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Diagram drafting with Microsoft Visio

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Purpose of this thesis was to create a functional Microsoft Visio template and write basic drawing rules both for piping and instrumentation and for process flow diagram drafting for Evac. The template was to contain the needed drawing sheets, stencils and shapes. Also the necessary page settings were adjusted so that the template would work. Drawing rules were to be in common level and include some basic instructions on how to use Microsoft Visio.

The template, stencils and shapes were all made by using Microsoft Visio Professional 2013. Microsoft Visio is Microsoft's software for diagram drafting. Diagrams created with Visio can illustrate different kind of processes, organization charts or even floor plans.

The template is a pre-formatted file, which serves as a starting point for a new drawing. The template for Evac contains the needed pages, stencils and shapes. Shapes were made according to the chosen standards. For part of the shapes, pre-defined data were added. Also, tag codes were defined according to the chosen engineering numbering system for all shapes. Shapes were created and divided into eight different stencils. Stencils are files that hold drawing shapes. The template contains multiple pages for different purposes: front page, drawing page, revision page and several background pages.

Rules and instructions were written for drawing process diagrams. Those include basic rules about page size, about notes and markings, process flows, flow direction, revision making, sheets naming, and the minimum information required in P&ID. Also some instructions on topics such as how to add data into shapes and how to insert a new page were written.

As a result of this thesis, a working template for Visio and drawing rules were created. Consequently, the template can be used for drafting diagrams in Evac.

Keywords	template, stencil, shape, Microsoft Visio, process diagram

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Tämän insinöörityön aiheena oli luoda Evacille toimiva piirustusmalli prosessikaavioiden piirtämiseen Microsoft Visio -ohjelmalla. Lisäksi luotiin säännöt ja käyttöohjeet prosessikaavioiden piirtämiselle. Piirustusmallin oli tarkoitus sisältää tarvittavat kaavaimet, muodot ja sivut. Myös asetukset toteutettiin niin että, malli sopii käyttötarkoitukseensa. Sääntöjen ja käyttöohjeiden oli tarkoitus olla perustasoa.

Tässä insinöörityössä ohjelmana käytettiin Microsoft Visiota, joka on Microsoftin ohjelma kaavioiden luontiin. Ohjelmalla voi luoda kaavoita, kuten prosessikaavioita, organisaatiokaavioita tai vaikka pohjapiirustuksia.

Piirustusmalli on valmiiksi muotoiltu tiedosto, jota voi käyttää uuden piirustuksen tekemiseen. Mallia varten luotiin kaavaimia ja kaavaimiin luotiin tarvittavat muodot. Muodot luotiin valittujen standardien mukaisesti. Muodoille myös määritettiin tunnistekoodit valitun standardin mukaan. Osaan muodoista lisättiin valmiiksi dataa. Piirustusmalliin luotiin valmiiksi useita sivuja: etusivu, piirustussivu, revisiosivu sekä usea taustasivu.

Insinöörityössä kirjoitettiin myös säännöt ja käyttöohjeita prosessikaavioiden piirtämiseen Microsoft Visiolla. Säännöt olivat yksinkertaisia, kuten mitkä ovat sallitut kaavion koot, miten merkinnät tehdään kaavioihin, miten eri prosessilinjat kuvataan, miten revisiot merkitään ja mitkä ovat kaavioiden vähimmäistiedot. Käyttöohjeisiin kirjoitettiin ohjeita, kuten miten luodaan uusi sivu ja miten lisätään dataa muotoihin.

Insinöörityön lopputuloksena syntyi toimiva piirustusmalli sekä kaavioiden piirtämistä tukevat säännöt sekä käyttöohjeet. Piirustusmallia voidaan käyttää Evacissa prosessikaavioiden piirtämiseen.

Avainsanat	piirustusmalli, kaavain, muoto, Microsoft Visio, prosessikaavio

Contents

List of Abbreviations

CEN *European Committee for Standardization*. Association that brings together the National Standardization Bodies of 33 European countries.

ISO *International Organization for Standardization*. Association that administrates international standards.

Instance shape
Copy of a master shape.

Master shape
Shape that always remains in stencil.

P&ID *Piping and instrumentation diagram*. A diagram, that represents the technical realization of process by means of graphical symbols representing equipment and piping.

PFD *Process flow diagram*. A diagram, that represents the process with the main process information.

SFS *Finnish Standards Association*. Association that administrates Finnish national standards.

SN *Standards Norway*. One of the three standardization bodies in Norway.

Stencil File that hold collection of drawing shapes.

Tag Unique identifier for component.

Template Pre-formatted file, which serves a starting point for a new drawing.

1 Introduction

1.1 Evac

Evac was established in 1979 and is nowadays world's leading provider of integrated waste, wastewater and water management systems for the marine, offshore and building industries. Evac has about 216 employees in Finland, Germany, France, China, Korea, USA, Brazil and Norway. Evac also has representatives and service specialists in over 40 countries. Evac's headquarters is located in Espoo, Finland. [2; 3]

Evac is concerned about the environment and therefore follows the ISO 9001 and 14001 requirements in everyday operation. Evac's products and processes also meet or exceed the IMO MEPC.159 (55) and Alaska 33CFR 159.309 regulations and Baltic MEPC 62 rules. [1]

1.2 Purpose of the thesis

This thesis had two main objectives. The first objective was to create a Microsoft Visio template for process diagram drawings. The second main objective was to write a guide on how to draw diagrams with Microsoft Visio. In this thesis, the Microsoft Visio Professional 2013 was used.

The need for the Microsoft Visio template arose from the willingness to start using Microsoft Visio as a drafting program. The purpose of the template was to contain stencils that hold shapes made according to the chosen standards. The aim was also to define tag codes for the shapes according to the chosen engineering numbering system. In addition the template was to include pages defined in advance to make sure that the settings were right.

The purpose of the drawing guide was to include basic rules about drafting and basic instructions on how to use Microsoft Visio. The importance of the guide was high because there was not much expertise of using the Microsoft Visio in the company. Also because Evac has offices and designers all around the world, the instructions helps in sharing information and introducing the software.

2 Process diagrams

2.1 Process flow diagram

The process flow diagram (PFD) is a diagram that represents the process and the main process information. The process flow diagram is needed for the making piping and instrumentation diagrams, for preliminary equipment and pipeline specification and for budget planning. The process flow diagram is needed when briefing the staff that is participating in a project and also in various license proposals. [4] Process flow diagrams are also used in marketing to give a general view of the process in the bidding stage.

Chemical, mechanical and physical part processes are represented in functional order in process flow diagrams. Process operation is represented in stationary status at design conditions. PFD contains the following:

- main equipment
- equipment names, identifiers and size or capacity descriptive quantities
- process flows
- pipeline identifiers
- control necessities
- flow rate and quality of the flow substances
- inflows and outflows of substances and energy
- address for coming and leaving process lines

In the creation of process flow diagram, there are a few principles that are normally followed. The PFD should be drawn loose enough, the direction of main process flows should be from left to right, the main equipment should be drawn as simply as possible, and, if possible, the process should be drawn in one straight vertical or horizontal line depending on the system. [5]

2.2 Piping and instrumentation diagram

The piping and instrumentation diagram (P&ID) is based on the process flow diagram (PFD). P&ID represents the technical realization of the process by means of graphical symbols representing equipment and piping. P&ID also includes graphical symbols for process measurements and control functions. [5]

Purpose of the piping and instrumentation diagram is to provide information about the technical solutions of the process. P&ID represents detailed paths of the pipelines including common information about pipelines. P&ID gives data for creating a component list and an estimate of costs. P&ID works as an introduction to the process for designers, technicians, maintenance and operators. [4]

Piping and instrumentation diagram consist of the following items:

- equipment
- process lines
- valves
- measuring points and control functions
- reject, cleaning and ventilation couplings
- equipment numbers and names
- pipeline identifiers
- delivery lines
- address for coming and leaving process lines. [4]

A piping and instrumentation diagram that was drafted by using an Evac template and shapes is presented in Appendix 1.

3 Standardization and Standards

3.1 Standardization

Creating an agreed way to do something is called standardization. The purpose of standardization is simplifying how to do things. Standardization makes the authorities work, economic life and the consumer's life easier. [6]

Standardization affects the many variables. Standardization improves product compatibility and safety, protects consumer and the environment and makes both domestic and international trade easier. [6]

Standardization makes sure that products, service and processes are suitable for intended usage and circumstances. Standardization also ensures compatibility of products and processes and ensures that products and processes work together. [6]

3.2 Standards

Standards are documents that include requirements, specifications, guidelines and characteristics for materials, products and processes. Using standards consistently ensures that materials, products, processes and services are fit for their purpose. Anyone can purchase and use standards. Purchasing standards is chargeable, but using and applying them is free. [7]

A product that is manufactured according to the standards is acceptable on the global market. Standards remove trade barriers and make global trade easier. [7]

There are many different kinds of standards in the world. For example paper and envelope sizes, clothing and shoe sizes, food packaging and screws are based on standards. Products manufacturing, construction, installation, repairing and maintenance work are conducted in accordance with standards. Standards are required for using systems, devices and equipment, as well as for operating and maintaining them. [8]

In some standards, the letter combination on the standard's name tells in which organizations the standard is confirmed. The letter combination SFS tells that the standard is

confirmed in Finland, EN means that the standard is confirmed in the European Committee for Standardization (CEN), and ISO means that the standard is confirmed in the International Organisation for Standardization. Every country has its letter combination as an identifier. [9]

3.3 Standardization organizations

3.3.1 Finnish Standardization Association (SFS)

The Finnish Standardization Association is the main organization for standardization in Finland and, it was founded in 1924. [11] SFS is a non-government and a non-profit aiming organization. [10] Members of SFS are commercial and industrial organizations and the state of Finland. [11]

The main task of SFS is to create, verify, publish and sell standards. Informing about the standards to public is also one of the main tasks of SFS. [11] SFS takes care that in Finland we have a collection of standards that meets the national needs. [10]

SFS is a member of the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). Most of the SFS standards are based on European or international standards. [11]

3.3.2 International Organization for Standardization (ISO)

International Organization for Standardization (ISO) started its official operation on 23 February, 1947. ISO is an independent, non-governmental international organization. ISO has 162 members from national standards bodies and 3368 technical bodies. The Central Secretariat of the ISO is based in Geneva, Switzerland. [12]

ISO has published over 19000 international standards, and the standards covers almost every industry. Standards are developed voluntaries by the members of the ISO to support innovation and provide solutions to global challenges. [12]

3.3.3 Standards Norway (SN)

Standards Norway is one of the three standardization bodies in Norway. It was founded on 24 June 2003. Standards Norway is a non-governmental and independent member organization. The organization is not responsible for standardization activities in electro technical field and telecommunications field. It is responsible for standardization activities in all other areas. [13]

Standards Norway is a national member of the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). [13]

About 1200 new Norwegian Standards (NS) are published every year by Standards Norway (SN). At the present there are more than 15000 valid Norwegian Standards existing. [13]

3.3.4 European Committee for Standardization (CEN)

European Committee for Standardization is an association that unites the National Standardization bodies of the European countries. The number of the National Standardization bodies is 33. [14]

CEN is a private and non-profit organization. CEN aims to produce high-quality standards for products and services, thus, the need of stakeholders becomes fulfilled. [15]

The European Union and The European Free Trade Association (EFTA) has officially recognized CEN as an official European Standardization Organization due to being responsible and defining voluntary standards at the European level. [14]

CEN closely co-operates with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) and is committed to supporting the international standardization system. [15]

3.4 Purpose of the used standards

The purpose of standards in this thesis was using them as a reference in stencils and tagging system creating. The SFS ISO-EN 10628-2:2012 and the NORSOK Z-004 standards were used as references in the creation of stencils. The tagging system was created by using the Engineering Numbering System that is created by Hyundai Heavy Industries' ship building division.

3.4.1 SFS ISO-EN 10628–2:2012

The standard SFS ISO-EN 10628-2:2012 contains the English text of the European standard EN ISO 10628-2:2012 *Diagrams for the chemical and petrochemical industry. Part 2: Graphical symbols (ISO 10628-2:2012)*. This European standard EN ISO 10628-2:2012 is confirmed as a Finish national standard in 21.January, 2013. Confirmation for this standard is made by the Mechanical Engineering and Metals Industry Standardization in Finland. This standard is also approved in CEN. This standard SFS ISO-EN 10628-2:2012 replaces the standard SFS ISO-EN 10628:2001. [16]

In practice this standard SFS-EN ISO 10628-2:2012 defines graphical symbols for the preparation of diagrams for the chemical and petrochemical industry. Symbols included in this standard are, for example, pumps, valves, filters, heat exchangers, compressors, blowers and agitators. [16]

The purpose of this standard in this thesis was to use it as a reference in creating the needed shapes. Shapes that are made according to this standard are presented in Appendix 2.

3.4.2 NORSOK Z-004

With the support of the Norwegian Oil Industry Association (OLF) and Federation of Norwegian Engineering Industries (TBL), Norwegian petroleum industry has developed Norsok standards for petroleum industry developments and operations. [17] The purpose of the Norsok standards is to ensure appropriate safety, value adding and cost effectiveness. The Norsok standards are administered by Standards Norway (SN). [18]

The purpose of the NORSOK Z-004 standard is to define drawing symbols for offshore engineering. The symbols of this standard are designed so that they are in compliance with ISO and other standards where possible. Some of the symbols are unique to the offshore industry. [17] Shapes created according to NORSOK Z-004 are presented in Appendix 3.

3.4.3 Engineering numbering system by HHI

The Engineering Numbering System (ENS) that is used in this thesis has been developed by Hyundai Heavy Industries (HHI) ship building division. The purpose of the standardised ENS is to provide abbreviated identifications and classifications for engineering data such as equipment, instruments, piping, systems, documents and drawings. [19]

In this thesis the HHI Engineering Numbering System was used to define tag codes for the shapes. A tag code for the shapes that was found from HHI ENS is presented in Appendix 4. ENS does not include tag codes for all shapes, for those symbols the tag code was defined by me and my thesis instructor. For valves we made an exception and agreed that all tag codes for valves is defined to be “V”.

4 Microsoft Visio

Microsoft Visio is a diagram drafting software. Diagrams created with Visio can illustrate different kind of processes, organization charts or even floor plans. Three main properties have been defined for Visio. It is a supporting tool for office software, meaning that diagrams with information can be created to support other documents. Visio is software for technical design, management and support so technical personnel can create diagrams from existing systems and engineer new ones. Visio can be used for making customized presentations; hence, unique diagrams can be created and organizations can define their own standards which can be utilized with Visio. [20, p. 4]

Using Visio with other Microsoft office programs makes presentation, document and table designing and execution easier. It also helps in project management. The functionality of user interface can be visualized, for example, by creating hyperlinks between diagram sheets. [20, p. 4]

4.1 Basics

The external look of Microsoft Visio is very similar compared to other Windows software (Image 1). [20, p. 8] Earlier use of other Windows software definitely helps learning the basics of Visio.

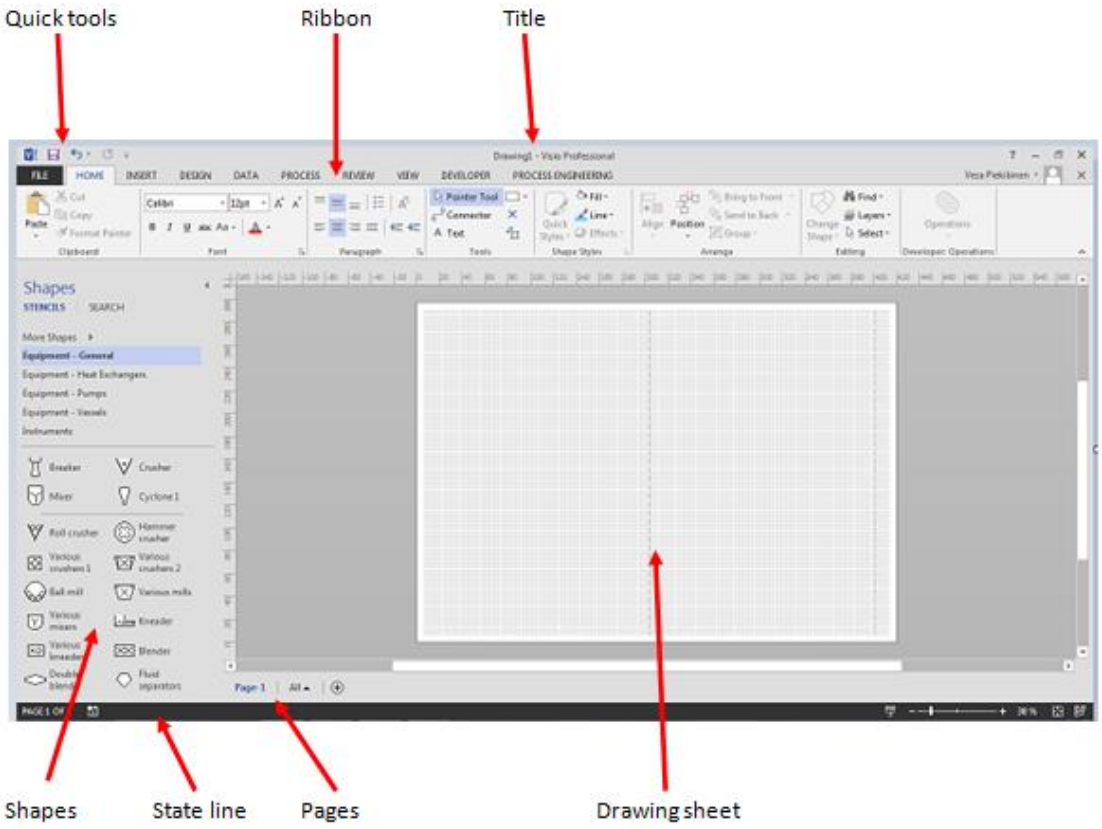


Image 1. Resemblance between the external look of Visio reminds and that of other Windows software [20, p. 8]

In the option ribbon there are the following basic tabs: **File**, **Home**, **Insert**, **Design**, **Data**, **Process**, **Review** and **View**. In addition to this, there can be alternative tabs depending on the diagram type. [20, p. 9] For example in, process diagrams there is **Process Engineer** tab.

General control tools such as opening a new file, saving, printing and Visio settings can be found from **File** tab. **Home** tab contains formatting tools for shapes and text, shapes alignment tools and basic tools for drawing. With the commands of the **Insert** tab pictures, hyperlinks, comments and other objects can be added into document. The **Design** tab holds drawing layout tools. Behind the **Data** tab can be found data manage-

ment tools. The **Process** tab holds commands for sub processes, validity control and task path. The **Review** tab contains checking tools and, the **View** tab contains display features. [20, p. 9]

4.2 Starting a drawing

Before starting to draw the actual drawing, it is good to think what type of drawing is going to be made. When this is known, the right kind of diagram type can be chosen. Also page settings should be set properly so that are drawing area can be utilized as efficiently as possible. [20, p. 10]

The diagram type can be selected in the opening window of Visio. Choosing the right diagram type helps starting the drawing. Visio contains many different diagram types such as block diagrams, project schedules, software diagrams, network diagrams and process diagrams. The diagram type affects what kind of stencils are available for creating drawings. Other stencils can still be opened. If you want to open a new diagram, choose **File**, choose **New** and then choose the wanted diagram type. [20, p. 10]

After choosing the diagram type, it is recommended that page settings be adjusted. When adjusting the page setting, it is good to consider for which purpose the diagram will be used. The page setting can be accessed from the **Design** tab and pressing the **Page Setup** extension button (Image 2).

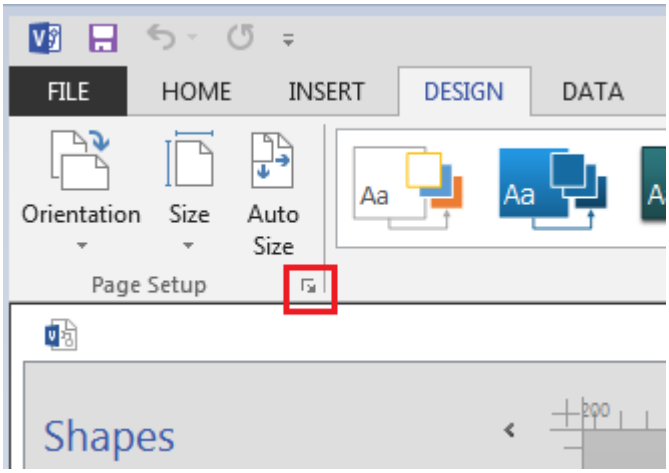


Image 2. **Page Setup** extension button

Pressing the **Page Setup** extension button opens a **Page Settings** window. In **Page Settings** it is possible to set settings, such as printing settings, page size, drawing scale, page name, type and layout as well as routing settings. [20, p. 11-13].

4.3 Drawing tools and drawing

Drawing tools can be found in the **Tools group** in the **Home** tab. The **Tools** group contains tools for pointing, connecting, text, geometric shapes, lines and text rotating. By using these tools, it is possible to create shapes, make connections between shapes and write information.

Drawing the diagram happens by choosing the wanted shape, by pressing the left mouse button and by dragging the shape into the drawing sheet. After releasing from the left mouse button the selected shape appears into the drawing sheet. After being added into the drawing, the shape can be moved, rotated and resized. Connections between shapes are made with the **Connector tool**. Text can be added into a shape by double clicking the shape or by choosing the text tool and by pressing the shape where text is needed.

4.4 Benefits of Microsoft Visio for Evac

In addition to the basic tools of Microsoft Visio, there are lot of advanced and useful properties in Visio. In the following chapter I will introduce some of the properties that are beneficial for Evac at the moment. The beneficial properties are the following:

- Data can be added to shapes
- Data can be exported into Microsoft Excel
- Data can be linked from Microsoft Excel to Microsoft Visio
- Automatic tag coding
- Multiple design can be drafted into one drawing

The fact that data can be added into shapes (Appendix 5) and the fact that data can be output to Microsoft Excel are heavily linked together. Data that is included in the

shapes are the data that can be output to Excel. The benefit is that when creating a diagram that contains data, component lists can be created more quickly and easier. Hence, when the data is in the diagram, it is possible to output the component list from Visio as an Excel sheet. Appendix 5 shows how to generate component lists in Evac.

Linking data from Excel to Visio is a quality that is used when there is a need to link data (such as mass balances) to process flow diagram so that the data can be refreshed. This is beneficial because you need only one mass balance template and you can use it for every process flow diagram.

Automatic tag coding is beneficial because it makes drawing a diagram quicker because, you do not have to add tags manually. It also prevents using wrong tag codes because in the Evac template the tag codes are already defined.

Multiple designs can be drafted into one drawing by using layers. This means that when Evac has different standard designs from membrane bioreactors, all designs can be drafted into one drawing. This helps in maintaining documents.

5 Creating the Microsoft Visio template

One of the main priorities in this thesis was to create a complete Microsoft Visio template for Evac. Template is a pre-formatted file, which serves a starting point for a new drawing. The template was supposed to include all the needed pages and stencils. It was also ensured that the settings of the template were right. Creating a template is very easy in practice. As its simplest, it can be just one blank drawing sheet and saved in template format (.vstx). However, the template can also be very versatile and practical with different kind of sheets, settings and stencils. Having an own standard template makes it is easy to maintain likeness in every drawing in every project.

5.1 Pages

A template can contain multiple pages for different purposes. Pages that the Evac template contains are named as front page, drawing page, revisions page and background page. Background page is made for different page sizes (A0 – A3).

Front page is a page that includes symbol and abbreviation explanations. There are explanations for valve shapes, pipelines, instruments, some main equipment shapes and a list of abbreviations (Image 3). Information in the front page can vary according to project needs. The idea is that only the used valve shapes and abbreviations, and the most used equipment shapes and the shapes that need to be explained are shown in the front page.

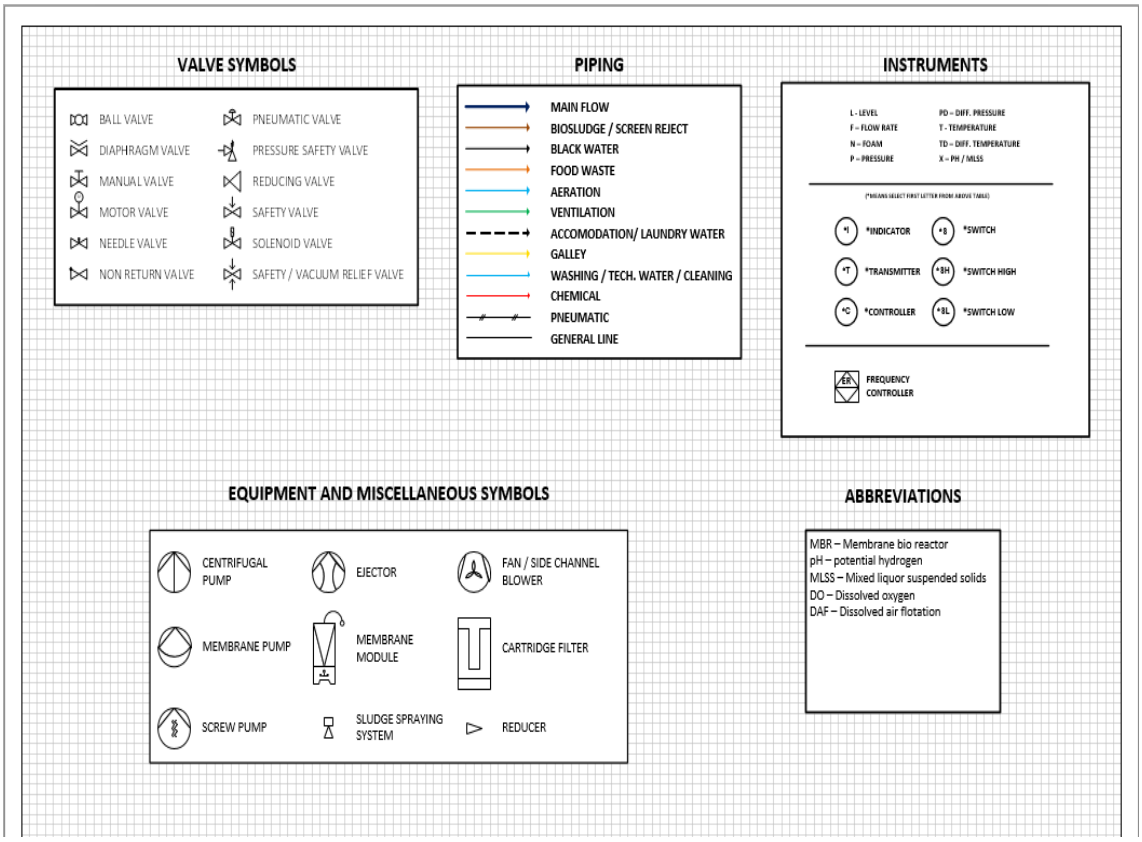
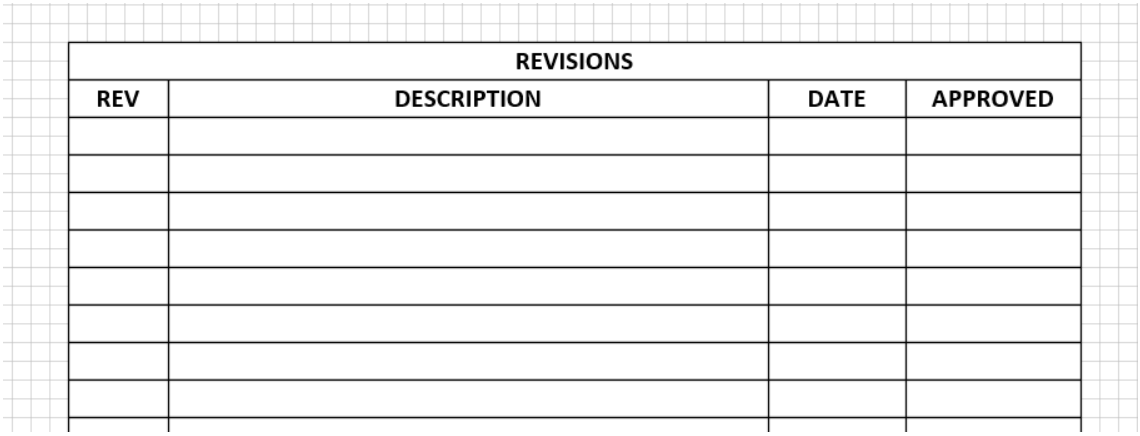


Image 3. Front page example, shapes can vary according to project needs.

The actual drawing page is a blank page where to start a drawing. The size of the drawing page is A3. The drawing is to be drawn to several A3 pages according to the process.

The revision page includes a table for revision marking as Image 4 shows. The fields that revision table contains are **Revision**, **Designer**, **Date** and **Description**. This is an easy way to follow in which revisions the drawing has undergone and what changes there have been made to the drawing. A separate page for revision marks also leaves more space for the drawing page.



REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

Image 4. Revision table as own page makes following in revisions easier

The background page contains the title block. Image 5 shows that the title block contains fields for inserting the name (title) and type of the drawing (PFD or P&ID), the designer, the approver, the date, the sheet number, the page name (drawing no.) and the proprietary notes. The sheet number field and Page name field are automated. The background page reflects to every page so all the marking that is made to background page appears on every page. Different page size (A0-A4) needs different background; therefore, there are five different backgrounds in the Evac template.

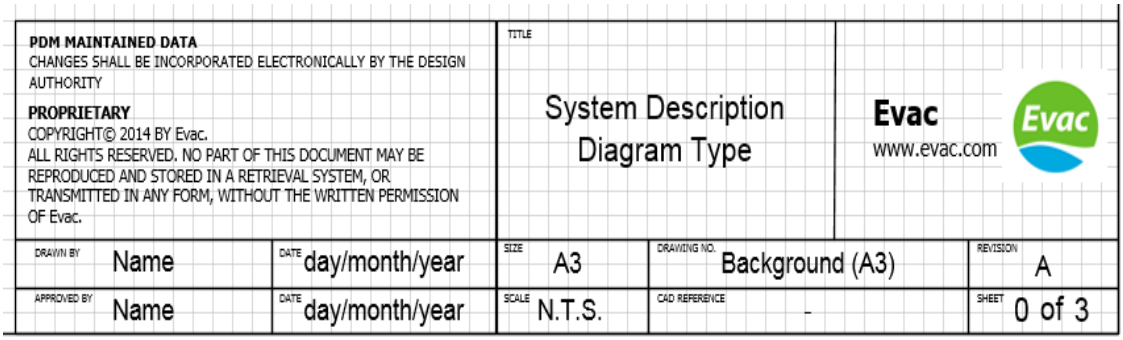


Image 5. Title block

Pages can be inserted in two ways in Visio. The first way is to go into the **Insert** tab and in the **Pages** group click **New Page** (Image 6). After clicking **New Page**, Visio gives three different options, **Blank Page**, **Background Page** and **Duplicate This Page**. **Blank Page** opens a new blank page with similar settings to those of the page that is on display. **Background Page** opens a **Page Setup** window where settings such as page size and name for the background can be set. **Duplicate This Page** duplicates the current page.

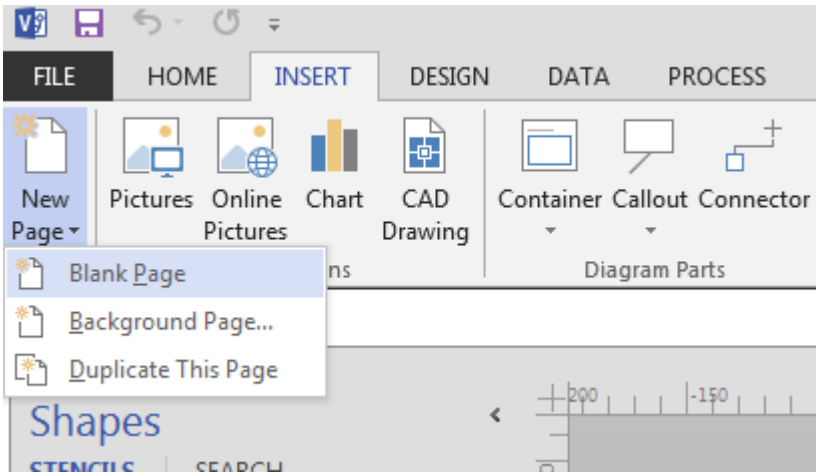


Image 6. New page can be inserted from **Insert** tab.

The second way to insert a new page is to right click the **Page Name** ribbon. Right clicking the **Page Name** ribbon opens a shortcut menu. In the shortcut menu there are few different options, **Insert**, **Delete**, **Rename**, **Duplicate**, **Page Settings** and **Reorder Pages**. **Insert** opens a **Page Setup** where the page settings, such as page **Type** (foreground or background), **Name** of the page and **Page Size**, can be adjusted. After adjusting the settings right, click **Ok** and Visio creates new page.

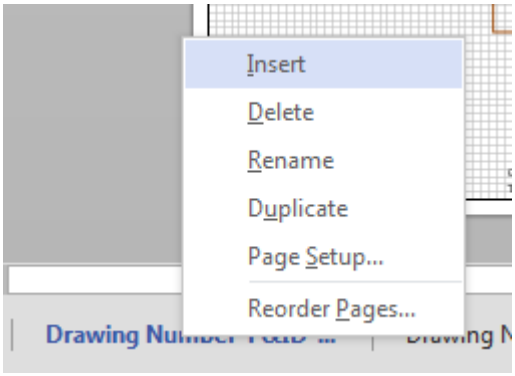


Image 7. New page can be inserted by right-clicking the name ribbon.

Delete deletes the current page. **Rename** option allows renaming the page. **Duplicate** duplicates the current page. **Page Settings** opens a **Page Setup** window where different settings can be adjusted. Option **Reorder Pages** opens a **Reorder Pages** window, where it is possible to put pages to specific order.

5.2 Settings

Adjusting settings properly can make the template work better. Properly adjusted settings also make drafting easier and viewing the drawings clearer. Some settings adjustments were made, so that the use of the template runs effortlessly.

A background page is added to every page. The background page is part of the template but it has to be added to every page. When background is added to every page already, designer does not need to pay attention to it. The designer only needs to insert the needed information in the title block.

The grid is set to be shown. Grid spacing is adjusted to be 3 mm x 3 mm. Grid spacing can be adjusted to a desirable spacing but a 3 mm x 3 mm spacing or a 1 mm x 1 mm spacing is recommended. The grid makes drafting much easier. Without the grid it is very hard to align the equipment.

Line jump size is adjusted to be 1 vertically and 1 horizontally. Line jump style is Arc, and the adding of the line jumps is set to appear on horizontal lines. With these setups the line jump is clear enough even with the widest lines.

A custom equipment list has been added into **Shape Reports**. That is the list that is used when making a component list (Appendix 6). This already modified list makes making component lists faster and easier.

Tag code formats are modified according to the chosen tag codes (Appendix 4) from HHI ENS. It is important that this setup is correct so that the right tag code appears on the right when a shape is added into a drawing. Tag code formatting is presented in Appendix 7.

5.3 Stencils

Visio stencils are the files that hold collections of drawing shapes. Each stencil is made so that the shapes have something in common. [21] Visio contains already a considerable number of stencils, but if some particular shapes are not found in the existing

stencils, creating own one's stencils and adding shapes created by oneself into those stencils is a possibility.

Stencils that are made for the Evac template contains a large number of shapes that are self-made with Visio. Evac template contains the following stencils:

- Evac General Equipment (ISO)
- Evac General Equipment (NORSOK)
- Evac Pumps & Blowers (ISO)
- Evac Pumps & Blowers (NORSOK)
- Evac Instruments
- Evac Pipelines
- Evac Text Boxes
- Evac Fresh Water Systems.

Evac General Equipment (ISO & NORSOK) stencils contains basically the same shapes. ISO is made according to SFS-EN ISO 10628-2:2012 and NORSOK is made according to NORSOK Z-004. These stencils hold all the different shapes except for the Evac Fresh Water Systems shapes, which are made for the template. These two stencils hold also shapes that are not made according to the standards. That is because there were many of shapes that were wanted for the template, but those shapes do not exist in the used standards. Shapes included into these two stencils do not contain pre-defined data.

Evac Pumps & Blowers' (ISO & NORSOK) stencils hold different pump and blower shapes. These shapes are named according to different pump and blower models that are often used in Evac projects. These shapes contain pre-defined data (Image 8).

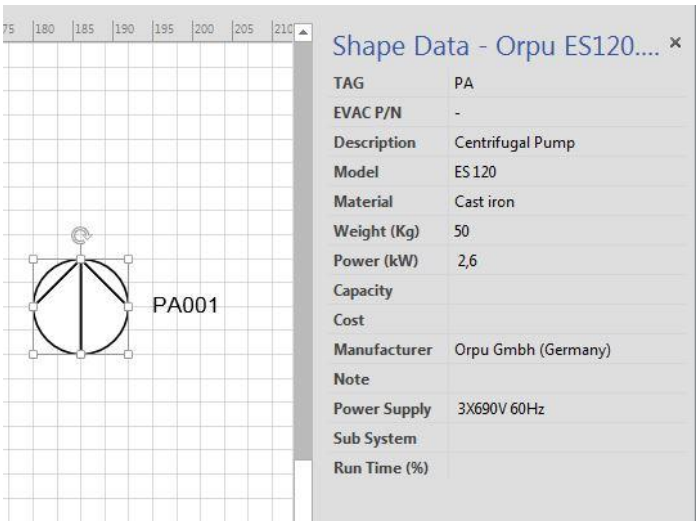


Image 8. A shape with pre-defined data.

Evac Instruments' stencil holds different type of instruments. These instruments are named according to different instrument models that are the most used in Evac projects. These instruments contain pre-defined data (image 8).

Evac Pipelines' stencil holds the connectors that are modified to reflect different process flows. These connectors have different colours and widths and are named according to their functions of use.

Creation of a new stencil is simple and can be done in two ways (Appendix 8). The first way to create a new stencil is to click **More Shapes** in **Shapes** window and clicking the option **New Stencil (Metric)** or **New Stencil (US Units)** from the menu that opens. The second way to create a new stencil is to from the **Stencil** group in **Developer** tab click either option **New Stencil (Metric)** or **New Stencil (US Units)**. The **Developer** tab is not displayed as default. It can be added to the ribbon in Visio's **Options**. The new stencil appears into the **Shapes** window named as **Stencil1** if it is first one made. The name of the stencil can be changed by right clicking the stencil and choosing **Properties**. In **Properties** window, write the name of the stencil into the **Title** section.

Stencils do not have many adjustable configurations. In the **Properties** window there is no important configurations, only the **Title** of the stencil. Right clicking the stencil name opens a floating menu. In the section **View** it is possible to choose how the shapes icons and names are shown in the stencil. In the section **Order** the stencils can move

up or down to put stencils in a desirable order. This can also be done by dragging the stencils in the **Shapes** window.

Stencils contain an area for **Quick Shapes** where shapes can be added. This “Quick Shapes” area is located always at the top of the stencil so the shapes are always in top. This is a useful attribute if stencil hold lot of shapes. If there are some shapes that is used more frequently than others, these can be add to the “Quick Shapes” area.

5.4 Shapes

Shapes are the symbols for different process equipment. Microsoft Visio contains a large number of ready-made shapes already. These shapes are so called master shapes. A master shape remains always on the stencil even if you drag one onto your drawing page. The shape that you drag onto your drawing is called an instance, a copy of that master shape. Instances of the same shape can be dragged onto drawing as many times as wanted. [21]

Even Microsoft Visio contains a large number of ready-made shapes, I needed to create many of shapes (Appendix 9) by myself because the shapes needed to meet the requirements of standards SFS-EN ISO 10628-2:2012 or NORSOK Z-004. New master shapes can be created for a stencil in two different ways.

One way to add a new master shape is to right click the stencil shape area and choose **New Master**. **New Master** window opens where properties can be modified such as **Name**, **Prompt** and **Icon Size**. After the properties have been set, click **Ok**. A new empty master appears into a stencil. The other way to make new a master shape is to copy the wanted shape from a drawing and paste it into the stencil. This way the shape icon appears immediately into the stencil. The master name can be changed by right clicking the master, choosing **Edit Master** and then clicking **Master Properties** or double clicking the master name.

Master shapes can be edited (Appendix 10). Right click the master, choose **Edit Master** and click **Edit Master Shape**. A master editing window opens where the master shape can be edited or a completely new shape can be created. It is also possible to bring a shape from other sources.

When making a customized shape, it is important to make sure that the shape category and the tag format is right. The shape category and the tag format can be changed in **Process Engineering** tab. In **Process Engineering tab**, go to **Manage** group and click **Shape Conversion**. **Shape Conversion** window opens (image 9) and there the category and tag format can be changed.

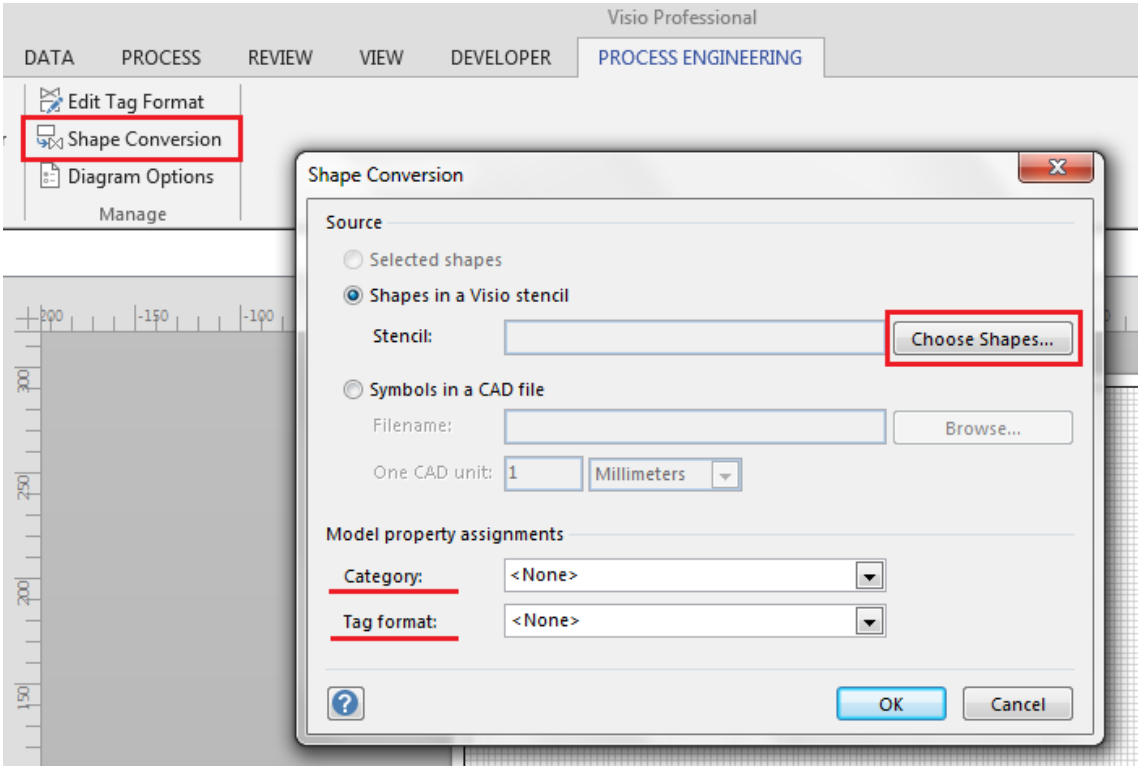


Image 9. **Shape Conversion** window

Shapes can hold data in Microsoft Visio (Image 6). To be able to hold data, the shape needs data fields where to add the data. Data fields can be added into a master shape or into the instance of the master shape (Appendix 11). If data fields are added into the master shape, the same data fields appear into every instance that is made from that master shape. If data fields are made into an instance shape, the data fields are specific for just that shape. Data fields can be added into the master shape in the master editing window, whereas the data fields can be added into an instance shape by right clicking the shape, choosing **Data** and clicking **Define Shape Data**.

Shapes that are modified for one's own purposes like adding data and making custom tag formats are so called smart shapes. With these kinds of shapes, making diagrams such as piping and instrumentation diagrams is more efficient and professional.

6 Drafting rules

One main priority of this thesis was to create rules for Evac's standard products drafting. The rules created for the Evac company sets the format and technical basis for drawing the piping, instrumentation diagrams and process flow diagrams of Evac's standard products. Processes can be different such as wastewater treatment or solid waste handling processes.

As design software, Evac uses Microsoft Visio and Microsoft Excel to produce process diagrams and component lists.

6.1 Representation

The representation and designation of all equipment, instrumentation and piping should comply with the requirements of these rules. Auxiliary systems may be represented by rectangular boxes with reference to separate diagrams

The graphical symbols for process measurement and control functions for equipment, machinery and piping, as well as piping and valves themselves, shall be shown in the logical position with respect to their functions.

6.2 Drafting

6.2.1 General rules

Drafting shall be in accordance with the requirements outlined in these rules. Allowable drawing sheet sizes are A3 – A0.The drafting must be of sufficiently high quality to maintain legibility when the drawing is printed to an A3 size sheet. The Evac template shall be used. Backgrounds shall be used on every page.

6.2.2 Naming of the drawing sheets

There are two different ways to name the drawing sheets depending whether there is a process flow diagram sheet or not. Drawing without a process flow diagram sheet is named in the following way:

- Front page: drawing number – Front page – 101
- P&ID sheets: drawing number – P&ID – running number from 102

If there is a process flow diagram included into a drawing, sheets are named following way:

- Front page: drawing number – Front page – 101
- PFD sheets: drawing number – PFD - 102
- P&ID sheets: drawing number – P&ID – running number from 103

These naming instructions shall be followed. Naming of the sheet must be done manually but the name of the sheet automatically updates to into a drawing title block, section drawing number.

6.2.3 Process lines and direction of flow

Process lines in a drawing represent the substances that are flowing in a process. To obtain a clear representation, different line widths and colours shall be used for different process lines. Different line widths help when viewing a drawing in greyscale, and different line colours help when viewing a drawing in colour. Process lines, process lines colours and widths are introduced in Table 1. Process line examples are presented in Appendix 12.

Table 1. Colours, dash types and widths of a process lines

Process line	Colour	Dash Type	Width
Main flow	Dark blue	Solid	2,5 pt
Accommodation & Laundry grey water	Black	Dashed	1,25 pt
Bio sludge / Screen Reject	Brown	Solid	1,25 pt
Black water	Black	Solid	1,25 pt
Food waste	Orange	Solid	1,25 pt
Galley	Yellow	Solid	1,25 pt
Ventilation	Green	Solid	1,25 pt
Chemical	Red	Solid	0,25 pt
Washing / Technical water	Light blue	Solid	0,25 pt
Aeration	Light blue	Solid	0,25 pt
Pneumatic	Black	PID Pneumatic	0,75 pt

The direction of main flow shall be proceeding from left to right and from top to bottom. Other process lines such as recycling lines, chemical feeds, washing lines and technical water lines can proceed also from right to left and from bottom to top. Inlet and outlet arrows shall be used for indicating the inflows and outflows into and out of the process.

Arrows are used to indicate the direction of the flow. Arrows are used at the inlets and outlets of process tanks, every time when two different process lines connect. Generally the direction of flow shall be easy to recognize.

If a diagram consists of several sheets, the incoming and outgoing process flow lines on a sheet may be drawn in such a manner that the lines continue at the same level when the individual sheets are horizontally aligned.

6.2.4 Notes and markings

Markings into a drawing shall be written by using the font type Arial. The font size depends on the note or marking type. Table 2 shows font sizes for different notes and markings.

Table 2. Font size and font type for markings

Marking	Font size	Type
Drawing title	12 pt	Regular
Tag for tanks	12 pt or bigger	Regular
Tag for pumps	8 pt	Regular
Tag for blowers	8 pt	Regular
Tag for valves	6 pt	Regular
Tag for instruments	6 pt	Regular
Tag for other equipment	6 pt	Regular
Tag for pipelines	6 pt	Regular
Inflow or outflow inscriptions	12 pt	Bolded
Designation of process lines	minimum 10 pt	Regular

These instructions apply when the drawing size A3 is used. If the drawing size is bigger than A3, font sizes can be bigger. Font sizes for page sizes bigger than A3 are not defined.

6.2.5 Minimum information

Each P&ID shall present all information as required in Table 3 during the implementation of a project in detailed design phase. The Extent of information shown on each P&ID in the basic design stage shall be agreed in advance.

Table 3. Minimum information to be shown in piping and instrumentation diagrams

Equipment	Minimum Information to be shown
Tanks	Tag, Description, Nominal capacity ($m^{3)}$
Pumps	Tag
Blowers	Tag
Valves	Tag
Instrumentation	Tag
Otherequipments	Tag

6.3 Tag codes

The tag code is a unique identifier to a piece of equipment. Each piece of equipment shall be given a tag code to identify the equipment in piping and instrumentation diagrams. In Evac standard products tag code is formatted from the tag code (according to Hyundai Heavy Industries Engineering Numbering System if possible) and a running number beginning from 001. For example, the tag format for a centrifugal pump is as Image 10 shows.

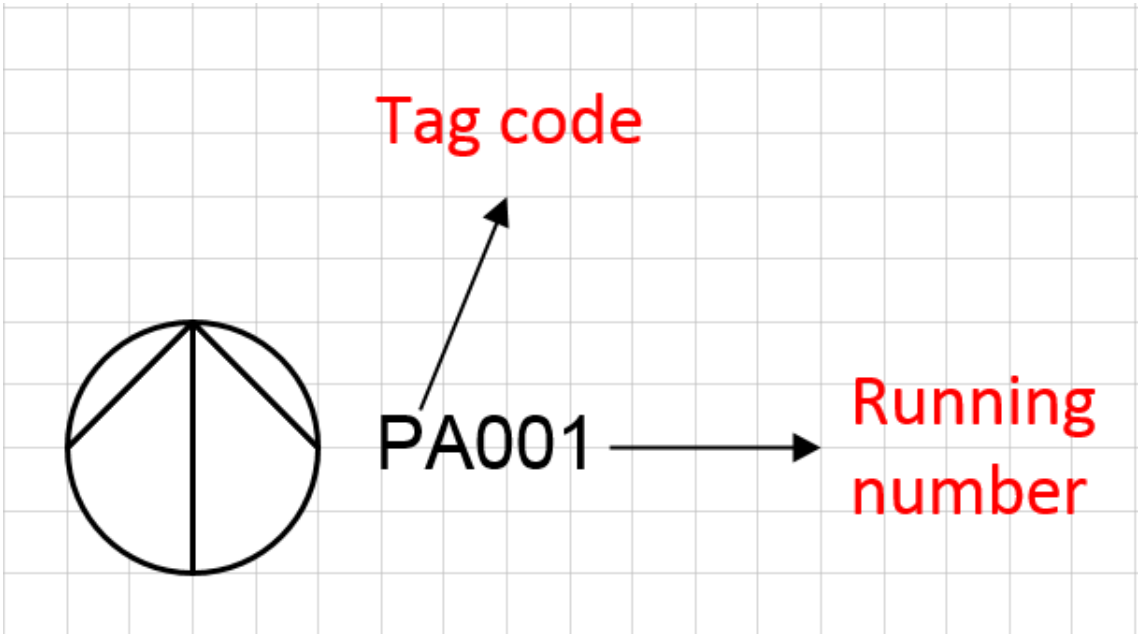


Image 10. Tag code format for centrifugal pump

Microsoft Visio adds the tag code automatically when a shape is added into a drawing.

6.4 Revisions

The piping and instrumentation and process flow diagrams shall be revised depending on the type of change. In the Evac revision system, there are two different revision changes: minor and major (Image 11). When a major change is made to a drawing, such as customer interface change or major process change, the revision letter shall be changed. If a minor change is made to a drawing, the revision number shall be changed.

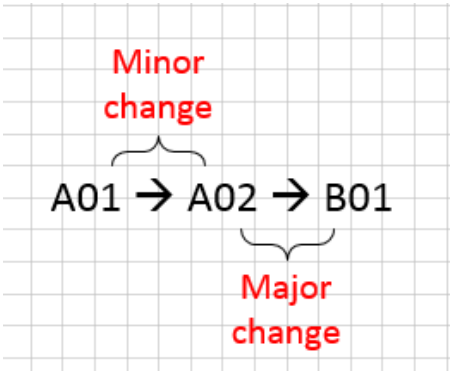


Image 11. Minor and major revision change.

The latest revision changes shall be marked on the piping and the instrumentation diagrams. The revision change shall be marked by using revision cloud and revision mark symbols according to Image 12.

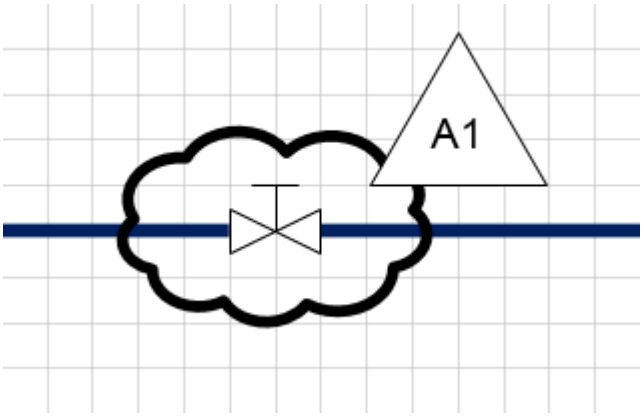


Image 12. Example how to use revision cloud and mark.

Only the latest revision marking shall be presented on the drawing, other revision markings shall be hidden.

7 Up keeping, updating and development

Updating and developing the Evac template and stencils became current when the first versions of the template and stencils were launched. We, I and my thesis instructor decided that I continue controlling the master files updating. I also continued developing the template and the stencils.

7.1 Updating

At the beginning updates were made almost every day. There were lots of minor issues in the shapes. Most of the issues were shapes handling issues. At the beginning many updates were also made because some important and frequently used symbols were missing from the stencils. When most of the issues were solved, the updating frequency was decreased so that updates were made just at the end of the week. When the template started work as wanted and stencils hold shapes that were really needed, updates were made just when necessary.

7.2 Development

The template being functional enough, the next step is development. The main target of development is to make a template even more functional, to check whether there is something new what can be done or if something can be done in different way. Shapes data fields can be developed to be more accurate to their own function. Even encoding is a possibility because Visio drawings can contain VBA coding. Some on how to develop the template, shapes, drafting rules and on how to use Visio more effectively have been collected into the following list:

- Define the use of layers as drafting rules
- learn to use data linking between Excel and Visio more deeply
- acquire new standards
- modify the shapes data fields to be more accurate to their own function

In drafting rules there is no mentioning about layers. Hence, defining how to use layers could be smart in near future and considering if there are more benefits in using layers.

Data linking between Excel and Visio is something that I handle somehow already. Learning to use the programs more deeply could be good so that the using can be more efficient and the benefits of it could be used.

Acquiring new standards in the future could be one thing how to develop the template, shapes and drawing rules.

Modifying the data fields of the shapes to be more accurate to their own function could help the designer in drawing a diagram. It could also prevent putting data into wrong fields and makes working easier and more effective.

8 Discussion

This objective of the thesis was to create a functional Microsoft Visio template and to write drawing rules for both piping and instrumentation and process flow diagram drafting for Evac. The template was meant to contain the needed drawing sheets, stencils and shapes. Also page settings should be set right. The purpose of drawing rules was to be at a common level and to include some basic instructions on how to use Microsoft Visio.

Both objectives were successfully reached. All the needed features that template should contain were made successfully and drawing rules were written. Settings that are adjusted into the template work well, and shapes that needed to be made according to chosen standards, have been done. All in all, the template runs very well.

The template works so well that it can be used in drawing the piping and instrumentation- and process flow diagrams. In fact, it has been used already for a few months because it has worked well enough from the very first version. But it has to be remembered that the template fulfils the current needs. The template can be even more functional in the future; thus, its development of it has not stopped here. Also the drawing rules might need to be revised according to standards, such as ISO, in the future.

I have learned a much during this thesis project. My experience about Microsoft Visio was almost zero before this. Hence, before I started to make anything, I needed to learn how to use the software and make all the needed features. Luckily, it turned out that learning to use Visio was not so hard. Especially, the experience about other Microsoft's software helped because the internal interface is very similar. Also the Norsok standards and Engineering Numbering System were new to me; thus, this has been a big learning process for me.

All in all, I think that Microsoft Visio is a proper software for diagram drafting. With Visio it is possible to create professional diagrams. I think the only negative point about Visio is that it is not so commonly used in the world yet.

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20 Visio 2013 Pro. PFD-file. 2014. Helsinki: Salcom Group.

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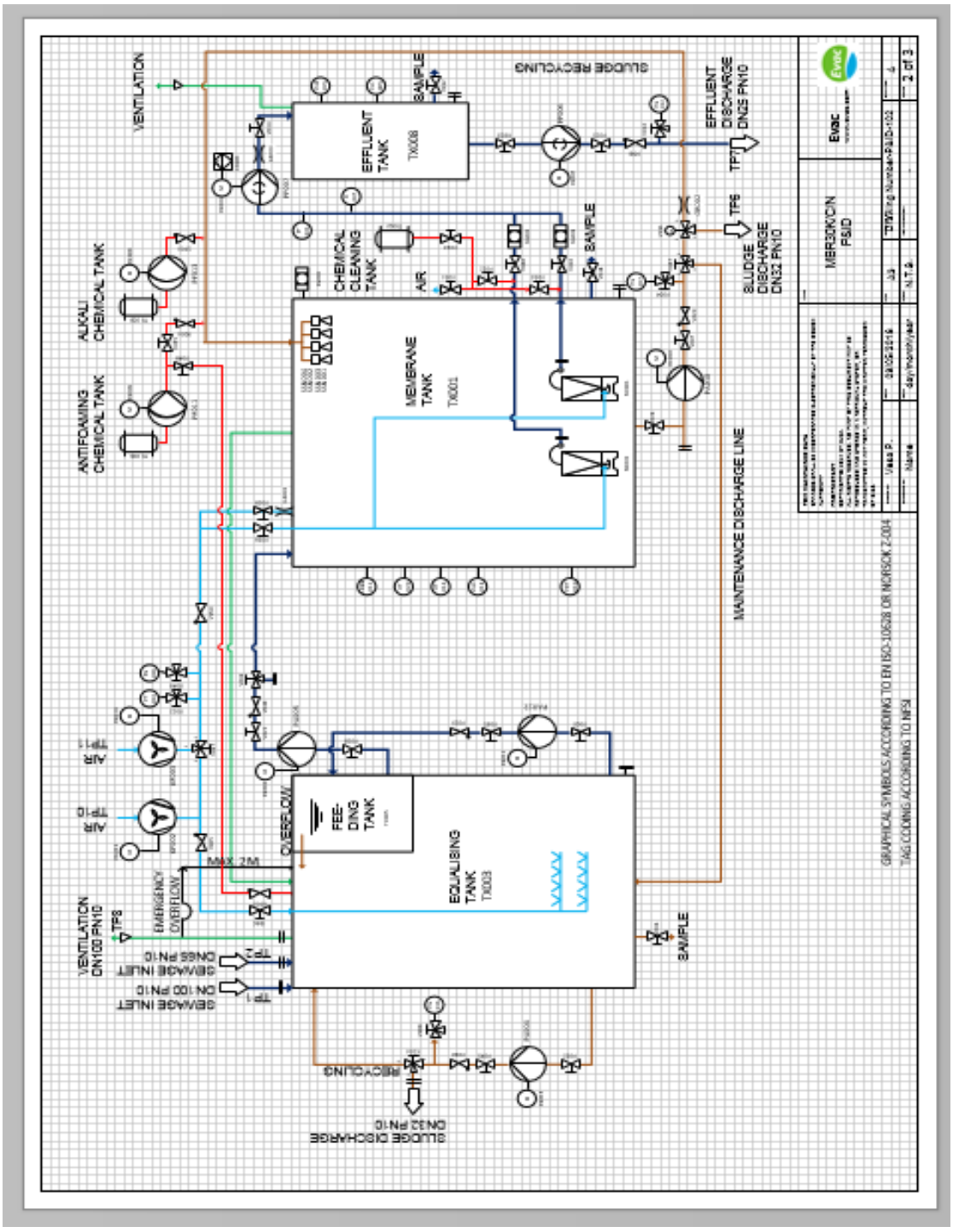
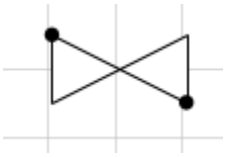
Appendix 1. MBR30K piping and instrumentation diagram

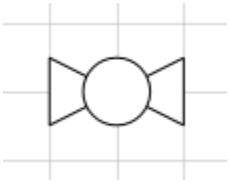


Appendix 2. Shapes according to the SFS-EN ISO 10628-2:2012

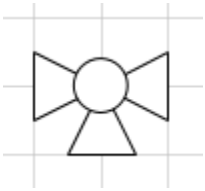
Aeration valve



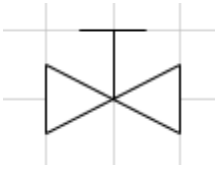
Ball valve



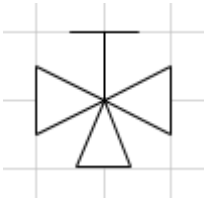
Ball valve 3-way



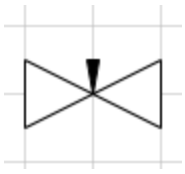
Manual valve



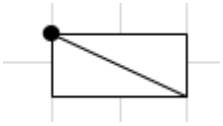
Manual valve 3-way



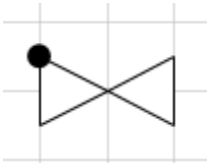
Needle valve



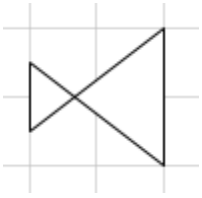
Non return flap



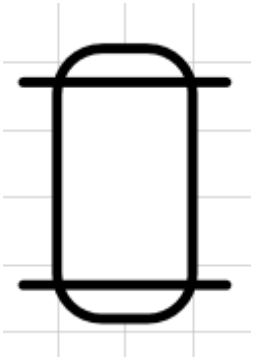
Non return valve



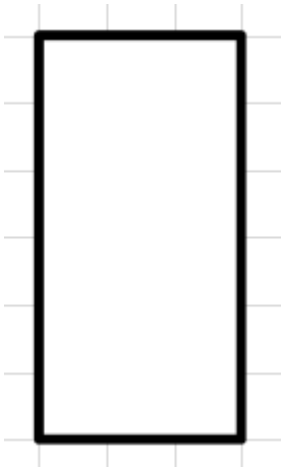
Reducing valve



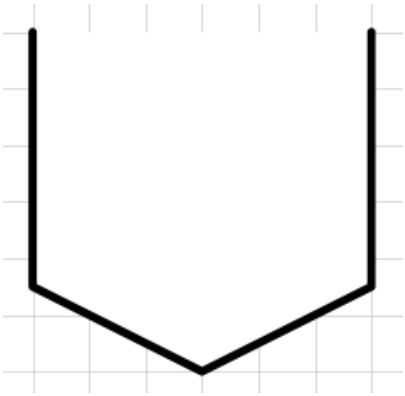
Chemical tank



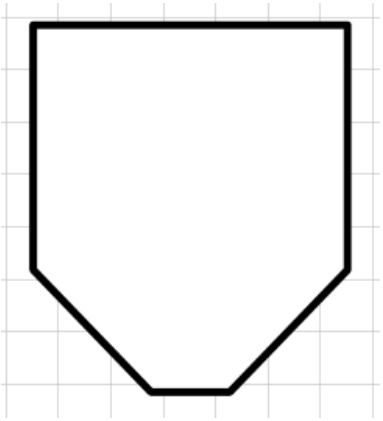
Process tank



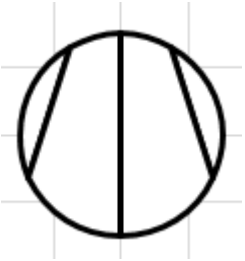
Hopper tank



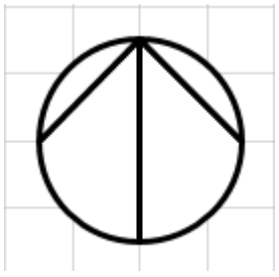
Sump Tank



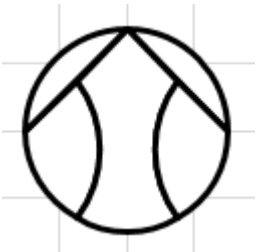
Centrifugal compressor



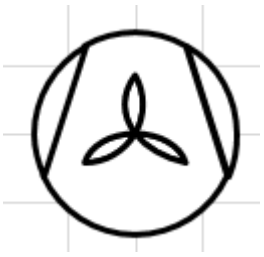
Centrifugal pump



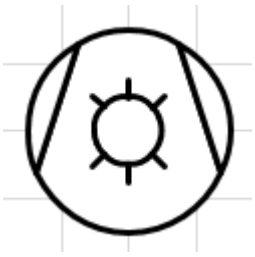
Ejector



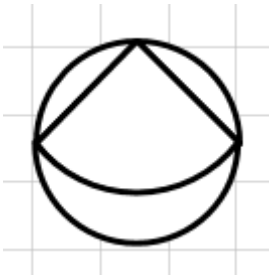
Fan



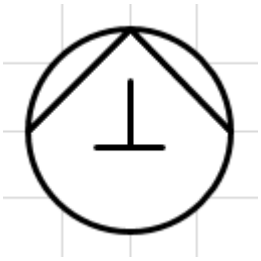
Liquid ring helical screw pump



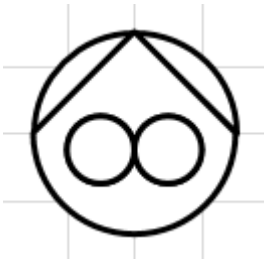
Membrane pump



Piston pump



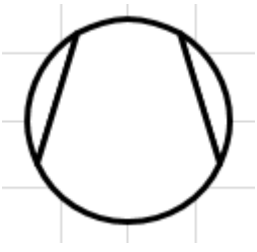
Rotary lobe pump



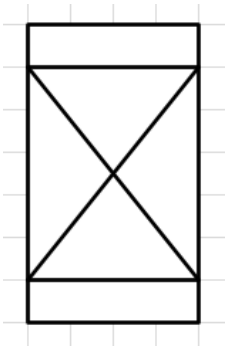
Screw pump

Side channel blower

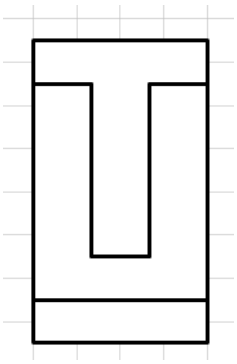
Vacuum pump



Bulk filter

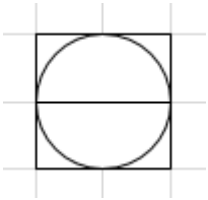


Cartridge filter

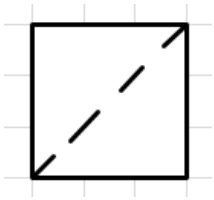


Compensator

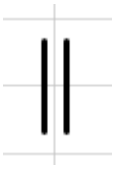
CRT



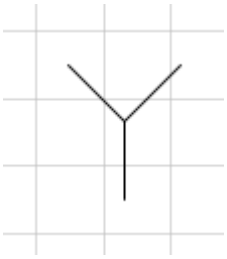
Filter



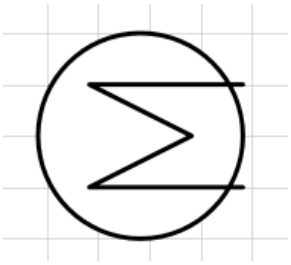
Flanges



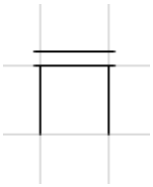
Funnel



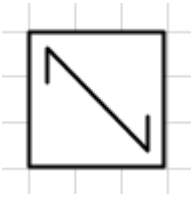
Heat Exchanger



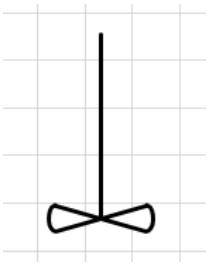
Manway



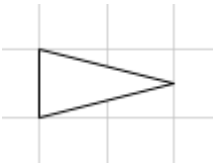
Mixing tube



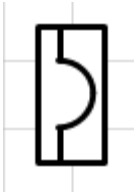
Mixer



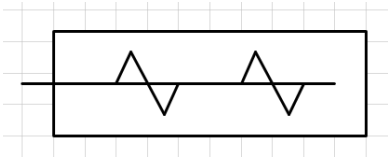
Reducer



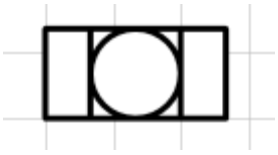
Rupture disc



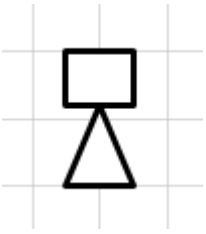
Screw conveyer



Sight glass



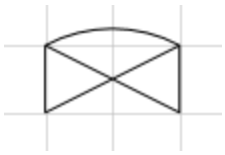
Sludge spraying system



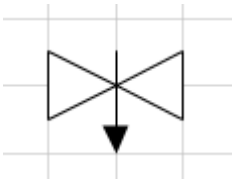
Appendix 3. Shapes according to NORSOK Z-004

Ball valve (V)

Diaphragm valve (V)

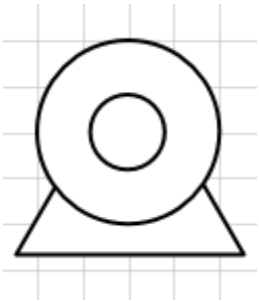


Needle valve (V)

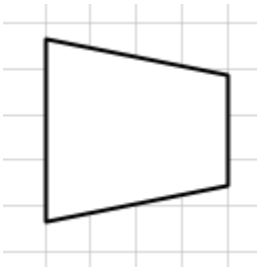


Non-Return valve (V)

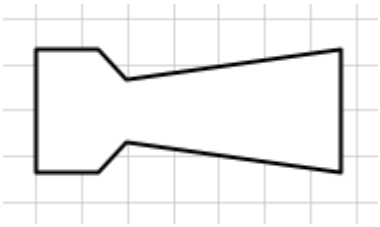
Centrifugal pump (PA)



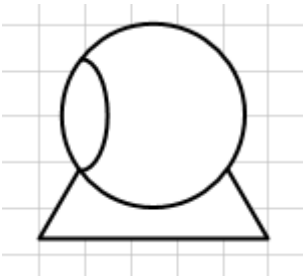
Centrifugal compressor (KA)



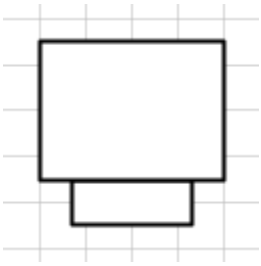
Ejector (CQ)



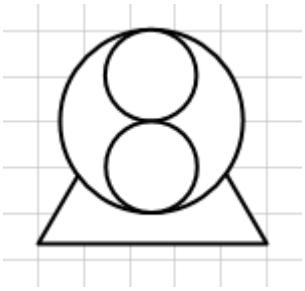
Membrane pump (PF)



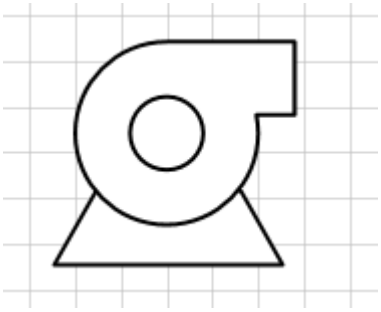
Piston pump (PB)



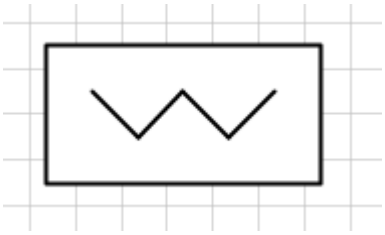
Rotary lobe pump (PC)



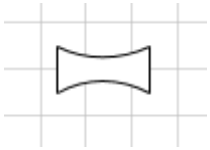
Side channel blower (KF)



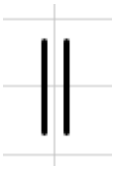
Screw pump (PG)



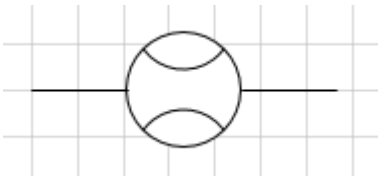
Air nozzle



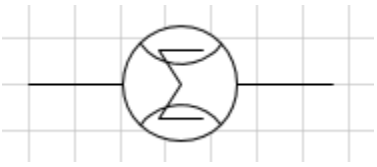
Flanges



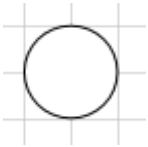
Flow indicator (FI)



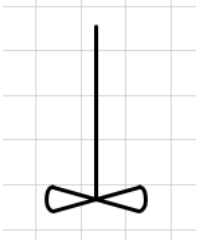
Flow indicator transmitter



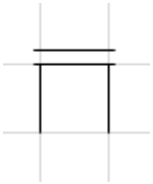
Instrument



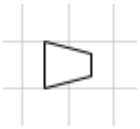
Mixer (CJ)



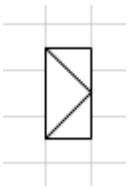
Manway



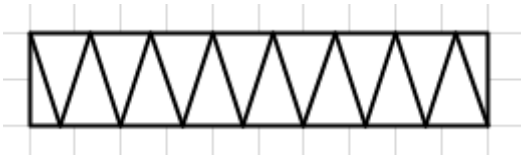
Reducer



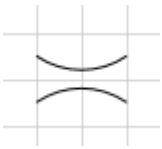
Rupture disc (PSE)



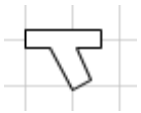
Screw conveyer (NC)



Throttling washer (GR)



Y-Strainer



Appendix 4. Tag codes according to HHI Engineering Numbering System: Equipment

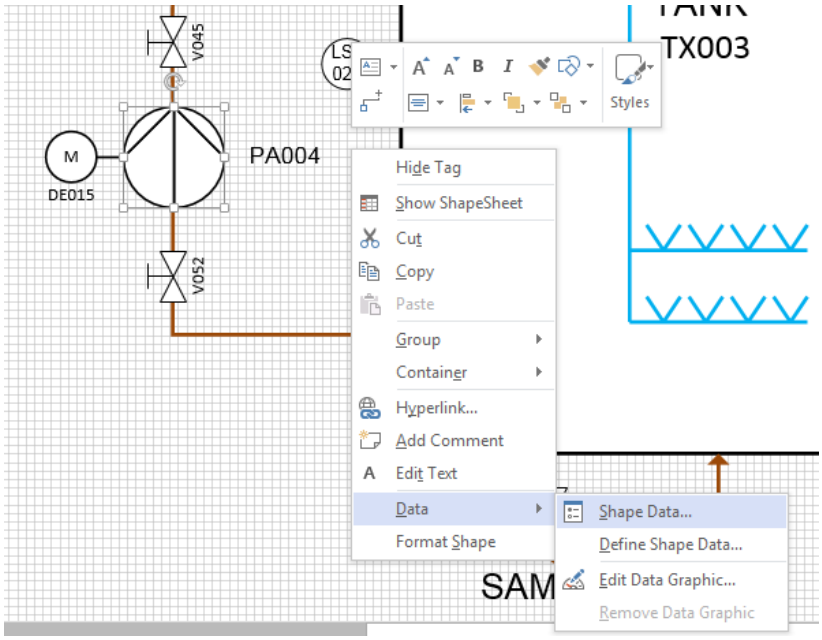
CA – Regenerative filters
CJ – Mixer/Agitators
EC – Control Equipment
FE – Electric heater
HA – Shell and Tube Heat Exchangers
KA – Centrifugal Compressors
KE – Fans
KF – Blowers
NC – Screw Conveyors
NX – Other Solids Mechanical Equipment
NZ – Other Solid Mechanical Equipment Packages
PA – Centrifugal Pumps
PB – Reciprocating Pumps
PC – Rotary Pumps
PE – Gear Pumps
PF – Diaphragm Pumps
PG – Screw Pumps
PX – Other Pumps
TE – Hoppers
TG – Sumps
TK – Containers
TX – Other Tanks/Containment Equipment

Appendix. 4 Tag codes according to HHI Engineering Numbering System: Instruments

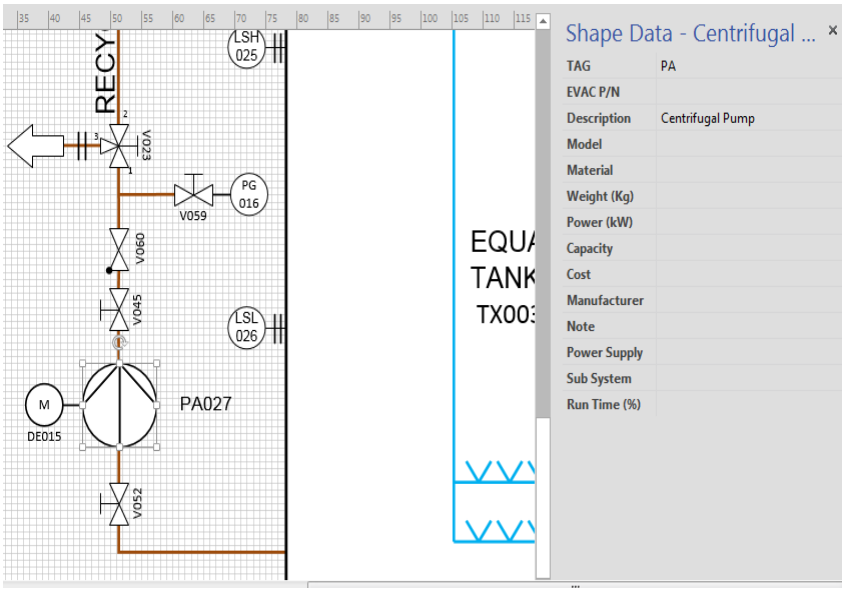
FI – Flow Indicator
FIT – Flow Indicating Transmitter
FT – Flow Transmitter
LI – Level Indicator
LS – Level Switch
LSH – Level Switch, High
LSHH – Level Switch, High-High
LSL – Level Switch, Low
LSLL – Level Switch, Low-Low
PC – Pressure Controller
PI – Pressure Indicator
PIC – Pressure Indicating Controller
PG – Pressure Gauge
TI – Temperature Indicator

Appendix 5. How to add data into shapes

1. Right-click a shape, go to “Data” and click “Shape Data”.



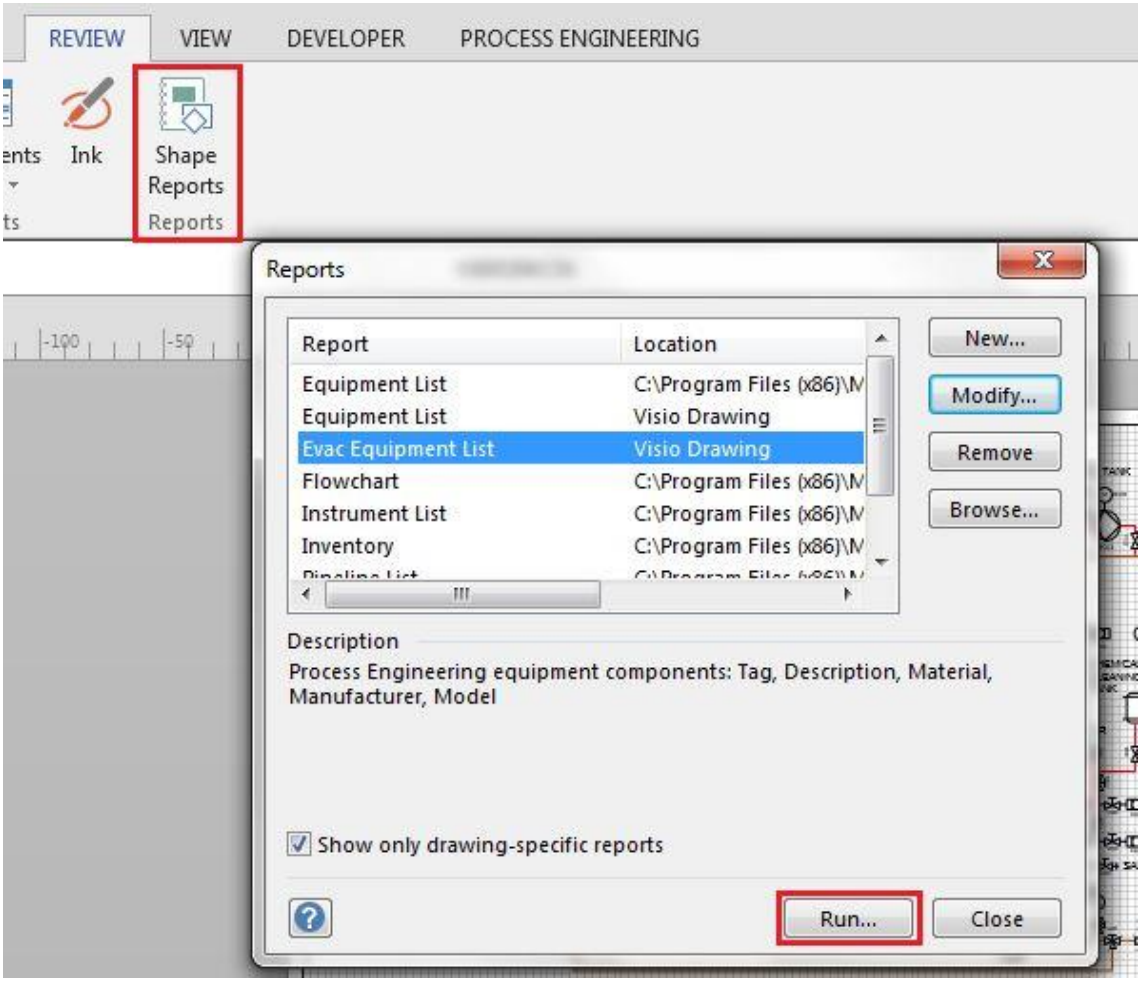
2. The Shape Data window opens and data can be inserted into a shape



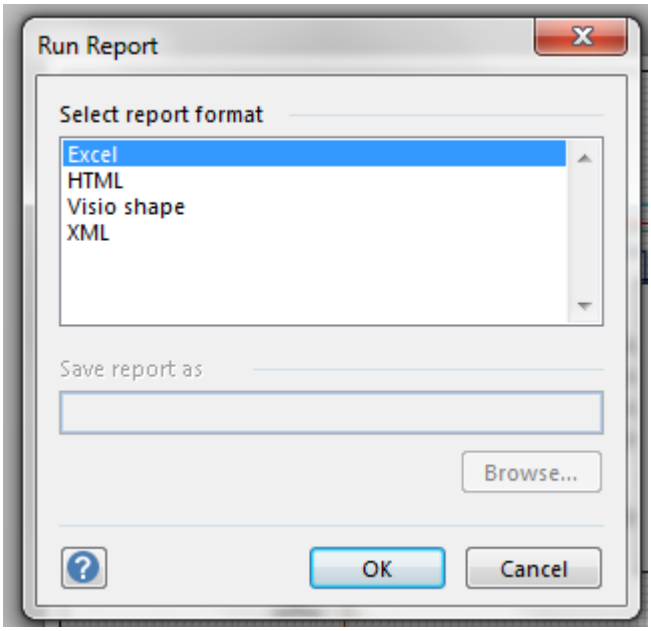
3. Close the Shape Data window

Appendix 6. How to generate component list

This is instruction how to generate component list in Evac. First step in generating the component list is to go into ”Review” tab and clicking “Shape Reports” from ”Reports” group. “Reports” window opens. Choose the “Evac Equipment List” and click “Run”.



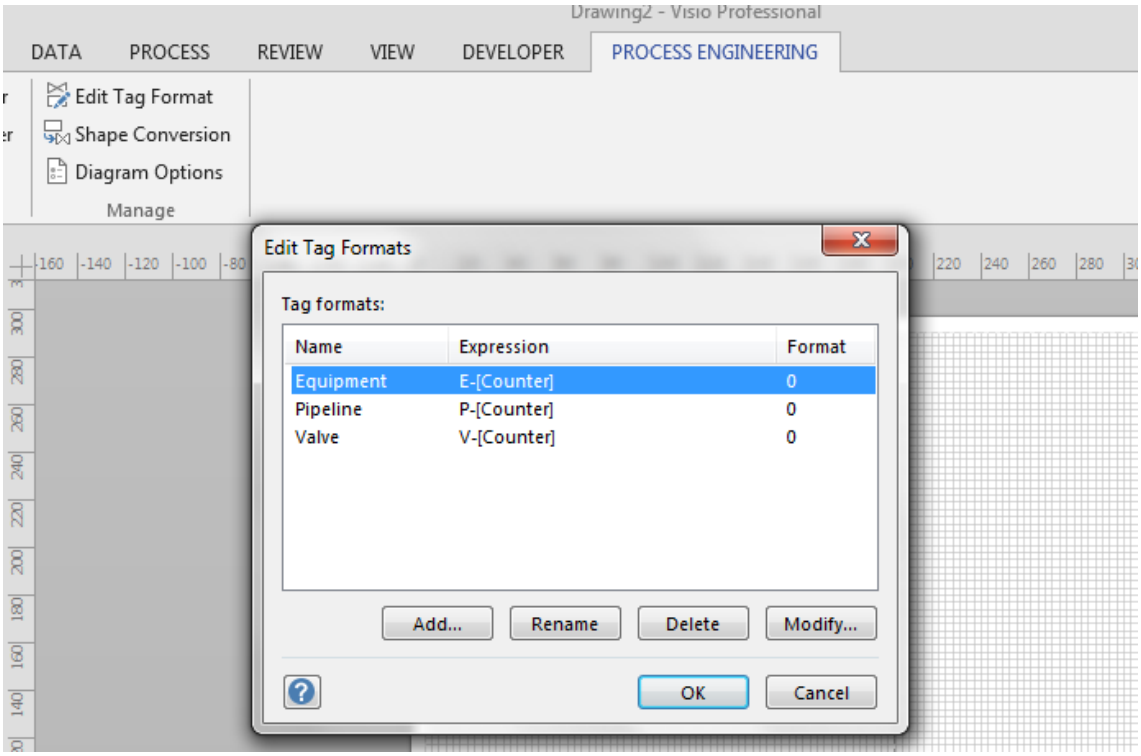
After clicking the “Run”, “Run Report” window opens. In “Run Report” window the format of the report is chosen. Choose Excel and click “Ok”.



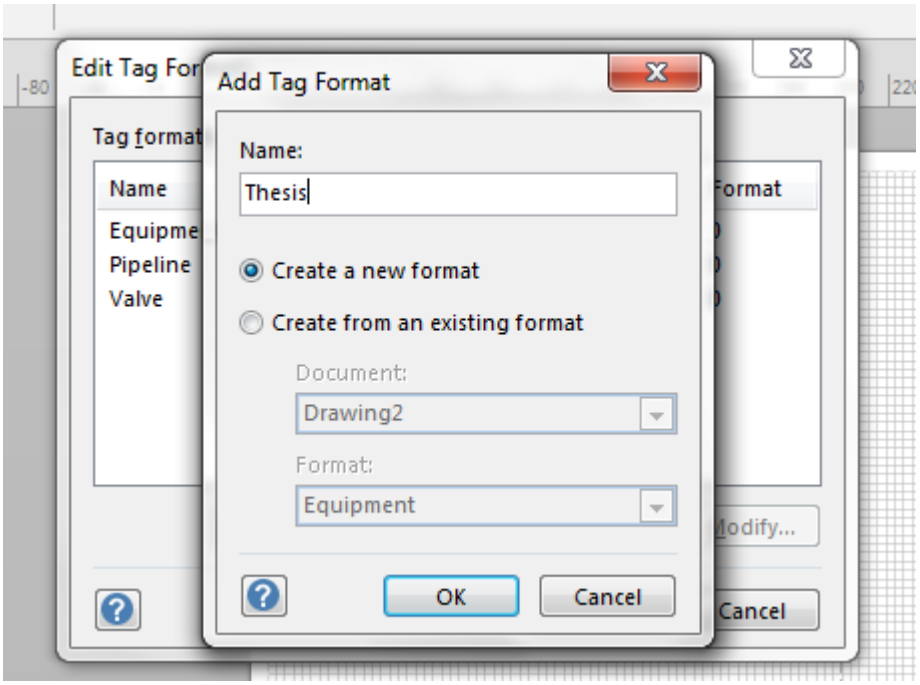
After clicking “Ok”, Visio generates the component list and opens it in Excel.

Appendix 7. Tag code formatting

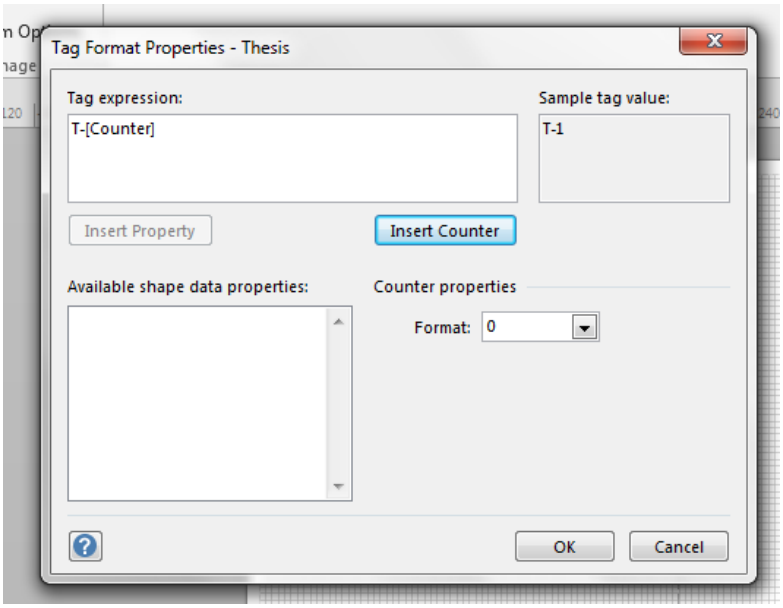
Tag code can be formatted in “Process Engineering” tab. In “Process Engineering” tab, go to “Manage” group and click “Edit Tag Format”. “Edit Tag Formats” menu opens, where tag code can be formatted.



In “Edit Tag Formats” menu there are 4 different options; “Add”, “Rename”, “Delete” and “Modify”. “Rename” option allows renaming the tag format name. “Delete” option deletes the tag format. “Modify” option allows modifying the tag format and “Add” allows to add new tag format. Clicking the “Add” options opens a “Add Tag Format” menu where new tag formats can be created. In creating a new tag format, it is possible to use existing tag format or make a completely new tag format.

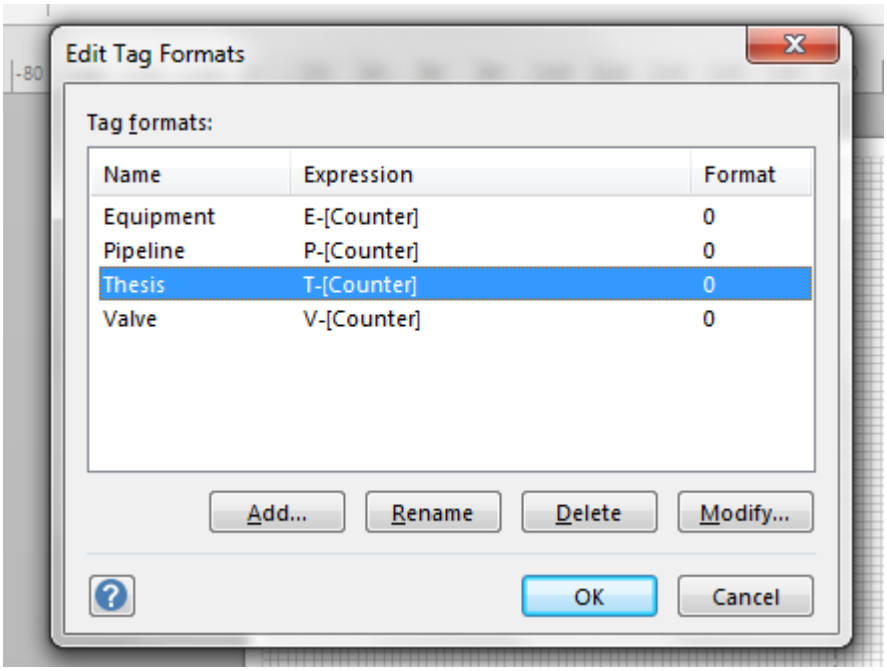


After making the new tag format, it can be edited by clicking the “Modify” option in “Edit Tag Formats” menu” (Image 1.). “Tag Format Properties” menu opens.



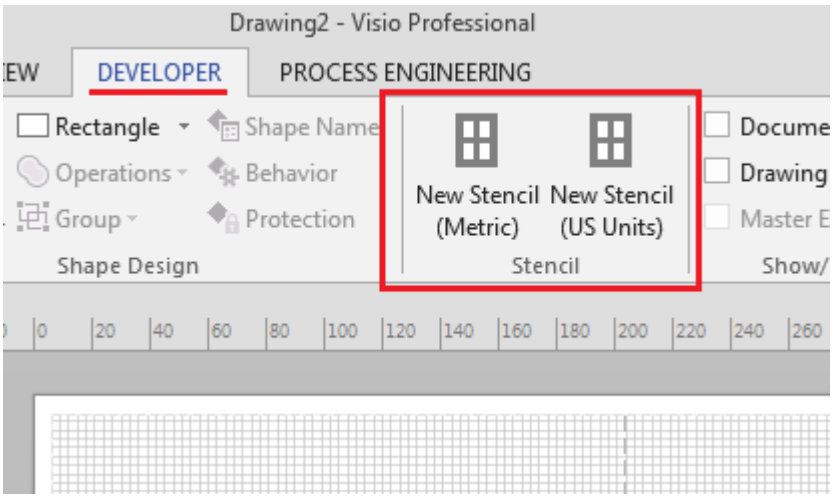
In “Tag Format Properties” menu, it is possible to add available shape data properties into the tag format. Also counter can be added and counter format can be chose. To the “Tag expression” field it is possible to write anything that is needed to make tag

format look like wanted. In the top right corner there is a “Sample tag value” what shows what kind of looking the tag format will be.

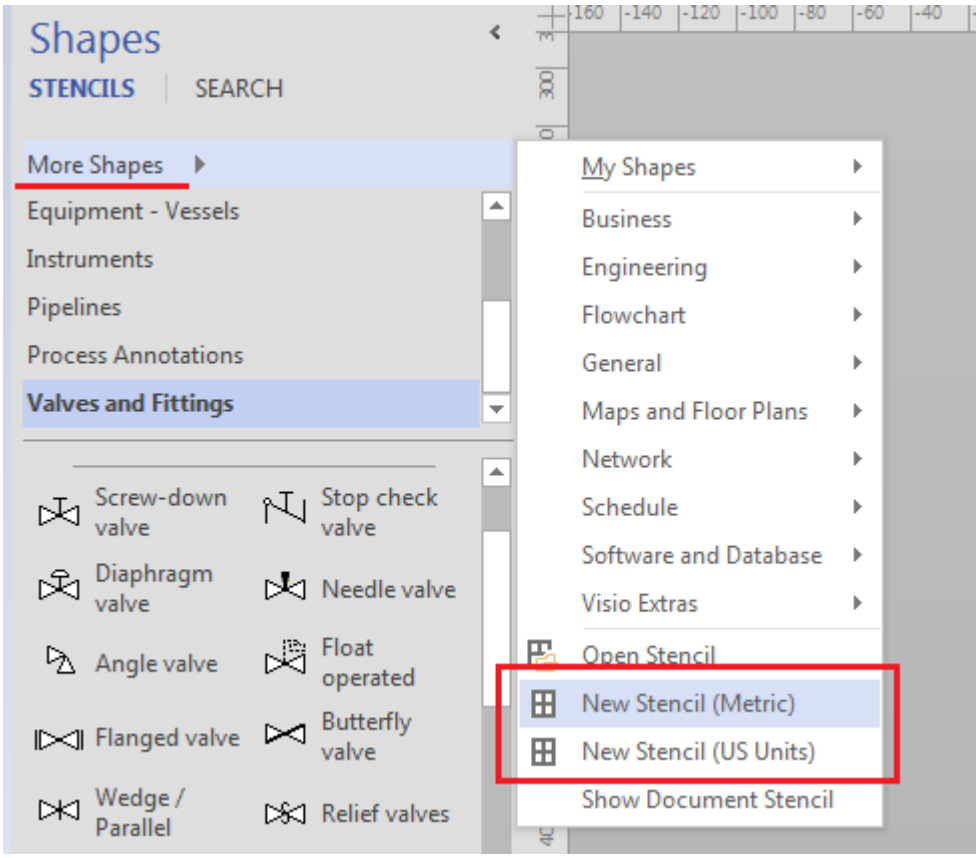


Appendix 8. How to create a stencil

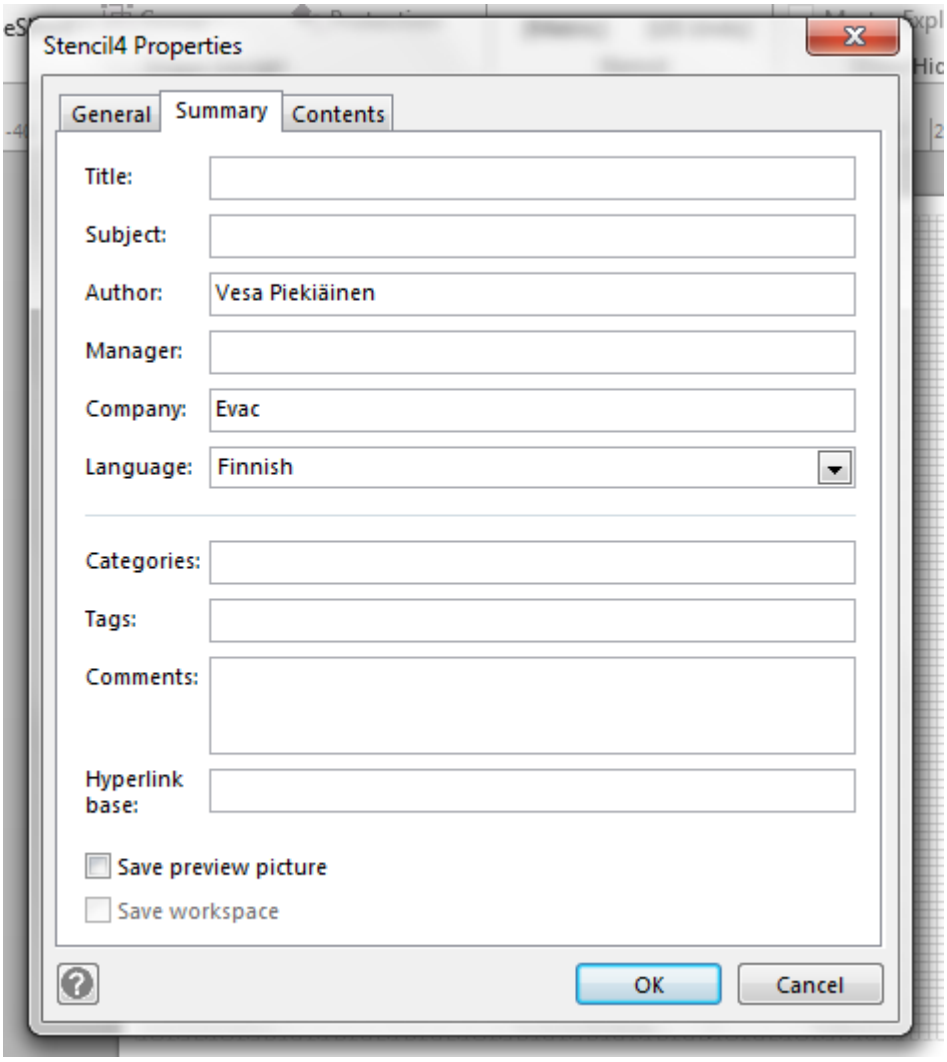
There are two ways to create a new stencil. First way create a new stencil is to from “Stencil” group” in “Developer” tab click either option “New Stencil (Metric)” or “New Stencil (US Units)”. “Developer” tab is not displayed as default. It can be added to ribbon from Visio’s “Options”.



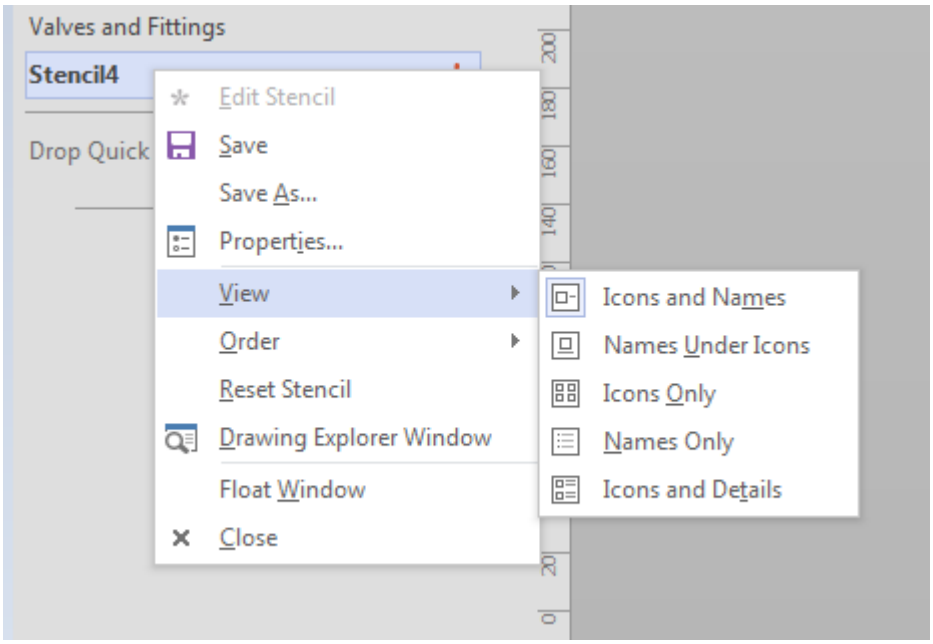
Second way to create a new stencil is to click “More Shapes” in “Shapes” window and clicking the option “New Stencil (Metric)” or “New Stencil (US Units)”from the menu that opens.



Stencil properties can be changed by right clicking the stencil and choosing "Properties". Stencil "Properties" menu opens where properties such as "Title", "Subject", "Author", "Manager" and "Company" can be define.

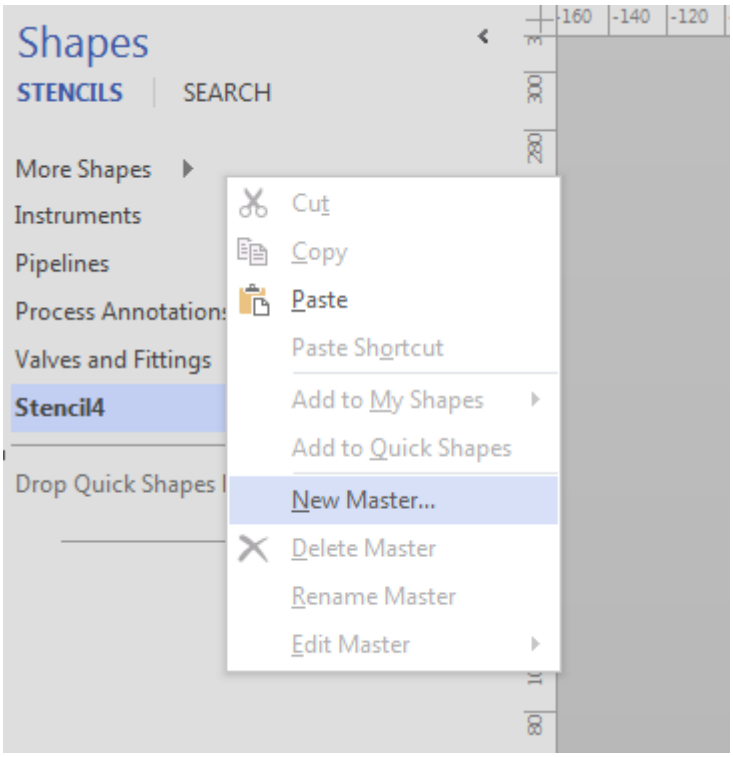


Right clicking the stencil name opens a floating menu. In section "View" it is possible to choose how the shapes icons and names are showing in stencil. In section "Order" the stencils can move up or down to put stencils in desirable order.

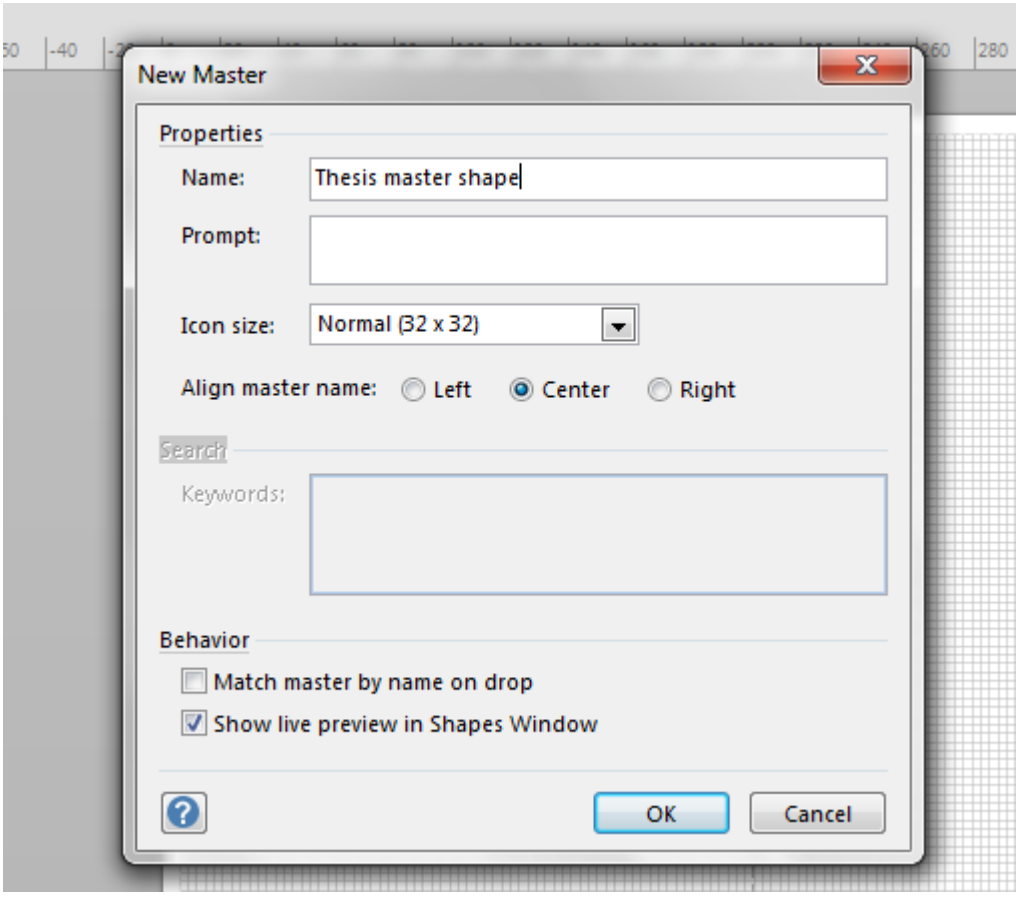

Valves and Fittings
Stencil4
Drop Quick
Edit Stencil
Save
Save As...
Properties...
View
Order
Reset Stencil
Drawing Explorer Window
Float Window
Close
Icons and Names
Names Under Icons
Icons Only
Names Only
Icons and Details
200
180
160
140
20
0

Appendix 9. Creating a master shape

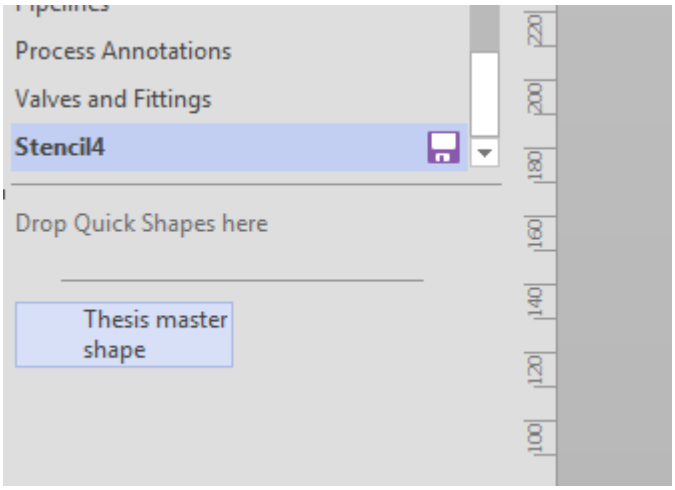
One way to add new master shape is right click the stencil shape area and choose “New Master”.



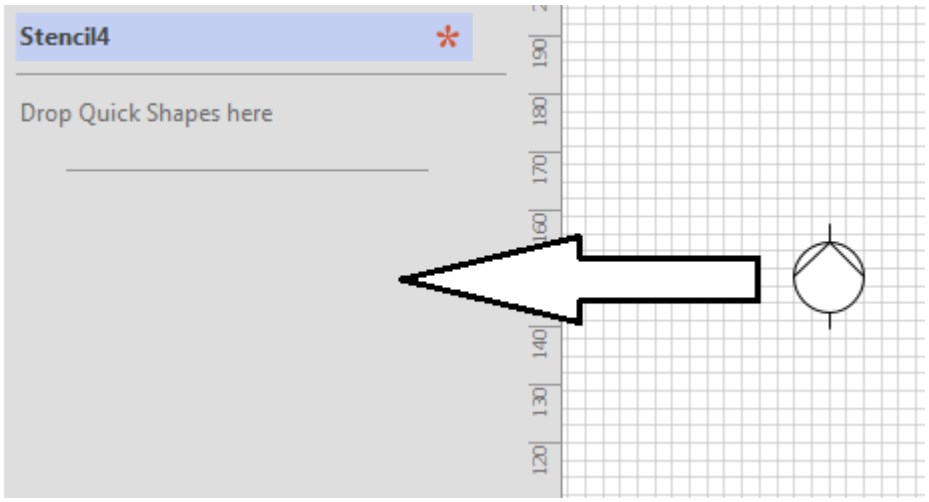
“New Master” window opens where properties can be modified such as “Name”, “Prompt” and “Icon Size”. After when properties are set, click ok.



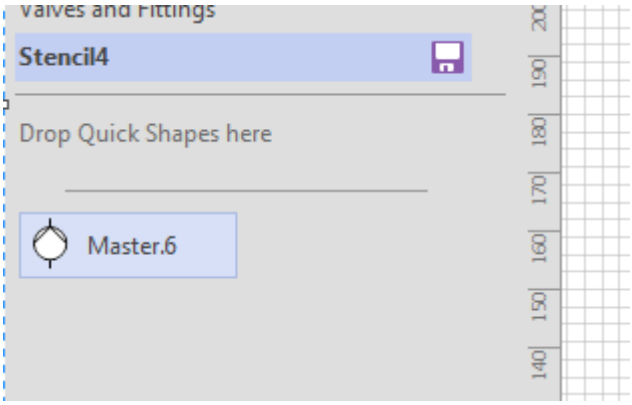
After clicking “Ok”, a new empty master appears into a stencil.



The other way to make a new master shape is to drag shape from the drawing sheet into the stencil shape area.



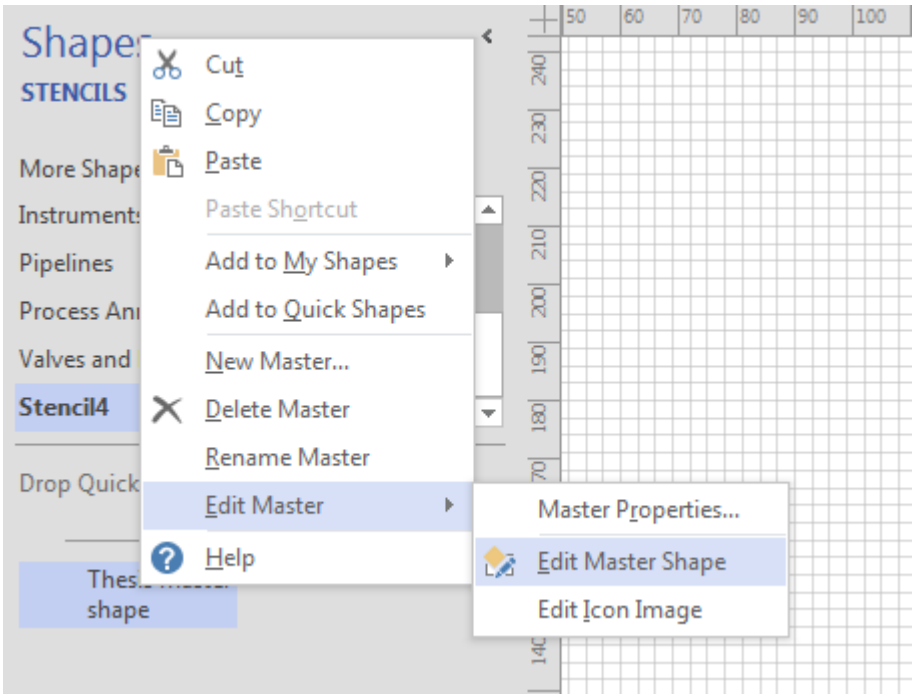
After dragging the shape into the stencils shape area, it appears to there as a master shape.



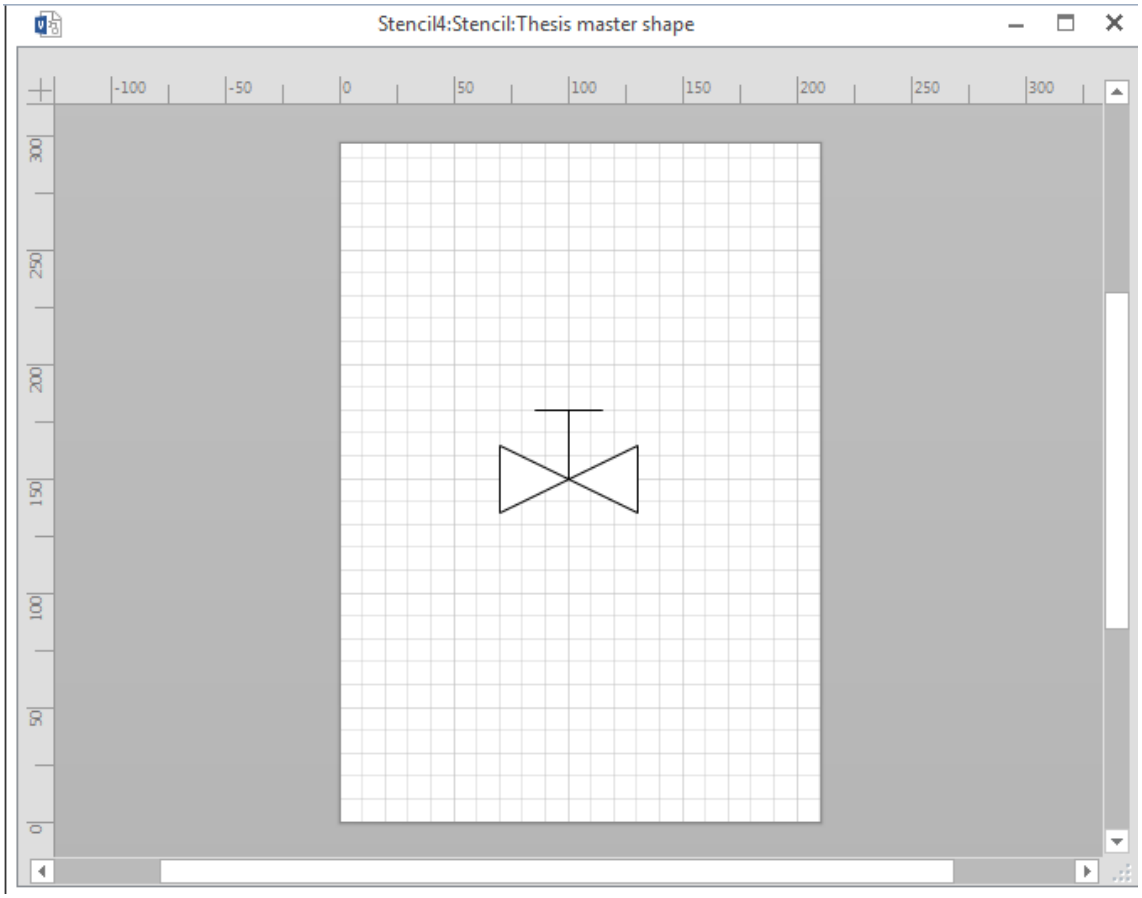
Master name can be changed by double clicking the name. Master properties can be changed by right clicking the master, choosing "Edit Master" and selecting "Master Properties".

Appendix 10. Editing the master shape

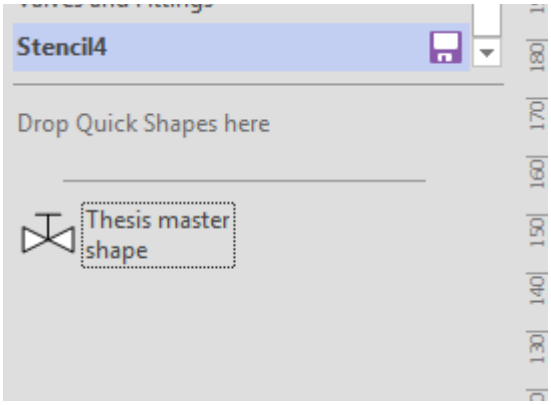
Master shapes can be edited. Right click the master, choose “Edit Master” and click “Edit Master Shape”.



Master editing window opens where master shape can be edited or completely new shape can be created.

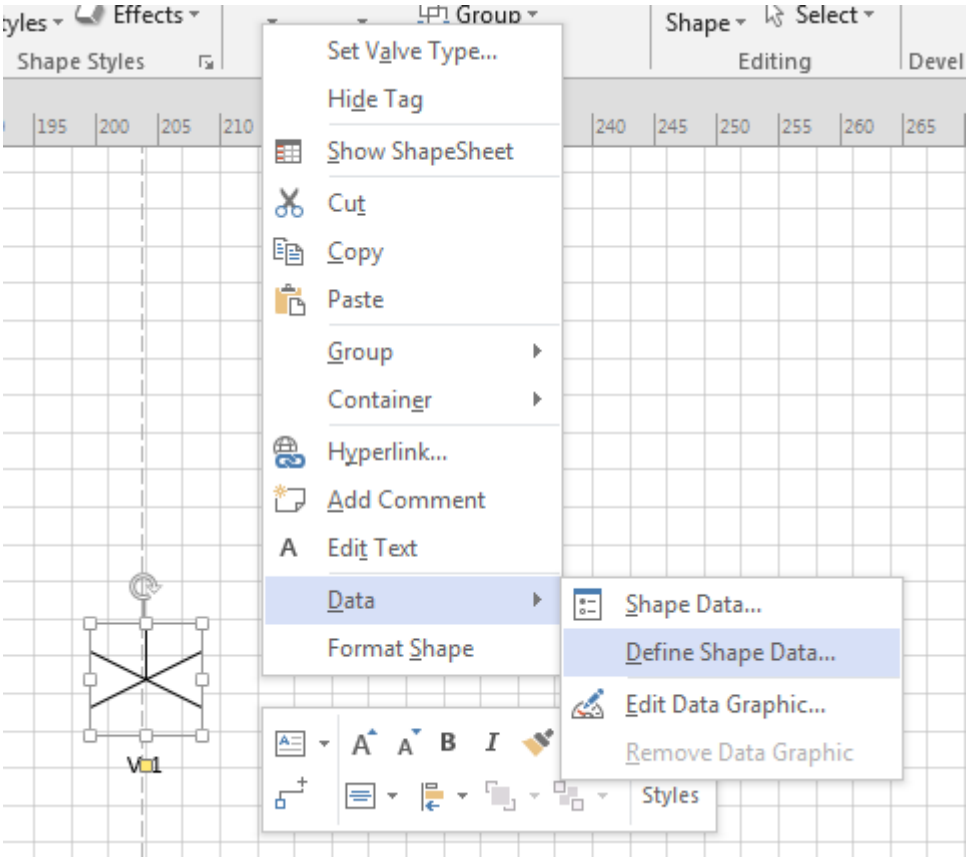


In the master editing window a completely new master shape can be created by using the Visio's drawing tools or edit shape that exist in Visio, just drag the shape into the editing window and edit it. After editing the shape, close the window and the shape appear into the stencil.

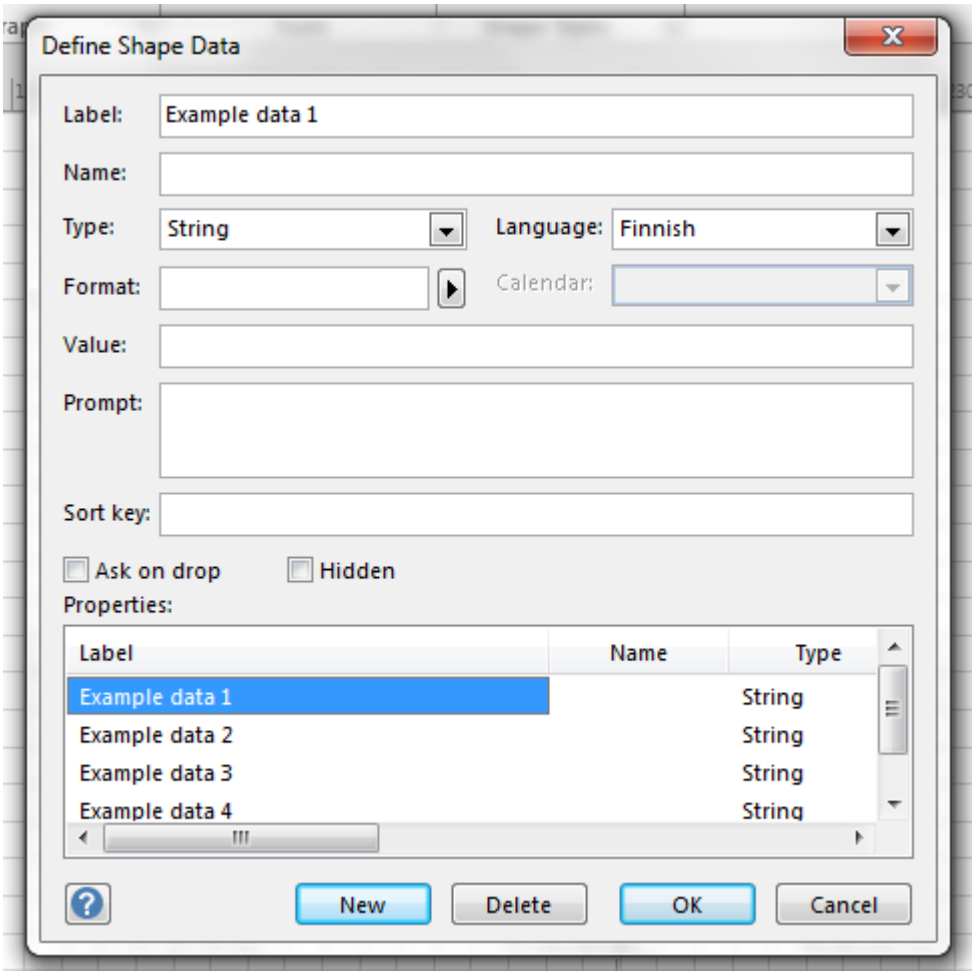


Appendix 11. How to add data fields into shapes

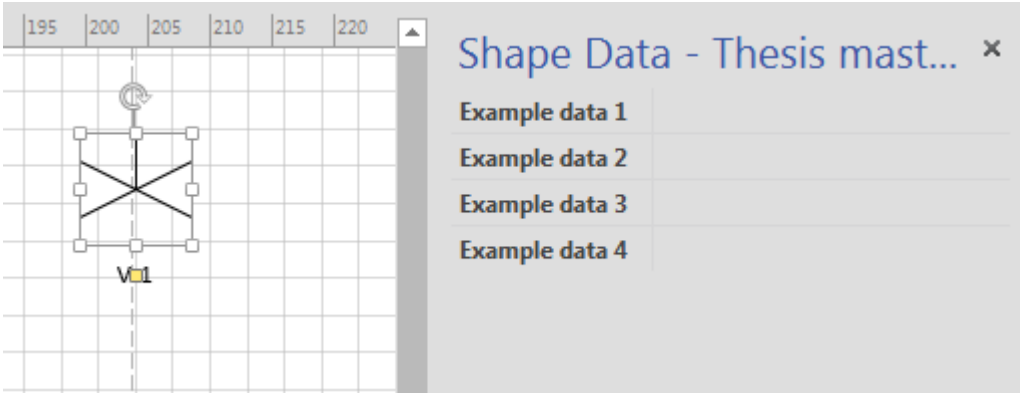
Data fields can be added into master shape in the master editing window (Appendix 10) by right clicking the shape, choosing “Data” and clicking “Define Shape Data”. Into an instance shape, the data fields can be added same way.



Clicking the “Define Shape Data” opens “Define Shape Data” window, where shape data properties can be set. Click “New” to add new data fields. When needed data fields are made, click “Ok” to close the window.



After clicking “Ok”, the added data fields appear into the shape.



Now data can be added into the shape (Appendix 5).

Appendix 12. Process lines

Main flow
Color: Dark blue
(R 0, G 32, B 96)

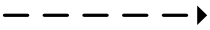
Biosludge/Screen Reject
Color: Brown
(R 156, G 75, B 9)

Ventilation
Color: Green
(R 0, G 176, B 80)

Foodwaste
Color: Orange
(R 234, G 112, B 14)

Blackwater
Color: Black
R 0, G 0, B 0)

Accomodation / Laundry GW
Color; Black dashed
(R 0, G 0, B 0)



Aeration
Color: Light blue
(R 0, G 176, B 240)

Galley
Color: Yellow
(R 255, G 220, B 0)

Washing
Color: Light blue
(R 0, G 176, B 240)

Chemical
Color: Red
(R 255, G 0, B 0)

Pneumatic
Color: Black
Type: PID Pneumatic

General line
Color: Black
(R 0, G 0, B 0)