

Investigation of Brazilian Regulatory Standards Compliance

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Abstract

This thesis aims to evaluate the Brazilian Regulatory Standards (Normas Regulamentadoras – NRs) and identify their impact on the electrical design of auxiliary equipment in shipbuilding for Wärtsilä. The study involves reviewing the NR standards, selecting those relevant to electrical design, and analysing their requirements and recommendations.

A thorough review of each standard will provide a summary and description to address the challenge of the original documentation being available only in Brazilian Portuguese.

By systematically assessing the Brazilian NR standards, this research seeks to bridge potential gaps in compliance, ensuring that auxiliary equipment meets both classification society rules and the specific expectations of shipbuilders and shipowners.

The final outcome of this thesis is a comprehensive list of Brazilian NR requirements applicable to electrical design in shipbuilding, serving as a reference for future projects.

Language: English

Key words: brazilian nr, standards, electrical design

EXAMENSARBETE

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Abstrakt

Detta examensarbete utvärderar de brasilianska regulatoriska standarderna, Normas Regulamentadoras – NRs och identifierar deras påverkan på den elektriska designen av hjälputrustning inom skeppsbyggnad för Wärtsilä. Examensarbetet innefattar en granskning av NR-standarderna, urval av de som är relevanta för elektrisk design samt en analys av deras krav och rekommendationer.

En noggrann genomgång av varje standard tillhandahåller en sammanfattning och beskrivning för att hantera utmaningen med att den ursprungliga dokumentationen endast finns tillgänglig på brasiliansk portugisiska.

Genom en systematisk bedömning av de brasilianska NR-standarderna strävar detta examensarbete efter att överbrygga potentiella brister i överensstämmelse och säkerställa att hjälputrustningen uppfyller både klassificeringssällskapets regler och de specifika kraven från skeppsbyggare och fartygsägare.

Det slutliga resultatet av detta examensarbete är en omfattande lista över brasilianska NR-krav som är tillämpliga på elektrisk design inom skeppsbyggnad, vilket ska fungera som en referens för framtida projekt.

Språk: engelska

Nyckelord: brasilianska nr, standarder, elektrisk design

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Tiivistelmä

Tämän opinnäytetyön tavoitteena oli arvioida Brasilian sääntelystandardeja (Normas Regulamentadoras – NRs) ja selvittää niiden vaikutus apulaitteiden sähköiseen suunnitteluun laivanrakennuksessa Wärtsilälle. Opinnäytetyö sisältää NR-standardien tarkastelun, sähköiseen suunnitteluun liittyvien standardien valinnan sekä niiden vaatimusten ja suositusten analysoinnin.

Jokaisen standardin perusteellinen tarkastelu tarjoaa yhteenvedon ja kuvauksen, jotta voidaan ratkaista haaste, jonka aiheuttaa alkuperäisen dokumentaation saatavuus ainoastaan brasilianportugaliksi.

Arvioimalla Brasilian NR-standardeja järjestelmällisesti tämä tutkimus pyrkii paikkaamaan mahdollisia vaatimustenmukaisuuden puutteita ja varmistamaan, että apulaitteet täyttävät sekä luokituslaitosten säännöt että laivanrakentajien ja laivanomistajien erityisvaatimukset.

Tämän opinnäytetyön lopputuloksena on kattava luettelo Brasilian NR-vaatimuksista, jotka koskevat laivanrakennuksen sähköistä suunnittelua ja toimivat viitteenä tulevia projekteja varten.

Kieli: englanti

Avainsanat: brasilian nr, standardit, sähköinen suunnittelu

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1 Introduction

At the beginning of the summer of 2024, I had the privilege of starting my journey at Wärtsilä as a summer trainee with the E&A Engineering team in the Customer Delivery Department. As a third-year student, I was able to apply the knowledge I had gained during my studies and found success in the role. As a result, I was offered the opportunity to continue working part-time as an on-call trainee during my final year. During this period, the topic of my bachelor's thesis was brought up, and I was given the opportunity to undertake this very task. In the following sections, the key theoretical concepts relevant to the equipment addressed in this thesis are presented.

1.1 Objectives and Scope of Work

The shipbuilding industry is undergoing significant changes, with an increasing focus on compliance with various standards. Some of these standards are mandatory, as they are referenced in classification society rules, while others are defined by shipbuilders or owners for specific vessels.

Auxiliary equipment, such as motor starters and power supply units included in engine deliveries, complies with the requirements set by classification societies. However, there may be discrepancies regarding the requirements and recommendations outlined in shipbuilders' and shipowners' specifications, as these standards have not been thoroughly examined in this case.

The objective of this thesis is to evaluate Brazilian NR standards from an electrical design perspective, selecting the relevant ones and identifying key requirements and recommendations. This will help assess whether the current electrical design of auxiliary equipment and interconnections aligns with these standards.

As part of the final thesis, the initial step involves a thorough review of the Brazilian NR (Normas Regulamentadoras) standards. Following this, the focus is on identifying which of these regulations are specifically applicable to electrical design. Once the relevant standards have been pinpointed, they are studied in depth to gain a comprehensive understanding of their content and implications. Based on this detailed analysis, a complete and structured list of Brazilian NR requirements relevant to electrical design is developed.

1.2 Cabinet Technical information

The electrical cabinets used in Wärtsilä's auxiliary equipment are built to adhere to a series of technical requirements that ensure both operational reliability and compliance with international maritime and safety standards. These requirements are essential not only for maintaining functionality in harsh marine environments but also for satisfying classification society regulations and local legislation in various markets, including Brazil.

One of the key design specifications is the degree of protection provided by the cabinet's enclosure, classified according to the IP (Ingress Protection) (Ingress Protection (IP) ratings, 2025) rating system. This rating, established under standards such as IEC 60529 (IEC 60529, 2019), defines the cabinet's resistance to solid objects and liquids. A high IP rating ensures that internal components are shielded from water ingress and dust, which is particularly important in marine environments where exposure to saltwater and humidity is possible.

Another important consideration is the approximate weight of the cabinet. Knowing the weight is vital for several reasons, including structural integration aboard ships, compliance with transport regulations, and safe handling during installation. Excessive weight may affect mounting stability and increase mechanical stress, particularly in vessels subject to vibrations and dynamic loads.

All components installed within the cabinet must be approved for marine use (Buellelectric, 2023). This requirement ensures that each part has been tested for robustness under marine-specific conditions such as salt spray, vibration, and temperature variations. Marine approvals from recognized bodies like DNV (DNV Maritime, 2025), ABS (Marine Industry Solutions, 2025), or Lloyd's Register (Lloyd's Register: first for trusted advice in the maritime industry, 2025) provide additional assurance of product quality and suitability.

In addition, all components must be flame-retardant (Flame retardant, 2024), reducing the risk of fire propagation in the event of a short circuit or electrical failure. This is a critical safety measure, especially on ships where fire hazards pose serious threats to life and infrastructure. Flame-retardant materials are typically tested according to standards like IEC 60695 (IEC 60695-2-11, 2021).

For operational clarity and maintenance efficiency, the cabinets must also feature clear markings on all components. These markings include labels for breakers, relays, terminals, and other internal hardware. Proper labelling not only assists in troubleshooting and repairs but is often a requirement in safety audits and inspections.

All wires used within the cabinet are required to be halogen-free. Halogen-free cables, in the event of combustion, emit low smoke and non-toxic, non-corrosive gases, significantly improving visibility and reducing inhalation risks for personnel (Labgroup, 2025). This is especially crucial in enclosed shipboard environments where evacuation time may be limited.

Wire colors are specified in accordance with standardized color-coding schemes, which assist technicians in identifying circuit types and voltage levels at a glance. Consistent use of color-coding enhances electrical safety and reduces the potential for wiring errors during installation or maintenance.

Finally, markings must be present on all wire and cable ends, enabling fast identification during wiring, testing, and service procedures. These markings typically align with the schematic documentation and help ensure traceability throughout the system.

Collectively, these technical specifications form the baseline for a compliant and high-performance electrical cabinet suited for shipboard use. Their adherence not only guarantees safer operations but also simplifies conformity assessments in international and local regulatory contexts, including the Brazilian NR standards explored in this thesis.

1.3 Cabinet Applicable standards

The electrical cabinets utilized in Wärtsilä's auxiliary equipment are designed in strict accordance with several international standards, particularly those established by the International Electrotechnical Commission (IEC). These standards ensure that the cabinets not only fulfill technical and safety requirements but also maintain compatibility and reliability across global maritime applications. Adhering to these standards is critical for achieving classification approvals and for aligning with international best practices in electrical design.

One of the foundational standards applied is IEC 60092-101 (IEC 60092-101, 2018), which outlines the definitions and general requirements for electrical installations in ships. This standard serves as a cornerstone for marine electrical systems, specifying the terminology, voltage classifications, and environmental considerations necessary to guide safe and efficient design within a shipboard context. Its provisions ensure that the installed systems can withstand the operational conditions encountered at sea, such as mechanical vibrations, high humidity, and fluctuating temperatures.

Complementing this is IEC 60092-302-2 (IEC 60092-302-2, 2019), which specifically addresses low-voltage switchgear and controlgear assemblies for marine applications. This standard defines the mechanical and electrical construction requirements for assemblies used in shipboard power distribution. It emphasizes aspects such as dielectric properties, thermal behaviour, and short-circuit protection, ensuring that the switchgear systems can maintain stability under load variations and fault conditions.

Another core reference is IEC 61439-1 (IEC 61439-1, 2020), which provides the general rules for low-voltage switchgear and controlgear assemblies. This standard ensures the safety, performance, and reliability of assembled systems by defining the responsibilities of both the original manufacturer and the final assembler. It requires type testing of enclosures, insulation coordination, and proper protection against electric shock. The modular and systematic approach promoted by this standard supports flexibility in cabinet design while maintaining compliance.

IEC 60947 (IEC 60947, 2025), a broader standard that encompasses the design and testing of low-voltage switchgear and controlgear, is also included. This series of standards includes detailed requirements for components such as circuit breakers, contactors, overload relays, and motor starters. Compliance with IEC 60947 guarantees the interoperability and safety of these components within the cabinet and contributes to standardized maintenance and replacement procedures globally.

To ensure a proper human-machine interface, IEC 60445 (IEC 60445, 2021) is utilized. This standard specifies the basic and safety principles for the identification of equipment terminals, conductor terminations, and conductors. By standardizing the use of colors and alphanumeric codes for markings, IEC 60445 promotes intuitive understanding and minimizes human error during installation, operation, or troubleshooting.

Lastly, IEC 60417 (IEC 60417, 2025), which deals with graphical symbols for use on equipment, is applied to improve the clarity and international comprehensibility of safety and operation markings. These symbols ensure that users, regardless of language or background, can quickly interpret warnings, operating modes, and equipment functions.

Together, these standards provide a robust framework that governs the design, construction, and maintenance of Wärtsilä's electrical cabinets. Their combined implementation ensures that all installed equipment is safe, efficient, and internationally compliant. These standards also serve as a benchmark when comparing to regional regulations, such as the Brazilian NR

standards explored in this thesis, facilitating the alignment between global engineering practices and local legal requirements.

2 What are Brazilian regulatory standards?

Brazil's Regulatory Standards, known as Normas Regulamentadoras (NRs), are a comprehensive set of guidelines designed to promote occupational health and safety across various industries. Established by the Ministry of Labor and Employment, these standards aim to prevent workplace accidents and occupational diseases, ensuring a secure environment for both employers and employees. (Brazilian Regulatory Standards, 2025)

2.1 Difference between NRs and national legislation

NRs are specialized regulations within the broader framework of national legislation, focusing exclusively on workplace safety and health, while national legislation governs all aspects of Brazilian law and policy. (Brazilian Regulatory Standards (NR), 2025)

2.2 Difference between NRs and international standards

Brazilian NRs address specific industries or hazards in detail. For instance, NR-10 focuses on electrical installations and services, providing comprehensive guidelines tailored to Brazil's unique industrial landscape. (Brazilian Regulatory Standards, 2025)

International Standards Frameworks like ISO 45001 (ISO 45001:2018, 2024) and the ILO's OSH 2001 (Guidelines on occupational safety and health management systems (ILO-OSH 2001), 2001) offer broader guidelines applicable across various sectors, emphasizing general principles of risk management and worker safety.

2.3 Purpose and Objectives

The primary goal of the NRs is to establish mandatory procedures and criteria that safeguard workers' health and safety. By setting clear guidelines, they help mitigate risks associated with different occupational activities, thereby reducing the incidence of work-related injuries and illnesses. (Brazilian Regulatory Standards (NR), 2025)

2.4 Scope and Content

The NRs cover a wide array of topics pertinent to occupational safety and health, realized as the following list:

NR1 – General Provisions and Occupational Risk Management

NR2 – Prior Inspection (Repealed by Ordinance SEPRT 915 of July 30, 2019)

NR3 – Embargo and Prohibition

NR4 – Specialized Services in Occupational Health and Safety (SESMT)

NR5 – Internal Committee for Prevention of Accidents and Harassment (CIPA)

NR6 – Personal Protective Equipment

NR7 – Occupational Health Medical Control Program (PCMSO)

NR8 – Buildings

NR9 – Assessment and Control of Occupational Exposure to Physical, Chemical, and Biological Agents

NR10 – Safety in Electrical Installations and Services

NR11 – Transport, Moving, Storage, and Handling of Materials

NR12 – Machinery and Work Equipment Safety

NR13 – Boilers and Pressure Vessels

NR14 – Furnaces

NR15 – Unhealthy Activities and Operations

NR16 – Hazardous Activities and Operations

NR17 – Ergonomics

NR18 – Health and Safety in Construction

NR19 – Explosives

NR20 – Health and Safety at Work with Flammables and Combustibles

NR21 – Open Air Work

NR22 – Occupational Health and Safety in Mining

NR23 – Fire Protection

NR24 – Sanitary and Comfort Conditions in the Workplace

NR25 – Industrial Waste

NR26 – Safety Signs

NR27 – Professional Registration of Occupational Safety Technician (Repealed by Ordinance 262 of May 30, 2008)

NR28 – Enforcement and Penalties

NR29 – Health and Safety in Ports

NR30 – Health and Safety in Waterways

NR31 – Health and Safety at Work in Agriculture, Livestock, Forestry, Logging, and Aquaculture

NR32 – Health and Safety at Work in Health Services

NR33 – Health and Safety in Confined Spaces

NR34 – Work Conditions and Environment in Shipbuilding and Ship Repair Industry

NR35 – Working at Height

NR36 – Health and Safety at Work in Slaughterhouses and Processing Meat and Derivatives

NR37 – Health and Safety on Oil Platforms

NR38 – Health and Safety in Urban Cleaning and Solid Waste Management

These standards are regularly updated to reflect technological advancements and emerging workplace hazards, ensuring their relevance and effectiveness in promoting occupational safety. (Brazilian Regulatory Standards, 2025)

2.5 Historical Context

The inception of the NRs dates back to June 8, 1978, with the issuance of Ordinance No. 3214, which introduced the initial set of standards. This initiative was a response to the growing need for structured regulations to address occupational hazards and improve working conditions in Brazil. Over time, additional standards have been developed to encompass a broader range of industries and work environments. (Brazilian Regulatory Standards, 2025)

2.6 Development Process

A distinctive feature of the NRs is their development through a tripartite parity system, aligning with the International Labour Organization (ILO) guidelines. This collaborative approach involves representatives from the government, employers, and workers, who collectively discuss and define the standards. The Tripartite Permanent Paritarian Commission (CTPP) serves as the principal forum for these deliberations, ensuring that the standards are comprehensive and balanced. (Brazilian Regulatory Standards, 2025)

2.7 Implementation and Compliance

Compliance with the NRs is mandatory for all employers and employees operating within Brazil. The Ministry of Labor and Employment oversees the enforcement of these standards, conducting regular inspections to ensure adherence. Non-compliance can result in penalties, including fines and, in severe cases, the suspension of operations until the necessary safety measures are implemented. (Brazilian Regulatory Standards (NR), 2025)

2.8 Summary

In summary, the Brazilian Regulatory Standards (NRs) serve as a fundamental framework for ensuring occupational health and safety across the nation. Through their comprehensive guidelines and collaborative development process, they play a pivotal role in fostering safer work environments and protecting the well-being of the Brazilian workforce.

3 Way of working

All Brazilian Regulatory Standards are available on the Brazilian government's official website at <https://www.gov.br/pt-br>. In Brazil, the official language is Portuguese, which is

spoken by the vast majority of the population and is used for government, education, media, and everyday communication. However, just like the official language, the vast majority of the website is also in Portuguese, and naturally, the Regulatory Standards are written in Portuguese as well. Specifically in Brazilian Portuguese which differs slightly from European Portuguese. (Just Learn, 2024)

To address this language barrier, assistance has been obtained from another website, <https://braziliannr.com>, which provides translations of all regulations into English for a monthly subscription fee of approximately €10. To ensure the accuracy and reliability of the translated documents, a process of cyclical cross-checking is implemented. This involves verifying that no critical information has been lost in translation by comparing the official Portuguese versions with the English translations.

This verification process is relatively straightforward since most points of legislation are concise, often only a few sentences long, and are clearly numbered. Any discrepancies or omissions in the translation would therefore be easy to detect. By using the convenience of translated services while maintaining rigorous checks, the quality of the research is not only preserved but also enhanced, thanks to the efficiency and ease provided by these translations.

Artificial intelligence has been used to refine and improve the clarity of the English language in this work, making the text easier to read and understand. The workflow followed a structured approach: first, the original text was written independently; then, ChatGPT was used to enhance the language and improve readability; finally, suggestions were reviewed and adapted to preserve the author's original voice and writing style. (ChatGPT, 2025)

3.1 Example of a translated point

First, a point taken from the government legislations scripture NR10:

“10.8.8.3 A carga horária e o conteúdo programático dos treinamentos de reciclagem destinados ao atendimento das alíneas “a”, “b” e “c” do item 10.8.8.2 devem atender as necessidades da situação que o motivou”. (Normas Regulamentadoras Vigentes, 2024)

Second, the same point taken from the translated scripture:

“10.8.8.3 The workload and program content of refresher training aimed at meeting paragraphs (a), (b), and (c) of item 10.8.8.2 shall meet the needs of the situation that justified it.” (Brazilian Regulatory Standards, 2025)

3.2 Hybrid Solution

Since such a thorough investigation is done of each Brazilian NR standard, a short description of the history, implementation and scope of each standard is written, for little to no extra work. Grandly broadening the usefulness of the document to anyone who seeks to be informed of what these regulations are and why. Because every standard has been read through, bullet by bullet, at the end of each Regulation (that will not affect our electrical design at Wärtsilä), a “What we can learn” section has been added. Here a snippet has been taken out with important, good-to-know information, that has been deemed either useful or important. In cases where such information is unavailable, lighter, more engaging content has been provided to maintain interest.

4 Choosing the relevant NR Regulatory Standards for consideration

This chapter presents a thorough and detailed examination of the standards most relevant to the investigation. It is critical that this process is approached meticulously, leaving no stone unturned. By doing so, it is aimed to ensure that every potential factor is considered and accounted for, ultimately achieving the highest possible level of confidence in our findings. Neglecting any aspect, no matter how seemingly minor, could compromise the entire purpose of the investigation. Therefore, the focus is on comprehensive analysis, ensuring that nothing is overlooked and that the integrity and reliability of the conclusions are preserved. This chapter serves as the foundation for establishing a clear and robust framework that guides the rest of the investigation.

4.1 Method of choosing

Each NR standard is summarized, looking into its content and deciding whether the standard is suitable for the investigation and later on creating the NR requirements list for the electrical equipment using this information.

Each standard is marked with a (✓) in the headline if it applies to the list of requirements, allowing for quick and easy identification.

4.1.1 NR1 – General Provisions and Occupational Risk Management

The NR-1 standard aims to provide a framework for managing occupational risks and ensuring workplace safety. It establishes general guidelines and requirements for employers and workers to identify, assess, and mitigate risks in various work environments. By aligning with international standards like ISO 45001, NR-1 seeks to promote consistency, protect employee well-being, and adapt safety measures for businesses of all sizes, including simplified processes for low-risk and small enterprises. Its ultimate goal is to create safer workplaces and reduce occupational hazards across Brazil.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Brazilian employers are responsible for providing employees with proper training for their tasks and workplace safety. They must also maintain important documents for up to 20 years and ensure these records are readily available for review by authorized government officials.

4.1.2 NR2 – Prior Inspection (Repealed by Ordinance SEPRT 915 of July 30, 2019)

Revoked by ordinance July 30, 2019. Not in use, not applicable.

4.1.3 NR3 – Embargo and Prohibition

NR-3, titled "Embargo and Prohibition," is a regulation focused on preventing serious and imminent risks to workers' health and safety. First issued in 1978 by the Ministry of Labor, it establishes administrative measures, empowering Labor Inspectors to halt work activities or impose embargos when hazardous conditions are identified. These measures are preventive rather than punitive.

The standard has undergone multiple revisions, with minor updates in 1983 and 2011, and a comprehensive review in 2019. The latest revision introduced clear and objective criteria for assessing risks, ensuring consistency and transparency in decision-making. It also involved

collaboration with various stakeholders, including labor organizations, employers, and government representatives, to enhance its effectiveness.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: A labor inspector can only impose a prohibition in cases of significant or extreme safety risks. However, since it is a possibility, it is crucial to stay compliant with regulations and maintain safe ways to avoid disruptions that could negatively impact business operations.

4.1.4 NR4 – Specialized Services in Occupational Health and Safety (SESMT)

NR-4, originally introduced in 1978 under Ordinance MTb No. 3.214, mandates companies to employ occupational safety and health professionals based on their workforce size and risk level. These professionals, collectively known as SESMT (Specialized Services in Occupational Health and Safety), are responsible for implementing safety engineering and occupational health practices within the workplace.

Over the years, NR-4 has undergone significant revisions. In 1983, its name was updated to reflect its current focus, and from 1983 to 2013, twelve updates were made. These updates included changes to qualification requirements and the creation of a Professional Identification Card for Occupational Safety Technicians.

In 2007, a provision was added to allow companies to share SESMT services. Later, in 2014, regulations required SESMT professionals to register with their respective Professional Councils, permitted hiring more than one full-time occupational physician, and mandated the recording of monthly data on workplace accidents and occupational diseases.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“4.3.2 The SESMT must be composed of an occupational physician, an occupational safety engineer, an occupational safety technician, an occupational nurse, and an occupational nursing assistant/technician, as specified in Annex II.*

4.3.3 *SESMT professionals must have the necessary training and professional registration as required by the professional regulation and the normative instruments issued by the respective professional council, if existing.*”

4.1.5 NR5 – Internal Committee for Prevention of Accidents and Harassment (CIPA)

NR-5 establishes the Internal Committee for Prevention of Accidents (CIPA) to mitigate workplace accidents, harassment and promote worker safety. It requires every workplace to set up a committee with representatives from employers and employees, scaled to workforce size and risk level. Major revisions have standardized practices like training, record-keeping, and risk mapping. Updates have also introduced blended learning for training and streamlined committee operations.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Number of CIPA members according to the number of employees.

Table 1. Sizing of CIPA. (Brazilian Regulatory Standards, 2025)

Number of Employees in the Establishment										
Risk Level	Number of CIPA Members	0 to 19	20 to 29	30 to 50	51 to 80	81 to 100	101 to 120	121 to 140	141 to 300	301 to 500
1	Effective					1	1	1	1	2
	Substitute					1	1	1	1	2
2	Effective				1	1	2	2	3	4
	Substitute				1	1	1	1	2	3
3	Effective		1	1	2	2	2	3	4	5
	Substitute		1	1	1	1	1	2	2	4
4	Effective		1	2	3	3	4	4	4	5
	Substitute		1	1	2	2	2	2	3	4

4.1.6 NR6 – Personal Protective Equipment

NR-6 sets forth regulations governing the use of personal protective equipment (PPE) by workers, along with the responsibilities of employers, manufacturers, and importers of PPE. Originally published in 1978 under Articles 166 and 167 of the Consolidation of Labor Laws

(CLT), NR-6 has undergone several revisions through collaboration among government, employer, and worker representatives. The most recent update in 2018 focused on adapting PPE for individuals with disabilities.

Applicable to all industries and economic sectors requiring PPE, NR-6 mandates that PPE must have a Certificate of Approval (CA) issued by the Ministry of Labor.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“6.8 Responsibilities of the manufacturer and importer b) Market PPE with instructions in Portuguese language regarding its use, maintenance cleaning and disinfection procedures, restrictions and other instructions for its use.”* This is rather important since it’s the responsibility of each individual worker to maintain and care for their own equipment, reporting if any damaged or faulty equipment needs to be replaced.

4.1.7 NR7 – Occupational Health Medical Control Program (PCMSO)

NR-7 governs occupational health through the PCMSO, transitioning from basic medical exams to an integrated health program addressing workplace risks. Major updates include a 1983 revision for technological advancements, the 1990 elimination of mandatory chest X-rays, and the 1994 introduction of PCMSO for comprehensive worker health management.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“7.6.1.1 The employee’s medical file must be kept by the organization for at least 20 years after the employee’s termination, except as otherwise provided in the Annexes of this NR.”*

4.1.8 NR8 – Buildings

NR-8 sets workplace building safety standards. Major revisions occurred in 1983 to reflect technological progress, with minor updates in 2001 (floor-to-ceiling height) and 2011 (adjustment to item 8.3.6), ensuring compliance with evolving safety requirements. These updates were discussed within the Tripartite Permanent Paritarian Commission (CTPP).

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: The requirements for buildings outlined in NR-8 are minimal by today's standards, especially when compared to those of more developed countries. For example, one provision states, “8.3.3.3 *Workplace roofs shall be protected against rain.*” Notably, the regulation does not address critical safety features such as fire-exits or fire-extinguishers. (Mentioned in NR23 – Fire Protection)

4.1.9 NR9 – Assessment and Control of Occupational Exposure to Physical, Chemical, and Biological Agents

NR-9 outlines the requirements for evaluating and controlling workplace exposures to chemical, physical, and biological agents. Initially issued in 1978 under the title "Environmental Risks," the regulation has undergone multiple revisions, including significant updates in 1983 and 1994. The 1994 revision introduced the Environmental Risk Prevention Program (PPRA).

The most comprehensive revision occurred in 2020, aligning NR-9 with broader regulatory changes.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Ties heavily into NR-15 and NR-16 “*For the purpose of characterizing unhealthy or hazardous activities or operations*”.

4.1.10 NR10 – Safety in Electrical Installations and Services (✓)

NR-10 governs the safety and health of workers interacting with electrical systems in Brazil. First introduced in 1978, based on French standards, it has been revised four times (1983, 2004, 2016, and 2019) to align with industry advancements and legislative changes.

The regulation applies to all electrical installations and services, regardless of voltage or activity type, including work conducted near electrical systems. It sets fundamental guidelines for implementing risk controls and preventive measures, such as risk assessments,

safety protocols, training, qualifications, personal protective equipment, and emergency planning.

NR-10 also established the National Permanent Commission on Safety in Electric Energy (CPNSEE), which oversees compliance and suggests ongoing improvements to the regulation.

This regulation does contain information that is taken into consideration when making our Brazilian NR Requirements compliance list regarding our electrical equipment at Wärtasilä.

4.1.11 NR11 – Transport, Moving, Storage, and Handling of Materials

NR-11 establishes safety guidelines for the transportation, storage, handling, and movement of materials in workplaces, regardless of sector or economic activity. Originally issued in 1978, it regulates Articles 182 and 183 of the Consolidation of Labor Laws (CLT). Over the years, it has undergone three significant revisions to address industry-specific risks and safety concerns:

2003 Revision: Introduced Annex I to NR-11, focusing on technical regulations for handling stone slabs due to high accident rates in the marble and granite sectors.

2004 Revision: Limited stack heights in warehouses and removed outdated provisions, ensuring safer material storage practices.

2016 Revision: Updated Annex I to further refine safety measures.

It appears that there are no specific provisions applicable to Wärtasilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“11.1.5 Operators of self-propelled transport equipment must receive specific training provided by the company to qualify them for this function.*

11.1.6 Operators of motorized transport equipment must be qualified and can only operate during working hours if they carry an identification card with their name and photograph in a visible place.”

4.1.12 NR12 – Machinery and Work Equipment Safety (✓)

NR-12 outlines the minimum safety requirements to prevent accidents and occupational diseases related to machinery and equipment use. Originally issued in 1978 under Articles 184 to 186 of the Consolidation of Labor Laws (CLT), it underwent various updates, culminating in a comprehensive revision in 2010 to reflect technological advances and workplace safety needs.

NR-12 applies to all stages of machinery and equipment handling, including design, manufacturing, importation, sale, installation, operation, maintenance, and worker training. It encompasses both new and used machinery across all types and industries.

The regulation consists of a main body with 19 titles and 11 annexes. The main body establishes technical references, fundamental principles, protection measures, and basic safety requirements. The annexes provide additional guidelines specific to certain types of machines and equipment. NR-12 aligns with national and international technical standards, integrating modern safety practices.

This regulation does contain information that is taken into consideration when making our Brazilian NR Requirements compliance list regarding our electrical equipment at Wärtsilä.

4.1.13 NR13 – Boilers and Pressure Vessels

First issued in 1978, NR-13 has undergone eight revisions, the latest in 2019, to harmonize and simplify its provisions with the updated NR-01. It applies to equipment operating under pressure or vacuum, containing fluids categorized by toxicity, flammability, and combustibility. These are classified into risk groups based on the product of pressure and volume.

The regulation defines responsibilities for employers, legally qualified professionals, operators, and inspection services. It also establishes protocols for handling serious risks, documentation, communication, and equipment certification. Specific guidelines for installation, operation, and safety of boilers, pressure vessels, pipes, and storage tanks are detailed, with additional information provided in its four annexes.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“13.4.3.1 Every boiler shall have an updated operating manual in Portuguese, within easy access to the operators, containing at least:*

- a) starting and stopping procedures;*
- b) routine operating procedures and parameters;*
- c) procedures for emergency procedures;*
- d) general procedures for safety, health and environmental preservation.”*

4.1.14 NR14 – Furnaces

NR-14 defines the minimum safety standards for the construction, installation, operation, and maintenance of furnaces, in compliance with Brazilian labor laws. Initially issued in 1978, the regulation underwent a single revision in 1983.

Unlike other standards revised after 1996, NR-14 was not updated using Brazil's tripartite model, which involves input from government, employers, and workers.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Radiant heat of a furnace must be within limits set by NR-15 Unhealthy Activities and Operations

4.1.15 NR15 – Unhealthy Activities and Operations

NR-15 regulates unsafe and unhealthy work conditions in Brazil, establishing criteria for additional worker compensation. Originally issued in 1978 under Ordinance MTb No. 3.214, it governs Articles 189 to 196 of the Consolidation of Labor Laws (CLT) and identifies activities and conditions considered hazardous to health.

The regulation includes a general section and 13 annexes that define tolerance limits for physical, chemical, and biological agents. These limits are based on 1976 American Conference of Governmental Industrial Hygienists (ACGIH) standards, adjusted for Brazil's 48-hour workweek at the time. NR-15 covers exposure to various risks, including noise, heat, radiation, vibration, humidity, chemicals (e.g., benzene, asbestos), and biological

agents. Specific thresholds require quantitative evaluations for several hazards, such as noise and heat.

In 2010, discussions on revising NR-15 began, prioritizing updates to heat exposure standards. A draft was released for public consultation in 2012, and by 2019, the tripartite group finalized the review of heat exposure criteria. Updates aligned with the 2017 Fundacentro Occupational Hygiene Standard (NHO 06). The revised NR-15 was published in December 2019 through Portaria SEPRT No. 1.359, harmonizing technical standards and exposure limits.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Annex 1 - Tolerance limits for noise

Table 2. Tolerance limits for noise. (Brazilian Regulatory Standards, 2025)

NOISE LEVEL DB(A)	MAXIMUM PERMISSIBLE DAILY EXPOSURE
85	8 hours
86	7 hours
87	6 hours
88	5 hours
89	4 hours and 30 minutes
90	4 hours
91	3 hours and 30 minutes
92	3 hours
93	2 hours and 40 minutes
94	2 hours and 15 minutes
95	2 hours
96	1 hour and 45 minutes
98	1 hour and 15 minutes
100	1 hour
102	45 minutes
104	35 minutes
105	30 minutes
106	25 minutes
108	20 minutes
110	15 minutes
112	10 minutes
114	8 minutes
115	7 minutes

4.1.16 NR16 – Hazardous Activities and Operations

NR-16 regulates hazardous activities in Brazil and establishes criteria for hazard pay for workers. It was first issued in 1978 under MTb Ordinance No. 3.214 to govern Articles 193–196 of the Consolidation of Labor Laws (CLT). Classified as a Special Standard, its updates are discussed by the Permanent Tripartite Commission (CTPP) since no National Tripartite Thematic Commission (CNTT) exists for NR-16.

The regulation consists of a general section and annexes that define hazardous activities and procedures for hazard pay. The general section has seen minor updates, such as adding risk area delimitation in 1994 and aligning combustible liquid definitions with NR-20 in 2012.

Although Annex IV addresses hazardous activities and operations involving electricity, it primarily focuses on determining when employees are entitled to hazard pay. Therefore, it has limited relevance to the design and delivery of our electrical equipment at Wärtasilä.

What we can learn: *“16.2 Working in hazardous conditions entitles the worker to a hazard pay of 30% (thirty percent) over the base salary, excluding any increments due to bonuses, prizes, or profit-sharing.”*

4.1.17 NR17 – Ergonomics (✓)

NR-17, established by the Ministry of Labor and Employment in 1978, focuses on workplace safety and health by adapting working conditions to the psychophysiological characteristics of workers. Over the years, it has undergone multiple revisions, including significant updates in 1990 and 2007, when two annexes were added: Annex I (Checkout Operators) and Annex II (Tele-Service/Telemarketing).

The latest update in 2018 revised subitem 17.5.3.3 regarding workplace illuminance, replacing the canceled ABNT NBR 5413 standard with the Occupational Hygiene Standard No. 11 (NHO11) for lighting evaluation. The current version of NR-17 has been in effect since January 3, 2022, following its approval at the 97th Ordinary Meeting of the Tripartite Commission.

It appears that there are select provisions applicable to Wärtasilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

4.1.18 NR18 – Health and Safety in Construction (✓)

NR-18, issued in 1978, regulates safety in construction, demolition, and repair work. It has undergone two major revisions, in 1995 and 2020, along with 24 minor updates. The 1995 revision introduced key programs like the Program of Conditions and Work Environment (PCMAT) and a permanent committee (CPN) to improve construction site safety.

The 2020 revision modernized the standard, addressing gaps for heavy construction projects like bridges and dams. It emphasized a streamlined Risk Management Program, requiring professional oversight on all construction sites, with simplified requirements for smaller projects. Additional changes included limiting manually excavated caissons to 15 meters and phasing out hyperbaric caissons within 24 months. These updates are expected to save Brazil's construction industry R\$ 5 billion over a decade.

It appears that there are select provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

4.1.19 NR19 – Explosives

NR-19, established in 1978, regulates safety measures for the manufacturing, storage, and transportation of explosives and fireworks in Brazil. Classified as a Special Standard, it has undergone three revisions: two minor (1979 and 2007) and one major (2011). Updates are discussed by the Permanent Tripartite Commission (CTPP).

The 1979 revision updated rules for barricaded storage and mandated risk area delimitation. In 2007, an annex introduced specific health and safety measures for the fireworks industry, requiring companies to implement preventive measures for worker protection. This annex was developed with input from worker and employer organizations. The 2011 revision reorganized the standard and updated Annex II, defining maximum explosive storage quantities and required distances.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Manufacturing fireworks and explosives requires a Certificate of Conformity from the Brazilian Army as well as permanent electronic monitoring according to the Directorate of Controlled Products Supervision of the Brazilian Army

4.1.20 NR20 – Health and Safety at Work with Flammables and Combustibles

NR-20, first issued in 1978, governs the handling of flammables and combustibles, addressing activities, installations, and equipment across various industries. Classified as a Special Standard, it has undergone six changes, including two major revisions.

The first major revision, finalized in 2011 and published in 2012, established the National Tripartite Thematic Commission (CNTT) for NR-20 to promote legislative improvements. This update prioritized simplifying and harmonizing regulations while maintaining workplace safety and health.

Certain provisions apply to electrical equipment, as it can ignite flammable and combustible materials. However, this does not apply to us, as our electrical equipment will not be used in explosive environments.

4.1.21 NR21 – Open Air Work

The latest update was in 1999. The regulation is very short and governs basic safety for outdoor workers and sanitary guidelines for their accommodation. There are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“21.14. Private facilities shall be airy, with abundant ventilation, be kept clean and in good sanitary conditions, as well as protected against the proliferation of insects, rats, animals and pests.”*

4.1.22 NR22 – Occupational Health and Safety in Mining

NR-22, issued on June 8, 1978, aims to improve safety and working conditions in the mining sector, reducing accidents and occupational illnesses. The regulation underwent its first major revision in 1999, influenced by European directives, international standards, and ILO Convention No. 176. The revised version, effective April 21, 2000, introduced key updates, including:

- Employer and employee responsibilities.
- The right to refuse unsafe work.
- A mandatory Risk Management Program (PGR).
- Establishment of the Internal Committee for Accident Prevention in Mining (CIPAMIN).
- Requirements for wet drilling to reduce silicosis risks and adoption of NIOSH dust exposure guidelines.

In 2018, updates to Annex I (airborne mineral dust exposure) were finalized following the 2015 Mariana dam disaster. After the 2019 Brumadinho dam disaster, further amendments prohibited administrative and recreational facilities downstream of mining dams. These updates reflect NR-22's focus on enhancing worker safety and addressing industry-specific hazards.

Although NR22 mentions and has a chapter for Electrical installations, these mentions are under mining circumstances and are therefore not applicable to Wärtsiläs requirements in their projects and is therefore not included in final conformity list.

What we can learn: *“22.18.2 Electrical supply cables and conductors used must be certified by a certification body accredited by the National Institute of Metrology, Standardization, and Industrial Quality (INMETRO).”*

4.1.23 NR23 – Fire Protection

Issued by MTP Ordinance No. 2.769 on September 5, 2022, NR-23 outlines fire prevention measures for workplaces. It applies to all establishments, ensuring compliance with national legislation and official technical standards. Organizations are required to inform workers about the use of firefighting equipment, emergency response procedures, safe evacuation protocols, and alarm systems.

There are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: Similar fire safety measures as used in Finland

4.1.24 NR24 – Sanitary and Comfort Conditions in the Workplace

Initially issued in 1978, NR-24 sets workplace hygiene and comfort standards in line with Clause VII of Article 200 of the CLT. Classified as a Special Standard in 2018, it underwent limited updates until a major revision in 2019 addressed outdated and impractical provisions.

A comprehensive review began in 2012, involving public consultations and a Tripartite Working Group (GTT) established in 2014. Despite extensive discussions, consensus on key issues like accessibility and implementation timelines proved challenging. Further revisions and administrative adjustments in 2018 and 2019 led to additional negotiations.

In August 2019, the Permanent Tripartite Commission (CTPP) approved the revised text, resolving remaining issues through negotiation. Published on September 23, 2019, the updated NR-24 reflects modern standards for workplace hygiene and comfort.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“24.9.1 In all workplaces, drinking a water must be provided to workers, with the use of collective cups prohibited.”*

4.1.25 NR25 – Industrial Waste

NR-25 defines industrial waste as any byproduct from industrial processes—solid, liquid, gaseous, or a combination—that differs from domestic waste due to its physical, chemical, or microbiological properties (e.g., ash, sludge, oils, acids, or pollutants).

NR-25 ensures that industrial waste is managed responsibly to safeguard worker health and safety and comply with environmental standards.

There are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“25.3.1 The organization shall seek to reduce occupational exposure to industrial waste by using the best available technological and organizational practices.”*

4.1.26 NR26 – Safety Signs (✓)

Originally published in 1978 under articles 166 and 167 of the Consolidation of Labor Laws (CLT), NR-26 regulates the use of colors for identifying safety equipment, marking areas, and signaling workplace hazards. It also includes guidelines for labeling hazardous products.

NR-26 ensures effective hazard communication and safety measures through standardized color use, chemical classification, and product labeling, improving workplace safety and compliance.

This regulation does contain information that is taken into consideration when making our Brazilian NR Requirements compliance list regarding our electrical equipment at Wärtsilä.

4.1.27 NR27 – Professional Registration of Occupational Safety Technician (Repealed by Ordinance 262 of May 30, 2008)

Revoked by ordinance July 30, 2019. Not in use, not applicable.

4.1.28 NR28 – Enforcement and Penalties

NR-28, issued in 1978, establishes procedures for workplace safety and health inspections, as well as penalties for noncompliance, based on Articles 161 and 201 of the Consolidation of Labor Laws (CLT). Classified as a general standard in 2018, it includes guidelines for inspections, embargoes, interdictions, and infractions related to worker safety and health. Its key components are:

-Annex I: Fine grading.

-Annex IA: Fines specific to port work.

-Annex II: Infractions and penalties linked to regulatory items.

Infractions are graded (1 to 4) by severity and classified as either safety ("S") or occupational medicine ("M"). Penalties consider factors such as employee numbers and the severity of the infraction.

NR-28 has undergone two major revisions (1983 and 1992) and several updates, primarily to Annex II, to align with other regulatory standards. These changes ensure it reflects evolving workplace safety and health requirements.

What we can learn: 123 pages describing exactly what grade of penalty will be issued for breaking each ruling in every NR ever created. This regulation gets an update almost every year.

4.1.29 NR29 – Health and Safety in Ports

NR-29, "Safety and Health in Port Work," was first issued in 1997 to establish occupational safety and health (OSH) regulations specific to port activities. Its development was driven by the recognition of OSH challenges in ports during the 1980s, Brazil's ratification of ILO Convention No. 152 in 1990, and the publication of Provisional Measure No. 1575, which clarified OSH responsibilities in ports.

A tripartite group, later formalized as the National Permanent Port Commission (CPNP) in 2002, was created to oversee the standard's implementation and adapt it to port-specific needs through port visits and consultations.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“29.26.4 In work performed on offshore vessels, effective communication and means to quickly remove an injured port worker must be ensured, and first aid must be provided by a trained worker for this purpose.”*

4.1.30 NR30 – Health and Safety in Waterways (✓)

NR-30, introduced on December 4, 2002, through Ordinance SIT No. 34, was created to fill gaps in Brazil's occupational health and safety regulations for waterway work. Based on ILO Convention 147 (1976) and initially focused on maritime work, its scope expanded to include all waterway professions under Law No. 9.537 (LESTA). This includes maritime, fishing, fluvial, diving, piloting, and docking workers, with annexes addressing specific activities.

Developed with input from the Ministry of Health and the Brazilian Navy, NR-30 was approved during the 32nd CTPP Meeting. Updates followed in 2013 and 2014, and in 2018, NR-37 was introduced for oil platforms, revoking Annex II of NR-30. The latest modernization, finalized in 2019, took effect on January 3, 2022.

It appears that there is one specific provision applicable to Wärtasilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment and it's the following:

“30.16.1 Machines and equipment used in waterways must comply with NR-12 (Machinery and Equipment Safety).”

4.1.31 NR31 – Health and Safety at Work in Agriculture, Livestock, Forestry, Logging, and Aquaculture

NR-31, published in 2005 by Ordinance MTE No. 86, regulates safety in agriculture, livestock, forestry, logging, and aquaculture. Initially, rural workers were excluded from labor laws, but the Rural Worker Statute (1963) and Law No. 5.889 (1973) introduced safety standards. The 1988 Constitution further equalized workers' rights.

In 2000, the Grito da Terra Brasil movement pushed for reforms due to high accident rates in sectors like timber and sugarcane. This led to NR-31, which also established the National Permanent Rural Commission (CPNR).

NR-31 was updated twice:

2011: Machinery safety aligned with NR-12.

2018: Sector-specific updates and definitions.

NR-31 remains the main regulation for rural worker safety.

This regulation does not contain information that is taken into consideration when making our Brazilian NR Requirements compliance list regarding our electrical equipment at Wärtasilä.

What we can learn: *“31.11.1 The employer must provide workers with appropriate tools and accessories free of charge, replacing them whenever necessary.”*

4.1.32 NR32 – Health and Safety at Work in Health Services

NR-32, introduced on November 11, 2005, was developed in response to concerns from healthcare unions in São Paulo about workplace safety in the sector. It provides guidelines for the safety and health of healthcare workers in clinics, laboratories, and hospitals, excluding animal health services.

NR-32 builds on the Environmental Risk Prevention Program (PPRA) in NR-9 and the Occupational Health Medical Control Program (PCMSO) in NR-7, focusing on risks specific to healthcare, such as biological, chemical, and ionizing radiation hazards. It also covers waste management, ergonomics, and environmental conditions like noise, lighting, and thermal comfort.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“32.10.4 Manufacturer manuals for all equipment and machines, printed in Portuguese, must be available to the workers involved.”*

4.1.33 NR33 – Health and Safety in Confined Spaces

The development of NR-33 began in February 2002 with a Technical Group (GT) comprising representatives from various organizations, tasked with drafting a regulation for confined spaces. While other NRs addressed confined spaces in specific sectors, many industries were not covered. The GT referenced Brazilian technical standards (NBR 14787 and NBR 14606) and international guidelines.

After public consultation and revisions based on 190 suggestions, the final regulation, titled "NR-33 Health and Safety in Confined Spaces," was approved by the Permanent Tripartite Commission (CTPP) on September 14, 2006, and published on December 22, 2006. The standard was classified as a Special Standard in 2018 by SIT Ordinance No. 787.

NR-33 underwent two key revisions:

2012: Changes to training frequency and hours for workers.

2019: Alignment with NR-01 on confined space training.

NR-33 outlines preventive measures, training, and emergency procedures for confined spaces, and it was the first to include psychosocial risk assessments.

What we can learn: *“33.5.17.1 In classified areas, electrical and electronic equipment must be certified or have a document within the National Metrology, Standardization, and Industrial Quality System (Sinmetro).”*

4.1.34 NR34 – Work Conditions and Environment in Shipbuilding and Ship Repair Industry (✓)

NR-34 was developed in response to the revival of the shipbuilding sector in 2003, driven by offshore oil exploration. NR-18 was found inadequate for shipbuilding and repair, leading to the creation of the Tripartite Commission on Working Conditions in the Naval Industry (CT Naval) in 2008. The commission held nationwide meetings to develop safety procedures for various shipbuilding activities.

On July 10, 2009, CT Naval proposed a new standard to the Permanent Tripartite Commission (CTPP). After public consultation, NR-34 was approved and published on January 20, 2011, focusing on safety in shipbuilding and repair industries.

NR-34 addresses safety measures for activities such as hot work, working at heights, exposure to radiation, load handling, scaffolding, and emergency response plans. Classified as a Sectoral Standard in 2018, NR-34 has undergone eight amendments, all approved by the CTPP.

This regulation does contain information that is taken into consideration when making our Brazilian NR Requirements compliance list regarding our electrical equipment at Wärtsilä.

4.1.35 NR35 – Working at Height

NR-35, published in March 2012, was created to prevent workplace falls and ensure safety in activities involving work at height. The need for this regulation emerged in 2010, following the 1st International Forum on Safety in Working at Height in São Paulo. The Engineers' Union of São Paulo and the National Federation of Engineers presented the need for a comprehensive standard to the Ministry of Labor and Employment (MTE).

The development process began in September 2010, with input from government representatives, workers, and employers. The standard outlines general safety conditions for working at heights, emphasizing planning, risk analysis, and the use of tools like Work Permits to minimize risks.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“35.3.1 g) ensure that no work at height starts until the preventive measures defined in this NR have been adopted;”*

4.1.36 NR36 – Health and Safety at Work in Slaughterhouses and Processing Meat and Derivatives

NR-36, published on April 18, 2013, regulates health and safety in the meat processing industry and is classified as a Sectoral Standard by Ordinance SIT No. 787 in 2018. The creation of NR-36 was initially proposed by worker representatives in 2010 during the 62nd CTPP meeting. After being rejected, the proposal was reconsidered, and a Tripartite Study Group (GET) was formed in 2011 to draft the standard.

The final proposal was approved in November 2012 at the 71st CTPP meeting, leading to the publication of NR-36. The Tripartite Thematic National Commission (CNTT) was established to oversee its implementation.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“36.7.6 The electrical installations of machines and equipment must be designed and maintained to prevent, by safe means, the risks of electric shock and all other types of accidents, complying with the provisions in NR-12 (Machinery and Equipment Safety) and NR-10 (Safety in Electrical Installations and Services).”*

4.1.37 NR37 – Health and Safety on Oil Platforms

NR-37, published on December 20, 2018, by MTb Ordinance No. 1186, sets safety and health standards for workers on oil platforms in Brazilian Jurisdictional Waters (AJB). It aims to reduce accidents, prevent occupational diseases, protect the marine environment, and maintain platform integrity. The regulation consists of 33 chapters and 9 annexes.

The development of NR-37 involved several stages:

-2011-2013: A Technical Group (GT) formed by the Permanent Tripartite Commission (CTPP) worked on the draft, which was then subjected to public consultation in 2013, receiving 3,500 suggestions.

-2015-2018: A Tripartite Working Group (GTT) refined the text, meeting 22 times. The final version was unanimously approved at the 95th CTPP meeting in November 2018.

In 2019, concerns from business representatives led to a 12-month extension for implementing some provisions through SEPRT Ordinance No. 1.412.

Mainly focuses on the teachings of NR-10 regarding electrical installations. Should be revisited in case of oil platform project instances, the separate annex regarding high voltage installations should also be revisited.

4.1.38 NR38 – Health and Safety in Urban Cleaning and Solid Waste Management

NR-38, established by MTP Ordinance No. 4.101 on December 16, 2022, aims to ensure the safety and health of workers involved in urban cleaning and solid waste management activities. It sets out preventive measures and safety requirements for various tasks, including:

- Collection, transportation, and disposal of urban and healthcare waste.
- Sweeping, washing, and maintenance of public areas.
- Green space maintenance, tree pruning, and street cleaning.
- Handling of recyclable materials and waste disposal.

The standard applies specifically to urban solid waste, excluding industrial, construction, agricultural, transportation, and mining waste. It also requires organizations to maintain up-to-date records of work areas, routes, team composition, and equipment used.

It appears that there are no specific provisions applicable to Wärtsilä in terms of requirements we need to follow or improvements we need to implement for compliance concerning our electrical equipment.

What we can learn: *“38.9.1 The organization must provide training to employees, considering the activity being performed and the risks they are exposed to.*

38.9.2 The training required by this NR must comply with the provisions of NR-01 and be conducted during the workday, at the organization's responsibility and cost, as outlined in this NR.”

5 Brazilian NR requirement list

A detailed list of the selected NRs, outlining the aspects that are considered from each regulation. This section also includes various recommendations from different companies that have implemented these standards, offering insights into best practices for ensuring compliance. By combining these elements, a well-rounded reference list is created, that enhances understanding and facilitates adherence to the NRs.

Since it is important that no human error or personal viewpoint may alter the purpose of this regulation, the format is kept in its original form and taken directly from the translated scripture at BrazilianNR.com (Brazilian Regulatory Standards, 2025). This affects chapter 5.1 to 5.7.

5.1 NR10 – Safety in Electrical Installations and Services - Compliance

“10.2.3 Companies are required to keep up-to-date single-line diagrams of the electrical installations in their establishments with the specification of the grounding system and other protection devices and equipment.

10.2.4 Establishments with an installed load greater than 75 kW shall establish and maintain an Electrical Installation Documentation, containing, in addition to the provisions of item 10.2.3, at least:

- a) set of procedures and administrative and technical guidelines for health and safety, implemented and related to this NR and the description of existing control measures;*
- b) documentation of inspections and measurements of the lightning protection system and electrical grounding;*
- c) specification of collective and personal protective equipment and the tools, applicable as determined by this NR;*
- d) documents proving the qualification, skills, training, authorization of the workers and the training conducted;* *e) results of electrical insulations tests performed on personal and collective protective equipment;*
- f) certifications of electrical equipment and materials in classified (hazardous) areas;*

g) technical reports of current inspections with recommendations, compliance schedules, covering the items (a) to (f)."

"10.2.8.2 The collective protective measures comprise, as a priority, electrical de-energization in accordance with this NR and, if this is not possible, the use of safe working voltage.

10.2.8.2.1 If it is impossible to implement the provisions of item 10.2.8.2, other collective protective measures shall be used, such as: insulation of live parts, obstacles, barriers, signs, automatic disconnection of supply, blocking of auto recloser."

"10.2.9.3 It is forbidden to wear personal adornments when working in or around electrical installations."

"10.3.6 Every project shall foresee conditions for the use of temporary grounding."

"10.3.9 The descriptive memorial of the projects shall contain at least the following safety items:

a) specification of the characteristics relating to protection against electric shock, burns, and other additional risks;

b) indication of the position of the electric circuits switching devices: (Green - "D", off and Red "L", on);

c) description of the identification system of electrical circuits and equipment, including switches, control, protection and interlocking devices, conductors and the equipment and their structures, defining how such indications shall be physically applied to the installation's components;

d) recommendations for restrictions and warnings regarding the access of people to the components of the installations;

e) precautions applicable to external influences;

f) functional principle of the protective devices in the project, intended for the safety of people;

g) description of the compatibility of the protective devices with the electrical installation.

10.3.10 The project shall ensure that the installations provide workers with adequate lighting and a safe working position in compliance with NR-17 (Ergonomics)."

"10.10.1 Adequate safety signs shall be adopted in electrical installations and services, intended for warning and identification, complying with the provisions of NR-26 (Safety Signs), to meet, among others, the following situations:

- a) identification of electrical circuits;*
- b) locking of control devices and systems;*
- c) access restrictions and impediments;*
- d) delimitation of areas;*
- e) marking of circulation areas, public ways, vehicles, and cargo movement;*
- f) signs to prevent energization;*
- g) identification of locked equipment or circuit."*

"10.14.6 This NR does not apply to electrical installations powered by extra-low voltage. (Under 120VDC/100VAC)"

5.2 NR12 – Machinery and Work Equipment Safety – Compliance

"12.15 The installations, casings, housings, shielding or conductive parts of machinery and equipment that are not part of electrical circuits, but may be under voltage, shall be grounded according to current official technical standards.

12.16 The electrical installation of machinery and equipment that are or may be in direct or indirect contact with water or corrosive agents shall be designed with means and measures to assure their shielding, tightness, insulation and grounding in order to prevent accidents.

12.17 The power lead of machinery and equipment shall meet the following minimum safety requirements:

- a) provide mechanical strength compatible with its use;*

- b) have protection against the possibility of mechanical failure, abrasive contacts and contact with lubricants, combustibles and heat;*
- c) located in a way that no segment is in contact with moveable parts or sharp edges;*
- d) facilitate and not prevent the movement of persons and materials or the operation of machinery;*
- e) not pose any other types of risks;”*

“12.18 The power enclosures of machinery and equipment shall meet the following minimum safety requirements:

- a) have an access door, kept permanently closed;*
- b) have signs about the danger of electrical shock and restricting access of unauthorized persons;*
- c) be maintained in good condition, clean and free of objects and tools;*
- d) have protection and identification of circuits; and*
- e) meet the appropriate degree of protection depending on the environment of use.”*

“12.20 The electrical installations of machinery and equipments that use electrical energy supplied by an external source shall have an over-current protection which is sized according to the consumption demand of the circuit.

12.20.1 The machinery and equipments shall have a protective device against over-voltage when an increase in voltage can cause risk of accident.

12.20.2 When the power supply allows the inversion of phases which may lead to accidents, there shall be a monitored device for phase sequence detection or other measures of protection with the same effectiveness.

12.21 Followings are prohibited in the machinery and equipments:

- a) the use of disconnect switch as a start or stop device;*
- b) the use of switches, such as a knife-type, on electrical circuits; and*
- c) the existence of energized parts exposed to the circuits that use electricity.*

12.22 The batteries shall meet the following minimum safety requirements:

- a) located so that their maintenance and replacement can be performed easily from the ground or from a support platform;*
- b) setting up and fixing so that there will be no accidental displacement; and*
- c) positive terminal protection in order to prevent accidental contact and short circuit.”*

“12.24 The starting, actuation and stop devices of machinery shall be designed, selected and installed so that they:

- a) are not localized in their hazardous areas;*
- b) can be activated or turn off in case of emergency by a person other than the operator;*
- c) prevent inadvertent actuation or shut down by the operator or any other accidental way;*
- d) do not provide additional risks; and*
- e) cannot be bypassed.*

12.25 The starting or actuation commands of the machinery shall have devices to prevent their automatic operation when energized.”

“12.119 The inscriptions on the machinery and equipments shall:

- a) be written in Brazilian Portuguese;*
- b) be legible.*

12.119.1 The inscriptions shall clearly indicate the risk and the part of the machinery or equipment to which they relate, and shall not be used only the inscription of "danger".

12.120 The inscriptions and symbols shall be used on the machinery and equipments to indicate their specifications and technical limitations.

12.121 Active warning or alert signs, such as intermittent luminous and audible signals that indicate the imminence of a hazardous event, such as starting or overspeed of a machine, shall be adopted, where necessary, so that they:

- a) are issued before the hazardous event occurs;*

b) are not ambiguous;

c) are clearly understood and distinguished from all other signals used; and

d) can be positively recognized by the workers.”

“12.123 The machinery and equipments produced as from the effective date of this Standard shall have indelible information in a visible place, containing at least:

a) company name, corporate identity number (CNPJ) and address of the manufacturer or the importer;

b) information on type, model and capacity;

c) identification or serial number and year of manufacture;

d) registration number of the manufacturer or the importer in the CREA; and

e) weight of the machinery or equipment.”

“12.125 The machinery and equipments shall have instruction manuals provided by the manufacturer or the importer with safety information in all phases of use.”

“12.127 The manuals shall:

a) be written in Brazilian Portuguese, with legible type and size of characters, accompanied by explanatory illustrations;

b) be objective, clear, unambiguous and easy to understand language;

c) have signs or warnings regarding to safety; and

d) be available to all users in the workplaces.

12.128 The manuals of the machinery and equipments manufactured or imported as from the date of this Standard shall contain the following informations at least:

a) company name, corporate identity number (CNPJ) and address of the manufacturer or the importer;

b) type, model and capacity;

c) serial or identification number and year of manufacture;

- d) observed standards for design and construction of the machinery or equipment;*
- e) detailed description of the machinery or equipment and their accessories;*
- f) diagrams, including electrical circuits, especially the schematic representation of the safety functions;*
- g) definition of the use expected from the machinery or equipment;*
- h) risks, to which the users are exposed, with the respective quantitative assessments of emissions generated by the machinery or equipment at their maximum utilization capacity;*
- i) definition of existing safety measures and those to be adopted by the users;*
- j) technical specifications and limitations for the safe use;*
- k) risks that may result from tampering or removal of safety guards and devices;*
- l) risks that may result from uses other than those prescribed in the design;*
- m) technical information to support the elaboration of work and safety procedures at all stages of use; (Amended by Ordinance no.211, on December 9th, 2015)*
- n) procedures and schedule for inspections and maintenance;*
- o) procedures to be followed in emergency situations;*
- p) indication of the service life of the machinery or equipment and/or the components related to safety.”*

5.3 NR17 – Ergonomics – Compliance

“17.7.2 Manufacturers of machinery and equipment shall design and construct components, such as video monitors, signals, and controls, in such a way as to enable clear and precise interaction with the operator to reduce the possibility of misinterpretation or feedback of information in accordance with item 12.9.2 of NR12.

17.7.2.1 The location and positioning of the control panel and controls shall facilitate access, easy and safe operation, and visibility of process information.

17.7.3 Equipment used for electronic data processing with video terminals shall allow the worker to adapt it to the tasks to be performed.

17.7.3.1 The equipment shall be sufficiently mobile to allow the screen to be adjusted to the ambient lighting, to protect it from reflections and to provide the worker with the correct viewing angles.”

5.4 NR18 – Health and Safety in Construction – Compliance

“18.6.9 The use of Residual Current Devices (RCD) is mandatory as an additional safety measure in electrical installations, in situations provided for in current national technical standards.

18.6.10 Electrical distribution boards must:

- a) be sized to install the components of the electrical circuits that constitute them;*
- b) be made of materials resistant to the heat generated by the components of the installations;*
- c) have inaccessible and protected live parts for unauthorized workers;*
- d) have unobstructed access;*
- e) be installed with sufficient space for servicing and operation;*
- f) be identified and marked regarding electrical risk;*
- g) comply with the required protection class;*
- h) have their circuits identified.*

18.6.11 The storage of any materials or objects in the distribution boards is prohibited.”

5.5 NR26 – Safety Signs – Compliance

“26.3 Color codes

26.3.1 Colors shall be used for safety communication in establishments or workplaces to indicate and warn of existing hazards and risks.

26.3.2 *Colours used to identify safety equipment, to demarcate areas, to identify pipes carrying liquids and gases and to warn of hazards shall conform to official technical standards.*

26.3.3 *The use of colors does not exempt the use of other forms of accident prevention.*

26.3.4 *The use of colour shall be kept to a minimum so as not to distract, confuse or fatigue workers.”*

5.6 NR30 – Health and Safety in Waterways – Compliance

“30.16.1 Machines and equipment used in waterways must comply with NR-12 (Machinery and Equipment Safety).”

5.7 NR34 – Work Conditions and Environment in Shipbuilding and Ship Repair Industry – Compliance

“34.13 Temporary Electrical Installations

34.13.1 Electrical cables must be arranged in overhead or underground structures to ensure the protection of workers and not obstruct accesses, passages, and escape routes.

34.13.2 Only two or three-conductor cables with plastic (PP) or rubber (PB) insulation should be used in electrical circuits.

34.13.3 Distribution boxes must be:

- a) Adequately sized;*
- b) Made of non-combustible material, free of sharp edges;*
- c) Grounded and protected by circuit breakers;*
- d) Equipped with shock protection devices and Residual Current Device (RCD);*
- e) Identified by voltage and marked to prevent electric shock;*
- f) Equipped with doors and locks;*
- g) Equipped with a fixed barrier to prevent accidental contact with energized parts.”*

5.8 Previous shipyard recommendations

A gathering of visual information from previous projects has been combined for reference. The images have been taken from Emails and Excel Sheets regarding previous projects and their respective shipyard recommendations.

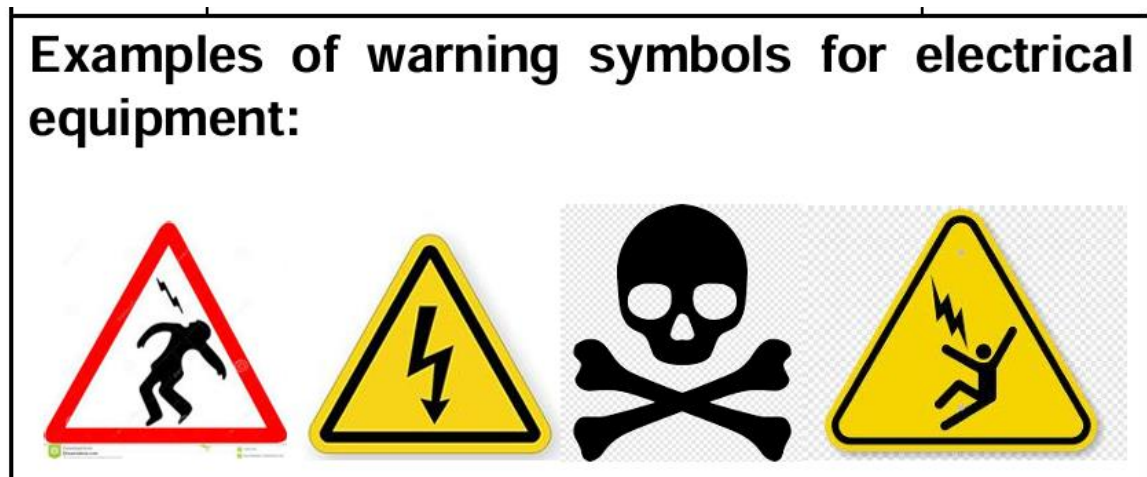


Figure 1. Warning symbols to use.

Second one already in use.



Figure 2. Portuguese warning labels.

Danger – dont use this equipment



(symbol M005 of standard ISO 7010)

Figure 3. Earthing symbol taken from ISO 7010.

Concern, the mention items are missing when the package ready for Inspection

- Status and Indication for Electrical System
- Perspex sheet for un-protected live parts (busbar/fuse/electrical panel,etc)
- Orange Paint color code: Munsell 2.5YR 6/14 per NBR7195 alternately can use RAL2008 orange on the Guard for Moving parts
- Label (dual language) English & Portuguese
- Batteries and Battery Rack
- Grounding
- Cable shield
- Wire (core) Marking refer TP52 Electrical Installation Detail
- Cable Gland & IP Washer
- Stopping Plug
- Teflon washer for dissimilar material
- Instrument Junction Box Assembly

Figure 4. Checklist for project.

Brazilian NR-10 Philosophy for Electrical System

INDICATING LAMP	
Description	NR-10 Color Comply
Breaker ON	RED
Breaker OFF	GREEN
Breaker Trip	YELLOW
Line and Bus Voltage Supply ON	RED
Control Power Supply UPS ON	RED
Control Power Supply Non-UPS ON	RED
Motor Running	RED
Motor Stop	GREEN
Motor Space Heater ON	BLUE

Figure 5. Color suggestions for compliance.

Brazilian NR-10 Philosophy for Electrical System

PUSH BUTTON	
Description	NR-10 Color to Comply
Breaker Close	GREEN
Breaker OPEN	RED
Breaker Trip Reset	BLACK
Breaker Fault Reset	BLACK
Earth Fault Reset	BLACK
Lamp Test Switch	BLACK
Start	GREEN
Stop	RED

Figure 6. Color suggestions for compliance 2.

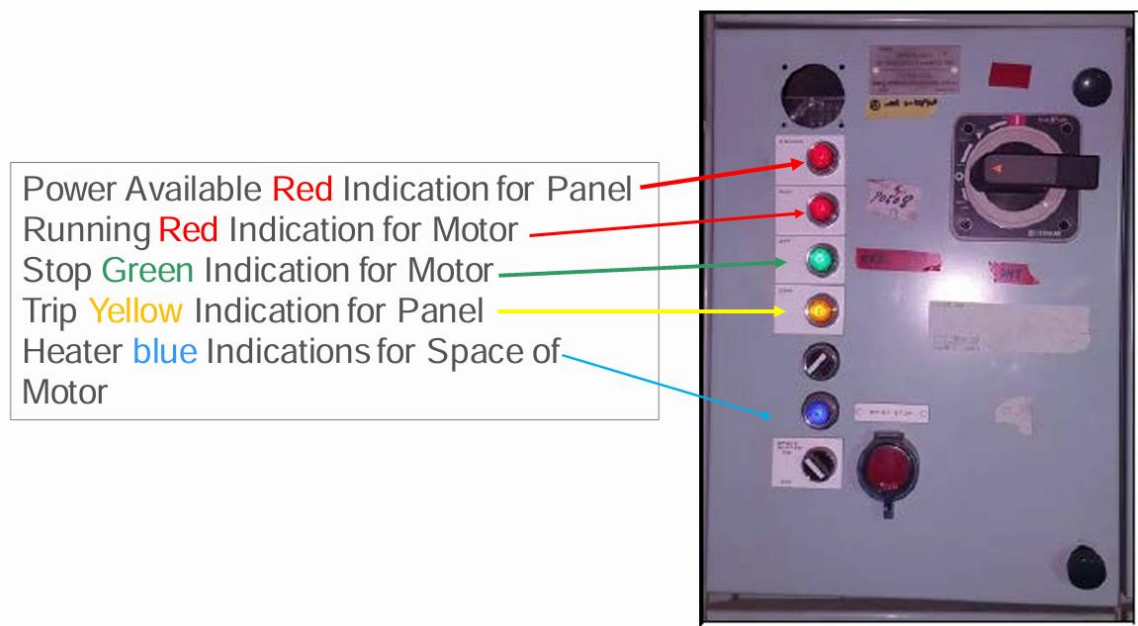


Figure 7. Color suggestions for compliance 3.

LIVE PART PROTECTION & GROUNDING AND MOVING PART	
Description	NR-10 Comply
Un-Protected Busbars	Perspex cover needed
Terminations Blocks	To access in, keep clear from Live Parts for future maintenance or Install barrier (Perspex)
Fuses	Install Fuse along with enclosure type fuse holder or Install Perspex sheet
Grounding Bonds	Across Joints (flange of pipe), JB, Control Panel, access ladder and Equipment (Refer Electrical Installation Detail TG-01 to TG-26)
To be orange paint on the Back Plate for MSWB/LVSB, Power JB, Electrical Panel Note: wherever can be access to live part / components / relay / contactors assembled on the back-plate inside enclosure orange paint needed	Orange Color paint Munsell 2.5 YR 6/14 per NBR7195 Alternately can use RAL 2008 Orange
Orange paint shall be applied on the Guard of moving parts (Motor/pump) Refer NR-30	Moving parts shall be covered fully with Guard and needs Orange Color paint Munsell 2.5 YR 6/14 per NBR7195 Alternately can use RAL 2008 Orange

Figure 8. Protection suggestions for compliance.

Label for Brazil Project, it is mandatory that the function description is available both English and Portuguese

The below is for example



Figure 9. Function description for compliance.



Figure 10. Main Switch color for compliance.

Main switch to be green when off and red when on



Figure 11. Typical stickers for compliance.

6 Results

The results of this investigation are both comprehensive and conclusive. A structured and methodical approach was employed throughout the thesis to ensure a high level of accuracy and relevance. Beginning with an extensive review of the Brazilian Normas Regulamentadoras (NRs), each regulation was individually evaluated for its applicability to Wärtsilä's electrical cabinet design. The selection process was informed not only by the wording of the standards themselves but also by contextual considerations such as marine use cases, electrical safety, and visual communication requirements aboard ships.

Out of the 38 NR standards reviewed, a total of eight were deemed directly relevant to the electrical design of auxiliary equipment: NR-10, NR-12, NR-17, NR-18, NR-26, NR-30, and NR-34. These were selected based on their explicit technical and safety requirements that correspond with the components, materials, and documentation used in Wärtsilä's cabinets. The remainder, while informative, did not present actionable directives for this context but still offered useful insights, which have been summarized in a "What we can learn" section within the body of each chapter.

The final Brazilian NR compliance list was constructed by extracting individual regulatory points from the selected standards. Each point was analyzed in terms of its relevance, implementability, and alignment with existing IEC standards and Wärtsilä's engineering practices. The key areas of compliance revealed several important themes.

First, there is a strong emphasis on comprehensive documentation and electrical labeling, particularly within NR-10 and NR-12. These include the requirement for up-to-date single-line diagrams, detailed descriptions of protective devices, and the proper marking of all circuit components and enclosures. These practices not only contribute to regulatory compliance but also support safer and more efficient maintenance procedures.

Second, ergonomic considerations outlined in NR-17 were found to be particularly relevant. These standards address visibility, access to components, and the proper placement of controls. By integrating such principles into the design of electrical cabinets, Wärtsilä can further reduce operator fatigue and potential hazards during operation or troubleshooting.

Third, visual communication and hazard identification are central topics in NR-26. This standard prescribes specific requirements for color coding, signage, and warning symbols on equipment. For example, safety labels must be presented in Portuguese, use standardized graphical symbols, and clearly indicate areas of risk. Compliance with NR-26 not only meets legal obligations but also enhances usability for Brazilian personnel working aboard vessels.

In addition, protective measures for installations, both temporary and permanent, are extensively discussed in NR-18 and NR-34. These standards highlight the need for construction-phase safety, grounding procedures, emergency response readiness, and access control-elements that intersect directly with the safe integration of electrical systems during shipbuilding and retrofitting operations.

Finally, maritime-specific provisions from NR-30 further contextualize these requirements for operations conducted on or near water. In particular, NR-30 reinforces compliance with NR-12 for all machinery and equipment used in waterways, underscoring the need for unified application of mechanical and electrical safety principles in marine environments.

These findings have been synthesized into a practical compliance checklist that engineers can refer to during cabinet design and assembly for the Brazilian market. This checklist is supplemented with visual aids and references from previous shipyard projects, gathered through internal communication and legacy documentation. These include color scheme recommendations, warning label formats, grounding methods, and common layout preferences that have been accepted by Brazilian authorities and clients.

Furthermore, an appendix with personal remarks and observations expands on softer aspects of compliance such as project communication, team knowledge-sharing, and documentation

quality. These observations serve as qualitative reinforcement for the more quantitative findings and underscore the importance of compliance strategy.

Collectively, these results offer Wärttilä a robust foundation for both ongoing and future projects in Brazil. By identifying the regulatory demands early in the design phase, the company can avoid costly retrofits, ensure smoother processes, and strengthen its reputation for legal and technical due diligence.

7 Discussion

The findings presented in this thesis underscore the value of integrating regulatory compliance early and systematically into the design process, particularly when entering markets with distinct legal frameworks such as Brazil. Reflecting on the work conducted, several themes emerge that warrant further discussion, especially regarding methodology, challenges encountered, and future opportunities.

One of the most critical success factors in this thesis was the careful selection and evaluation of the NR standards. While initially straightforward, the process revealed nuances in how Brazilian safety regulations interact with international standards like the IEC and ISO frameworks that Wärttilä already adheres to. For example, while many NR requirements mirrored IEC standards, certain mandates, such as the use of dual-language labels in Portuguese or the specific visual safety signage required, were uniquely Brazilian and would not have been captured through international compliance alone.

A key challenge was the language barrier. Most NR standards are published only in Brazilian Portuguese, necessitating a dual translation and verification process. This was addressed by using both paid English translations and manual cross-checks against official Portuguese versions. Although time-consuming, this process increased the overall confidence in the accuracy of the extracted requirements and highlighted the importance of linguistic and cultural localization in regulatory engineering.

Another point of discussion is the visual and ergonomic design considerations identified through NR-17 and NR-26. These often-overlooked factors directly affect safety and usability, especially in emergency situations. Integrating these insights into Wärttilä's design practices could provide competitive advantages, not only in Brazil but also in other regions where user safety and interface accessibility are critical concerns.

The recommendations from Brazilian shipyards, included as figures in earlier chapters, reinforced the importance of local feedback. Items such as preferred cable colors, switch labeling, and cabinet layout preferences demonstrate that compliance is not solely a legal matter, it also reflects end-user expectations and operational culture. This observation suggests that collaboration with local partners should extend beyond procurement and into the design and validation stages of product development.

Looking forward, the compliance list generated in this thesis could be the foundation for an automated compliance verification tool integrated into Wärtsilä's engineering systems. By digitalizing these requirements and associating them with design elements in CAD or PLM tools, future projects could instantly check whether they meet Brazilian NR standards, greatly reducing manual review time and increasing regulatory assurance.

In conclusion, this thesis not only met its objective of mapping Brazilian regulatory requirements but also showcased the importance of cultural, linguistic, and industry-specific adaptation in global engineering. The work completed here will continue to serve as a practical reference for future projects, offering both technical clarity and strategic insight into navigating Brazil's complex but well-structured regulatory environment.

7.1 Personal thoughts

Reflecting on what I've accomplished in this thesis, I can say with confidence that I'm proud of the result. A task was given, and it was completed successfully. While it was challenging to shape the assignment into a deliberately educational and theoretical piece, given its straightforward and practical nature, I believe the outcome strikes a good balance. Relevant information was carefully selected and included, and adding more content purely for the sake of volume would not have served the purpose of this document. I've been genuinely pleased with the feedback received from both the company team and my supervisor, Matts Nickull.

With that, I feel it's time to move on to the next challenge, whatever it may be, I'm ready.

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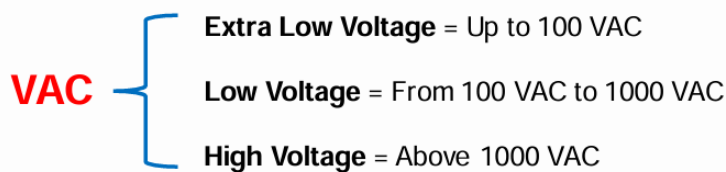
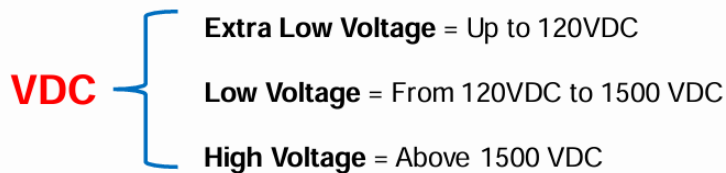
Appendix 1: Other remarks/Conclusions, Recap

Danger stickers on equipment in Portuguese, Voltage level specified, Danger can't be general – must be specified what is dangerous, who can touch the equipment,

Total safety instructions in Portuguese, including maintenance, dangers and de-energizing procedures.

All live parts must be covered/shielded, All rotating, moving and live parts has to be shielded to remove access.

The NR10 define the Voltage levels as below



Nameplates on cabinet in dual language, one being Portuguese, labels must be riveted in place, not allowed to be glued/ movable.

Function descriptions in dual language, one being Portuguese,

LOCKOUT TAGOUT MANDATORY, equipment built to allocate function.