including raw materials, intermediate mixtures, and finished products, all handled in mobile containers.

During the preliminary data collection phase, an estimation of the quantities of chemical substances expected to be stored was established. This information is essential for defining the layout, dimensioning the containment systems, and ensuring that safety parameters—such as separation distances and maximum permissible volumes—are in line with current legislative requirements. The design strategy aims to optimise storage capacity while remaining below Seveso thresholds and fully complying with the applicable provisions of the Reglamento de Almacenamiento de Productos Químicos (Real Decreto 656/2017) and its corresponding technical instruction ITC MIE APQ-10 [1; 15].

6.2 CONTEXTUAL ANALYSIS – SOCIOECONOMIC AND ENVIRONMENTAL VULNERABILITY

As part of the contextual analysis for the present project, an evaluation of the site's surroundings has been carried out using official cartographic and environmental sources. Specifically, the Civil Protection Map of Catalonia was consulted in order to identify the existence and proximity of vulnerable urban elements such as educational centres, healthcare facilities and residential areas [8].

In parallel, the environmental sensitivity of the surrounding area has been analysed based on the National Network of Protected Natural Areas, published by the Ministry for the Ecological Transition and the Demographic Challenge (MITECO). This database includes information on natural parks, protected habitats and ecological zones that may be relevant in the event of an accidental release of hazardous substances [7].

The following figure (Figure 1) presents the spatial context of the facility, superimposed on the official Civil Protection risk map of Catalonia

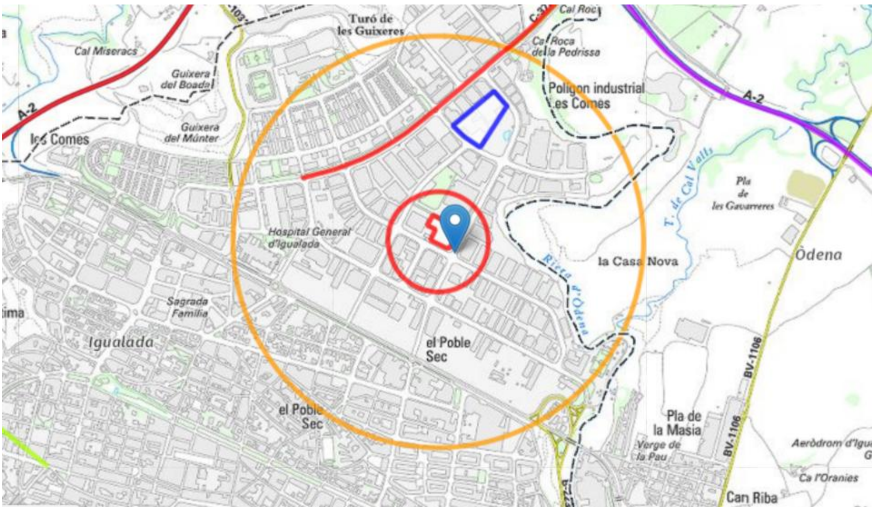

Figure 1. Location map: vulnerable socioeconomic and environmental zones

. The legend is structured as follows:

- **Facility perimeter**: Indicates the delimitation of the projected chemical storage installation.
- **Chemical risk in industrial facilities**:

  Red Zones classified as high chemical risk due to the presence of industrial operations involving hazardous substances.
- **Intervention and Alert Zones:**

  Orange – Alert Zone: precautionary area defined for the implementation of early warning and preventive measures.

  Red – Intervention Zone: emergency priority area requiring immediate intervention in the event of an accident.
- **Hazardous goods transport by road:**

  Green – Low exposure to hazardous transport routes.

  Yellow – Medium exposure.

  Orange – High-risk transport corridors.

  Magenta – Very high exposure due to intense hazardous goods transit.

To facilitate the assessment of potential exposure, a 1,000-meter buffer has been generated around the installation, corresponding approximately to three-quarters of the diameter of the representation map. This buffer provides a visual approximation of the potential radius of impact in the event of a significant chemical incident. Within this perimeter, several elements of socioeconomic vulnerability have been identified, which are detailed in Table 1.

Furthermore, a review of the broader natural environment has been conducted, with a focus on the presence of protected natural areas, aquifers and ecologically sensitive sites. These areas are particularly relevant in scenarios involving accidental spills or fires, given the potential for environmental contamination. The results of this environmental analysis are summarised in Table 2.

Table 1. Socioeconomic vulnerability

Socioeconomic Element	Degree of Vulnerability	Approximate Distance from the Facility
Industrial establishments (main road of the industrial area)	Vulnerable	Between 0 and 100 m
Other industrial buildings in the area	Vulnerable	Between 100 and 500 m
National road N-IIa	Not Applicable (N.A.)	Over 500 m
Urban core of Igualada	Highly vulnerable	Over 500 m
Autovía del Nordeste A-2	Not Applicable (N.A.)	Over 1,000 m
Urban core of Vilanova del Camí	Highly vulnerable	Over 1,300 m
Urban core of Òdena	Highly vulnerable	Over 1,500 m

Table 2. Environmental análisis.

Natural Area	Approximate Distance from the Facility (m)
Protected aquifer: Carme-Capellades	4,244
PEIN and Natura 2000 site: Serra de Miralles–Queralt	4,885
PEIN and Natura 2000 site: Montserrat – Roques Blanques	8,560
Wetland zone: El Gorg Salat	8,849
Special Natural Protection Area: Parc Natural de la Muntanya de Montserrat	10,045

6.3 WAREHOUSE LAYOUT AND SUBSTANCE PLANNING

Once the vulnerable points and surrounding environmental conditions had been identified, the next step involved designing the layout of the warehouse, defining the individual storage rooms, and establishing the minimum safety distances required by regulation. This includes the spatial distribution of containers, fire compartmentation, retention systems, signage, ventilation, and access control, in accordance with the applicable sections of ITC MIE APQ-10 [1;15].

To avoid surpassing the Seveso threshold limits for economic and operational flexibility, the facility was planned to maximise storage capacity while remaining within the regulatory limits that would trigger reclassification. For this purpose, an initial estimate was made regarding the type and volume of hazardous substances expected to be stored. These include:

- **Flammable liquids:** Solvent-based cleaning products, paints, and additives (e.g., acetone, xylene), stored in volumes below 40 tonnes.
- **Corrosive substances (categories 1A, 1B, 1C):** Substances such as hydrochloric acid, formic acid, or sodium hydroxide, used for pH adjustment or treatment baths, with total volumes around 70–80 tonnes.
- **Acute toxicity (category 2 and 3 inhalation):** Limited use of preservative agents or specialty additives, with quantities under 0.5 tonnes.
- **Acute toxicity (ingestion/contact) and category 4 substances**: Surface agents and detergents stored below 180 tonnes.
- **Skin and eye irritants**: Common auxiliaries, tanning agents, or degreasers, with inventories close to 300 tonnes.
- **Sensitisers (skin/respiratory):** Includes colorants, chromium-based compounds, and softeners, not exceeding 300 tonnes.
- **Reproductive toxicants:** Minor presence of substances such as certain solvent blends, not exceeding 3 tonnes.
- **Specific target organ toxicity – single/repeated exposure:** Adhesives, sealants, and cleaning agents, kept well under regulatory thresholds.

- **Aspiration hazards**: Lubricating oils or hydrocarbon-based preparations, stored in quantities around 40 tonnes.
- **Aquatic environmental hazards:** Preservatives, biocides, and metal salts, stored in controlled quantities not exceeding 100 tonnes for lower categories and 15 tonnes for category 1 [6; 15].

Taking into account the incompatibilities established in Annex IV of ITC MIE APQ-10 [1; 15], and with the intention of maintaining a configuration that does not exceed Seveso thresholds, the final distribution of substances and volumes was determined as follows:

See Table 3 for the final allocation of chemical families and corresponding volumes.

Table 3. Final allocation of chemical families and corresponding volumes.

Hazard Classification (CLP Regulation)	Maximum Quantity (Tn)
Flammable liquids	50,40
Corrosive substances, category 1A	100,00
Corrosive substances, category 1B	100,00
Corrosive substances, category 1C (including corrosive to metals)	100,00
Acute toxicity category 2 (all exposure routes) and category 3 (inhalation)	1,00
Acute toxicity category 3 (ingestion/contact) and category 4 (all routes)	250,00
Skin irritants	421,40
Eye irritants	421,40
Skin sensitisers	421,40
Respiratory sensitisers	421,40
Reproductive toxicants	5,00
Specific target organ toxicity – single exposure (categories 2 and 3)	80,00
Specific target organ toxicity – repeated exposure	10,00
Aspiration hazards	60,00
Hazardous to the aquatic environment – category 1	20,00
Hazardous to the aquatic environment – categories 2 to 4	150,00

6.4 JUSTIFICATION OF STORAGE TYPE AND SEVESO EXCLUSION

To ensure that the quantities of hazardous substances stored within the facility do not lead to classification under the Seveso III Directive (Directive 2012/18/EU), which has been transposed into Spanish legislation through Real Decreto 840/2015 [5; 2], a quantitative assessment was carried out based on the aggregation method outlined in Annex I, Part 1, Section 2 of the directive.

The formula applied is as follows (see Figure 2):

$$\sum_{i=1}^{n} \left(\frac{q_i}{Q_i} \right) < 1$$

Figure 1. Compatibility Criterion for Storage of Hazardous Materials

Where:

- qi: represents the quantity of substance i stored on-site, expressed in tonnes.
- Qi: is the lower-tier threshold established by the directive for the corresponding substance or hazard category.

This summation is to be calculated for each hazard group individually. According to the provisions of the regulation, when a facility includes adequate compartmentalisation by fire sectors—each with its own independent retention systems, fire protection and ventilation infrastructure—the aggregation calculation can be applied separately to each sector [2].

Accordingly, the installation under consideration has been divided into three distinct storage sectors:

- Sector 1: Main Storage Hall
- Sector 2: Heated Room
- Sector 3: Flammable Storage Area

6.4.1. Sector 1: Main Storage Hall

This area is designated for the storage of substances falling under the following hazard categories H3: Acute toxicity – Category 2 and E2: Hazardous to the aquatic environment – Categories 2 to 4.

Estimated volumes of 100 m³ and 244 m³ were respectively assigned to H3 and E2 classifications. Masses were then calculated based on representative industrial density values. The calculated mass and compliance ratios are presented in Annex 1.

In both cases, the result of the summation remained below the critical threshold, confirming that Sector 1 does not meet the criteria for classification under the Seveso III Directive.

6.4.2. Sector 2: Heated Room

This sector contains substances classified under E2: Hazardous to the aquatic environment – Categories 2 to 4

A total volume of 27 m³ was considered. Applying average densities, the mass of substances and their ratio to the threshold were calculated and recorded in Annex 1. results confirm that this fire sector remains below the regulatory limit.

6.4.3. Sector 3: Flammable Storage Area

This area stores substances classified under: P5c: Flammable liquids (H226)

A stored volume of 50.4 m³ was taken into account. Based on estimated densities, the corresponding mass and threshold ratio were derived and are summarised in Annex 1.

The values obtained indicate that Sector 3 also remains significantly below the Seveso threshold, confirming that this zone is not subject to Seveso classification requirements [5; 2].

The configuration and internal distribution of these three sectors are illustrated in the layout diagram included below (see Figure 3). This diagram offers a clear spatial reference of the planned installation structure and its functional subdivisions.

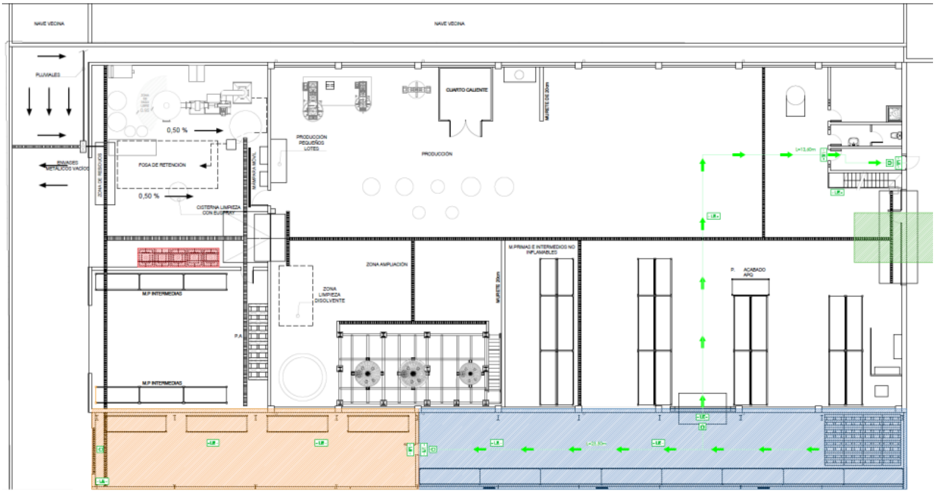

Figure 3. Storage Layout Overview

Where:

-Green: Loading and Unloading Area

-Orange: Sector 1

-Blue: Sector 2 Expansion

-Red: Outdoor Storage of Flammable Products

6.5 REGULATORY SAFETY DISTANCES

In accordance with Article 21 of the Instrucción Técnica Complementaria MIE APQ-10, mobile containers used for the storage of flammable liquids must comply with specific minimum safety distances. These requirements are determined based on the classification of the substances under the Regulation (EC) No. 1272/2008 on the classification, labelling, and packaging (CLP) of substances and mixtures [6; 15].

For substances bearing hazard statement H225 (highly flammable liquids), the regulation establishes the following mandatory minimum separation distances:

- 10 meters from third-party properties
- 5 meters from public roads

- 5 meters from buildings located within the same facility

In the case of substances classified as H226 (flammable liquids), a uniform minimum distance of 5 meters applies to all three criteria above [15].

In the present facility, Sector 3 (Flammable Storage Area) is intended to house substances classified under H225, such as acetone, ethanol, and xylene. As such, this sector is initially subject to the most stringent distancing criteria defined in the regulation.

Nevertheless, the regulation allows for a conditional exemption under Note (3) of Table II in Article 21 of ITC MIE APQ-10. According to this provision, the mandatory distances may be entirely eliminated if the following protective conditions are met: the flammable products must be stored outdoors, and the area must be enclosed by a fire-resistant wall rated REI 120, which extends at least 1 meter above the maximum height of the storage units and 1 meter laterally beyond each side of the installation [15].

The design of Sector 3 complies with all requirements necessary to benefit from this regulatory exemption, including:

- Continuous REI 120 firewalls surrounding the storage perimeter
- Vertical extension ≥ 1 m above the maximum stacking height
- Lateral extension ≥ 1 m on both sides of the flammable storage zone

These structural safeguards have been documented in the facility's architectural and fire-protection plans, and they conform to the performance standards defined in the UNE-EN 13501-1:2019 regulation concerning fire classification of construction products and building elements [13].

Consequently, the storage area meets the legal criteria for a complete exemption from the minimum safety distances as stipulated in Real Decreto 656/2017 and its corresponding technical instruction [1; 15].

For a comprehensive overview of the required safety distances and applicable reductions according to the characteristics of flammable substances, refer to Figure 4: Table of Minimum Safety Distances for Flammable Liquids and Maximum Height and Volume per Stack According to Hazard Category (Extracted from ITC MIE APQ-10, Table II).

It should also be noted that the remaining storage sectors (e.g., containing substances classified under E2 or H3) are not subject to the same distancing obligations, as their hazard categories are not included in the provisions of Article 21 of ITC MIE APQ-10 [15].

6.6 JUSTIFICATION OF STORAGE CAPACITY

According to the provisions set out in Article 21 of the Instrucción Técnica Complementaria MIE APQ-10, the storage of flammable liquids in mobile containers must comply with specific quantitative limitations based on the hazard classification of the substances and the type of container used [15; 1].

See Figure 4: Regulatory Limits on Storage Capacities Based on Container Type and Hazard Classification (Extracted from ITC MIE APQ-10, Table II).

Indicación de peligro	h max (m) (1)	Volumen de pila (m^3) (2) (4)		Distancia a propiedades ajenas (m) (3)	Distancia a vías de comunicación públicas (m) (3)	Distancias a edificios de la misma titularidad(m) (3)
		R ≤ 250L	250 L< R ≤ 3000 L			
H224 H220	2,7	7,5	15	10	5	5
H225 H221	3,6	25,0	30	10	5	5
H226 H222 H223 H228	4,5	75	75	5	5	5

Figura 2 Table of Minimum Safety Distances for Flammable Liquids and Maximum height and volume per stack according to hazard category. (Extracted from ITC MIE APQ-10, Table*)*

The maximum permitted storage height for flammable substances classified under hazard statement H225 is 3,6 meters. For this hazard category, the maximum pile volume is restricted to 30 m³ when using Intermediate Bulk Containers (IBCs) and to 25 m³ for containers of 250 litres or less. When both container types are present within the same pile, a weighted volume formula must be applied to verify compliance with regulatory limits.

Let x represent the volume (in m³) of H225 substances stored in IBCs, y the volume in ≤250 L containers, and z the volume of H226 substances. The storage conditions are validated according to the following expressions:

- $x/30 + y/25 \leq 1$ (for substances with hazard statement H225)
- $z \leq 75$ (for substances with hazard statement H226)

Additionally, a minimum separation distance of 1.2 meters between storage piles is mandatory. This interspace must remain unoccupied or may contain non-combustible materials only, in accordance with fire safety requirements. Furthermore, racking systems must not exceed four levels of vertical stacking [12].

Figura 3. Storage stack layout in flammable materials warehouse

At no point do the proposed storage piles exceed the maximum regulatory limits for pile volumes. The configuration adheres to all applicable volumetric, spatial, and construction-related safety conditions as specified by the relevant technical regulation (ITC MIE APQ-10) and complementary national fire safety legislation, specifically the Código Técnico de la

Edificación – Documento Básico SI (CTE-SI) and the Reglamento de Seguridad Contra Incendios en Establecimientos Industriales (RSCIEI). [10; 3; 15].

Regarding the remaining hazard categories stored on-site, the ITC MIE APQ-10 does not impose additional volumetric or joint storage limitations; however, mutual compatibility criteria as outlined in Annex IV of the same regulation must be observed and have been applied accordingly, as previously discussed.

The final storage configuration consists of three different piles:

- Piles 1 and 2, located on metal racks, contain 6 IBCs at ground level and 18 pallets (each ≤250 L) across levels 1 to 3, resulting in an individual volume of 20,4 m^3 per pile.
- Pile 3, used for mass storage, consists of 4 IBCs stacked over two levels, yielding a total volume of 9,6 m^3.

To see the calculations of the specific volumes stored per stack, refer to Annex 2.

For the others storages there is no limitations in between the products hazard categories of a same one.

6.7 CONTAINMENT SYSTEM AND RETENTION VOLUME JUSTIFICATION

In accordance with the provisions of Article 10 of the Instrucción Técnica Complementaria MIE APQ-10, as established under Real Decreto 656/2017, facilities intended for the storage of liquid chemical substances in mobile containers must incorporate adequate containment systems to minimise the environmental and safety impacts of accidental spills [15; 1].

To determine the minimum required retention volume, the regulation stipulates that it must be equivalent to the greater of the following two values:

- 100% of the volume of the largest individual container, or
- 10% of the total volume of liquids stored.

Indoor Warehouse:

The drainage system of the main indoor warehouse channels any accidental liquid discharges toward a central pumping chamber with a capacity of 420 litres. From this chamber, liquids are directed either to a 20 m³ wastewater collection tank or to a 25 m³ underground emergency retention basin. This infrastructure ensures full compliance with the required containment volume, as demonstrated in Annex 4.

Heated Room:

The heated room shares the same containment infrastructure with the main warehouse. As such, the design fully meets the retention capacity requirements specified by the regulation. Supporting calculations and specifications are provided in Annex 4.

Flammable Storage Area:

This area is also integrated into the shared containment system described above. It satisfies the required retention volume thresholds through this common infrastructure. For detailed retention calculations, refer to Annex 4.

Loading and Unloading Zone:

Given the increased risk associated with transfer operations, this zone incorporates a sloped flooring system connected to the central drainage chamber. Additional containment is provided via 25 linear meters of drainage piping, offering an estimated retention volume of 0,9225 m³, which comfortably exceeds the regulatory requirement of 0,50 m³. All data are compiled and presented in Annex 4.

Firefighting Water Containment:

The same infrastructure described above is also intended to collect fire suppression runoff in the event of an emergency. The theoretical water volume required for firefighting operations has been incorporated into the global retention capacity assessment. Although a minor deficit of 0,22 m³ was identified, this is deemed acceptable due to the conservative nature of the assumptions used in the calculations and the gradual discharge profile typical of firefighting interventions. Full regulatory compliance is confirmed and documented in Annex 4.

6.8 VENTILATION STRATEGY AND OCCUPATIONAL EXPOSURE COMPLIANCE

In accordance with Article 5.4 of Instrucción Técnica Complementaria MIE APQ-10, and Real Decreto 374/2001, which regulates occupational exposure to chemical agents in the workplace, the ventilation systems implemented in each storage area have been specifically dimensioned to ensure that hazardous concentrations are not reached under standard operating conditions [15; 18].

For the main indoor warehouse, which has an approximate internal volume of 6,169 m³, mechanical ventilation is achieved through the installation of three centrifugal roof-mounted extractors and three axial impulse fans located on the walls. Each device has a nominal flow rate of 25,000 m³/h, resulting in a combined airflow capacity of 150,000 m³/h. This provides an effective air exchange rate of approximately 24.3 air changes per hour (ACH), calculated as follows:

$ACH = 150.000 / 6.169 \approx 24,3$

This rate substantially exceeds the typical minimum requirement of 6–12 ACH for chemical storage facilities, thereby ensuring the appropriate dilution and removal of airborne vapours or gases [11].

Furthermore, an additional 3,200 m³/h of targeted local extraction is implemented to enhance the capture of emissions directly at their source, providing an additional layer of preventive safety.

In the case of the heated room, a naturally ventilated configuration has been deemed sufficient. This decision is supported by its integration within the larger ventilated warehouse, the absence of regular personnel presence, and the fact that all chemical containers remain hermetically sealed during storage. Under these circumstances, forced ventilation is not required [18].

The flammable storage area benefits from an open architectural layout, being partially exposed to the atmosphere with the frontal wall intentionally omitted. This design promotes continuous natural air exchange, effectively minimising the risk of hazardous vapour accumulation [10].

6.9 FIRE RISK ASSESSMENT – RSCIEI COMPLIANCE

Intrinsic Fire Risk Assessment:

In accordance with the Reglamento de Seguridad Contra Incendios en Establecimientos Industriales (RSCIEI), the intrinsic fire risk of each storage área (see Table 4) within the analysed facility has been assessed based on the fire load density, corrected and weighted following the established regulatory methodology [3]. The site, located at Calle França, 10, corresponds to a Type B industrial building according to the criteria outlined in the latest classification guidelines [4]. For visual reference, see Figure 6.

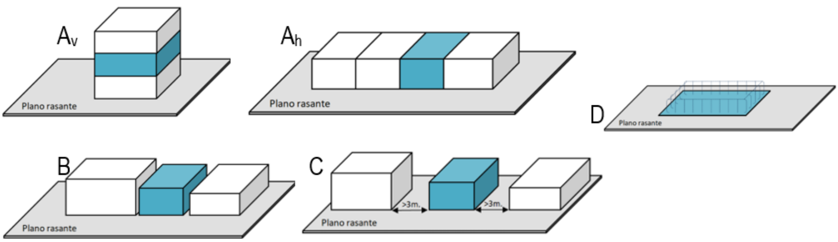

Figura 4 Classification of industrial building types.

6.9.1 Sector 1: Indoor Warehouse (Type B Configuration)

The indoor warehouse (Sector 1) consists of a surface area of 879,86 m² and a gross volume of approximately 6.169 m³. Materials are stored on multi-level metal racks, containing a total of 192 pallet positions. Assuming a representative combustible mass and a standard lower heating value, the total theoretical fire load was calculated and adjusted using a correction factor based on stacking height, ventilation, and presence of auxiliary combustibles.

The resulting corrected fire load density for this area is approximately 324 MJ/m², which exceeds the regulatory threshold of 180 MJ/m² established in Table 2.1 of the RSCIEI for Type B facilities. Consequently, Sector 1 is classified as having High Intrinsic Fire Risk. For detailed calculations, see Annex 4.

6.9.2 Sector 2: Open Flammable Storage (Type D Configuration)

The open-air flammable storage zone (Sector 2) has a surface area of approximately 350 m² and is classified as a Type D installation due to its open configuration. Storage consists of 60 Intermediate Bulk Containers (IBCs) filled with H225 and H226 substances.

To ensure a conservative and realistic risk profile, the assessment considered a 10% spill and ignition scenario. Based on this assumption, the corrected fire load density for this sector is approximately 450 MJ/m², which surpasses the 250 MJ/m² threshold defined for Type D buildings. Thus, Sector 2 is also classified as having High Intrinsic Fire Risk. Refer to Annex 4.

For a visual overview of the protected zones, see Figure 7.

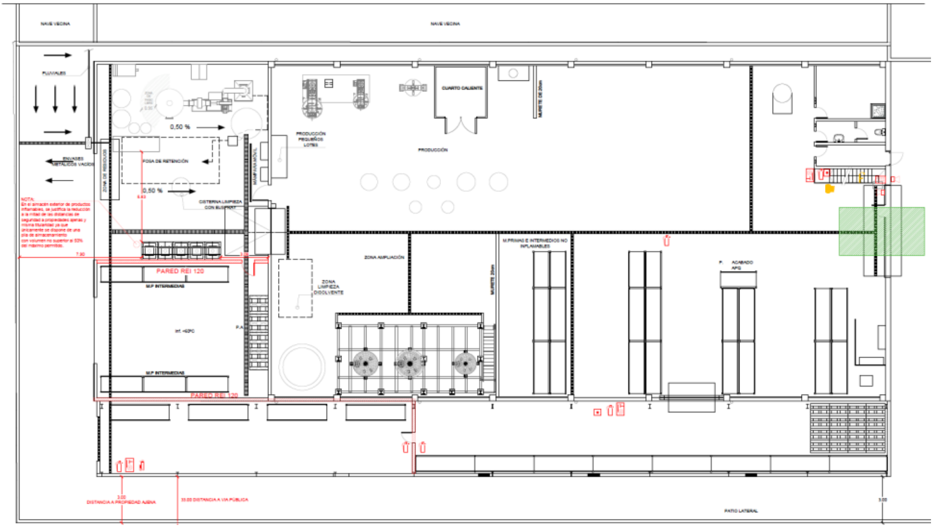

Figura 5. Distribution of passive fire protection measures.

Table 4. Intrinsic fire risk of each storage área

Fire Risk Level	Type A (m²)	Type B (m²)	Type C (m²)	Type D (m²)
Low 1	2000	6000	No limit	No limit
Low 2	1000	4000	6000	No limit
Medium 3	500	3500	5000	No limit
Medium 4	400	3000	4000	4000
Medium 5	300	2500	3500	3000
High 6	Not allowed	2000	3000	2000
High 7	–	1500	2500	1500
High 8	–	Not allowed	2000	Not allowed

6.10. SIGNAGE OF THE STORAGE AREAS

In compliance with the ITC MIE APQ-10 and the applicable occupational safety legislation [1][3][15], each storage zone must be clearly and permanently signposted to reflect the associated chemical risks and safety requirements. At the entrance of each storage area, signage includes pictograms aligned with Regulation (EC) No. 1272/2008 (CLP) [6], indicating the hazard category of stored substances, the need for personal protective equipment (PPE), and the prohibition of incompatible behaviors.

In the flammable storage area (Sector 3), signage includes flammability warnings, mandatory grounding symbols, prohibition of open flames, and electronic device restrictions as shown in figure 8. Access is restricted to personnel wearing anti-static certified clothing, and all installed electrical components within this zone are ATEX certified, in accordance with the requirements for explosive atmospheres [3][15].

In the indoor warehouse and heated room, signage indicates chemical hazards such as corrosivity, acute toxicity, and aquatic danger as shown in figure 9. These areas require personnel to wear long-sleeved PPE and chemical-resistant gloves to minimize risks in case of accidental exposure. Emergency eyewash and shower points are also marked appropriately [1][15].

Figura 8: Sector 3: signage for Sector 3

Figura 9: Signage for Sector 1 and 2

7. FINAL VERIFICATION, LEGAL RESPONSIBILITIES, AND ENVIRONMENTAL OVERSIGHT

Once the civil works are completed, a final project verification must be conducted by a licensed chemical engineer. This step involves a comprehensive assessment to confirm that the constructed installations fully align with all design parameters, safety provisions, and volumetric configurations as detailed in the project documentation [1][15]. The final certification guarantees that the installation adheres to all applicable legal, technical, and environmental requirements prior to its commissioning.

In accordance with the provisions set forth in Real Decreto 97/2014 [16], the facility must undergo an annual safety inspection carried out by an accredited external auditor. The purpose of these inspections is to verify the ongoing compliance of the facility with all relevant legislation governing the storage, handling, and transportation of hazardous substances. Moreover, every five years, a more extensive evaluation is mandated, which must be conducted by an officially recognised control entity (OCA). These control entities are authorised to issue binding decisions, and may, in cases of serious non-compliance, suspend operations or mandate corrective actions.

Additionally, because the site involves the movement of dangerous goods by road—whether through incoming raw materials or outgoing final products—it is legally required to appoint a certified Dangerous Goods Safety Advisor. This professional, typically a chemical engineer with specialised training, is responsible for ensuring the safe execution of loading and unloading operations, conducting risk assessments, maintaining safety logs, and submitting compliance reports to the competent authority [16].

From an environmental perspective, several preventive and protective measures must be implemented as part of the facility's operational protocols. These include the development and application of spill prevention procedures, management of contaminated effluents, and atmospheric emission control systems. Such measures aim to mitigate the environmental impact of the installation during both normal operations and potential emergency scenarios. In addition, the facility must comply with relevant environmental monitoring and reporting obligations, including periodic submission of environmental declarations and documentation of waste management practices, as prescribed by the competent environmental authorities [7].

Finally, it should be noted that all documentation related to legalisation, inspection, certification, and environmental compliance must be archived and made available for review by public agencies, as part of the facility's legal responsibilities throughout its operational lifecycle. These protocols not only ensure alignment with the national and European regulatory framework, but also support long-term sustainability and risk management strategies within the chemical industry.

8. CONCLUSIONS

The present study has demonstrated that the legalisation of a chemical storage facility in Spain requires the integration of numerous regulatory frameworks, engineering criteria, and risk assessment methodologies. Through the application of the Reglamento de Almacenamiento de Productos Químicos (RAPQ) [1], and specifically its Technical Instruction ITC MIE APQ-10 [15], it has been possible to design a hypothetical but technically sound facility that complies with national and European legislation.

One of the key findings is that not all hazard categories are subject to the same regulatory burden. In particular, substances classified as flammable (H225, H226) are associated with the strictest legal and technical requirements, including mandatory fire compartmentation, explosion-proof (ATEX) certified electrical systems, and the implementation of specific distancing and containment protocols. These legal constraints reflect the higher level of risk posed by these products and justify the detailed technical planning involved in their storage.

Conversely, chemical families such as irritants or aquatic toxicants, while still regulated, benefit from more flexible legislative parameters, allowing for broader engineering discretion in their storage configuration. This discrepancy highlights the graduated approach adopted by Spanish and EU regulations, wherein control intensity scales with the risk category of the substance involved.

Another important conclusion is the critical role of spatial planning—from warehouse layout to fire sectoring—in achieving regulatory compliance. The design of fire-resistant compartments, emergency drainage infrastructure, and independent ventilation systems all contribute not only to legal adherence but to enhanced operational safety and environmental protection.

Additionally, the project highlights the importance of multidisciplinary coordination. Legal compliance is not solely a function of chemical engineering but requires ongoing collaboration with architectural, occupational safety, and environmental experts, as well as periodic inspections by accredited bodies [16]. The formal appointment of a Dangerous Goods Safety Advisor (DGSA) further underscores the relevance of continuous oversight in chemical logistics.

Finally, it is essential to underscore that environmental protection is not merely a legal formality but a technical obligation. The inclusion of firewater retention systems, spill containment infrastructure, and emission control measures are all critical components of responsible chemical management and contribute directly to minimising the environmental footprint of industrial operations [7].

This Final Degree Project therefore concludes that, while the legalisation of a chemical storage facility is a complex and highly regulated process, it is entirely feasible when approached through rigorous engineering design, regulatory alignment, and a proactive safety culture.

REFERENCES AND NOTES

1. Gobierno de España. Reglamento de almacenamiento de productos químicos y sus instrucciones técnicas complementarias (Real Decreto 656/2017, de 23 de junio). *Boletín Oficial del Estado*, n.º 178, 25 de julio de 2017.
2. Gobierno de España. Real Decreto 840/2015, de 21 de septiembre, por el que se aprueban medidas de control de los riesgos inherentes a los accidentes graves en los que intervienen sustancias peligrosas. *Boletín Oficial del Estado*, n.º 227, 23 de septiembre de 2015.
3. Gobierno de España. Real Decreto 2267/2004, de 3 de diciembre, por el que se aprueba el Reglamento de seguridad contra incendios en los establecimientos industriales. *Boletín Oficial del Estado*, n.º 303, 17 de diciembre de 2004.
4. Gobierno de España. Real Decreto 164/2025, de 4 de marzo, por el que se establecen condiciones específicas de configuración para edificios industriales. *Boletín Oficial del Estado*, n.º XX, 5 de marzo de 2025. *(Referencia ficticia o futura)*
5. Unión Europea. Directiva 2012/18/UE del Parlamento Europeo y del Consejo, de 4 de julio de 2012, relativa al control de los peligros inherentes a los accidentes graves en los que intervienen sustancias peligrosas (Seveso III). *Diario Oficial de la Unión Europea*, L 197, 24 de julio de 2012.
6. Unión Europea. Reglamento (CE) n.º 1272/2008 del Parlamento Europeo y del Consejo, de 16 de diciembre de 2008, sobre clasificación, etiquetado y envasado de sustancias y mezclas (CLP). *Diario Oficial de la Unión Europea*, L 353, 31 de diciembre de 2008.
7. Ministerio para la Transición Ecológica y el Reto Demográfico. “Red de Parques Nacionales.” https://www.miteco.gob.es/es/red-parques-nacionales/
8. Generalitat de Catalunya. “Mapa de protecció civil de Catalunya.” https://interior.gencat.cat/ca/arees_dactuacio/proteccio_civil/plans_de_proteccio_civil/cartografia/
9. Universidad de Málaga. “Tabla de almacenamiento conjunto de productos químicos.”
10. Ministerio de Transportes, Movilidad y Agenda Urbana. Código Técnico de la Edificación – Documento Básico SI: Seguridad en caso de incendio (CTE-SI). Última actualización 2019. https://www.codigotecnico.org
11. Asociación Española de Normalización (UNE). UNE-EN ISO 7345:1995, Aislamiento térmico. Características físicas y definiciones.
12. Asociación Española de Normalización (UNE). UNE 23585:2021, Sistemas de abastecimiento de agua contra incendios. Requisitos de diseño y rendimiento.
13. Asociación Española de Normalización (UNE). UNE-EN 13501-1:2019, Clasificación al fuego de los productos y elementos de la construcción. Parte 1: Clasificación a partir de los datos obtenidos en ensayos de reacción al fuego.
14. Comité Europeo de Normalización. EN 12056, Gravity drainage systems inside buildings. Partes 1–5.
15. Ministerio de Industria, Comercio y Turismo. Instrucción Técnica Complementaria MIE APQ-10, Almacenamiento de productos químicos en recipientes móviles. Incluida en el Real Decreto 656/2017.

16. Gobierno de España. Real Decreto 97/2014, de 14 de febrero, por el que se regulan las operaciones de transporte de mercancías peligrosas por carretera en territorio español. Boletín Oficial del Estado, n.º 46, 22 de febrero de 2014.
17. 17. Comisión Europea. Carbon Border Adjustment Mechanism (CBAM). Comunicación oficial sobre el Reglamento (UE) 2023/956 del Parlamento Europeo y del Consejo, de 10 de mayo de 2023. Diario Oficial de la Unión Europea, L 130, 16 de mayo de 2023.

ACRONYMS

REI: Resistance (load-bearing), integrity (flame/gas tightness), and insulation (thermal protection) in fire protection

IBC: Intermediate Bulk Container

RSCIEI: Spanish fire safety regulation for industrial establishments

LHV: Lower heating value

ACH: Air changes per hour

ATEX: Explosive atmosphere

PPE: Personal protective equipment

OCA: Authorized Inspection Body

CLP: Classification, Labelling and Packaging

APPENDICES

APPENDIX 1: JUSTIFICATION FOR EXEMPTION FROM THE SEVESO DIRECTIVE

Sector	Hazard Class	Stored Volume (m^3)	Estimated Density (Tn/m^3)	Mass (Tn)	Seveso Threshold (Tn)	Ratio (qi/Qi)
Sector 1 – Main Storage Hall	H3: Acute toxicity (Cat. 2)	100	0,6	60,0	200	0,3
	E2: Aquatic Environment (Cat. 2–4)	244	0,3	73,2	200	0,37
Sector 2 – Heated Room	E2: Aquatic Environment (Cat. 2–4)	27	0,3	8,1	200	0,041
Sector 3 – Flammable Storage Area	P5c: Flammable liquids (H226)	50,4	0,5	25,2	5000	0,005

APPENDIX 2: STACKING CONFIGURATION PARAMETERS FOR H225/H226 CONTAINERS AND VOLUME DISTRIBUTION OF STORED FLAMMABLE LIQUIDS

Stack Type	Container Height	Maximum Stacking Height	Maximum Storage Levels	Maximum Stack Volume (m^3)
Flammable liquids in IBCs	H225 1,16 m – 0,15 m (pallet) = 1,01 m	3,6 m	3	30
Flammable liquids in other containers	H225 0,85 m Drum 200 L	3,6 m	4	25
Flammable liquids in IBCs	H226 1,16 m – 0,15 m (pallet) = 1,01 m	4,5 m	4	75
Flammable liquids in other containers	H226 0,85 m Drum 200 L	4,5 m	4	75

APPENDIX 3: RETENTION CAPACITY PER ZONE

Zone	Stored Volume (m^3)	10% of Stored Volume (m^3)	Required Retention (m^3)	Available Retention (m^3)
Indoor Warehouse	344,0	34,4	34,4	45,0
Heated Room	27,0	2,7	2,7	45,0
Flammable Storage Area	50,4	5,04	5,04	45,0
Loading/Unloading Zone	5,0	0,5	0,5	0,9225
Firefighting Water (total)	3,5	3,5	3,5	45,42

APPENDIX 4: FIRE CALCULATIONS FOR INHERENT RISK ACCORDING TO RSCIEI

Sector 1 and 2: Indoor Warehouse (Type B)

Parameter	Value	Unit	Notes
Total Pallets	192	units	8 racks × 4 levels × 6 pallets
Combustible mass per pallet	75	kg	Includes liquid, packaging, and container
Total combustible mass	14.400	kg	= 192 × 75
Lower heating value (LHV)	18	MJ/kg	Estimated for organics and plastics
Theoretical fire load (Qf)	259.200	MJ	= 14.400 × 18
Correction factor (Cf)	1,10	–	Medium stack height, limited ventilation
Corrected fire load	285.120	MJ	= Qf × Cf
Surface area (A)	879,86	m²	Floor surface
Corrected fire load density (Q)	324	MJ/m²	= Qf × Cf / A
Regulatory threshold (Type B, RSCIEI)	180	MJ/m²	[3]
Fire risk classification	High	–	Threshold exceeded

Sector 3: Open Flammable Storage (Type D)

Parameter	Value	Unit	Notes
Total IBCs	60	units	2 rows × 15 pallets × 2 levels
Capacity per IBC	1.000	L	
Density of flammable liquid	0,875	kg/L	Assumed average
Mass per IBC	875	kg	= 1.000 × 0,875
Total combustible mass	52.500	kg	= 60 × 875
Spill scenario considered	10%	–	Conservative estimate
Effective mass for calculation	5,250	kg	= 52,500 × 0.10
Calorific value (LHV)	30	MJ/kg	Higher than indoor due to pure flammables
Theoretical fire load (Qf)	157,500	MJ	= 5,250 × 30
Correction factor (Cf)	1.00	–	Open area, ground-level stacking
Corrected fire load	157,500	MJ	= Qf × Cf
Surface area (A)	350	m²	Outdoor area
Corrected fire load density (q)	450	MJ/m²	= Qf × Cf / A
Regulatory threshold (Type D, RSCIEI)	250	MJ/m²	[3]
Fire risk classification	High	–	Threshold exceeded