YRKESHÖGSKOLAN NOVIA

Design, Development and Introduction of Smart P&I Diagrams for Wärtsilä 31 Engine

Robin Linman

Bachelor´s thesis

Degree Programme in Mechanical and Production Engineering

Vaasa 2019

BACHELOR'S THESIS

Author: Robin Linman
Degree Programme: Mechanical and Production Engineering, Vaasa
Specialization: Mechanical Engineering
Supervisor(s): Franco Cavressi (Wärtsilä) and Kenneth Ehrström (Novia)

Title: Design, Development and Introduction of Smart P&I-Diagrams for Wärtsilä 31 Engine

---

Date April 1, 2019 Number of pages 43 Appendices 7

Abstract

This thesis has been made for Design team W31 which is a part of Wärtsilä Finland. Design team W31 is primarily working with creating new designs and updating drawings and instructional documents for the Wärtsilä 31 engine.

The purpose of this thesis was to create a template in Microsoft Visio that will make it easy for engineers to create Piping and instrumentation diagrams. Microsoft Visio is a drawing program for creating different types of diagrams. A template is a document that works as a foundation for a new drawing and can contain special features and a predefined layout. A Piping and Instrumentation diagram is a detailed flow diagram that describes how piping, equipment and instrumentation are placed and work together in a process.

The result of this thesis is a customized template in Microsoft Visio. The template was tested and implemented by drawing and redesigning different diagrams for the Wärtsilä 31 8-10V engine and a user guide for that explains how to use Microsoft Visio and the template was also created.

Language: English
Key words: Microsoft Visio, piping and instrumentation diagram, Template, Wärtsilä

EXAMENSARBETE

Författare:
Utbildning och ort: Maskin- och Produktionsteknik, Vasa
Inriktningsalternativ: Maskinkonstruktion
Handledare: Franco Cavressi (Wärtsilä) och Kenneth Ehrström (Novia)

Titel: Design, utveckling och untroduktion av smarta rör och Instrumentdiagram för Wärtsiläs 31 motorn

---

Datum 1.4.2019 Sidantal 43 Bilagor 7

Abstrakt

Detta examensarbetet gjordes för Design team W31, som är en del av Wärtsilä Finland. Design team W31 arbetar mestadels med att göra nya designer för komponenter och uppdateringar för ritningar och instruktionshandlingar som relaterar till W31 motorn.

Syftet med detta examensarbete var att skapa en mall i Microsoft Visio som skall göra det lätt för ingenjörer att rita rör och instrumentdiagram. Microsoft Visio är ett ritprogram ämnat för att skapa olika diagram. En mall är ett dokument som fungerar som en startpunkt för en ritning och det kan innehålla speciella funktioner oh ha ett förutbestämt utseende. Ett rör- och instrumentschema är ett detaljerat flödesschema som beskriver hur rör, utrustning, sensorer och givare är placerade och fungerar tillsammans I en process.

Resultatet av arbetet blev en anpassad mall i Microsoft Visio. Mallen testades och implementerades igenom att rita och designa om olika diagram för W31 8-10V motorn och även en användarguide för hur Microsoft Visio och mallen skall användas gjordes.

Språk: engelska
Nyckelord: Microsoft Visio, rör- och instrumentdiagram, mall, Wärtsilä

OPINNÄYTETYÖ

Tekijä: Robin Linman
Koulutus ja paikkakunta: Kone- ja tuotantotekniikka, Vaasa
Suuntautumisvaihtoehto: Koneensuunnittelu
Ohjaajat: Franco Cavressi (Wärtsilä) ja Kenneth Ehrström (Novia)

Nimike: Smart P&I -kaavioiden suunnittelu, kehittäminen ja käyttöönotto Wärtsilä 31 -moottorille

---

Päivämäärä 1.4.2019 Sivumäärä 43 Liitteet 7

Tiivistelmä

Opinnäytetyö on tehty Wärtsilä Finlandin Design team W31:lle. Suunnittelutiimi W31 työskentelee ensisijaisesti Wärtsilä 31 -moottorin uusien mallien ja päivitysten piirustusten ja opetusasiakirjojen luomisessa.

Opinnäytetyön tarkoituksena oli luoda Microsoft Visiossa malli, jonka avulla insinöörit voivat helposti luoda putkisto- ja instrumentointikaavioita. Microsoft Visio on piirustusohjelma erilaisten kaavioiden luomiseksi. Malli on asiakirja, joka toimii perustana uudelle piirustukselle ja joka voi sisältää erikoisominaisuuksia ja ennalta määritetyn ulkoasun. Putkisto- ja instrumentointikaavio on yksityiskohtainen vuokaavio, jossa kuvataan, miten putket, laitteet ja instrumentit on sijoitettu ja toimivat yhdessä prosessissa.

Opinnäytetyön tulos on Microsoft Vision räätälöity malli. Malli testattiin ja toteutettiin piirtämällä ja uudelleenmuotoilemalla erilaisia kaavioita Wärtsilä 31 8-10V -moottorille. Luotiin myös käyttäjän opas, jossa selitetään, miten Microsoft Visioa ja mallia käytetään.

Kieli: englanti
Avainsanat: Microsoft Visio, putkisto- ja instrumentointikaavio, malli, Wärtsilä

Table of contents

Abbreviations

CAD	Computer-Aided Design
PFD	Process Flow Diagram
P&ID	Piping and Instrumentation Diagram
DWG	File format (CAD File)
DXF	File format (CAD File)
VBA	Visual Basic for Applications
W31	Wärtsilä 31 Engine

Table Appendices

Table of Figures

Table of Tables

1 Introduction

This Bachelor´s thesis is made for Wärtsilä Finland. The thesis is about creating a template in Microsoft Visio that is going to be used for the design of P&ID for the Wärtsilä 31 engine. The scope for the thesis also includes the transferal and redesign for a few of the existing diagrams made for the engine and a user guide for Visio is also needed.

The Initial chapter contains information about the purpose of the thesis, problem definition, delimitation, disposition of the contents for the chapters in the thesis and a brief introduction to the Design team W31 and the company will be given.

1.1 Wärtsilä

Wärtsilä is a global company that has approximately 19000 professionals working in more than 80 countries, of which 20% are located in Finland. Wärtsilä specializes in providing solutions for marine and energy industries. They describe themselves as a smart technology company with their main aim being to increase efficiency of their products while enabling a zero-emission society. Wärtsilä is most widely known for their engines and generating sets but their portfolio also includes a vast number of other products. For example, electrical and automation solutions, ballast water management systems, communication and control systems, ship design, energy storage and even entertainment and lighting solutions. (Wärtsilä, 2018A)

1.2 Design team W31

I have been working with the W31 design team during the summer of 2018 and I have been continuing to work for the department under a part time contract alongside my studies after the summer. In addition to the part time contract I have been working on this thesis.

Design team W31 is working with creating new designs and updating drawings for the W31 engine. The main tool being used in day to day operation is the CAD software Siemens NX. The work is very varied and consists primarily of making 3D models, 2D drawings and instructional documents for many different components and processes.

Franco Cavressi is the Design Manager for the team and my supervisor for this thesis. During the project I have also worked in close contact with Fredrik Roos who is a senior design engineer in the team familiar with the design of P&ID.

1.3 Problem definition

The diagrams for the W31 engine was first designed in the CAD software I-DEAS (Integrated Design and Engineering Analysis Software). I-DEAS was widely used by Wärtsilä previously, but today Siemens NX and other software like AutoCAD are used for a variety of design tasks instead. This is one of the main problems with the current diagrams since it demands that at least one person working in departments that are faced with making changes to the P&ID needs to have an active I-DEAS license or export the diagrams to a DWG or DXF file that can be opened and edited in another program.

The process of creating the diagrams have been a slow and tedious process to do in I-DEAS because there are no predefined shapes for equipment in the program so the user has been forced to draw every symbol and line individually.

The diagrams have only been working as a visual representation for the process they describe. They have not had any description for where exactly the components shown in the diagram are placed on the engine. This makes it hard for design engineers to see the benefits of looking at these schemes in everyday work since they do not add any value in finding out placement or other important information that correlate to their daily work.

The PDF files created in I-DEAS are not searchable by text, so if someone would like to find a sensor or component they know the name of in a diagram they have been forced to manually search through the document.

1.4 Purpose

The purpose of this thesis was to customize Microsoft Visio so that it will be easy for engineers to use in their daily work when designing P&ID. Benefits for the customized version can for example be that it is faster and easier to use than previous methods, additional information for components can be added that can make locating parts and understanding systems on the engine easier.

1.5 Delimitation

The work that I am doing in this thesis will be limited to three main objectives. Objective one is making a usable template in Visio for creating piping and instrumentation diagrams. The second objective is testing the template out by starting to transfer and redesign the diagrams for the W31 8-10V engines, and finally create a user guide for the tool.

1.6 Disposition

Chapter 1 This chapter introduces the purpose of this thesis and its scope.

Chapter 2 gives theory about the W31 engine, modular design, standards, the usage of standards for this thesis and Microsoft Visio.

Chapter 3 Explains the methods that have been used in this thesis.

Chapter 4 presents the results.

Chapter 5 discusses the work and gives a summary of the project.

2 Theory

This chapter begins with introducing the Wärtsilä 31 engine, followed by a brief explanation of modularization. The theory also explains what standards are and how they are used in daily life and how they have been utilized in this thesis. After the standards have been explained a description about the different types of diagrams that are important to this thesis are explained. And lastly it introduces Visio, some features and possibilities in the program will be presented.

2.1 Wärtsilä 31 engine

The Wärtsilä 31 is a 4-stroke medium speed, Vee engine that comes in three alternative fuel versions: diesel, dual-fuel (DF) and spark-ignited gas (SG). The engine is available in a variety of different cylinder configurations. The configurations are 8V to 16V for both the energy and marine markets, these cylinder configurations have a power output ranging from 4.2 to 9.8 MW at 720 and 750 rpm. A 20-cylinder configuration is also available for the Energy market. The 20V engine has a power output ranging from 10.6-12.2MV. (Wärtsilä, 2017) (Wärtsilä, 2018B)

The W31 engine has been awarded the Guinness world record for being the most efficient 4-stroke diesel engine in the world. The diesel fuel consumption for the engine can be as low as 165g/kWh. This efficiency is accomplished by utilizing new technologies, such as adjustable valve actuation, 2-stage turbocharging and high-pressure fuel system, in combination with an advanced engine control system. (Wärtsilä, 2015A)

A key feature of the W31 is that it's built by using a modularized product structure. The concept of modularization will be described in more detail in Chapter 2.2. Modular design makes maintenance easier and more efficient which leads to maximized uptime. Since the components on the engine use standardized interfaces, this gives the opportunity for engines to be converted to run on different fuels e.g. a diesel engine can be changed to a DF or SG engine, without any machining. The way of designing things in modules with common interfaces will also support future upgrades which will make it easy for customers to upgrade their engine during its lifetime to ensure it's always up to date and as efficient as possible. (Wärtsilä, 2015B)

Figure 1. Wärtsilä 31 engine sales image **(Wärtsilä, 2018C)**

2.2 Modular design

The objective of a modular product is to create a flexible product that gives the opportunity for variations without requiring changes in the overall product design every time a new variant is introduced to the market. (Ericsson & Erixon, 1999)

Modules can be seen as building blocks with which different combinations and a large number of different final products can be built. Modules for the product that strategically should vary for customer satisfaction should be well defined and separated from the parts of the product that are kept as common units. (Ericsson & Erixon, 1999) An example of this for the W31 engine could be the engine block which should always be a common unit that allows different modules to be placed on it to fit the customer's needs.

A good example of another company besides Wärtsilä that have succeeded with modularization is Scania. The modular system at Scania has reduced development and production cost inside the company and at the same time enabled them to offer customers a tailored product, while only using a limited number of components. (Scania, 2015)

The concept of how different modular variants can be chosen to make a customized end product can be Seen in Figure 2 and 3. In Figure 2 the driver's cab is divided up into four different module variants and in Figure 3 sub module variants for the L-series cab is presented (Scania, 2015). This works in a similar way at Wärtsilä where the components for the engine can be chosen by the customer from a given number of variants for different systems.

Figure 2. Different module variants for the Scania driver's cab **(Sania, 2018)**

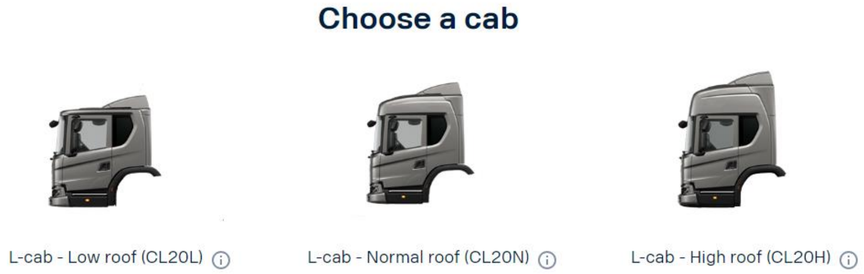


Figure 3. Different module variants for the Scania L-cab **(Sania, 2018)**

2.3 Standards

This sub-chapter will firstly present general information about what standards are and where they are used, then a brief introduction to the Standardization organization's SFS, CEN and ISO will be given since they correlate to this thesis, and lastly it will mention the standards that have been taken into consideration for different aspects of this work.

2.3.1 General

Standards are documents that administer requirements, guidelines, specifications and characteristics that can be used by companies and individuals to ensure that products, materials, processes and services fit their purpose. (ISO, 2018a)

Products manufactured according to the international standards are acceptable on the global market. Standards limit unnecessary technical barriers to trade and makes global trading between countries easy and safe. (ISO, 2018b)

In everyday life we are surrounded by products and objects that are following standards. For example, paper sizes, the hygiene and safety requirements for the food we eat, screws and shoes to name a few are based on standards. Construction, installation, manufacturing, and maintenance work are all conducted in accordance with standards. Standards are needed when operating and maintaining systems and equipment. (ISO, 2018c)

There are many different standardization organizations to name a few SFS (Finnish Standards Association), SIS (Swedish Standards Institute), ANSI (American National Standards Institute), CEN (European Committee for Standardization) and ISO (International Organization for Standardization). (Wikipedia, 2018)

This thesis will put a big emphasis on the use of standards in the creation of different aspects of the diagrams and symbols related to the processes they describe. Therefore, it is necessary to understand the fundamentals for what a standard is.

2.3.2 International Organization for Standardization (ISO)

ISO is an international independent organization founded in 1974, today the organization has 164 national standard bodies as members and per individual country there is only one member. Each member is the representative of ISO in their country.

Since the start of the organization 22538 international standards covering all aspects of life have been made. The main office for the organization is located in Geneva, Switzerland. (ISO, 2019a)

There are three different member categories for the organization:

- Full members have the ability to influence the development of ISO standards by participating and voting in policy and technical meetings. Full members also adopt and sell ISO standards nationally.

- Correspondent members can observe the strategy and development of standards by attending meetings as observers. Correspondent members can also sell and adopt the ISO standards nationally

- Subscribing members can keep up to date on the work being done by the organization but cannot participate and have an effect on the development of standards. They can also neither sell or adopt ISO standards. (ISO, 2019b)

2.3.3 European Committee for Standardization

European Committee for Standardization is an organization with 34-member countries. European Standards (ENs) aim to reflect the economic and social interests of 34-member countries. (CEN, 2018A)

As an outcome of the Vienna Agreement signed in 1991, new standards are planned collectively between CEN and ISO with the intent of preventing duplication of effort and minimize the time spent on developing standards. Cooperation with ISO ensures that international standards meet European legislation and market demands and that regions outside of Europe also implement these standards. (CEN, 2018B)

Standardization trough CEN plays a big role in the development of the European Single Market. The Single Market refers to the European Union as one market sector without any internal borders or other administrative obstacles to the free movement of products and services. The benefit of each European Standard becoming recognized across the whole of Europe, and automatically become the national standard in 34 countries at once, makes it easier for companies to sell their products and services to customers through the European single market. (European Commission, 2018) (CEN, 2018C)

2.3.4 Finnish Standards Association

SFS (Finnish Standards Association) was founded in the year 1924. It is the main organization for standardization in Finland. SFS is a member of CEN and which is an association that unites the standardization bodies of the European countries. SFS is also a full member in ISO. Most SFS standards are originally EN standards.

The main tasks of SFS are:

- to coordinate national standardization
- to publish SFS standards
- help with the implementation of standard
- to be the Finnish representative and give feedback to the international standards organizations
- to keep in contact with other foreign national standards organizations (ISO, 2018d), (SFS, 2018)

2.3.5 Utilisation of the Standards

The standards have been used and referenced in this thesis for the creation of the Visio template, creating graphical symbols, collecting information about diagrams and technical drawings, deciding what connecting lines to be use and general drafting rules.

Standards that have been used in this thesis are:

- ISO 10628-1:2014 Diagrams for the chemical and petrochemical industry Part 1: Specification of diagrams
- ISO 10628-2:2013 Diagrams for the chemical and petrochemical industry Part 2: Graphical symbols

- ISO 14617-5:2004 Graphical symbols for diagrams Part 5: Measurement and control devices
- ISO 14617-6:2004 Graphical symbols for diagrams Part 6: Measurement and control functions
- ISO 7200:2004 Technical product documentation -- Data fields in title blocks and document headers
- ISO 5457:1999 Technical product documentation Sizes and layout of drawing sheets
- ISO 3511-2: 1984 Process measurement control functions and instrumentation Symbolic representation Part 2: Extension of basic requirements
- ISO 3511-3: 1984 Process measurement control functions and instrumentation Symbolic representation Part 3: Detailed symbols for instrument interconnection diagrams

2.4 Flow diagrams

This sub-chapter will give a quick introduction to flow diagrams as a whole and brief information about different types of flow diagrams relevant to this thesis.

2.4.1 General information about flow diagrams

Flow diagrams contain visual information that is exchanged between different branches involved in assembly, design, operation and maintenance of the product the diagrams describe the process for. (SFS-EN ISO 10628-1, 2015)

The diagram should flow logically. This means that information or devices to be expected at the top of the process should be drawn at the top of the drawing and the devices expected at the bottom should be drawn lowest on the page. (SFS-EN ISO 10628-1, 2015)

The layout for flow diagrams does not need to reflect the real physical arrangement of components and the diagrams are not drawn to scale. (SFS-EN ISO 10628-1, 2015)

2.4.2 Process flow diagram (PFD)

A process flow diagram is a diagram that display the relationship between the major components in a system, by using recognizable symbols which are connected to each other with lines. The diagram shows the flow of energy, work, chemical materials and the connection between equipment involved in a process. (ISO 10628-1, 2015)

Basic information needed in a PFD:

- type of components and machinery needed for the process
- description for equipment and machinery
- route and direction of the ingoing and outgoing substances and energy flows
- flow rates and quantities of materials and energy flows
- classification of energy types and/or energy carriers
- characteristic for components and their operating conditions

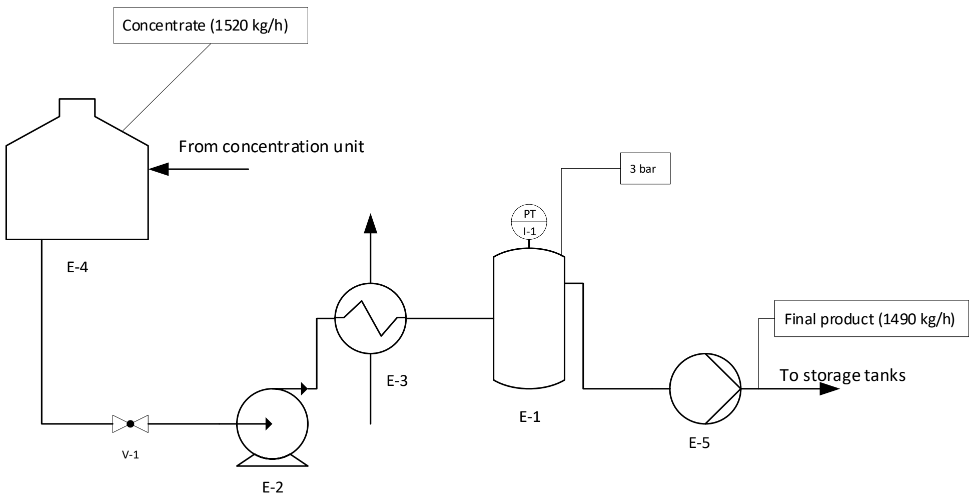


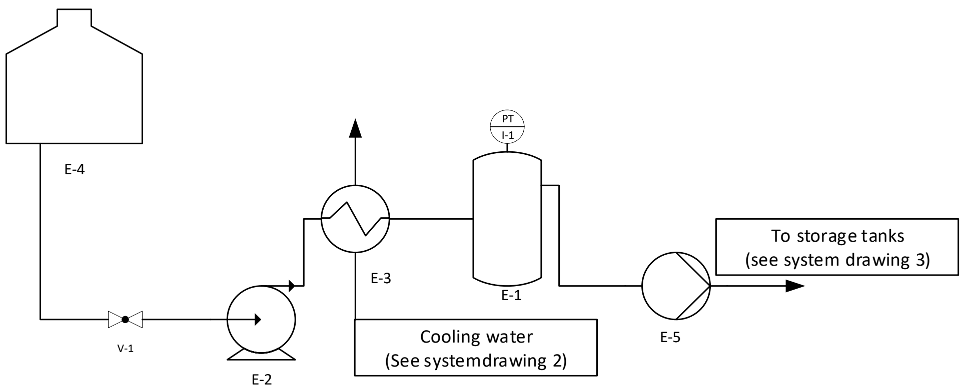
Figure 4. A simple PFD diagram with basic information.

2.5 Piping and instrumentation diagrams (P&ID)

The P&ID is usually based and derived from the process flow diagram and depicts the technical materialization of a process by having symbols represent equipment and piping, connected with symbols for control functions. (ISO 10628-1, 2015)

Piping and instrumentation diagrams need to contain the following information:

- description for the type and purpose of components
- designation of components and machinery
- information for components, given in lists if necessary
- indication of material, sizes, pressure ratings, and what type of piping is being used for pipelines
- details of components, piping, valves, and fittings e.g. pipe reducers given in separate list if necessary



Denomination	Vessel	Centrifugal pump	Heat exchanger	Primary tank	pump	Globe valve
technical data	10m³	5m³/h, 1450 rpm	-	18m³	4m³/h	-
Max. working pressure 3 bar	3 bar	4bar	3bar	3bar	5Bar	-
Max working temp	110°C	220°C	110°C	90°C	200°C	-
Material	Stainless steel	-	-	Stainless steel	-	-

Figure 5. A simple P&ID with basic information about the system components.

2.6 Using standards

This chapter describes how different aspects of the drawing sheet and the diagrams should be made to be in accordance with standards.

2.6.1 Drawing sheet

The drawing sheet for technical drawings should be made on the smallest sheet permitting the necessary legibility and resolution. This means that the designer should always to the best of his ability put a drawing on the smallest paper size he can that still makes the drawing legible.

The most common paper sheet sizes used are A4, A3, A2, A1 and A0. There are both smaller and larger size than these available on the market for different applications. The standards state that sizes larger than A1 should be avoided in the use for technical documents. (ISO 5457, 1999)

2.6.2 Border

According to the standards, technical drawing sheets should be surrounded by a border.

The sheet shall be divided into fields to make location of details on the drawing easy, See Figure 6 for an example. The fields should be referenced starting from the top of the page with capital letters, it should be noted that I and O shall not be used since they can be mistaken as representing a one or a zero, and from the left side to the right side of the sheet numbers shall be used starting from the number one. The number of fields depends on the sheet size See Table 1. (ISO 5457, 1999)

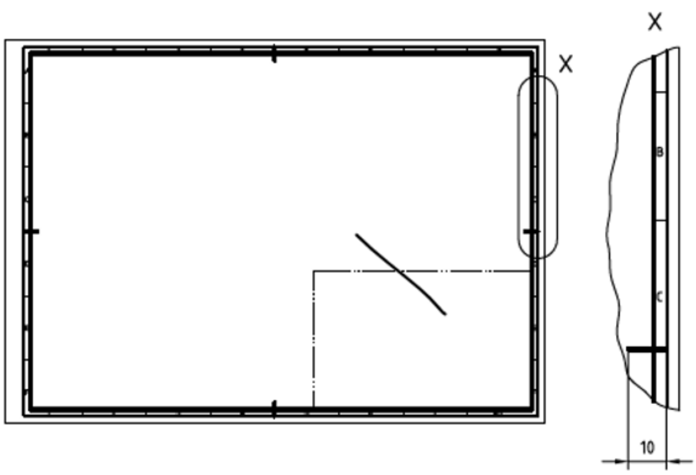


Figure 6. Border made from fields **(ISO 5457, 1999)**

Table 1. Number of fields depending on sheet size **(ISO 5457, 1999)**

Designation	A0	A1	A2	A3	A4
Long side	24	16	12	8	6
Short side	16	12	8	6	4

2.6.3 Title block

Technical drawings need to have a title block that contains information regarding the contents of the drawing. The data that is filled into the title block is standardized. The information presented in table 2 shows the mandatory and optional fields that make up a title block. (ISO 7200, 2004)

Table 2. optional and mandatory fields in title blocks for technical drawings **(ISO 5457, 1999)**

Field Name	Language dependent	Recommended number of characters	Obligation
Legal owner	-	Unspecified	M
Identification number	No	16	M
Revision index	No	2	O
Date of issue	No	10	M
Segment/sheet number	No	4	M
Number of segments/sheets	No	4	O
Language code	No	4 per language	O
Title	Yes	25/30[1]	M
Supplementary title	Yes	25/30[1]	O
Responsible department	No/Yes[1]	10	O
Technical refrence	No/Yes[1]	20	O
Approval person	No/Yes[1]	20	M
Creator	No/Yes[1]	20	M
Document type	Yes	30	M
Classification/key words	No/Yes[1]	unspecified	O
Document status	Yes	20	O
Page number	No	4	O
Number of pages	No	4	O
Paper size	No	4	O
M Mandatory. O Optional. 30[1] To support two-byte-character languages (like Japanese). Yes[1] To support presentation in different types of alphabets.			

The title block for paper sizes A0 to A3 should be located in the bottom right hand corner on the drawing sheet. Only sheets that are placed laying on its side can use these formats See Figure 7. For the paper size A4, the title block should be placed in the lower part of the drawing. Only sheets standing up vertically should use this format See Figure 7. (ISO 5457, 1999)

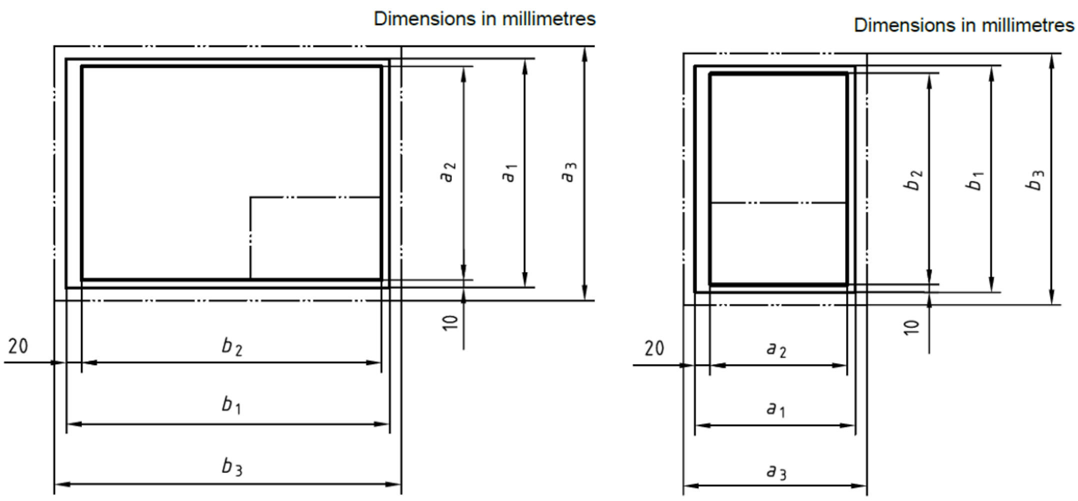


Figure 7. Placement of title block for different sheet sizes **(ISO 5457, 1999)**

2.6.4 Connection lines and flow direction

Lines that connect equipment in a P&ID represents the matter that is flowing in the process. To give a clear understanding for the process displayed on the page, different line widths should be used. (SFS-EN ISO 10628-1, 2015)

It is common practice to draw the main flow direction from left to right and from the top to the bottom. The flow direction shall be described with arrows pointing in the direction of the flow. (SFS-EN ISO 10628-1, 2015)

Different signal lines can be used to make it easier to differentiate between different flows on the diagram. (ISO 3511-2, 1984) (ISO 3511-3, 1984)

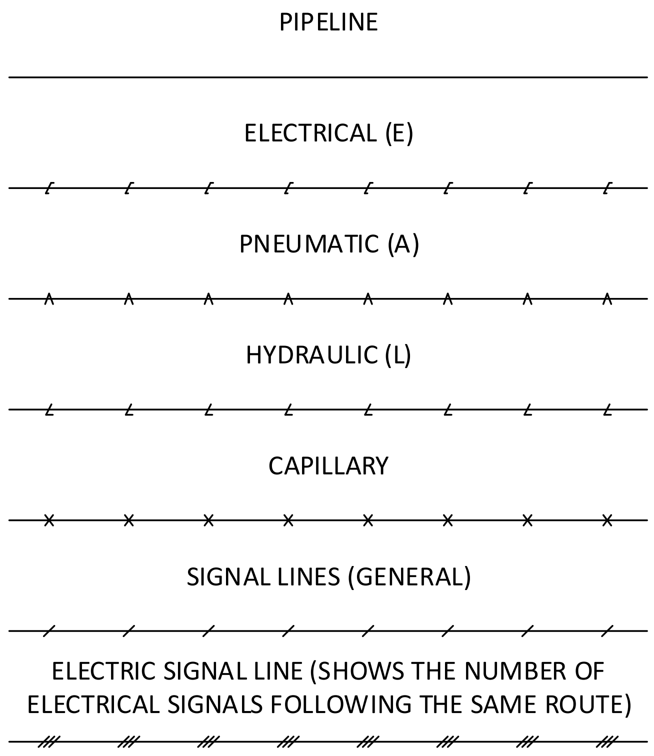


Figure 8. different lines that are according to the Iso standards **(ISO 3511-2, 1984) (ISO 3511-3, 1984)**

2.7 Visio

Visio is a Microsoft program designed for creating everything from diagrams, time schedules and floorplans to charts. There is not much it cannot be used for when you want to make a visual presentation of something. Visio comes with a wide variety of shapes and templates to work with. The user can also create own shapes, templates and objects to make whatever kind of drawings he desires. (Helmers, 2013)

Visio has a similar layout to other office programs, it resembles a Microsoft Excel or a Word file. The most regularly used commands are visible on the top of the page in the ribbon. On the left side of the document the most important window in Visio is visible, it is the shapes window where all the shapes are located and can quickly be accessed. To mention a few categories included in the shape window there is business, engineering, flowchart, network and a tab called the “my shapes tab” where users can create and store their own shapes. (Helmers, 2013)

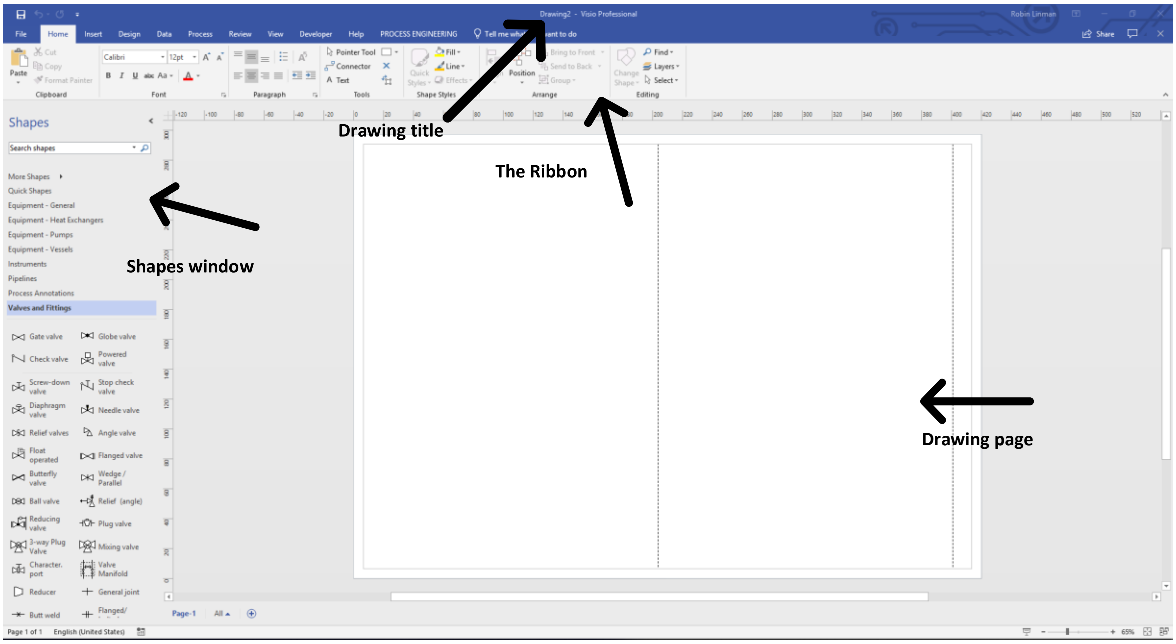


Figure 9. Visio layout

2.8 Working in Visio

This chapter describes different things that can be done in Microsoft Visio. Since the program is universal and can be used for many different applications this chapter will only focus on a few of the more important features that correlates to how Visio have been used in this thesis.

2.8.1 Shapes and shape data

Shapes are symbols that gives a visual representation of different objects and equipment. Visio has a large amount of predefined shapes. A few examples are rectangles, animals, office equipment, food, shapes for creating maps and shapes for mechanical and process engineering. (Helmers, 2013)

One of the most useable features of the software is the possibility to add shape data to the symbols on the drawing. When a shape is dropped on the drawing sheet it contains no specific data it is just a visual representation of a component or object. Some more advanced shapes have predefined categories that can be filled in, for example all valves usually contain the same information fields See Figure10. The data that can be filled into one shape is limitless. The user can add as many information fields as he desires See Figure 11. (Helmers, 2013)

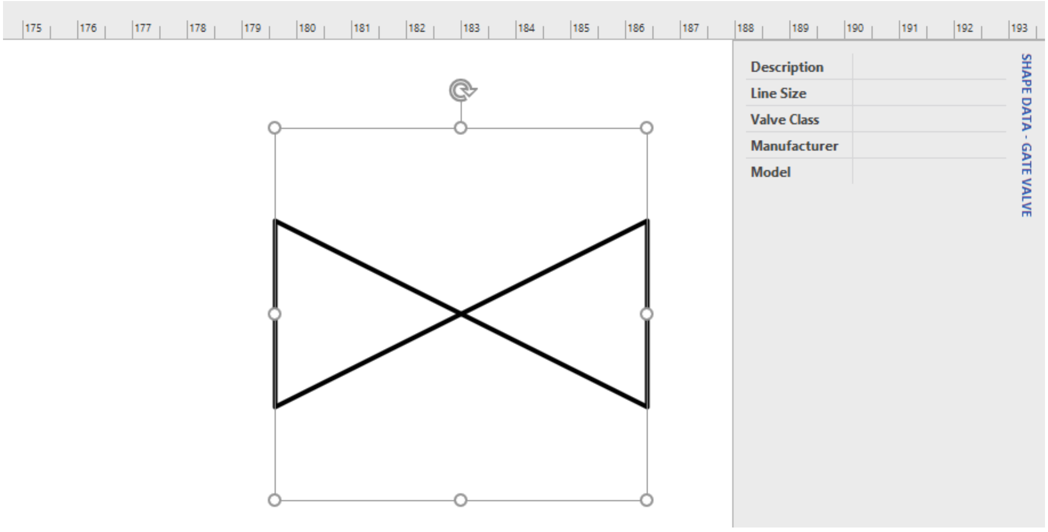


Figure 10. Default shape data fields for valves

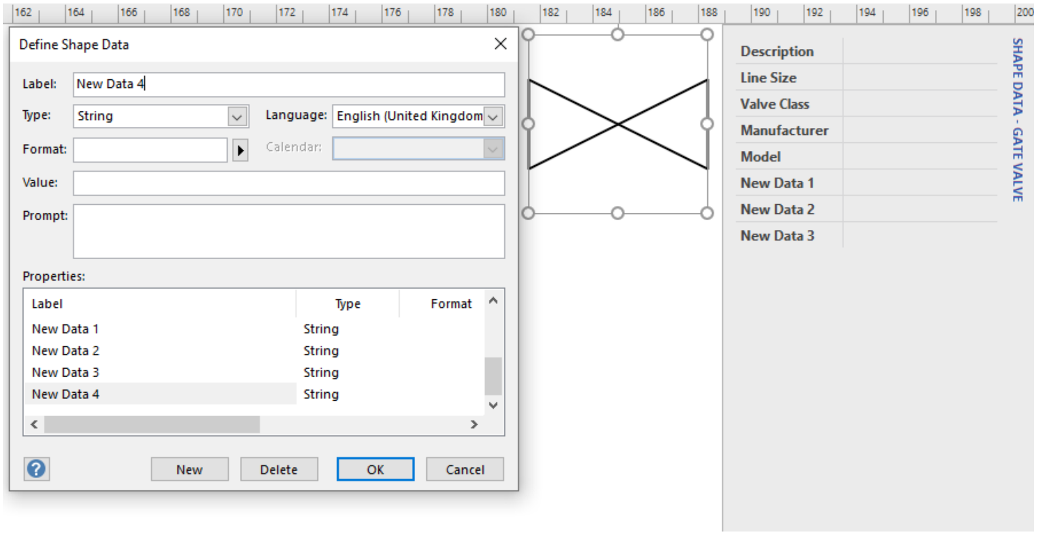


Figure 11. New shape data added to a shape

2.8.2 Creating Master shapes

The predefined shapes that come with the program are called master shapes. When the user drags a shape onto the drawing sheet it creates a copy of the master shape, and this can be done as many times as the user wants to. (Helmers, 2013)

The master shapes are located in something Visio calls a Stencil. Stencils are files that work as a collection of master shapes. New stencils can be created, and new master shapes can be added to them. (Microsoft, 2018A)

These are the steps to create a new master shape:

1. Open favorites stencil by going to the shapes window clicking more shapes, my shapes and then favorites. The favorites stencil that comes standard with Visio is meant be used for new shapes
2. Right click the stencil and select edit stencil
3. Draw the shape you want See Figure 12 and then drag it to the stencil
4. After the shape have been added to the stencil just click save as illustrated in Figure 13.
5. The new stencils that contain the master shapes drawn by the user are located on the local computer in the following location This PC-Local Drive-Users-username-Documents- My Shapes.
6. After the shapes are placed in the stencil the user can just right click and select edit shape to make new adjustments if needed to the master. (Microsoft, 2019)

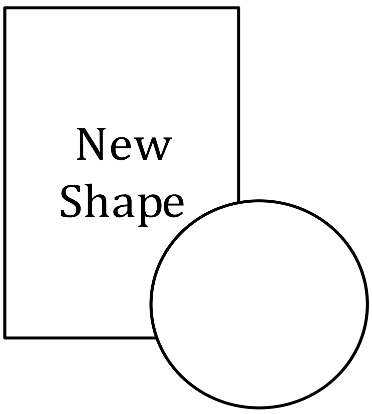


Figure 12. Example of a newly created shape

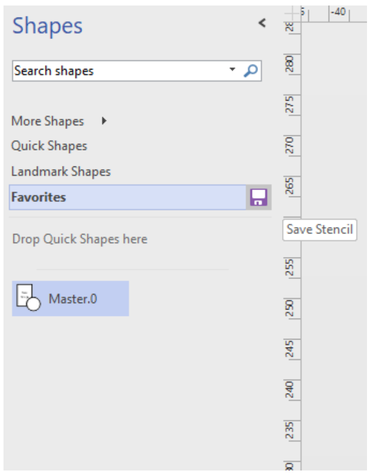


Figure 13. how to save a stencil and the shapes in it

2.8.3 Importing Data

Importing data to shapes from external sources like Microsoft Access or Excel is a feature in Visio. Importing the data from Excel can be done in two different ways. Quick import and custom import. The different methods can be found in the ribbon See Figure 14 (Microsoft, 2019)

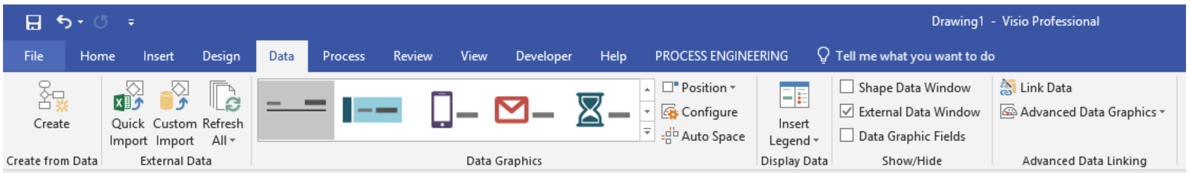


Figure 14. Data tab in the ribbon

To be able to do a quick import the shapes need to have shape data or informative text that corelates to the wanted Excel file. When using quick import, the shapes get automatically populated with the correct data.

Custom import is the second way and should be used if the quick import did not work, or when the user wants to have more control over what gets imported and what shapes are affected. After import the external data is visible in Visio`s external data window and the information can be linked to the correct shapes by dragging and dropping the data. (Microsoft, 2019)

If the information in the Excel file changes, the user does not need to import it again, he can just click the refresh button in the ribbon and all shapes are populated with the new information.

The data that has been imported is marked with a connection symbol See Figure 15 for how the linked data looks and shapes that have been linked to data rows now contain shape data Figure 16 for before and after data have been imported.

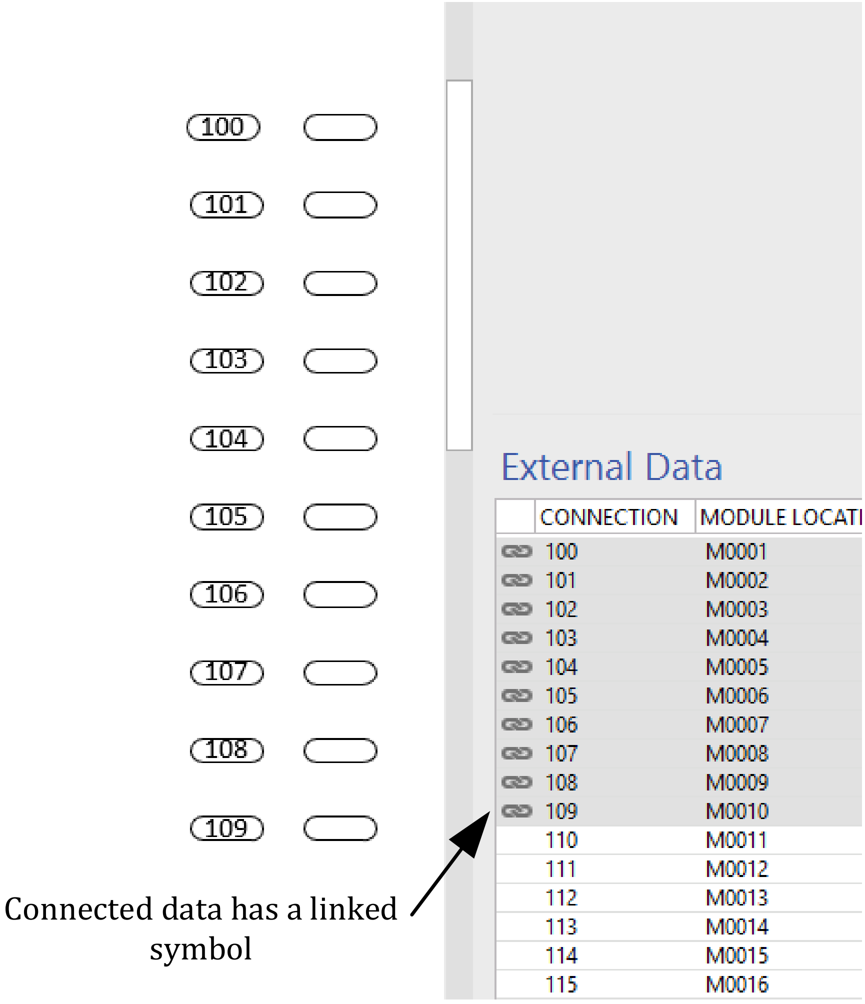


Figure 15. Imported shape data linked to shapes.

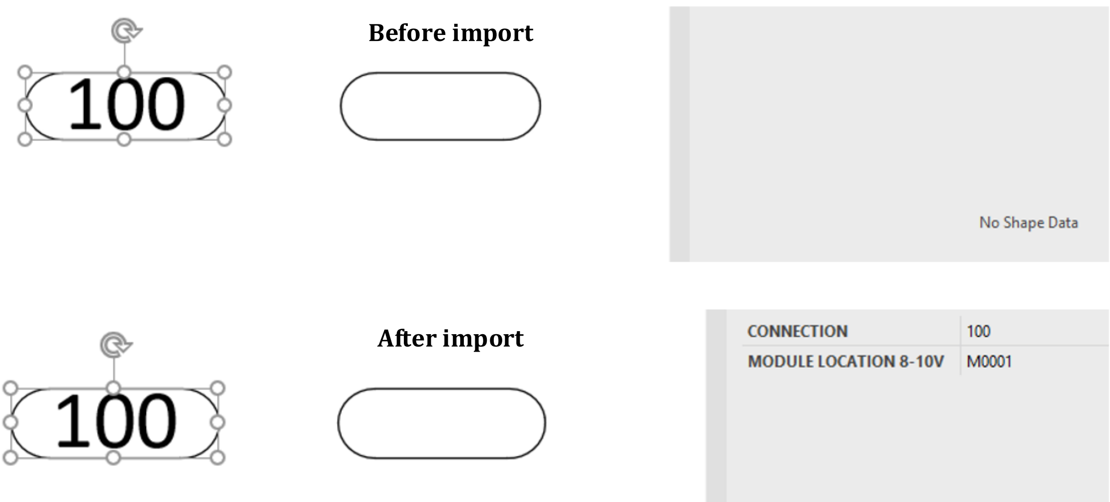


Figure 16. Shape before and after data have been added to it**.**

2.8.4 Templates

A template is a document that works as a foundation for a new drawing. A template can include stencils, a predefined amount of foreground and background pages, the pages could have shapes and text placed on them from the beginning. A template may also have special software for example VBA-code that only works in that template. (Helmers, 2013)

The first page that appears when Visio is opened is the template selector See Figure 17. There are templates for many different drawings and the user can create his own and tailor it to his needs. (Helmers, 2013)

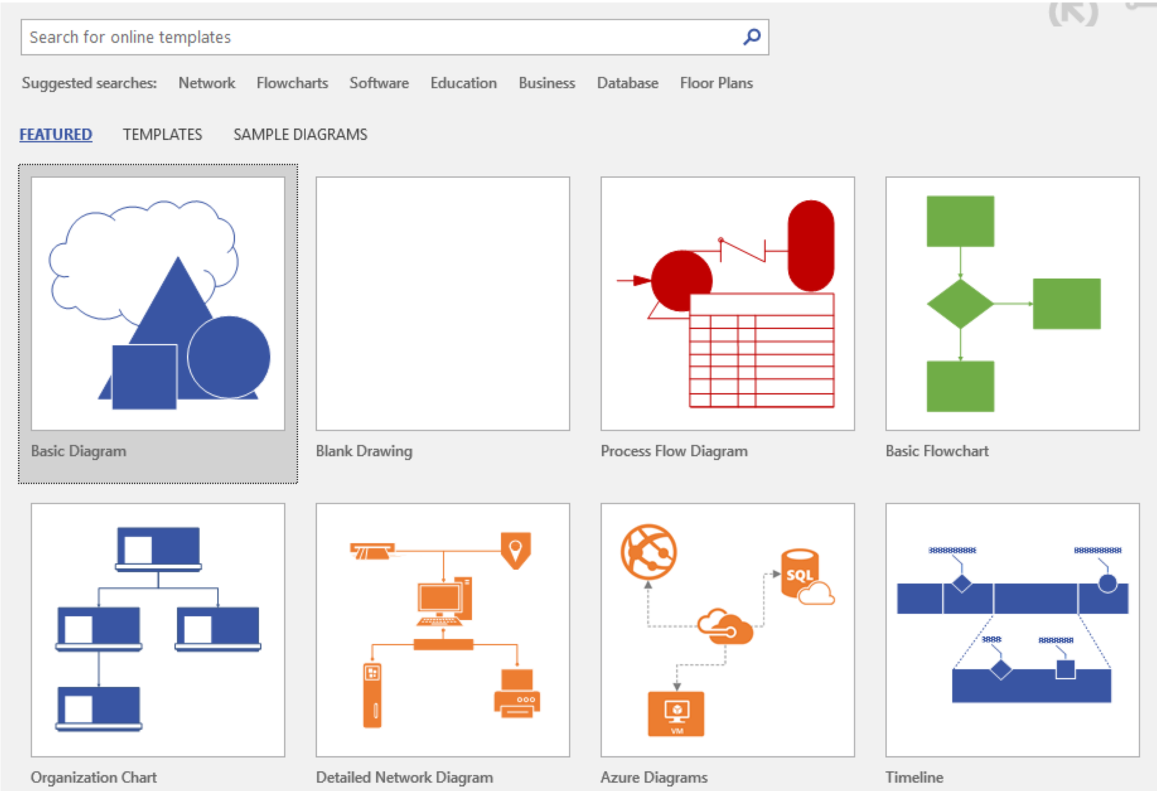


Figure 17. Visio starting screen and template selector.

2.8.5 Piping and instrumentation template

There is a default template in Visio for creating P&ID. In the template the most common components like valves, pumps, instrumentation and vessels are visible in the shape field from the start. Included in this template is a process engineering tab which contains different helpful features See Figure 18.

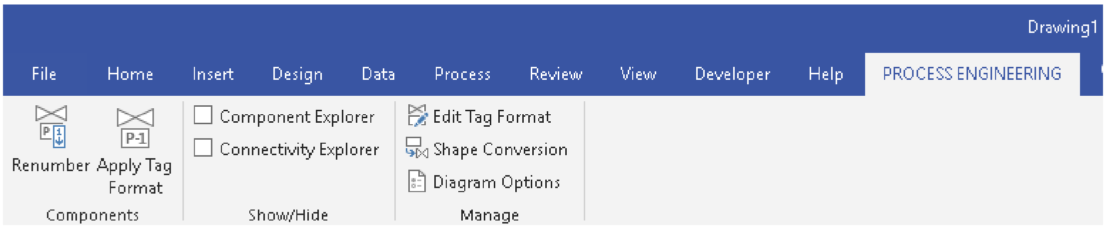


Figure 18. Process engineering tab in the piping and instrumentation template.

A default feature in this template is that when certain shapes are dropped on the page they are tagged with a letter and sequence number. E is for Equipment, V for Valves, I for instruments and P for pipelines. This makes it easy for the user to later reference and write comments to equipment when the drawing is completed.

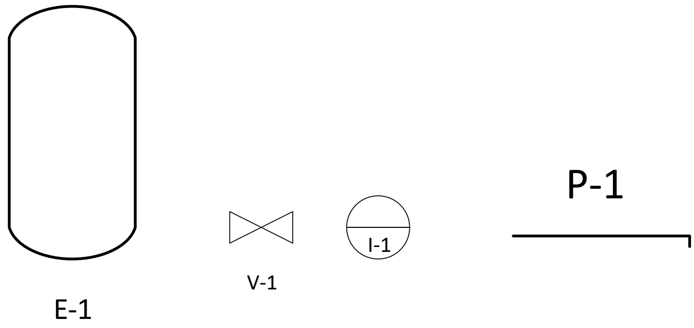


Figure 19. Different tag formats

Shapes can be converted, this changes their properties in the program, See Figure 20 where the category and tag format can be changed.

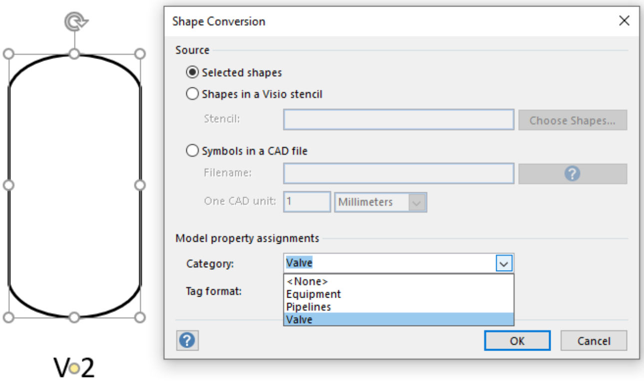


Figure 20. shape converted from equipment to valve format.

The tag format for the shapes can be edited or a new format can be created, any letter or number combination wanted can be used, for example the tags for Vessels can be modified and be made to have the tag format T-(counter) instead of E-(counter) for the tag formatting user form See Figure 21.

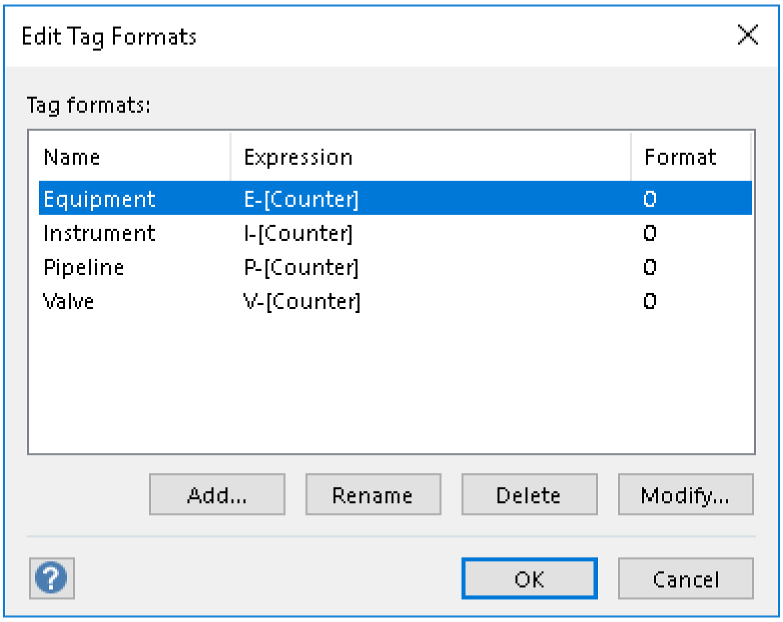


Figure 21. User form where tag formats can be added or modified

2.8.6 VBA code

VBA stands for Visual Basic for Applications and it is a programming language from Microsoft that is now mostly used with Microsoft office applications such as MS-Word, MS-Excel and MS-Access. (Microsoft, 2018B)

VBA is used to add new functions to Office applications to make every-day work quicker. It is smart to implement the use of VBA code when it comes to repetitive solutions to formatting or correction problems. If a command is needed to be used multiple times a day it might be worth writing some VBA code and automating that process to save time. (Microsoft, 2018B)

Creating a VBA macro can be done in more than one way. The most common way is usually to use the Record Macro button that is available under the developer tab in the ribbon See Figure 22 for the layout of the developer tab. The button automatically writes code that reproduces the actions that is performed in the application. The code can then be accessed and edited manually. (Microsoft, 2018B)

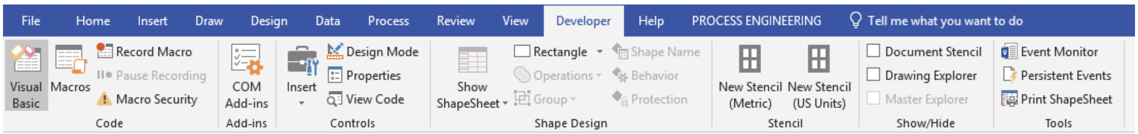


Figure 22. Developer tab in the ribbon

The visual basic code editor can be used to write code and create macros and user forms for pretty much any task or function that can be called and executed by the program itself See Figure 23. (Microsoft, 2018B)

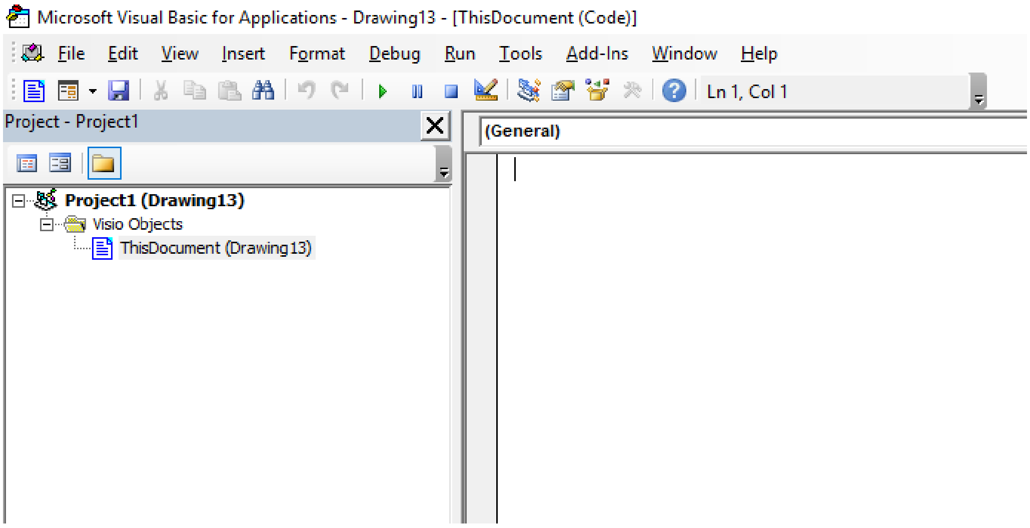


Figure 23. Visual basics editor

The possibility of tailoring Visio with VBA and other coding languages like C++ and C# where investigated during the process, but VBA was most widely used, therefore it is good to have a general understanding for how it works.

3 Method

This chapter will present the different methods that have been used during the project to develop the template. The chapter will begin with the importance of meetings and discuss why Visio was chosen and then dive into how certain things have been done and how it relates to the theory.

3.1 Meetings

Meetings and discussions have been a big part of this project throughout.

The thesis kicked off with a meeting with Franco Cavressi, Fredrik Roos and myself. The meeting gave a broad outline of what the wishes and ideas for the project was and the scope was also discussed. A second meeting was held closer to the end of the project where I showed some of my progress but was mainly used to discuss which aspects should be focused on more and the scope was also looked at.

Discussions have mainly been used to get a second opinion on things that have been done or get information on how to proceed with aspects of the project.

3.2 Why Visio was chosen

Before this thesis started it was decided that Visio should be tested as a new drafting tool for P&ID. Different software’s were looked at and Visio was found as an option since it had been implemented in the automation department for the drawing of engine wiring schemes. I was given the opportunity to start working on this project and write my thesis about it.

Visio works as a good base that can be built on and changed for the users’ needs. It is also possible to utilize the software for other types of tasks in daily work since it is compatible with other Microsoft programs. It could for example be used when wanting to make some illustrations and include them in a word document that is going to be used as an instruction or manual for something internally in the company.

The monthly price for a Visio license is substantially lower than most other software’s. A monthly license for AutoCAD costs around 260€ (Autodesk, 2019) while a monthly subscription for the version of Visio used in this thesis costs 15€ a month (Microsoft, 2019). This adds up to large savings for the company.

The PDF-files exported from the program are text searchable and makes it easy to find sensors and equipment on the page if the name is known.

3.3 Creating the border, revision field and title block

Deciding the design for the border, revision field and title block were done by following the standards and looking at the demands and wishes the company had. After that had been checked the standards where implemented as far as possible but the demands from the company was off higher importance to follow.

It was investigated if the shapes for title blocks, borders and revision fields that came pre-installed with Visio followed the standards and how they were designed. The shapes that came with the program that was looked at can be seen in Appendix 1. Inspiration for the design was also taken from the title block that had been made for automation schemes in Visio See Figure 24.

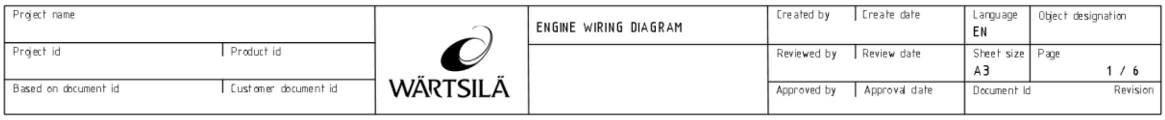


Figure 24. Title block wiring schemes

3.4 Creation of shapes

The standards ISO 10628-2, ISO14617-5 and ISO14617-6 contain an extremely large number of symbols and it is not logical to create every symbol since most of them will not be used in the company. which symbols should be made were needed to be decided to only include the one necessary for this project.

An interview was done with Fredrik Roos 31.12.2018 regarding which symbols should be made from the standards and which symbols should be excluded. During the interview we concluded that there is an internal document in the company that describes every symbol used in the current P&ID and this was referenced when making the new master shapes in Visio.

3.5 Layout

The layout for the diagrams where investigated and tested if they could be improved upon with better placement of components and different line routing paths.

This was done by firstly finding out and knowing the placement of the components on the engine. After the placement was known the symbols for the components where placed in the most logical location on the drawing. This could be done for most components but in some cases, they could not be placed as optimally as wanted due to the complexity of the system and number of components that needed to be included in the drawing.

3.6 Writing VBA code

The option of making the application more user-friendly and tailor made was investigated by starting with writing VBA code inside the document and making a few macros.

The method that was used for this part of the thesis was mostly trial and error. Many websites and online forums were visited looking at coding examples and tutorials for doing different things.

The way of choosing what type of macros should be made was done by having discussions about the topic and by testing out the software and finding things that could be improved upon. The coding part of this project was limited to only include the most essential things since the scope for the project was already very broad and writing usable macros is a very time-consuming process.

3.7 Location for outside connections and components

In this chapter the method for finding the module location for outside connections and components will be described.

The reason behind searching for components module location and adding it to the diagrams is primarily so that it can be used to speed up daily work. For designers this makes the diagrams more valuable since it is easy to see which parts belong to which modules and how they are connected to each other See Figure 25.

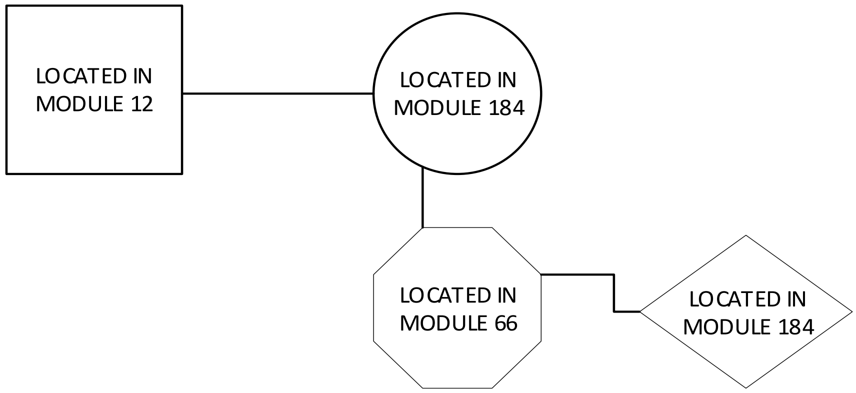


Figure 25. Simplified view of how components can be connected to each other.

3.7.1 Outside connections

Outside connections are for example pipes that are connected to systems outside the engine with primarily bolted flanges.

There is an internal document in the company that lists the code and name for all external connections used on all the engines in the Wärtsilä portfolio. The problem was that this document is universal and covers all different engines sold by the company, not only the W31. Since the document is universal it does not describe where on the engine these connections are located or the correct dimensions for them.

The placement for the connections attached to external systems were found by first looking at the P&ID, this gave a good overall view in which modules the connections could be located in, and after this step the 2D drawings were manually searched through to ensure the location.

3.7.2 Components

The location for components was determined in a similar way as it was for the outside connections. It started by looking at the P&ID and locating the major components first and finding their 2D drawing, and from the 2D drawings the minor components mentioned in the diagrams were found since they are usually attached to the major components.

After the components were found for the different systems they were either added to an Excel file or directly as shape data into Visio. For systems with an easier layout it was logical to add the information to the Excel file and import the data from there. For more advanced systems I preferred to add them into Visio directly since it was easier to maintain while searching for more information.

3.8 User guide

Since this is the start of implementing Visio as a drawing software for Instrumentation diagrams in our department, a user guide was needed to be made to make it easy for new users to get information about how to use the program efficiently.

The guide has been made by collecting information from online sources and by testing the program to learn different methods of doing things. From those experiences a way of working has been made and the guide is based on that.

4 Results

This chapter presents the result of this thesis. The results include the title block, revision field, border, lines that are going to be implemented, VBA code, importing and maintaining data and layout changes for the diagrams.

4.1 Presentation of the Systems in the drawing

When I started drawing the diagrams it was discussed if they should be kept as individual drawings as they have been previously or if another method of presentation was possible. It was decided during discussions that it would be good to have all the systems included in one document to give a complete view of the engine.

The decision was made to divide the P&ID into two different documents since the different engine configurations differ a bit regarding components involved in the process. 8-10V would be kept in one drawing and 12-20V would then be kept in another.

4.2 Drawing sheet size

The size of the drawing sheet was chosen by taking into consideration the aspects mentioned in chapter 2.6.1 and based on experiences from the company.

When looking at the old diagrams it was found that they have all been created on A3 and A2 paper sizes. I also tested by drawing a few diagrams and concluded that A1 sizes are not needed. Another reason for excluding A1 sizes were that in daily office work it is preferred to print on A4 paper because it is easy to show to other people, and it saves paper and printer ink. A3 and A2 Drawings are still readable after they have been scaled down and printed on A4 paper, but if you scale down an A1 to an A4 it becomes unreadable.

4.3 Title block

After the pre-installed shapes for the title block were looked at it was concluded that they could not be used because the title block could not contain all the information needed on a Wärtsilä drawing and it occupied an unnecessarily large amount of the drawing page.

For the title block it was decided that a similar design to the one used for automation schemes in Visio was the best solution. Our department needed to have optional fields for design group and product added. The first title block made can be seen in Figure 26 it was decided to not be used after the decision to include all the diagrams for the engine in one document was made, because the title and supplementary title 1 and 2 would need to be different for every page. With this taken into consideration the supplementary titles where deleted and only one title option was left on the drawing. The title changes depending on what page is currently active. the final title block was a minimalistic and easy to read design that can be interchangeable for all the different systems in the drawing Figure 27.

PIPING AND INSTRUMENTATION DIAGRAM	Created by	Create date	WÄRTSILÄ	Design group 1	Product THESIS
TITLE SUPPLEMENTARY TITLE 1	Reviewed by	Reviewed date		Sheet size A3	PAGE 1 OF 3
SUPPLEMENTARY TITLE 2 SECURITY LEVEL	Approved by	Approval date	Document Id DRAWING NUMBER		Revision -

Figure 26. Title block first suggestion for how it could look.

Created by	Create date	PIPING AND INSTRUMENTATION DIAGRAM	WÄRTSILÄ	Design group NUMBER	Product THESIS
Reviewed by	Reviewed date	Title CURRENTLY ACTIVE PAGE (NAME OF THE ACTIVE PAGE)		Sheet size A3	PAGE 1 OF 19
Approved by	Approval date	Document ID DRAWING NUMBER		Security level EXTERNAL	Revision -

Figure 27. Title block result

4.4 Border

The border that came with Visio did not follow the standards since the number of fields along the sides were wrong. Standard ISO-5457 dictated the number of fields depending on border size and that the fields should have a length of 50mm, this was taken in to account when making the borders to achieve two variants, a border for A3 and A2 paper sizes. The final design for the borders can be seen in Appendix 2.

4.5 Revision Field

The pre-made revision fields that came with the program could not contain all the information needed and therefore a revision field was needed to be made from scratch to fit the demands of the company. The extra information that needed to be included was a change notice number. A change notice is a written report that is made when changes and amendments are done to drawings and is always present on a Wärtsilä approved technical document.

The revision field was first designed so that it would be present on every page and reach the same height as the title block after 4 revisions have been made See Figure 28. After considering the factor that many different systems were going to be included in the same document this solution is not practical. The biggest reason for it not being practical is that it would show the revision number on pages that it does not correlate to since often changes are only made to one system at a time.

It was decided that the easiest solution would be to put it on a separate page where the user could also decide the height for the new revision fields added depending on how much text is needed, for the end result See Appendix 3. If the user wants to check what page a revision has been done on he can just double click the revision he is interested in seeing and he is brought to that page.

Revisions needs to be marked on the drawing sheet with a recognizable symbol. The method utilized is the same as for the rest of Wärtsilä's technical drawings, a hexagon shape placed next to the change made See Figure 29.

Rev.	Change notice	Created by	Approved by	Revision text

Figure 28. Revision field not used

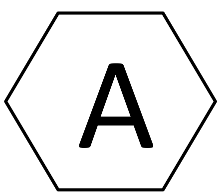


Figure 29. Hexagon revision symbol.

4.6 Lines

The Lines that shall be used were taken from the standards, except for the lines that are going to be used for the double wall gas pipes used on Wärtsilä's DF and SG engines. The lines for double wall gas system pipes have been chosen by implementing the same line selection that have been made for all the other diagrams inside the company. It was decided that every line included in the standard should not be implemented since they would be used very few times if ever at all, so only the most important will be implemented at first. The lines that are going to be used can be seen in Figure 30.

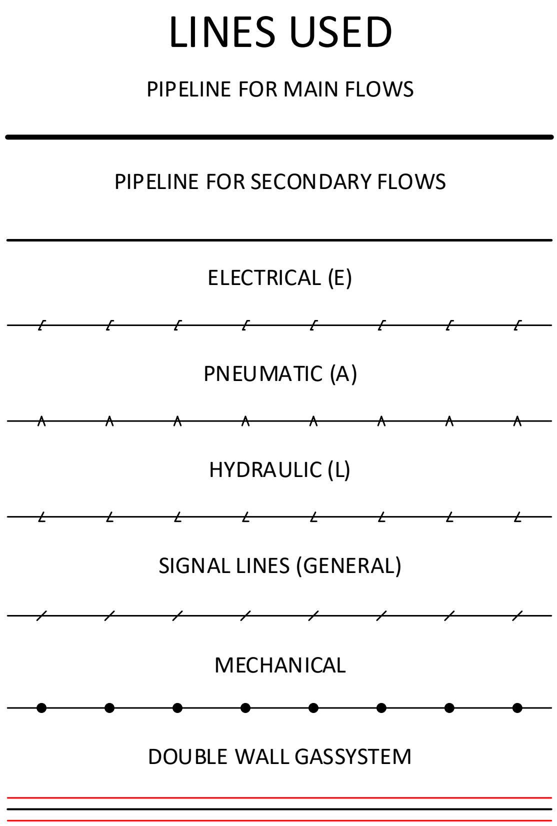


Figure 30. Lines being used in the diagrams

The standards mentioned that different line widths should be used so it was decided that main flow lines should have a width of 2,5pt and secondary lines shall have a width of 1,25pt to clearly state the difference between different flows. The lines shall also have a certain number of arrows that indicates the direction of the flow clearly.

The place on the drawing where the lines cross over each other should always be as clear as possible. This was achieved by changing the settings for the line jumps on the page. The line jumps should always be added to the horizontal lines and the size settings for the jump style should be 2 for vertical and horizontal See Figure 31.

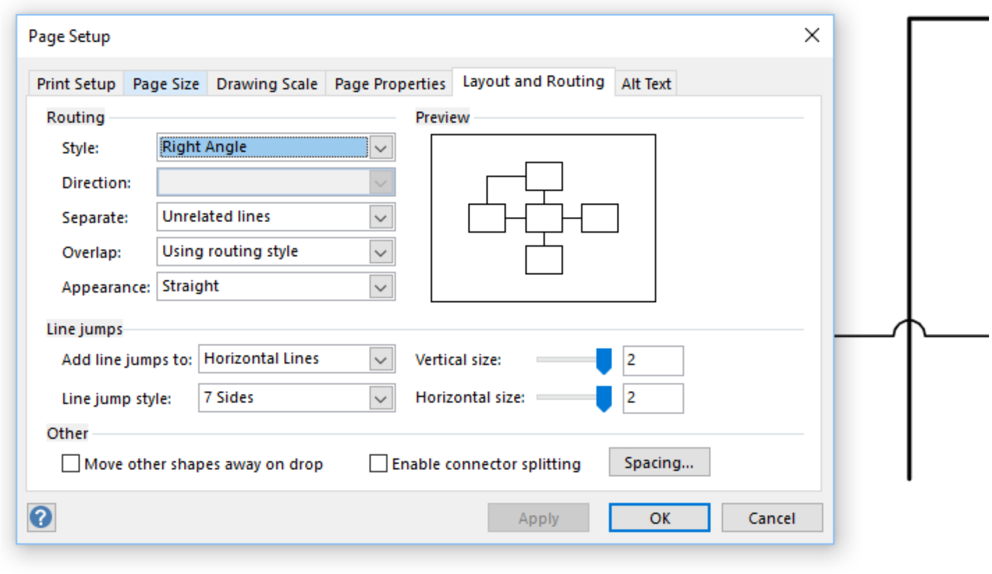


Figure 31. settings for the line jump.

Visio has more lines available that are in based on ANSI 5.1 (American National Standards Institute). These lines will however not be implemented and used at first since most of them are never going to be needed for the company's applications.

4.7 Creating master shapes

As it was mentioned in chapter 3.4 most of the shapes that have been included and made for this thesis have been limited to the ones mentioned in the internal document that are not already a part of Visio. Besides these symbols, a few specialized shapes have been made to describe a few engine components and the Wärtsilä logo. The shapes that have been created can be seen in Appendix 4.

4.8 VBA code

A user form that fills information into the title block on the drawing was the first feature to be created. This was made first to try out how time consuming the coding process would be and get a reference point to know how much time would needed to be spent on the coding aspect of the project. The user form was created for the first version of the title block made for this thesis and will not be implemented with the tool at first since it is easy for the user to fill in the information manually and other things where prioritized over this. The result of the user form can be seen in Appendix 5.

Another form was created, with the purpose of editing the tag format for newly made master shapes. When a master shape was created from an existing shape, like a valve or vessel the tag ended up in the right location underneath the shape, but when a shape was made from scratch without including an existing shape the tag would end up in the middle and could not be moved. This was solved by running the created user form that changes the tag position and makes it movable by the user See Appendix 5 for how this works.

An idea that most of the time used for coding have gone into is trying to develop a macro that would give the possibility of displaying shape data in a PDF file. The data is currently visible in Visio for every user that has the program but the most common way of distributing and viewing drawings are in PDF form and this would be a great feature to implement. This feature could not be completed before this thesis was delivered, so continued work is needed.

4.9 Tag format

In Chapter 2.8.5 it was described how the tag formatting works in Visios process and engineering template. It was decided to not utilize this feature since all symbols on the drawing sheet does not require a description for it and the codes used to describe components inside the company are pretty lengthy and a universal tag format cannot be made that resembles them. For an example of codes being used inside the company See Figure 32. Not using this feature forces the creator of the diagrams to add a text note next to the component he wants to describe. This is not a lot of work and it makes it easier for people viewing the diagrams to have the real component code next to the item instead of a simple tag like for example “V1” and then needing to search in the component list of the drawing to find out what the real code and name for the tag “V1” is.

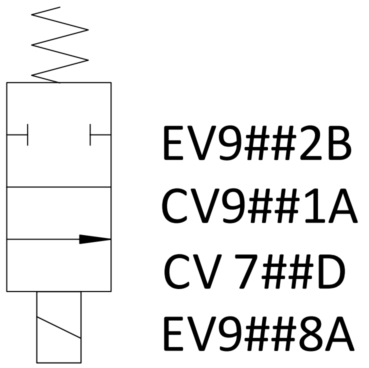


Figure 32. How codes for different components can look.

4.10 Outside connections

From the internal document it was found out that around 50 outside connections are used on the W31 engine. An Excel document was made with the information about connection number, dimension and module location See Table3. This information can then be imported into the Visio drawing and adds data to the shapes.

Table 3. The connections and Modules are only examples of the layout. Dimension and other information is not included. The numbers do not corelate to anything on the w31 engine

CONNECTION	MODULE LOCATION 8-10V
100	M0001
101	M0002
102	M0003
103	M0004
104	M0005
105	M0006
106	M0007
107	M0008
108	M0009
109	M0010
110	M0011
111	M0012
112	M0013
113	M0014

4.11 Components location

As it was mentioned in the method, after the components were found they were either added to an Excel file or directly to Visio.

The idea is that all the necessary information will eventually be stored in one Excel file with multiple sheets that are linked to the different systems. When a sensor or component is moved, changed or in need of more information, the Excel file can be edited and then the drawing can just be updated with the new data. Example of the data stored in Excel files can be seen in Table 4 and Table 5.

Table 4. system components example. No data corelates to the W31 engine

SYSTEM COMPONENTS			
CODE	NAME	MODULE LOCATION	PART NUMBER
##	BALL VALVE	M0001	123
##	RESTRICTOR	M0002	124
##	VENTING VALVE	M0003	125
##	AERATION VALVE	M0004	126
##	SAFETY FILTER	M0005	127
##	HEAT EXCHANGE	M0006	128
##	SOLENOID VALVE	M0007	129

Table 5. system sensors example. No data corelates to the W31 engine

SYSTEM SENSORS			
CODE	NAME	MODULE LOCATION	PART NUMBER
##	SPEED SENSOR	M0001	123
##	TEMP SENSOR	M0002	124
##	PRESSURE SENSOR	M0003	125

4.12 User guide

It was decided during conversations that the user guide should be created with emphasis on pictures and keeping the wordcount to a minimum. Since it is easier to show the different steps in picture form, and often when a guide is referenced in day to day work the user is usually only interested in refreshing his memory of one function or feature. Having as little text as possible makes it fast and easy to find what is wanted without spending time reading unnecessary text. The table of contents can be seen in Appendix 7.

4.13 Layout of the diagrams

The diagrams that have been made as a part of this thesis to try Visio is the nine different systems that relates to the 8-10V marine engines. The layout for every system that started to be transferred was changed in one way or another, except for the DF and SG gas system since they had already had the components and line routing paths made very clear.

Since the diagrams contain confidential information the old and new designs cannot be presented in this thesis. Instead a simplified before and after picture of the layout for one of the systems is presented. The pictures are extremely simplified with only basic shapes representing major components and no minor components illustrated.

In the pictures representing the diagrams the outside connections are marked 1A-6A and 1B-3B to show the order they are located on the engine in. It shows that previously for this system they were not placed on the diagram in the same order as they are placed on the engine. The idea behind these new diagrams have been to try and place the components as close to reality as possible See Figure 33 and Figure 34 for the example of the layout before and after.

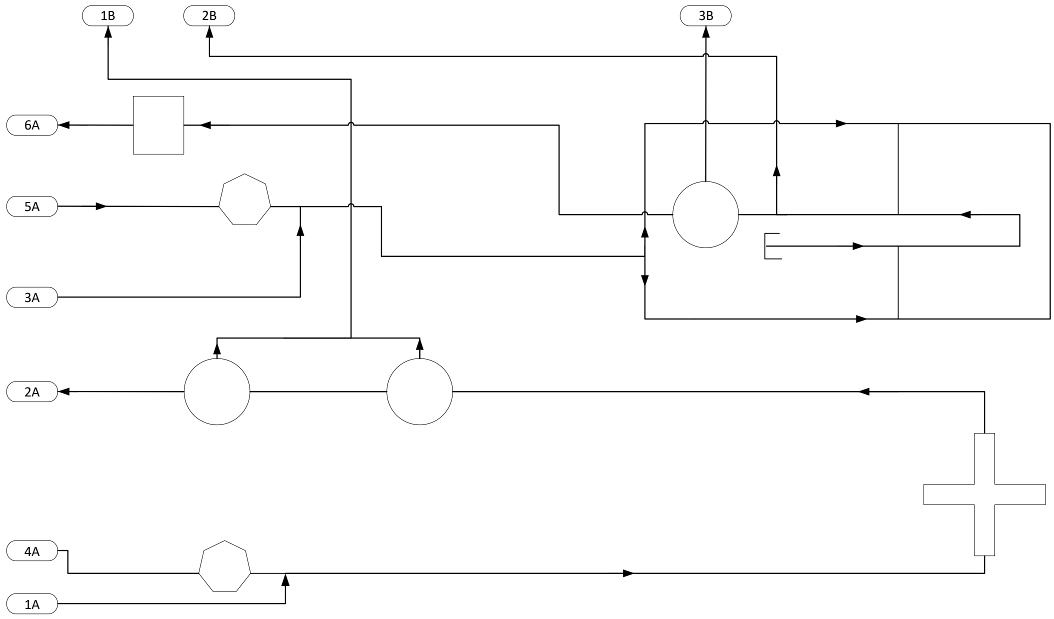


Figure 33. Simplified layout for the old diagram

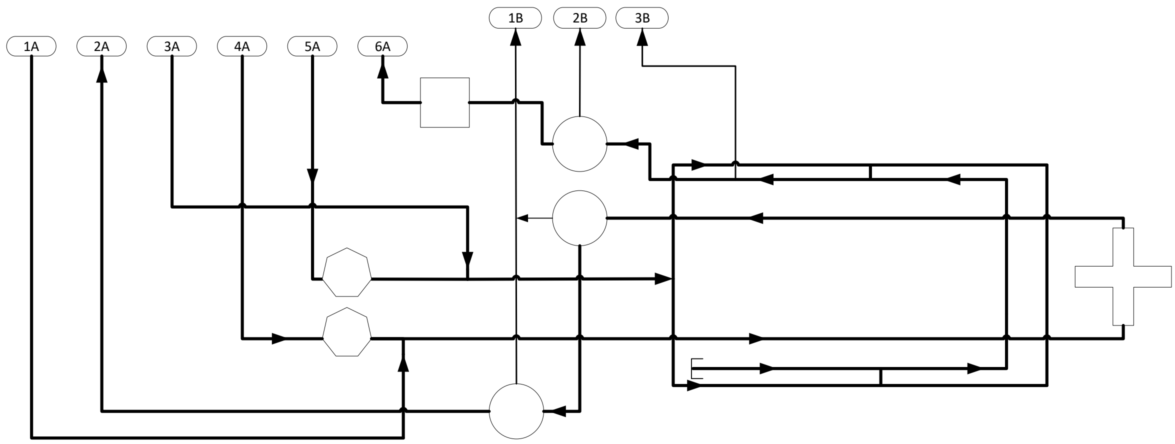


Figure 34. Simplified layout for the new diagram**.**

4.14 Template

The template that has been created is using all the other parts mentioned in this thesis. It is a multipage document with two background pages one for A3 and one for A2 drawings. When opened all the shapes made for this thesis and all other engineering shapes are accessible from the shapes window.

The document has a frontpage where there is a description for what lines are being used, a table of contents that can be clicked both in the PDF and Visio file to bring the user to the wanted page, and a abbreviations list have been made to make it easy for people viewing the diagrams to understand the process. The frontpage is minimalistic and only shows the most essential things but it can be developed upon in the future with new things that will be deemed as useful information. To view an example of the frontpage See Appendix 8.

5 Discussion

The template created for the drafting of diagrams is intuitive and easy to use and is in my opinion a great improvement from the methods used previously in our department.

This project has been interesting since it has given me the opportunity to work on challenging and interesting subjects. My knowledge about piping and instrumentation diagrams have expanded greatly during this thesis. My understanding about standards where very limited before I started this project. During the process I have gotten a new understanding and appreciation for the importance of using and implementing standards in different aspects of engineering and everyday life. It has also been interesting working with a software program since mechanical engineers usually take the tools they are using for granted without thinking about the effort behind them and the need for them to be user-friendly and fast to work with. A fast and user-friendly software means that more work can be done during the work day which leads to faster completion of tasks.

If I were to do this project again I would invest more time in investigating how long different aspects of the work is going to take. For this project I listed everything that should be done and made a rough estimate for how little or much time is needed. I should have started by spending a little time on every object in the list and establishing a more correct estimate since many things where taken for granted as being quick tasks to complete. For example, I thought the creation of the shapes would be a fast process but in the end it became much longer than expected since they needed to be dimensioned correctly and after all the shapes where made I noticed the problem with the tag formatting that was mentioned in Chapter 4.8 and I was then forced to focus my time on finding a solution for that. In the end the tag formatting was decided to not be used but this knowledge and VBA feature can be good to have in the future, if nothing else the tag format might be used on other types of drawings than P&ID.

The hardest parts of the project for my part would be to learn how to code with VBA. This was a steep learning curve since I have only done a few macros and improvements to Microsoft excel before this thesis. The way of defining things in Visio differs completely and Visio and Excel are meant to be used for two completely different types of tasks, so the knowledge I could start with was limited. It demanded that I frequently looked up coding examples and references online from a many different websites. I would have been interested in completing the macro that was made with the purpose of displaying shape data in the

PDF-file, since a significant amount of time and effort have been put into this part of the project.

Besides the template and the customizations made to Visio I also think that aspects of this thesis outside of the program can also be of good use. The collecting of the data for what module outside connectors and components are located in can work as an independent file that can be referenced if someone is in need of this information during their daily work. The user guide can be used as a quick starting guide by people who are interested in doing other things in Visio rather than P&ID.

The possibilities of this project growing to a very flexible and usable tool is very promising since it leaves the door open to new improvements and ideas in the future, once more people get to test the program and come give their opinions and suggestions to make it better and easier to use.

6 Bibliography

Autodesk. (2019). *Subscribe to Autocad*. Retrieved 2 2, 2019, from https://www.autodesk.fi/products/autocad/subscribe?referrer=%2Fproducts%2Fautocad%2Fsubscribe&plc=ACDIST&term=1-YEAR&support=ADVANCED&quantity=1

CEN. (2018A). *What we do ?* Retrieved 12 19, 2018, from https://www.cen.eu/work/Pages/default.aspx

CEN. (2018B). *ISO & IEC*. Retrieved 12 9, 2018, from https://www.cencenelec.eu/intcoop/StandardizationOrg/Pages/default.aspx

CEN. (2018C). *Our role in Europe*. Retrieved 12 8, 2018, from https://www.cen.eu/about/RoleEurope/Pages/default.aspx

Ericsson, A., & Erixon, G. (1999). *Controlling Design Variants: Modular Product Platforms.* Dearborn, Michigan:: Society of Manyfacturing Engineers.

European Commission. (2018). *The European Single Market*. Retrieved 12 8, 2018, from https://ec.europa.eu/growth/single-market_en

Helmers, S. A. (2013). *Microsoft Visio 2013 step by step* (1st ed.). Redmond, United States: Microsoft Press,U.S.

ISO 10628-1. (2015). *Diagrams for the chemical and petrochemical industry - Part 1.*

ISO 10628-2. (2012). *DIAGRAMS FOR THE CHEMICAL AND PETROCHEMICAL INDUSTRY. PART 2.*

ISO 14617-5. (2004). *GRAPHICAL SYMBOLS FOR DIAGRAMS. PART 5:.*

ISO 14617-6. (2004). GRAPHICAL SYMBOLS FOR DIAGRAMS. PART 6.

ISO. (2018A). *We're ISO: we develop and publish International Standards*. Hämtat från https://www.iso.org/standards.html den 4 12 2018

ISO. (2018A). *We're ISO: we develop and publish International Standards*. Retrieved 12 4, 2018, from https://www.iso.org/standards.html

ISO. (2018b). *International standards & trade agreements*. Retrieved 12 3, 2018, from https://www.iso.org/files/live/sites/isoorg/files/standards/benefits_of_international_standards/WSC_International_Standards_%26_trade_agreements_2018.pdf

ISO. (2018c). *ISO in brief*. Retrieved 12 3, 2018, from https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100007.pdf

ISO. (2018D). *SFS Finland*. Hämtat från https://www.iso.org/member/1734.html den 2 12 2018

ISO. (2018D). *SFS Finland*. Retrieved 12 2, 2018, from https://www.iso.org/member/1734.html

ISO. (2019a). *ALL about ISO*. Retrieved 2 20, 2019, from https://www.iso.org/about-us.html

ISO. (2019b). *ISO: a global network of national standards bodies*. Retrieved 2 20, 2019, from https://www.iso.org/members.html

ISO 3511-2. (1984). *Process measurement control functions and instrumentation -- Symbolic representation -- Part 2: Extension of basic requirements.*

ISO 3511-3. (1984). *Process measurement control functions and instrumentation -- Symbolic representation -- Part 3: Detailed symbols for instrument interconnection diagrams.*

ISO 5457. (1999). *ISO 5457 Technical product documentation. Sizes and layout of drawing sheets.*

ISO 5457 amendment. (2010). *Technical product documentation. Sizes and layout of drawing sheets amendment 1.*

ISO 7200. (2004). *Technical product documentation-Data fields in title blocks and document headers.*

Microsoft. (2018A). *Create a shape*. Retrieved 11 10, 2018, from https://support.office.com/en-us/article/create-a-shape-9acfe781-ae7e-43e5-ad69-9f3f89d0cf7c

Microsoft. (2018B). *Getting started with VBA in Office*. Retrieved 11 2, 2018, from https://docs.microsoft.com/en-us/office/vba/library-reference/concepts/getting-started-with-vba-in-office

Microsoft. (2019). *Compare Visio options*. Retrieved 2 2, 2019, from https://products.office.com/en-us/visio/microsoft-visio-plans-and-pricing-compare-visio-options

Microsoft. (2019). *Import data to shapes in your drawing*. Retrieved 2 12, 2019, from https://support.office.com/en-us/article/import-data-to-shapes-in-your-drawing-d174b3fd-3079-42fd-81e8-2dbf8d38bb03

Sania. (2018). *Scania configurator*. Retrieved 12 10, 2018, from https://configurator.scania.com/index.aspx?etel_market=5134&etel_language=5509

Scania. (2015). *The model for success*. Retrieved 12 2, 2018, from https://www.scania.com/group/en/the-model-for-success/

SFS. (2018). *Standardization worldwide*. Retrieved 12 2, 2018, from https://www.sfs.fi/en/standardization/what_is_standardization/standardization_worldwide

Wärtsilä. (den 2 June 2015A). *New Wärtsilä 31 engine achieves Guinness World Records title.* Hämtat från https://www.wartsila.com/media/news/02-06-2015-new-wartsila-31-engine-achieves-guinness-world-records-title den 1 12 2018

Wärtsilä. (den 20 October 2015A). *The new Wärtsilä 31 engine.* Hämtat från https://www.wartsila.com/twentyfour7/in-detail/the-new-wartsila-31-engine den 1 12 2018

Wärtsilä. (den 2 June 2015B). *New Wärtsilä 31 engine achieves Guinness World Records title.* Hämtat från https://www.wartsila.com/media/news/02-06-2015-new-wartsila-31-engine-achieves-guinness-world-records-title den 1 12 2018

Wärtsilä. (2015B, October 20). *The new Wärtsilä 31 engine.* Retrieved 12 1, 2018, from https://www.wartsila.com/twentyfour7/in-detail/the-new-wartsila-31-engine

Wärtsilä. (2017, May). *Wärtsilä W31 brochure.* Retrieved 1 12, 2019, from https://cdn.wartsila.com/docs/default-source/product-files/engines/ms-engine/brochure-o-e-w31.pdf?sfvrsn=22f3f345_13

Wärtsilä. (2018A). *Corporate presentation 2018*. Retrieved 2 7, 2019, from https://cdn.wartsila.com/docs/default-source/investors/financial-materials/corporate-presentations/corporate-presentation-2018.pdf?sfvrsn=cc4e5844_4

Wärtsilä. (November 2018A). *Wärtsilä 31 field experience & technology update.* Hämtat från https://www.wartsila.com/docs/default-source/marine-documents/presentations-technical-seminar-japan/presentations-in-english/wartsila-31-field-experience-technology-update.pdf?sfvrsn=c8011444_8 den 12 1 2019

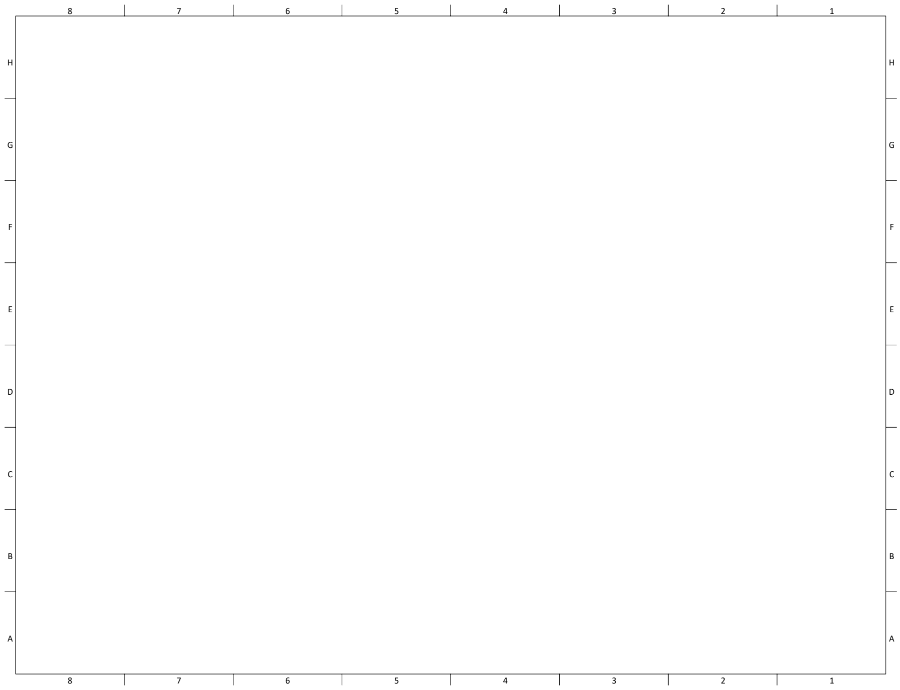
Wärtsilä. (2018B, November). *Wärtsilä 31 field experience & technology update.* Retrieved 1 12, 2019, from https://www.wartsila.com/docs/default-source/marine-documents/presentations-technical-seminar-japan/presentations-in-english/wartsila-31-field-experience-technology-update.pdf?sfvrsn=c8011444_8

Wärtsilä. (2018C). *Wärtsilä 31*. Retrieved 12 2, 2018, from https://www.wartsila.com/products/marine-oil-gas/engines-generating-sets/diesel-engines/wartsila-31

Wärtsilä. (den 2 12 2018D). *Wärtsilä 31*. Hämtat från Wärtsilä 31: https://www.wartsila.com/products/marine-oil-gas/engines-generating-sets/diesel-engines/wartsila-31

Wikipedia. (2018). *Standards organization*. Retrieved 12 5, 2018, from https://en.wikipedia.org/wiki/Standards_organization

Appendix 1. pre-existing Visio shapes



REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

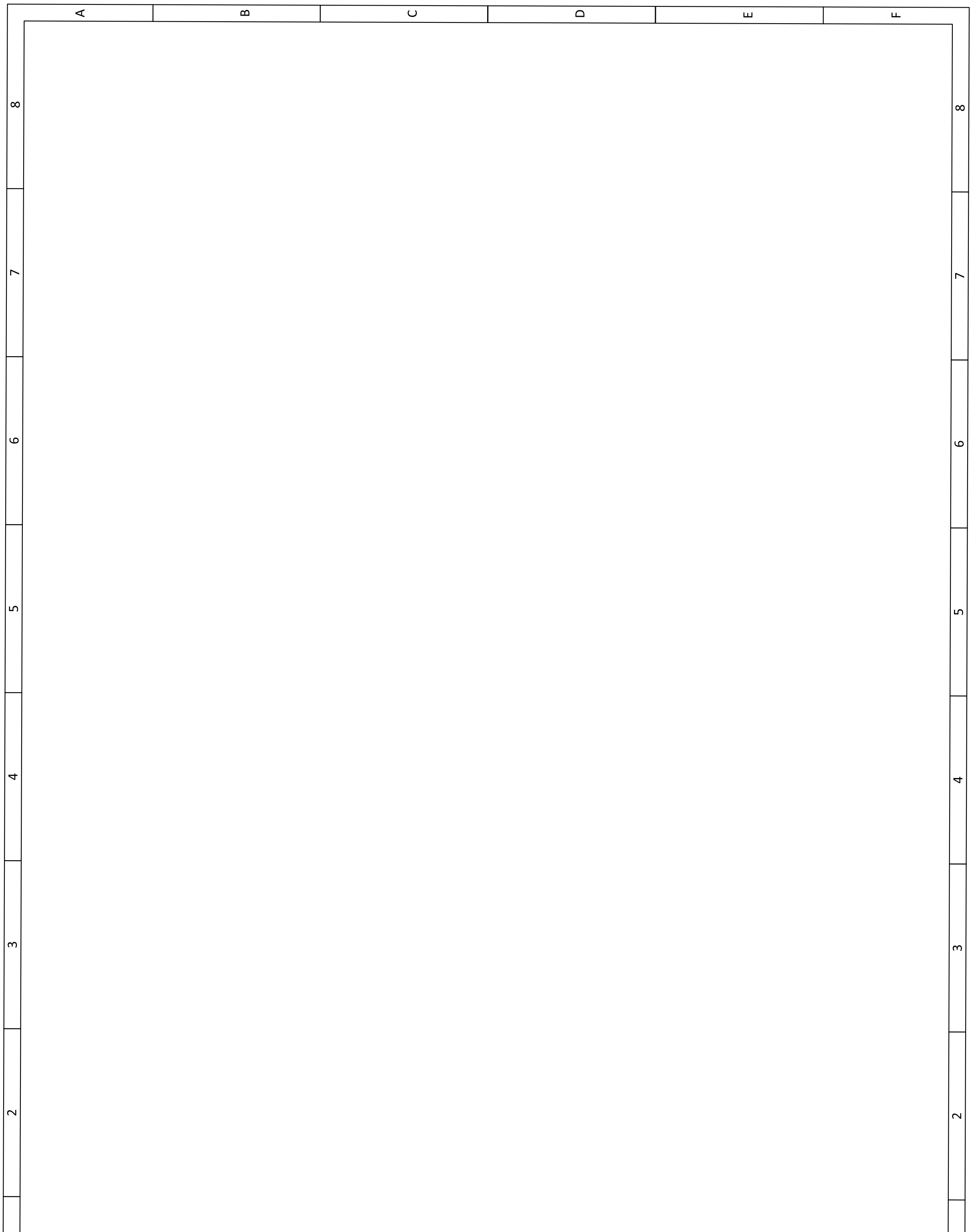
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

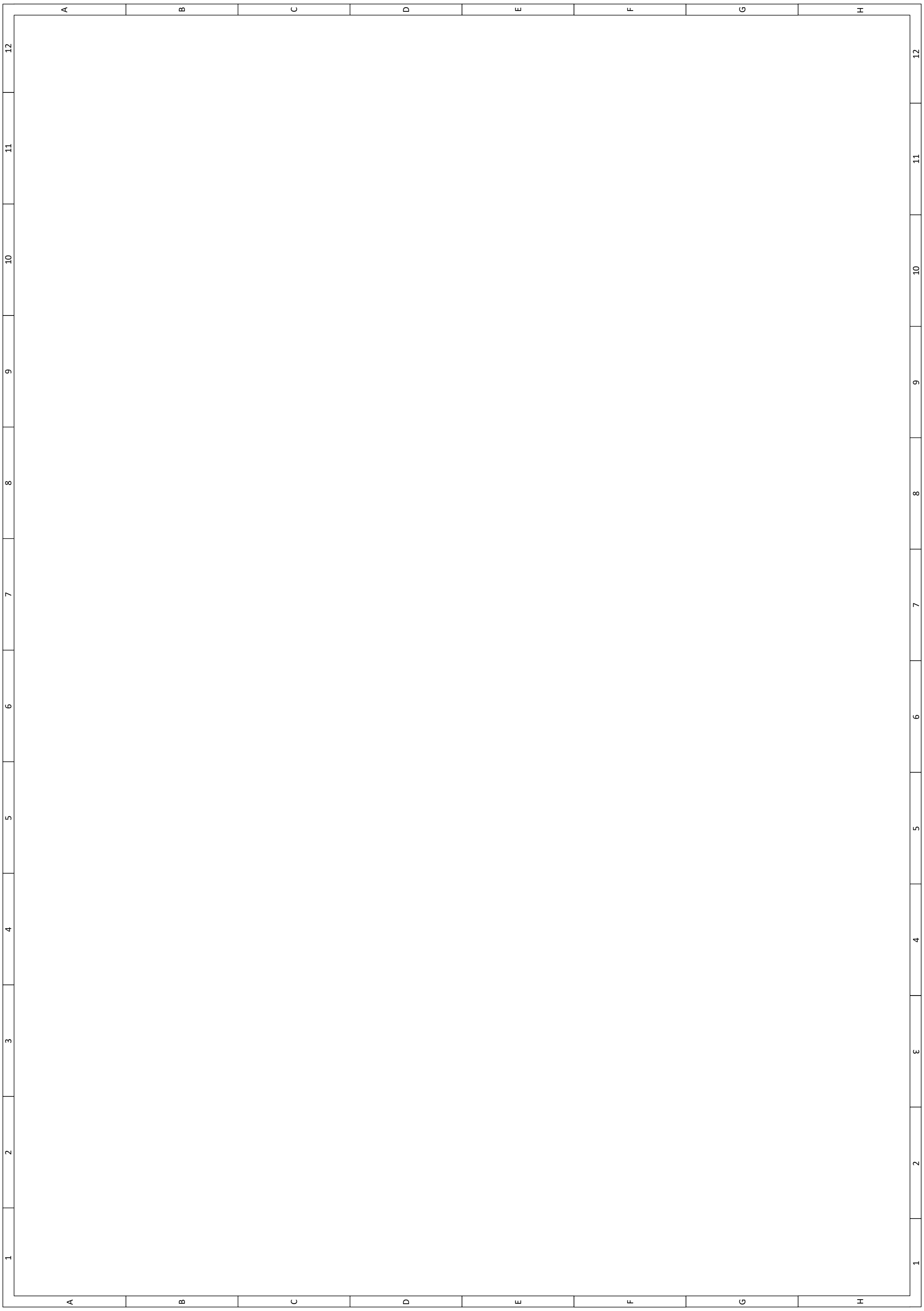
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Frame, title blocks and revision fields that came pre-installed with Visio

Appendix 2 Frames

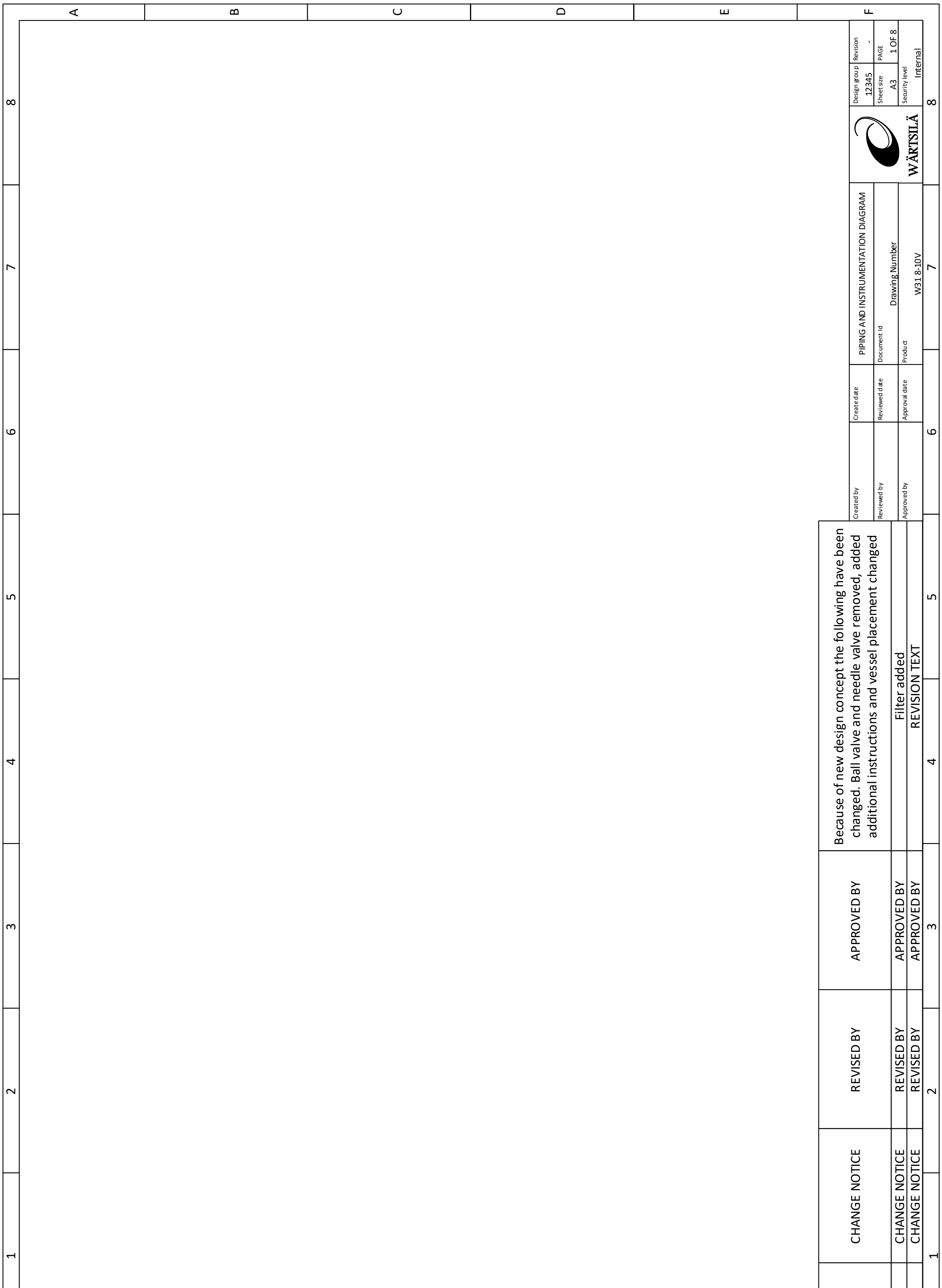


A3 Frame



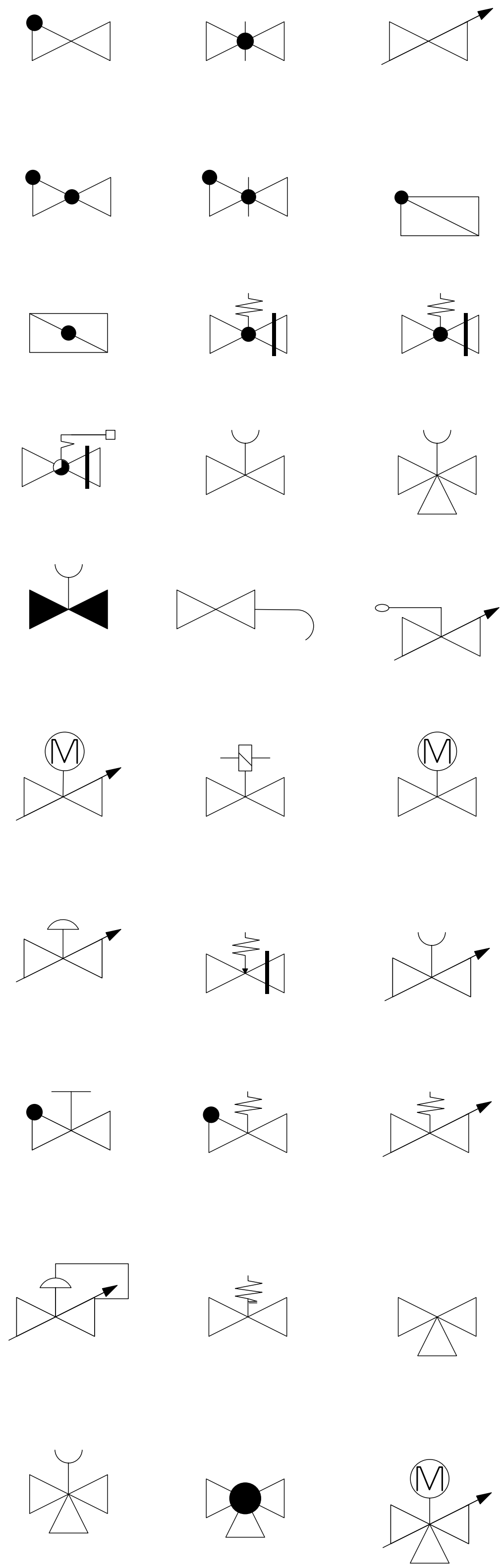
A2 Frame

Appendix 3 Revision field

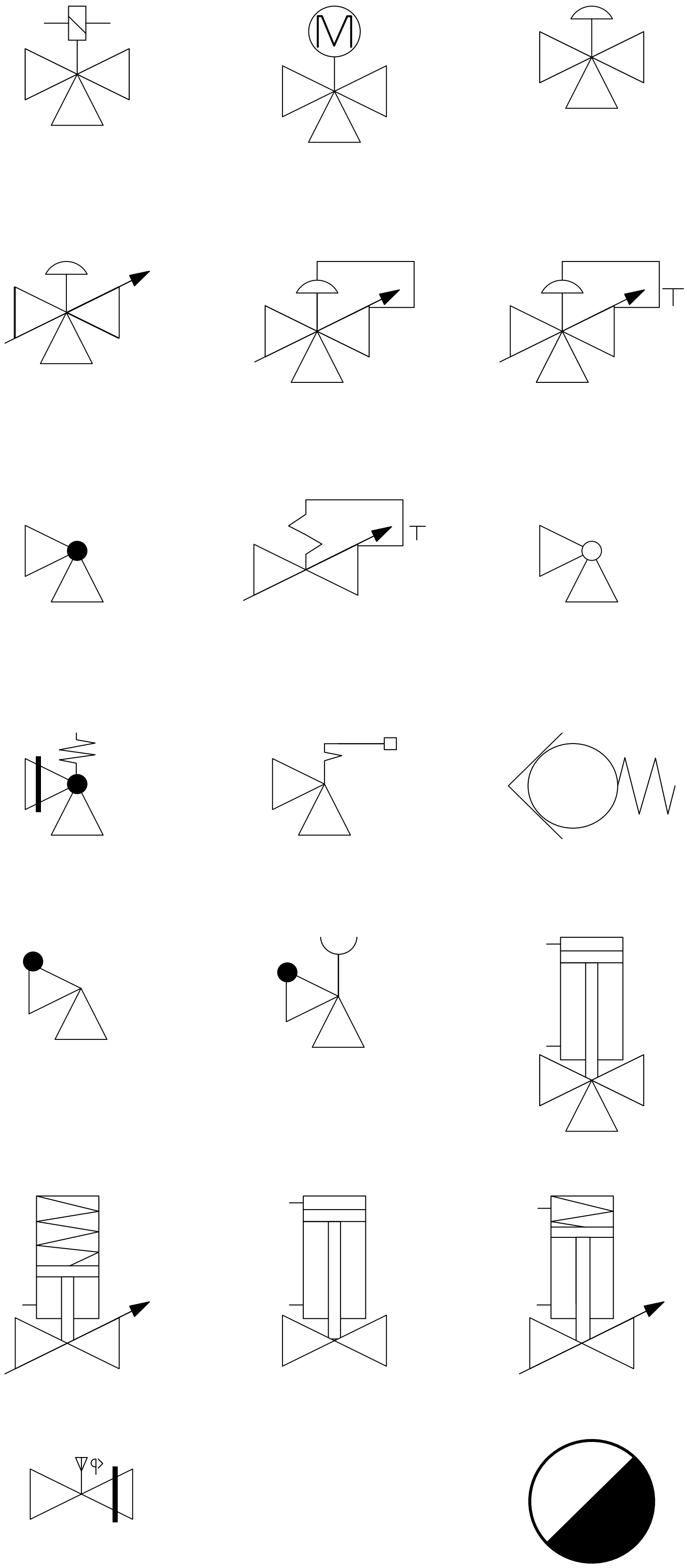


Revision field on its own page

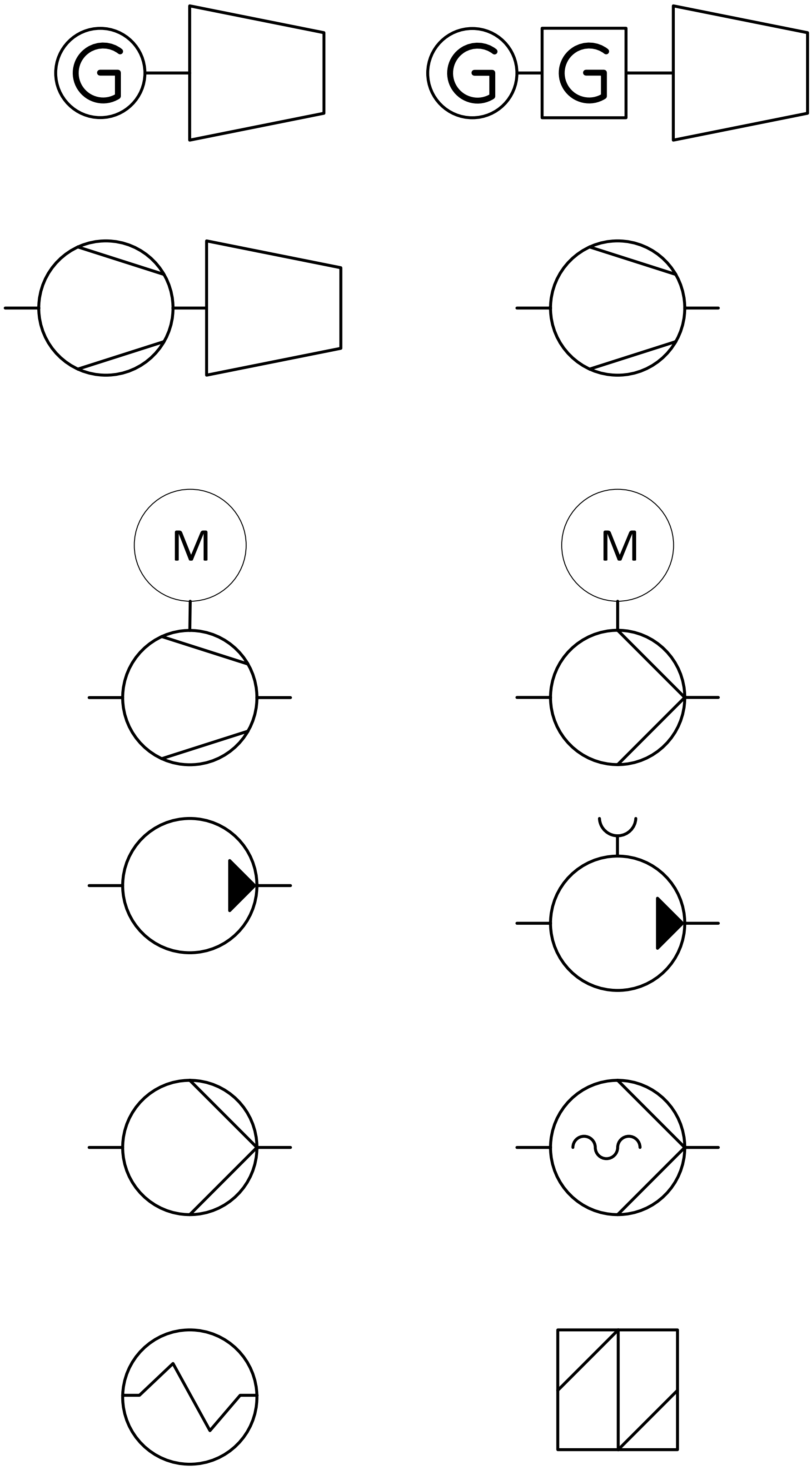
Appendix 4. Shapes created



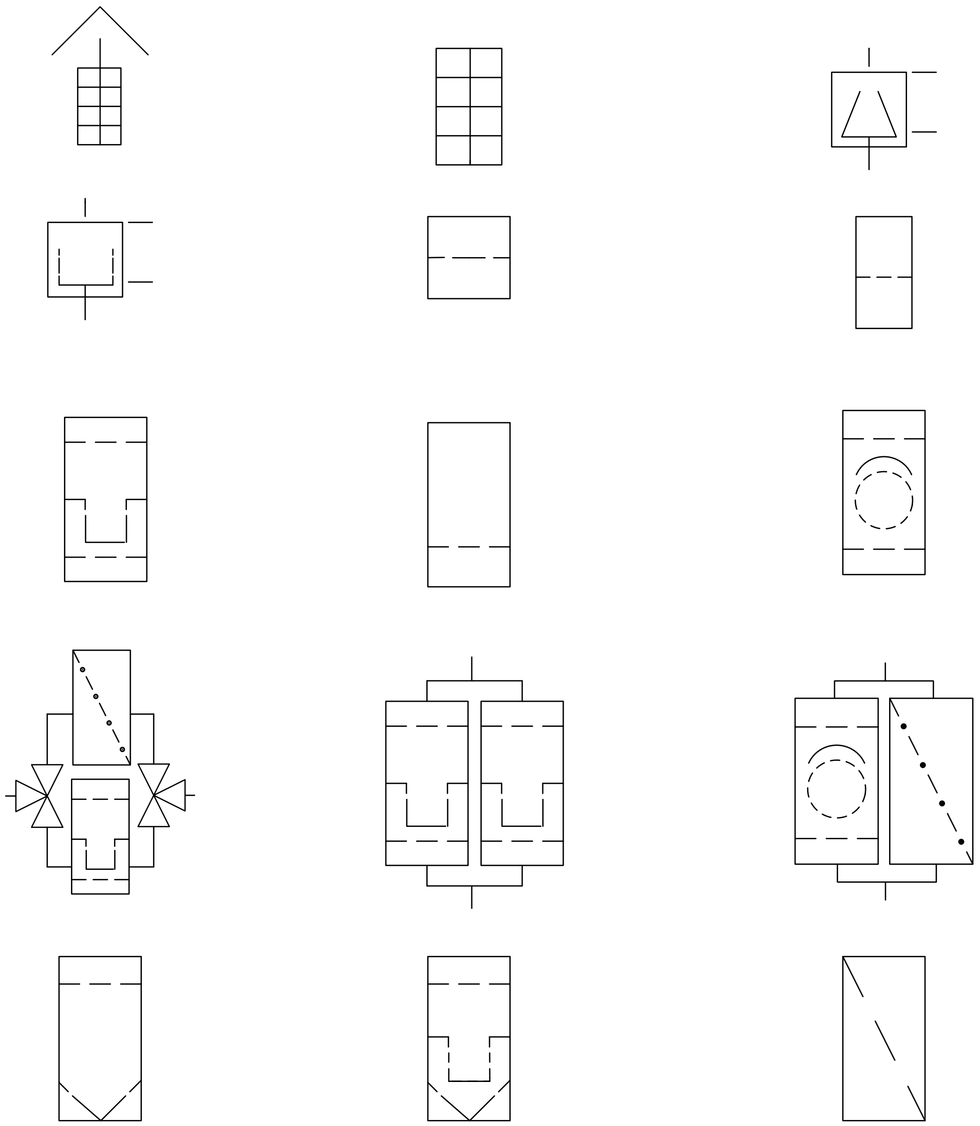
Valves created 1/2



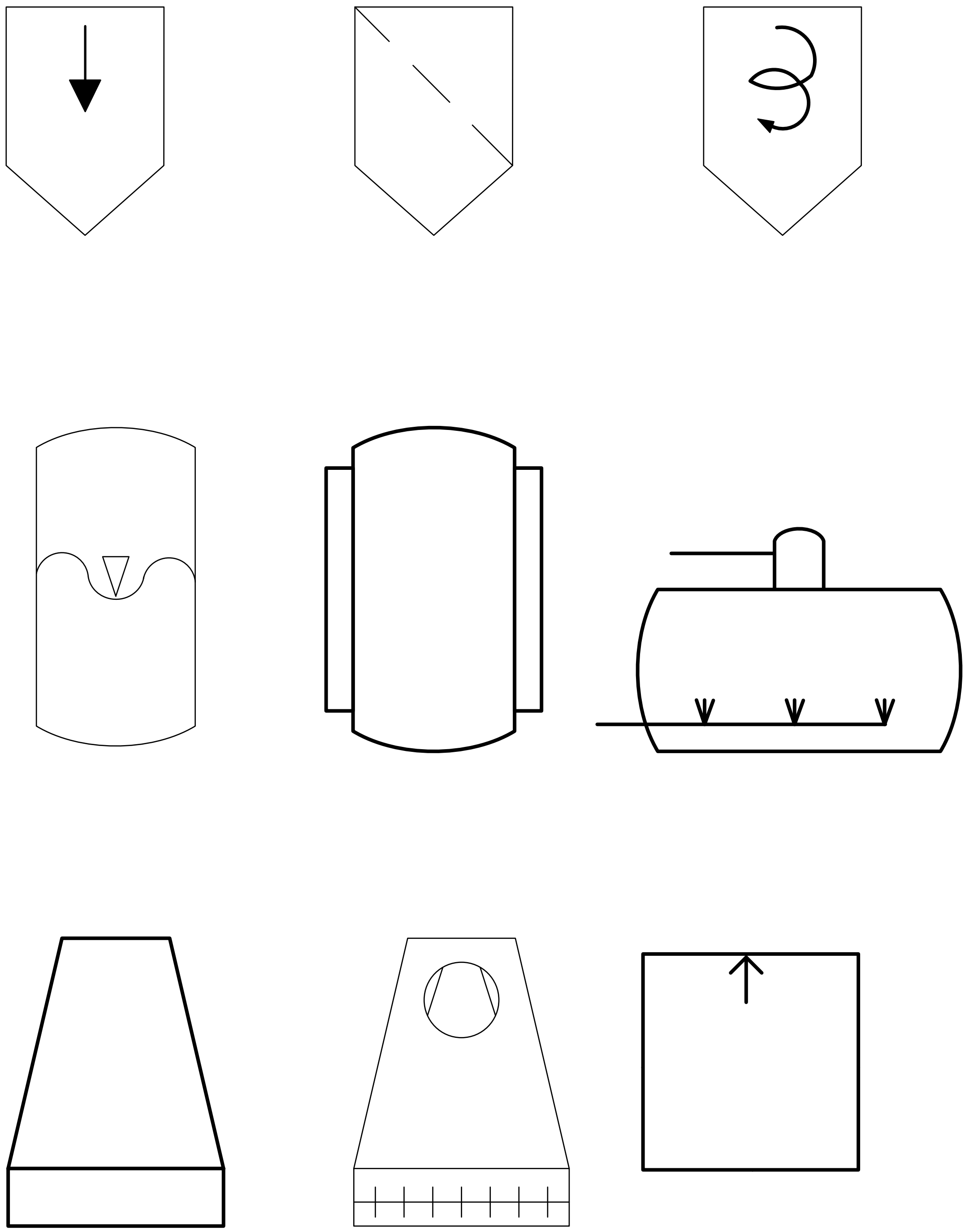
Valves created 2/2



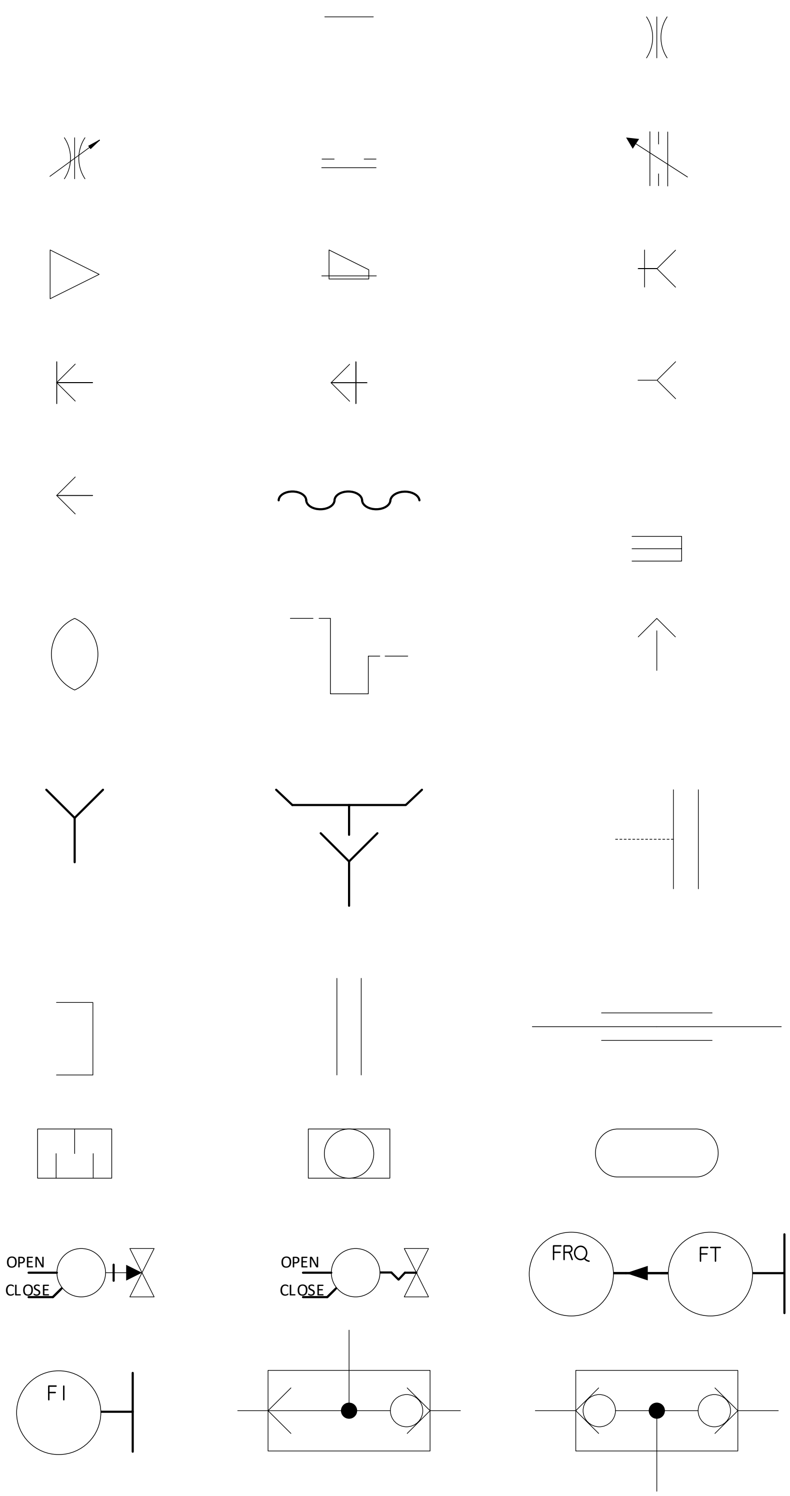
Pumps, Turbo configurations, compressors and heat exchangers



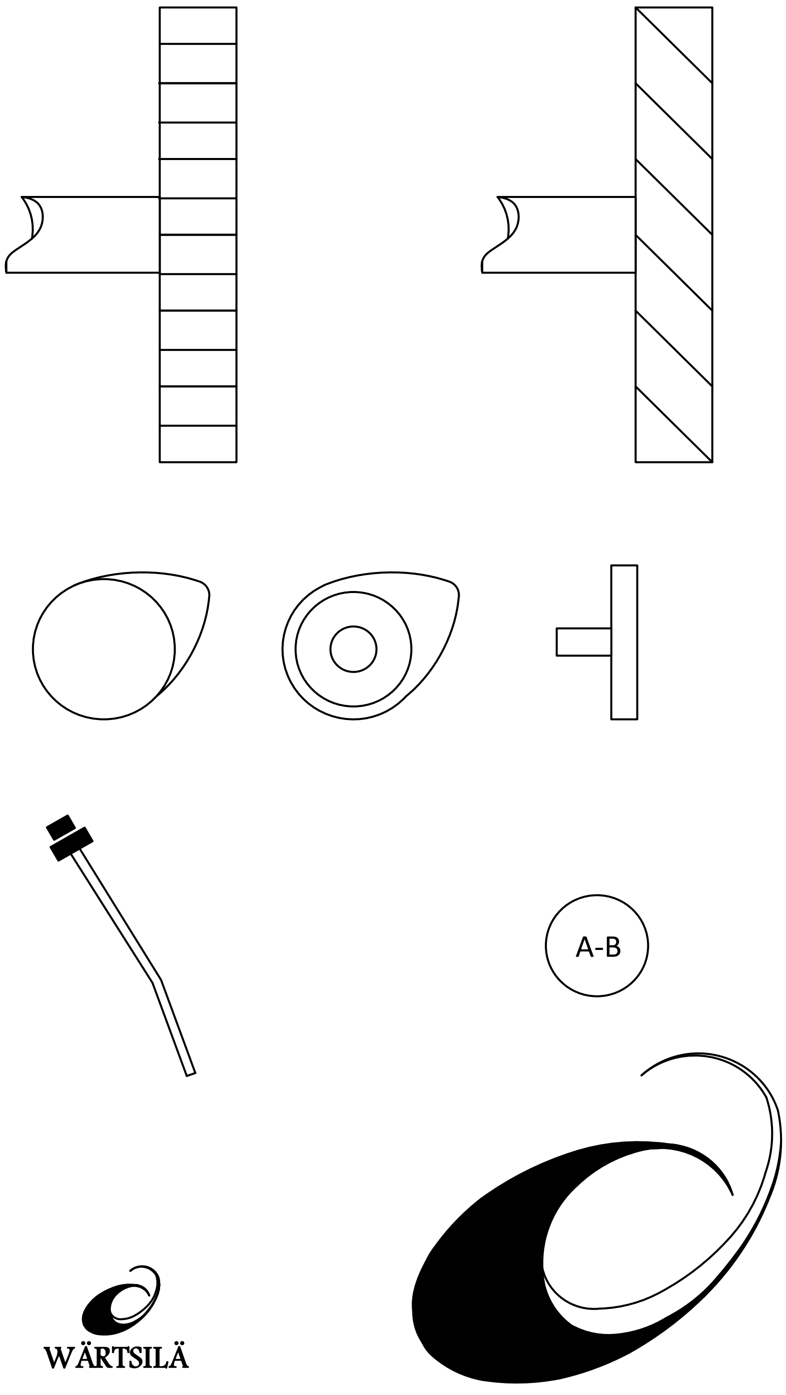
Flame arrestor, Filters and separators



Vessels, separators, cooling towers and Pneumatic-air lubricator

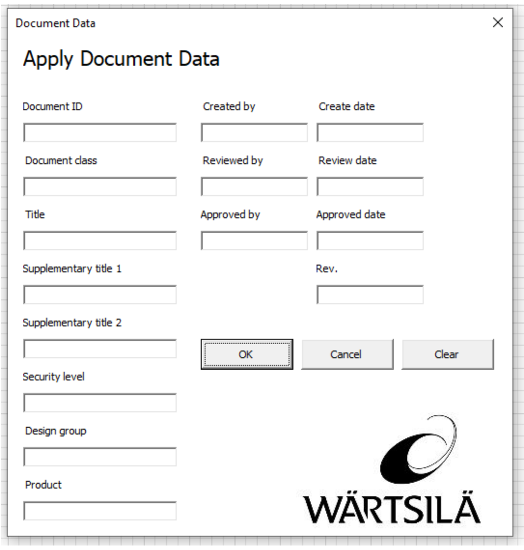


Flanges, end caps, flexible hose, silencers, indicators and other Miscellaneous components

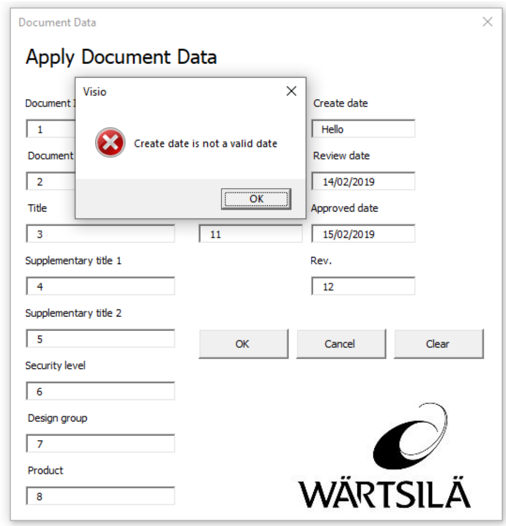


Special shapes made specifically for Wärtsilä.

Appendix 5 VBA code code 1 User form for filling in the first version of the title block



Look of the user form

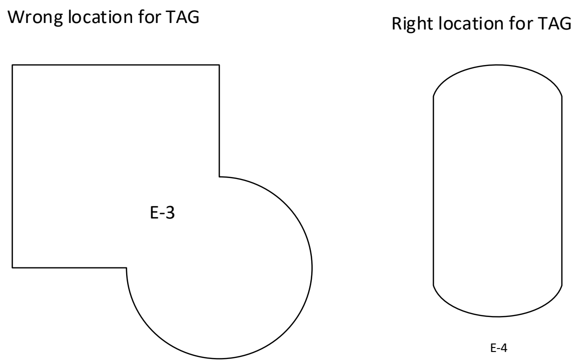


Userform does not allow incorrect numbering of dates

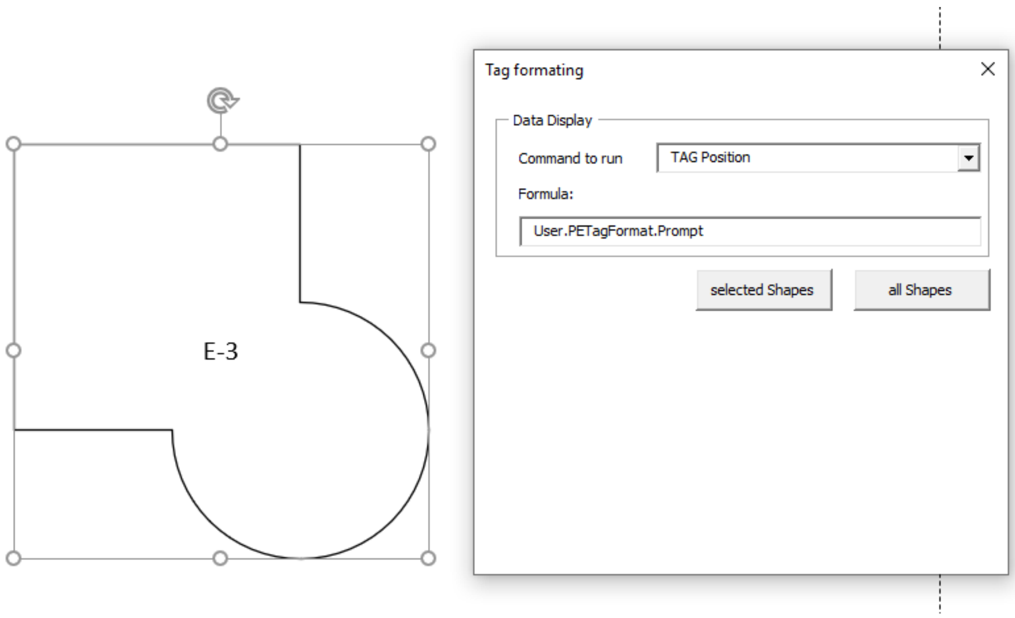
2	Created by 9	Create date 13/02/2019	WÄRTSILÄ	Design group 7	Product 8
3 4	Reviewed by 10	Reviewed date 14/02/2019		Sheet size A3	PAGE 1 OF 3
5 6	Approved by 11	Approval date 15/02/2019	Document Id 1		Revision 12

When the user form is run the title, block is filled in

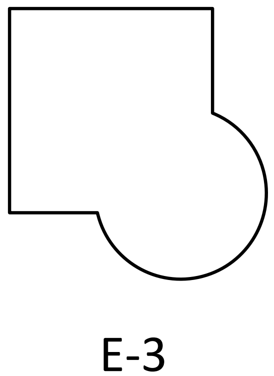
Appendix 5 VBA code 2 Changing tag formatting



Tag location before for a master shape and regular vessel.



Running the form



After the form have been run the tag have moved to the right location.

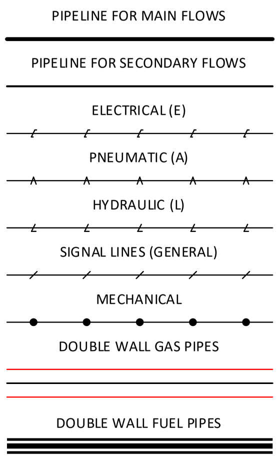
Appendix 6. User guide table of contents.

Table of contents

Appendix 7. Front page to the document

PIPING AND INSTRUMENTATION DIAGRAMS FOR W31 8-10V MARINE SOLUTIONS

LINES USED



DESCRIPTIVE DOCUMENTS

LIST OF SYMBOLS DAAF406507

SENSOR DESCRIPTION DAAB032864. DOCUMENT LOCATED IN M-FILES LEGACY 2 FOLDER

TABLE OF CONTENTS

ABBREVIATIONS

ABBREVIATION 1
ABBREVIATION 2
ABBREVIATION 3
ABBREVIATION 4
ABBREVIATION 5
ABBREVIATION 6
ABBREVIATION 7
ABBREVIATION 8
ABBREVIATION 9
ABBREVIATION 10
ABBREVIATION 11
ABBREVIATION 12
ABBREVIATION 13
ABBREVIATION 14
ABBREVIATION 15
ABBREVIATION 16
ABBREVIATION 17
ABBREVIATION 18
ABBREVIATION 19
ABBREVIATION 20
ABBREVIATION 21
ABBREVIATION 22
ABBREVIATION 23
ABBREVIATION 24
ABBREVIATION 25
ABBREVIATION 26
ABBREVIATION 27