YRKESHÖGSKOLAN
NOVIA

Implementation of UL 508A in Control Panel Design

Nicklas Kronqvist

Degree Thesis for Bachelor of Engineering

Degree program in Electrical Engineering and Automation

Vasa 2020

BACHELOR'S THESIS

Author:	Nicklas Kronqvist
Degree Programme:	Electrical Engineering and Automation, Vaasa
Specialization:	Automation technology
Supervisors:	Diana Lillhannus & Jan Berglund

Title: Implementation of UL 508A in Control Panel Design

Date: March 31, 2020 Number of pages: 43 Appendices 2

Abstract

This thesis was done for the department Industrial Automation and Energy Industries at ABB. The main goal was to implement the standard UL 508A into the design process of control panels delivered to the United States of America. The design process needed to become more efficient and impeccable. Another important goal was to identify differences in requirements when comparing these kinds of projects with projects that are made and delivered to the rest of the world.

An overview of the control system which the panels are made for was obtained by conducting a qualitative semi-structured interview with the engineering manager of the department. Needed information about applicable requirements from the standard UL 508A and the market in the USA was gathered by participating in training with an expert from Underwriter Laboratories. The obtained material and knowledge from the training was used when making the standard drawing package. Already fulfilled requirements were investigated by the help of design engineers from the department and by studying already applied international standards and the Low Voltage Directive (LVD).

The main result from this thesis was a standard drawing for a standard control panel. A summary of the main differences in requirements regarding the two project orientations was also made. The standard drawing fulfils the applicable requirements from the market in the USA and UL 508A. It is to be used as a starting point when the goal is to make a standard control panel that is to be delivered to that market.

The employer has considered the contents of this thesis to be sensitive material and parts of it are therefore not shared with the public.

Language: English Key words: Standard, control panel, power plant

---

EXAMENSARBETE

Författare: Nicklas Kronqvist
Utbildning och ort: El- och automationsteknik, Vasa
Inriktningsalternativ: Automationsteknik
Handledare: Diana Lillhannus & Jan Berglund

Titel: Implementering av UL 508A vid design av kontrollpaneler

---

Datum 31. mars 2020 Sidantal 43 Bilagor 2

Abstrakt
Detta examensarbete gjordes åt en avdelning inom företaget ABB och avdelningen heter Industrial Automation and Energy Industries. Det huvudsakliga målet med arbetet var att implementera standarden UL 508A i designprocessen för kontrollpaneler som levereras till USA, processen behövde bli mera effektiv och felfri. Det finns vissa skillnader mellan olika krav som ställs på de projekt som levereras till USA jämfört med resten av världen och ett annat viktigt mål med arbetet var att identifiera dessa skillnader.

En semistrukturerad intervju utfördes för att få en översikt av det kontrollsystem som panelerna tillverkas för, den tekniska chefen för avdelningen intervjuades. Det ordnades också en skolning med en expert från Underwriters Laboratories för att få information om de krav som standarden UL 508A och marknaden i USA ställer. Skolningsmaterialet användes när standardritningen framställdes. Kunskap om de redan uppfyllda kraven erhölls genom att rådfråga designingenjörer från avdelningen och genom att studera lågspänningsdirektivet (LVD) samt de internationella standarder som redan är implementerade i designprocessen.

Det huvudsakliga resultatet av detta examensarbete var en standardritning för en standardkontrollpanel. En sammanfattning av de huvudsakliga skillnaderna i kraven gjordes också. Standardritningen uppfyller de krav som UL 508A och marknaden i USA ställer. Det är meningen att ritningen skall användas när man skall planera en kontrollpanel som skall levereras till USA.

Uppdragsgivaren anser att innehållet i detta examensarbete är känsligt och har därför valt att sekretessbelägga arbetet.

Språk: Engelska Nyckelord: Standard, kontrollpanel, kraftverk

---

OPINNÄYTETYÖ

Tekijä:	Nicklas Kronqvist
Koulutus ja paikkakunta:	Sähkö- ja automaatiotekniikka, Vaasa
Suuntautumisvaihtoehto:	Automaatiotekniikka
Ohjaajat:	Diana Lillhannus & Jan Berglund

Nimike: UL 508A:n toteutus ohjauspaneelin suunnittelussa

Päivämäärä 31.3.2020 Sivumäärä 43 Liitteet 2

Tiivistelmä

Tämä opinnäytetyö tehtiin ABB:n Industrial Automation and Energy Industries-yksikön puolesta. Tärkein tavoite oli toteuttaa standardi UL 508A suunnitteluprosessissa projekteihin, jotka yksikkö myy Yhdysvaltoihin. Prosessista tulisi tulla tehokkaampaa ja virheetöntä. Näiden projektien vaatimukset ovat erilaisia toisiin maihin menevien projektien vaatimuksiin verrattuna. Toinen tärkeä tavoite oli tunnistaa nämä erot.

Saadakseen yleiskuvan valvontajärjestelmästä, johon paneeleja valmistetaan, puolistrukturoidu haastattelu tehtiin yksikön tekniikan päällikön kanssa. Koulutus oli myös järjestetty Underwriters Laboratories-organisaation asiantuntijan kanssa, saadakseen tietoa UL 508A:n ja Yhdysvaltojen vaatimuksista. Koulutuksen materiaalia käytettiin, kun mallipiirustus muotoiltiin. Tietoa jo täytetyistä vaatimuksista saatiin kysymällä yksikön suunnitteluinsinööristä ja lukemalla pienjännitedirektiivin (LVD) ja ne kansainväliset standardit, jotka ovat jo toteutettu suunnitteluprosessissa.

Tämän opinnäytetyön tärkein tulos on mallipiirustus standardiohjauspaneelille. Lopputulos on myös tiivistelmä keskeisistä eroista erilaisissa vaatimuksissa. Mallipiirustus täyttää UL 508A:n ja Yhdysvaltojen vaatimukset. Tarkoitus on, että mallipiirustus käytetään, kun suunnitellaan ohjauspaneeleja, jotka myydään Yhdysvaltoihin.

Työnantajan mielestä opinnäytetyö sisältää arkaluonteista tietoa ja sen takia työ on salassa pidettävä.

Kieli: englanti Avainsanat: standardi, ohjauspaneeli, voimalaitos

---

Table of content

Table of figures

List of appendices

1 Introduction

This thesis is about the implementation of the standard UL 508A in control panel design. The theoretical part will go through applicable parts of requirements from the market in the United States of America along with the applicable requirements from the Low Voltage Directive and relevant IEC standards. The differences that are found between the requirements will be presented and compared in the practical part of the thesis.

The practical part will consist of the mentioned comparison along with the making of new standard drawings for certain UL certified standard panels. The drawings will contain standard components and cables that are also to be made in order to make the designing process more efficient and error free.

The thesis is made for ABB's department IAEN which stands for Industrial Automation and Energy industries. The department makes control systems for the surrounding equipment of engines in power plants that are located all around the world.

The projects which are made by the department IAEN can be divided into two parts and it is important to know the general terms that are used by the department when referring to the two different project orientations. The term "UL projects" is used for projects that are delivered to North America while "IEC projects" is used for the projects that are not delivered there. Note that this thesis will only focus on the demands from the USA as it is most common that projects are delivered to that market.

1.1 Background

The idea of this thesis was born when the mentor at ABB was in the designing phase of a project that was to be delivered to the USA. There are no standard drawings or suitable cables and components in the drawing program for these kinds of projects and that leaves room for improvement of efficiency.

The engineering manager also found that IEC projects and UL projects have drifted apart. This means that some engineers have more expertise in UL projects than other. This thesis is intended to find out differences between the two project orientations and pull them closer to each other again.

1.2 Task

The task is to make standard drawings for the standard panels that are delivered in a typical UL project. Standard cables and components that are not yet existing is also to be made and added to the database of the drawing program.

Another task is to read the regulations and standards that are applied when making IEC projects. This is to be compared to the requirements stated by UL so that differences can be found and thereby make the two project orientations more uniform. Knowledge about European and IEC requirements are therefore important to know since the standard drawings for UL projects will be built upon the already existing standard drawings for IEC projects.

1.3 Angle of approach

Knowledge about the requirements for the European market will be gained by reading and understanding the low voltage directive. The international standards that is being applied already will be read through in order to get an insight of the design process when it comes to IEC projects.

ABB will provide for an UL training session with a UL expert in industrial control panel design. This training will be attended when the LVD and the international standards have been read through. The training will give an oversight of the requirements from the standard UL 508A along with requirements from the market in the USA. The material provided during the UL training will be used as a source throughout the thesis.

1.4 Employer – ABB Finland

ABB is a leader in the technology field and they promote the ongoing digitalisation. They are present in over 100 countries and the offices in Finland are situated in Hamina, Porvoo, Helsinki and Vaasa. The amount of offices is about 20 and ABB is employing about 5 400 people in Finland.

The offices in Vaasa focuses on low-voltage appliances and systems, transformers, motors, control and protection equipment for the electrical grid. Systems for power transmission, distribution, power generation and overall industry design is also dealt with in these offices. (ABB, 2020).

1.5 Disposition

Chapter 1. Brief introduction to the contents of the thesis and why it is needed.

Chapter 2. Introduction to the control system.

Chapter 3. Information about the drawing tool that will be used.

Chapter 4. Requirements from the market in the USA and UL.

Chapter 5. Requirements from the European market and already applied standards.

Chapter 6. Differences in requirements that can be found between the two markets.

Chapter 7. Making of the standard drawing package.

Chapter 8. Conclusion and discussion

Chapter 9. References.

1.6 Secrecy

This thesis contains information that is considered sensitive by ABB. The competitors may use it to their profit and some parts of the thesis are therefore classified.

2 Control system

A control system can be generally described as a block that gives an output based on an input, see Figure 1. The blocks can be described as a series of various interconnected appliances that work together in order to achieve a desired task.

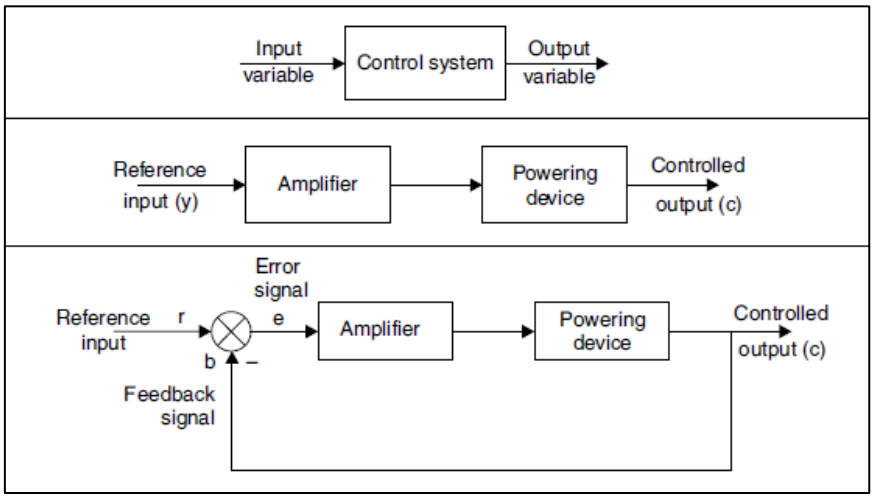

Figure 1. Examples of various control systems (Sivanagaraju & Devi, 2011)

There are two common types of control systems, open and closed loop (see Figure 1 for an example of both). Open loop is when the control system produces an output that is solely based on the input. This can be inaccurate as the control system does not take the change of environment into account. A closed loop control system takes an input and a signal from the output as a feedback signal. This means that the control system is aware of how much the environment or various disturbances is affecting the output and can take appropriate actions. (Sivanagaraju & Devi, 2011).

2.1 Control system made by ABB, IAEN (Confidential)

3 E3.cable

E3.cable is the program used by ABB IAEN for control panel design. It is an additional program to E3.schematic that is provided by Zuken. E3.schematic provide means for making of needed electrical drawings and other documentation when making various control systems. Functionalities provided from the tool are for example the detection of design errors and the tools for making various lists that are needed in the manufacturing process (terminal lists, wiring lists, parts lists and so on). Additional functionalities are also included in the program.

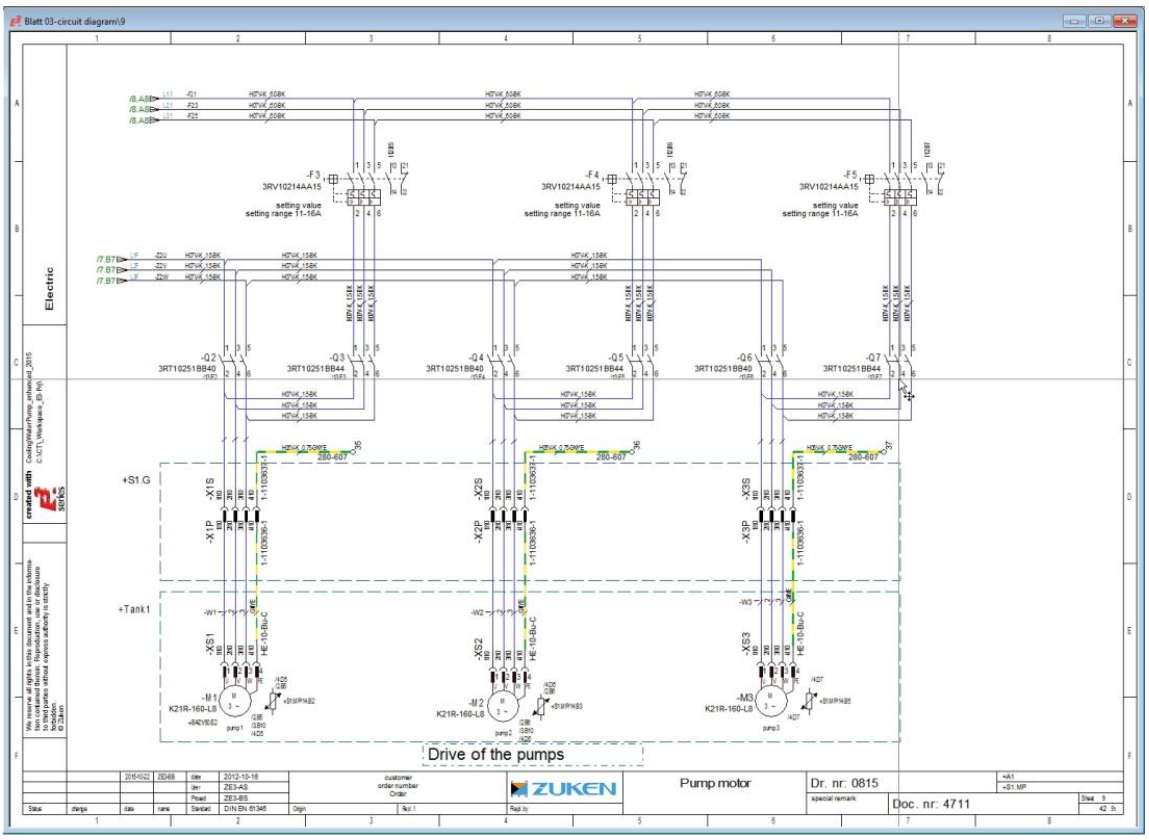

Figure 2. Example of E3-schematic (Zuken, 2020)

When it comes to designing of a harness or cable plan, an additional program is needed since E3.schematic alone does not provide the necessary tools. This is where E3.cable comes into the picture and the program makes it possible to pick separate wires in the electrical drawings and add them to a desired harness or cable. The different structures of different cables, shielding etc. can also be made and presented in the drawing. (Zuken, 2020).

4 UL (Confidential)

5 Low Voltage Directive

The Low Voltage Directive or LVD (2014/35/EU) is a directive that concerns electric appliances used under specific voltage ranges. The directive became effective on the twentieth of April, year 2016 and it replaced the older LVD (2006/95/EC).

The LVD covers not only electrical risks but all safety risks that can be associated with the electrical appliances. In other words, it is a "total harmonised safety directive" and it must therefore be noted that other legislation that exist on a national level in the same field is replaced by the LVD. All kinds of electrical appliances that is to be placed on the market (that are within the scope of the LVD) must fulfil the requirements that are stated in the directive. Member states cannot interfere and demand that a product which is fulfilling the requirements of the LVD are taken of market. This results in free movement on the Union market, which is the objective of the LVD.

Note that additional demands from other directives and regulations may be applicable on the same equipment that needs to fulfil the demands of the LVD. (European Commission, 2018).

5.1 Scope of the LVD

The voltage ranges for the electrical apparatus that fall under this directive are 75V – 1500V DC and 50V – 1000V AC. These voltage ranges should not be confused with those that are found on the inside of the component or appliance. It is the voltage ratings that the output and input are rated for that needs to fall within the mentioned ratings if the LVD is to be applicable.

If the highest rating of an electrical device is higher than the mentioned limits, or if it's listed in annex II as a component that is excluded from the scope, then the device is outside the scope of the LVD.

5.2 Obligation of manufacturers

A manufacturer has some obligations to fulfil according to the LVD. There are also obligations for importers and distributors, but those demands will not be reviewed further in this thesis as they do not apply to ABB in this case.

The manufacturer must make sure that the electrical equipment has been constructed and manufactured according to the demands of the LVD. The manufacturer must also conduct or have someone conduct an assessment of conformity with the directive. An example of such an assessment procedure, where it is the manufacturer that is conducting it, is described in the LVD. The procedure in question is called internal production control and means the following: By doing the internal production control conformity assessment, the manufacturer makes sure that they fulfil the duties (point two, three and four of Annex III in the LVD) and they thereby state, on their own responsibility, that their product fulfils the demands of the LVD.

The internal production control procedure can be divided into several main parts. These parts are technical documentation, manufacturing, applying of CE marking and the making of an EU declaration of conformity. The CE marking and declaration of conformity cannot be made for a product that is not fulfilling the demands of the LVD and these subjects will be reviewed further in chapter 5.4 CE marking and 5.5 Declaration of conformity.

The technical documentation must be kept for ten years after product release on the market. At least the following listed points shall be, if they are applicable to the product, a part of the technical documentation:

- Construction and fabrication drawings together with component schematics, circuits, subassemblies and so on.
- A common description of the product in question
- Instructions that are needed in order to understand the schematics and workings of the electrical product.
- A risk analysis and a list of how the risks have been eliminated and how the safety objectives have been fulfilled. If standards are used then their reference and applicable part is to be stated. (see chapter 5.3 Presumption of conformity)
- Test reports, the results of construction calculations, EU declaration of conformity, investigations that have been made etc.

Every conformity assessment procedure starts with a risk analysis. It is therefore required that a manufacturer conducts one so that the risks can be assessed and reduced or removed by applying correct measures. These measures can be applying of harmonised standards or

other technical methods (see also chapter 5.3 Presumption of conformity). This must also be a part of the technical documentation.

Furthermore, it is under the manufacturer's responsibility to take action and to supervise so that the fabrication process leads to products that fulfils the demands of the technical documentation and of the LVD. It is important to regularly check for updates in the products hardware and/or software along with updates that have been made in the applied standards and solutions in order to stay up to date and fulfil all of the safety demands.

There is a possibility that manufacturers are required to conduct tests on a certain product that they have placed on the market. This may be due to some risk that have appeared and may harm the people using it. The distributors need to have information about this matter and the manufacturer may need to keep track of non-compliant equipment, recalls and complaints.

When or if a manufacturer notices/suspects that his/hers product on the market is not compliant with the LVD, some measures need to be taken. The possibilities can be, for example, to make it comply with the LVD or to simply take it off the market. The national authorities of the Member State where the product is placed on the market must be informed about the non-compliance and what has been done in order to minimise or eliminate the hazardous risk. The decision if the risk can be accepted or not is decided by the manufacturer.

The products that are placed on the market must be made so that they can be identified. This can be done by providing the product with a serial-, type- or batch-number. Other solutions can also be used if they provide for the same result. Furthermore, the identification of the product must also provide means for finding the appropriate documentation which provides conformity of the product type in question. This information can be in the attached documentation/packaging if it is too problematic to affix it to the product itself. If this is the case, then it is important that one can easily and safely access it.

The manufacturer is required to give their contact information in the same way as described above. This information should consist of the following: Registered trademark/name, their name and the address that can be used to get a hold of them. The information and labels are to be in an appropriate language so that they can be easily understood, identifiable and interpretable in the language of the actual Member State.

Language requirements also need to be considered by the manufacturer (as previously mentioned). When considering which language to use then the national law of the Member

state where the product is to be placed on the market should provide the appropriate one. Documentation such as identifications, safety information and instructions about the product should be translated to the appropriate language.

It is the manufacturer's obligation, when receiving a motivated request from qualified national authorities, to cooperate and give them the needed information in order to prove the conformity of their product (with the LVD). It is required that the information in question is translated into a language that can be effortlessly understood by them. Furthermore, the manufacturer must cooperate on the authorities request if there are risks associated with the product that needs to be eliminated.

The CE-marking and EU declaration of conformity can be done by the manufacturer's representative, but it is then on the representative's responsibility. The representatives can also cooperate with authorities on other numerous points but the tasks of making technical documentation and making sure that the product have been constructed according to the safety demands of the LVD cannot be delegated. If a representative is used then their mandate need to contain and mention the responsibilities in question. The LVD mentions several minimum rights that are mandatory to be given to the representative. (European Commission, 2018).

5.3 Presumption of conformity

Presumption of conformity with the safety objectives of the LVD can be given to electrical products if they are made according to, and fulfils the demands of, appropriate technical standards. The types of technical standards to use in order to provide conformity are: Harmonised standards, international standards or national standards. They shall be used in the same order as described.

In other words, LVD simply states the general demands for the safety of electrical equipment while the standards give details on how to comply with the safety objectives of the LVD. It must however be noted that not every standard can provide for presumption of conformity and the manufacturer must check that the standard is good enough for this task. Some of the demands for a standard to be good enough will be reviewed further in the chapters that contain information about respective standard type. It must be determined after the risk analysis is done what type of standard that is to be used. Firstly, check for the availability of appropriate harmonised standards, then international standards and lastly national standards.

If the above-mentioned measures are not used, then no conformity is provided either. But, the product must however fulfil the demands of the LVD. This is achieved by providing a description in the technical documentation on which measures have been taken in order to fulfil the safety objectives of the LVD. (European Commission, 2018).

5.3.1 Harmonised standards

A harmonised standard is made upon a request from the European commission. The standard is to cover Union harmonisation legislation and it is to be made and adopted according to EU regulation 1025/2012. The development of harmonised standards is conducted by the European Standardisation Organisations (ESOs) and they do not provide presumption of conformity until their reference is listed in the Official Journal of the European Union or OJEU. (European Commission, 2016, pp. 43 - 46).

The OJEU also state the date when the applicable harmonised standard no longer provides presumption of conformity. This date is a date when the standard is considered to be outdated due to technological and safety development. (European Commission, 2018).

The LVD guide mentions that the ESOs ETSI, CEN and CENELEC have been given a mandate that requests them to uphold and make harmonised standards that fulfils the safety demands of the LVD for various electrical appliances. It is also stated in the guide that the use of harmonised standards is not mandatory, but they are needed if a presumption of conformity is to be given to the product.

5.3.2 International standards

If no existing harmonised standard is considered to be applicable for the fulfilling of the safety demands of the LVD then international standards can be used. The standard need however, according to article 13 in the LVD, be published by the IEC (International Electrotechnical Commission). The standard in question need to go through a publication procedure (stated in article 13 of the LVD) and the reference is to be published in the OJEU if it passes. The standard provides presumption of conformity after that.

However, it is a possibility that an international standard made by IEC is adopted by the ESO CENELEC. A standard that this has happened to will become harmonised in the same way as described in chapter 5.3.1 Harmonised standards. The adoption procedure in question is possible due to an agreement between the standardisation organisations IEC and CENELEC and the agreement allows the organisations to cooperate. (European Commission, 2018).

The agreement was called the Dresden agreement between the years 1996 and 2016 but it is now known as the Frankfurt agreement which is a newer edition of the Dresden agreement. The agreement states that electrotechnical standardisation should be conducted on an international level whenever possible. Parallel voting of international draft standards is conducted which results in the fact (according to the LVD guide) that a lot of CENELEC standards are identical to IEC standards.

EN standards that are adopted and exactly the same as the equivalent IEC standard gets the reference EN IEC 6xxxxx. (IEC-CENELEC, 2016).

5.3.3 National standards

If a situation presents itself where no harmonised nor international standards are appropriate for the product in question, then applicable national standards of the member state where the manufacturer is situated can be used as long as they fulfil the safety demands of the LVD. It is however important that the manufacturer check thoroughly that the national standard is good enough as it is possible that the national standard does not fulfil every needed safety demand. (European Commission, 2018).

5.4 CE marking

It is the manufacturers or his/hers authorized representative's responsibility to affix the CE-mark to the product that fulfils the demands of the LVD. The CE-mark notifies that the product is in conformity with the LVD and additional directives that may be applicable. In other words, the manufacturer states that it is upon him or her to make sure that the product is complying with applicable directives (according to the regulation 765/2008/EC). The general principles and rules of affixing the marking are stated in another EU regulation and that will not be reviewed thoroughly in this thesis as it is not considered to be of huge importance.

The main demands for the marking are that it has to be applied on the product or on its marking plate. However, if that is not attainable then it is to be found on the packaging and in the attached documentation. It must be easily readable, noticeable and durable. It is mandatory that the CE-marking is carried out before product release on the market. (European Commission, 2018).

When a product bears the CE mark, then it may be moved freely in the EEA (European Economic Area) and on the Turkish market. It must however be noted that the mark can't be

considered as proof of conformity with applicable EU legislation, it is merely an indication of it. Products do not need to be manufactured in the EU in order to comply with the appropriate EU legislation, so the CE mark do not state the where the product in question have been manufactured. (European Commission, 2016, pp. 58, 59).

There can be no other similar misinforming mark on the product. It must be easy to notice, read and distinguish a CE mark on a product. If other marks are to be applied, then they may not make the meaning and function of the CE mark worse. The Member States need to make sure in various ways that the marking is being used correctly. They must also act whenever they notice that CE-markings are not applied correctly or misused. The actions that they can take can be criminal sanctions or penalties, depending on how big a violation that has been committed. The goal with these actions is to scare people from misusing the mark. (765/2008, article 30).

5.5 Declaration of conformity

The purpose of the EU declaration of conformity is to show that the safety demands of the LVD are fulfilled. It is a legal statement and it have to be made according to Figure 8 and updated regularly. The Member State where the product is released on the market decides which language(s) the declaration of confirmation should be in.

If there are more than one Union-act that are applicable, then all of the references to the different acts should be put in the same declaration of conformity. The single declaration of conformity can however be made up of several separate declarations merged to be in the same file/place. It has to be kept with the technical documentation for the same period of time (ten years). The model of the EU declaration of conformity in the LVD is shown in Figure 8.

EU DECLARATION OF CONFORMITY (No XXXX) (1)

1. Product model/product (product, type, batch or serial number):

2. Name and address of the manufacturer or his authorised representative:

3. This declaration of conformity is issued under the sole responsibility of the manufacturer.

4. Object of the declaration (identification of electrical equipment allowing traceability; it may include a colour image of sufficient clarity where necessary for the identification of the electrical equipment):

5. The object of the declaration described above is in conformity with the relevant Union harmonisation legislation:

6. References to the relevant harmonised standards used or references to the other technical specifications in relation to which conformity is declared:

7. Additional information:

Signed for and on behalf of:

(place and date of issue):

(name, function) (signature):

Figure 3. Model for an EU declaration of conformity (European Commission, 2018)

The declaration must to be signed by someone (he/she needs to be authorized according to the Blue Guide) along with additional information in order to describe who the person that is signing it is. This is done by stating the persons function and name along with the signature (see Figure 8).

The date when the declaration of conformity was signed must also be stated along with the place. One can also give the declaration of conformity a number (note (1) in Figure 8) or include additional data that helps with the trackability of the product but that remains voluntary. (European Commission, 2018).

5.6 IEC 60204-1

IEC 60204-1 is part one of the IEC 60204 series. This part contains general demands for safety of machinery and electrical equipment of machines. CENELEC have adopted and maintains an EN-version of this standard. The objective of the standard is to make the servicing and use of the machine better along with making sure that the machine answers to different control commands. Furthermore, it is also a main objective to enhance people's safeness and making sure that properties also stays safe.

The standard provide means for the solving of many different demands. It states what need to be included in the technical documentation, what tests that need to be carried out, wiring demands etc.

Note, that IEC cannot be held responsible for any costs, injuries or damages that are relatable to the use of their standard publications. (IEC 60204-1, 2016).

5.6.1 Scope of IEC 60204-1

This standard starts to be applicable from the place where the electrical supply is connected to the machine's electrical equipment. A machine or machinery is defined as the following in IEC 60204-1:

"Assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material".

It is mentioned in IEC60204-1 that the component in this context is not limited to an electrical one. It must also be noted that there may be cases where the definition of a machine does not fit in but the standard may be applicable to the electrical equipment anyway.

The standard's max voltage ratings are the same as in the LVD (1000 VAC & 1500 VDC) and the supply frequencies of the electrical equipment can be up to 200 Hz. Equipment that belong under the scope of this standard are the electrical equipment of machines that falls under the given voltage range (and frequencies in the case of AC). This kind of equipment is considered not to be carriable by hand while it is running. The standard also mentions machine's systems, electronic equipment that are programmable and several machines that cooperates well and in a structured way to be included in the scope.

Excluded from the scope are some parts that are to protect people from those dangers that are not of an electrical nature. These kinds of parts may differ and be mandatory according to other standards depending on machine type. There can also be further special machine conditions that may have special demands on the electrical side (these conditions can be machines handling potentially explosive material, machines that are to be placed in a potentially explosive atmosphere, elevator machines and so on). These demands are not included nor described in the scope of IEC 60204-1.

The referenced standards under clause two that can be found within IEC60204-1 are considered necessary for the application of this standard. (IEC 60204-1, 2016).

5.6.2 Guidance on using IEC 60204-1

Annex F gives specific guidance on how this standard should be used. It is stated that one cannot simply use only desired parts of it to comply with. The whole standard is to be applied

due to the fact that there are a lot of common demands that need to be taken into account. There is however a possibility that all of them may not apply to the electrical equipment of the specific machine in question.

A provider of a machine without a specific standard or product family is prompted to apply this standard. The same goes for a technical committee that is in the making of a specific standard or product family. Where the standards offer for multiple alternatives in order to fulfil the demands, the most suited one is to be chosen. It is also stated that some parts may require some changes if those same parts are correctly dealt with in other applicable standards. IEC 60204-1 is to be used by reference and the modified clauses and chosen alternatives in the standard must not make the risks discovered in the risk assessment worse.

There are recommendations that certain references should be given. Those are: References to which parts in the standard that the product is in conformity with (that is if there are alternatives available in the parts then it is to be provided for the one that is chosen and conformed to), references to the parts that have been changed in order to fulfil demands of other applicable standards. The additional applicable standards with further demands are also to be referenced.

This standard provides for a model of a form (in Annex B) that can be used in order to exchange necessary information between a customer and manufacturer. A similar form can also be found in the standard 61439-1. The information to be provided concerns electrical supply, customer demands, protection measures and so on. (IEC 60204-1, 2016).

5.6.3 Additional requirements

As mentioned in the scope, there are some additional requirements that may fall out of the scope of this standard. There is a table in annex F (Table F.1) that states additional requirements that can be applicable. There is one particular point that needs to be determined on the basis of another standard series where IEC 60204-1 is simply not good enough. That point is mentioned under the subclause: selection of equipment and the subclause regarding this is called switchgear.

The following is stated in the general subclause in selection of equipment: Electrical appliances need to be appropriate for what they are to be used for, they need to be used and installed as the manufacturer or provider has intended them to be and conformance with applicable IEC standards are required (if they can be found and if the standard require so).

IEC does not give any further guidance on selection of switchgear and it is stated that the electrical planner can use applicable parts of the IEC 61439 series to comply with because of the machine specific differences that can be found. These differences can be machine types, electrical equipment or intended use and they may bring additional demands to light and that calls for the use of IEC 61439 series. The standard series covers the subject of different low-voltage switchgears and controlgear assemblies. (IEC 60204-1, 2016).

5.7 IEC 61439-1

IEC 61439-1 is the first part of the IEC 61439 series. The standards series cover the subject low-voltage switchgear and controlgear assemblies as previously mentioned. CENELEC have adopted and maintains an EN-version of the same standard. Part one of the series covers general rules while the others are so called assembly standards. There is also a part zero that aids one in the specification of an assembly.

The aim of this part of the standard series is to take all the common demands for low-voltage switchgear and controlgear assemblies and put them at the same place. This is done so that verification and demands can be the same for multiple types of assemblies and thus should only one standard be needed when it comes to verification. In other words, the common demands of the different assembly standards are in part one of the series. IEC have also added some other things to the standard and those are for example dielectric properties and temperature rise.

Two standards from the series are at least required for each assembly that falls under the 61439 series. One of them is part one (IEC 61439-1, general rules) and the other one is the part that is applicable to the specific assembly in question (IEC 61439-X). These two are needed in order to be able to identify what demands that are applicable for the specific assembly and how to fulfil and verify them.

IEC 61439-1 gives demands for verification and construction. Technical characteristics and service conditions are also something that is processed in the standard. The same is stated in IEC 61439-1 as it was in IEC 60204-1: IEC cannot be held responsible for any costs, injuries or damages that are relatable to the use of their standard publications. (IEC 61439-1, 2011).

5.7.1 Scope of IEC 61439-1

This standard is, according to the scope, applicable to those low-voltage switchgears and controlgear assemblies only when demanded so from the applicable assembly standard. The criteria for this to happen is:

The voltage ratings are to be in the correct range (max 1000 VAC and 1500 VDC). Further in the scope it is also stated that it does not matter if the assemblies have an enclosure or not and the assemblies can be in a fixed place or mobile. The scope also mentions several different kinds of applications where a low-voltage switchgear or controlgear assembly may be used. These applications require the applying of this standard along with the fact that additional demands that are stated by other applicable standards also need to be fulfilled.

The different applications that were mentioned previously are: In the case of electrical equipment of a machine (it is however noted in the scope that there are additional demands in the IEC 60204 series), where there are special service conditions such as in ships or rail vehicles (additional demands are found in IEC 60092-302), when controlling appliances that use electrical energy and when used together with the handling of electrical energy (distribution, generation, conversion and transmission).

Assemblies that are produced in series (fully standardised) falls within this scope as well as, assemblies that are not standardised and only planned, drawn up, made and verified one by one. The making of the assembly in question can be done by a third party.

The things that falls out of the scope of this standard are separate appliances and such components that have all the working parts within themselves (so called self-contained) in order to function properly. These kinds of appliances and components are covered by their own applicable product standards.

Note that references to other standards that are listed in the clause normative references are considered to be necessary if this standard is to be applied. (IEC 61439-1, 2011).

5.7.2 Additional requirements

When the goal is to obtain conformity or specify an assembly, then the IEC 61439-1 is not good enough. The applicable assembly standard of the 61439 series must be identified and complied with if this is to be achieved. (IEC 61439-1, 2011).

Another thing that provides for additional demands is the fact that ABB applies the standard on panels that are electrical equipment of machines. This calls for additional demands that are stated in the IEC 60204 series.

6 Differences between the markets in the USA and Europe (Confidential)

7 Making of a standard drawing package (Confidential)

8 Conclusion and discussion (Confidential)

9 References

ABB, 2020. *ABB Finland.* [Online]
Available at: https://new.abb.com/fi/abb-lyhyesti/suomessa
[Accessed 9 January 2020].

Ahoranta, J., 2008. KAPSLING AV ELMATERIEL OCH KLASSIFICIERING AV ELINSTALLATIONSUTRYMMEN. In: *INOMHUSINSTALLATIONER.* KEURUU: UTBILDNINGSSTYRELSEN, pp. 80-81.

European Commission, 2016. *The 'Blue Guide' on the implementation of EU products rules 2016.* 2016 ed. s.l.:Official Journal of the European Union.

European Commission, 2018. *LOW VOLTAGE DIRECTIVE 2014/35/EU GUIDELINES.* s.l.:Directorate-General for internal market, Industry Entreprenourship and SMEs in cooperation with Member states, European standardisation bodies, European industry, European consumer organizations and other relevant sectoral stakeholders.

Heine, L., 2020. *UL training.* Vasa, UL.

IEC technical committee 44, 2016. *IEC 60204-1.* 6 ed. Geneva: INTERNATIONAL ELECTROTECHNICAL COMMISION.

IEC-CENELEC, 2016. *IEC-CENELEC Frankfurt Agreement.* Frankfurt, European Committee for Electrotechnical Standardization.

Jonas, B., 2019. *Interview with engineering manager of IAEN, ABB* [Interview] (25 November 2019).

Occupational Safety and Health Administration, 2019. *NRTL Program Policies, Procedures, and Guidelines.* [Online]
Available at:
https://www.osha.gov/sites/default/files/enforcement/directives/CPL_01-00-004.pdf
[Accessed 21 January 2020].

Occupational Safety and Health Administration, 2020. *OSHA's Nationally Recognized Testing Laboratory (NRTL) Program.* [Online]
Available at: https://www.osha.gov/dts/otpca/nrtl/
[Accessed 20 1 2020].

Sivanagaraju, L. & Devi, L., 2011. *Control Systems Engineering.* Turnbridge Wells: New Academic Science.

Subcommittee 17D of IEC technical committee 17, 2011. *IEC 61439-1.* 2 ed. Geneva: INTERNATIONAL ELECTROTECHNICAL COMMISSION.

The European parliament and the council of the european union, 2008. REGULATION (EC) No 765/2008. *Official Journal of the European Union,* p. 43.

UL Product iQ™, 2019. *NITW.GuideInfo - INDUSTRIAL CONTROL PANELS.* [Online]
Available at: https://iq.ulprospector.com/en/profile?e=209520
[Accessed 18 1 2020].

UL standards, 2018. *UL508A Standard for safety.* Northbrook, Illinois: s.n.

UL, 2019. *UL Standards Labels List.* [Online]
Available at: https://marks.ul.com/about/designing-and-ordering-ul-marks/ul-standards-labels-list/
[Accessed 30 October 2019].

UL, 2020. *UL.* [Online]
Available at: https://www.ul.com/about/history
[Accessed 16 January 2020].

Zuken, 2020. *Zuken.com.* [Online]
Available at: https://digital.zuken.com/rs/707-ZQM-176/images/BR-E3.series-Overview-EN.pdf
[Accessed 8 January 2020].