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Intent-based AI Assisted Network Management System for Open Campus Networks

vorgelegt von
M. Sc.
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Doktor der Ingenieurwissenschaften
- Dr.-Ing. -

genehmigte Dissertation

Promotionsausschuss:

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Tag der wissenschaftlichen Aussprache: 1. Januar 2020

Berlin 2026

Eidesstattliche Erklärung

Hiermit erkläre ich gegenüber der Fakultät III der Technischen Universität Berlin, dass die vorliegende Dissertation selbständig und nur unter Zuhilfenahme der im Literaturverzeichnis genannten Quellen und Hilfsmittel angefertigt wurde. Alle Stellen der Arbeit, die eigenen oder anderen Werken dem Wortlaut oder dem Sinn nach entnommen wurden, sind kenntlich gemacht; dies schließt zur Veröffentlichung eingereichte Arbeiten mit ein. Ich reiche die Arbeit erstmals als Prüfungsleistung ein. Ich versichere, dass diese Arbeit oder wesentliche Teile dieser Arbeit nicht bereits im Rahmen eines Promotionsverfahrens an einer wissenschaftlichen Hochschule vorgelegt wurden.

Mit meiner Unterschrift bestätige ich, dass ich über fachübliche Zitierregeln unterrichtet worden bin und diese verstanden habe. Die im betroffenen Fachgebiet üblichen Zitiervorschriften sind eingehalten worden. Eine Überprüfung der Arbeit auf Plagiate mithilfe elektronischer Hilfsmittel darf vorgenommen werden.

Durch die Unterschrift bürge ich für den vollumfänglichen Inhalt der Endversion dieser Dissertation.

M. Sc.
Varun Gowtham
Berlin, 3. Januar 2026

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With my signature, I vouch for the entire content of the final version of this dissertation.

M. Sc.
Varun Gowtham
Berlin, January 3, 2026

I dedicate this great thesis to my gold fish, which has always been there for me

Danksagung

Ein paar nette Worte / Some nice words...

Zusammenfassung

Deutsch

Dies hier ist ein Blindtext zum Testen von Textausgaben. Wer diesen Text liest, ist selbst schuld. Der Text gibt lediglich den Grauwert der Schrift an. Ist das wirklich so? Ist es gleichgültig, ob ich schreibe: „Dies ist ein Blindtext“ oder „Huardest gefburn“? Kjift – mitnichten! Ein Blindtext bietet mir wichtige Informationen. An ihm messe ich die Lesbarkeit einer Schrift, ihre Anmutung, wie harmonisch die Figuren zueinander stehen und prüfe, wie breit oder schmal sie läuft. Ein Blindtext sollte möglichst viele verschiedene Buchstaben enthalten und in der Originalsprache gesetzt sein. Er muss keinen Sinn ergeben, sollte aber lesbar sein. Fremdsprachige Texte wie „Lorem ipsum“ dienen nicht dem eigentlichen Zweck, da sie eine falsche Anmutung vermitteln. Dies hier ist ein Blindtext zum Testen von Textausgaben. Wer diesen Text liest, ist selbst schuld. Der Text gibt lediglich den Grauwert der Schrift an. Ist das wirklich so? Ist es gleichgültig, ob ich schreibe: „Dies ist ein Blindtext“ oder „Huardest gefburn“? Kjift – mitnichten! Ein Blindtext bietet mir wichtige Informationen. An ihm messe ich die Lesbarkeit einer Schrift, ihre Anmutung, wie harmonisch die Figuren zueinander stehen und prüfe, wie breit oder schmal sie läuft. Ein Blindtext sollte möglichst viele verschiedene Buchstaben enthalten und in der Originalsprache gesetzt sein. Er muss keinen Sinn ergeben, sollte aber lesbar sein. Fremdsprachige Texte wie „Lorem ipsum“ dienen nicht dem eigentlichen Zweck, da sie eine falsche Anmutung vermitteln.

Schlüsselwörter: *Schlüsselwort1, Schlüsselwort2, Schlüsselwort3*

English

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Keywords: *Keyword1, Keyword2, Keyword3*

Publikationen

This thesis is partially based on already published contributions. In the following, these are divided into Journal articles, papers within conference proceedings, oral presentations without papers, and a list of all supervised theses.

This is only needed for dissertations and automatically removed if `isDiss` is false.

The following items do *not* appear in the references at the end of this dissertation if the `\printpublication` command is used! If you cite the reference in the text as well, it also appears at the end.

Theses and dissertations are cited using a used-defined entry type in Jabref (see **??**) called thesis in which you may enter the type as Bachelorarbeit, Masterarbeit, Dissertation, Bachelor's thesis, ... The entry type is part of the available .bib file in this template. If you want to create it on your own, it contains the entries author, title, school, year, type.

Zeitschriftenbeiträge

- E. Esche, C. Hoffmann, M. Illner, D. Müller, S. Fillinger, G. Tolksdorf, H. Bonart, G. Wozny, J.-U. Repke (2017): MOSAIC - Enabling Large-Scale Equation-Based Flow Sheet Optimization. *Chemie Ingenieur Technik* 89 (5), 620–635. DOI: 10.1002/cite.201600114

Konferenzbeiträge

– A. Penteado, H. R. Godini, E. Esche, G. Lovato, J. A. D. Rodrigues, J.-U. Repke (2018): Optimal Design of a CO2 Removal Section for a Biogas-based Oxidative Coupling of Methane Process. *Blucher Chemical Engineering Proceedings*. Bd. 1. Editora Blucher. DOI: 10.5151/cobeq2018-co.021

Vorträge ohne Proceedings

– H. R. Godini, T. Karsten, C. Hoffmann, O. Görke, G. Wozny, J.-U. Repke (2017): Integrated Membrane Reactors for Efficient Ethylene and Methanol Production. *Third European Workshop on Membrane Reactors*. March 9–10, Verona (Italy)

Betreute Abschlussarbeiten

– C. Hoffmann (2015): Real-time Optimization and Moving-horizon State Estimation for a Hydroformylation Plant. *Masterarbeit*. Technische Universität Berlin

– C. Hoffmann (2013): Simulation von Absorptionsprozessen mit ASPEN Plus für das Absorptionsmittel Methyldiethanolamin-Piperazin. *Bachelorarbeit*. Technische Universität Berlin

Inhaltsverzeichnis

Abbildungsverzeichnis

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Algorithmenverzeichnis

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Abkürzungsverzeichnis

If the horizontal space is too small or too large for you abbreviations, change the allocated space by entering the longest abbreviation in the `\settowidth{}` command in `f_Abbreviations.tex`.

Numerics

Software

Alternatively, you can only have one list of abbreviations without further classification:

ToDo-Verzeichnis

1 Introduction

Some introducing words ...

1.1 Motivation

Give a general overview on the subject of this thesis! In which context shall the content of this thesis be seen?

1.2 Research Goal

What questions shall be investigated and answered in this thesis? What is the scope of this work?

1.3 Outline of Work

What is the structure of this thesis?

2 Theoretical Background

Some introducing words ...

In this chapter, all fundamentals that are necessary to understand this work are introduced.

3 Methods

Please rename this chapter as you please.

3.1 New Section

Dies hier ist ein Blindtext zum Testen von Textausgaben. Wer diesen Text liest, ist selbst schuld. Der Text gibt lediglich den Grauwert der Schrift an. Ist das wirklich so? Ist es gleichgültig, ob ich schreibe: „Dies ist ein Blindtext“ oder „Huardest gefburn“? Kjift – mitnichten! Ein Blindtext bietet mir wichtige Informationen. An ihm messe ich die Lesbarkeit einer Schrift, ihre Anmutung, wie harmonisch die Figuren zueinander stehen und prüfe, wie breit oder schmal sie läuft. Ein Blindtext sollte möglichst viele verschiedene Buchstaben enthalten und in der Originalsprache gesetzt sein. Er muss keinen Sinn ergeben, sollte aber lesbar sein. Fremdsprachige Texte wie „Lorem ipsum“ dienen nicht dem eigentlichen Zweck, da sie eine falsche Anmutung vermitteln. Dies hier ist ein Blindtext zum Testen von Textausgaben. Wer diesen Text liest, ist selbst schuld. Der Text gibt lediglich den Grauwert der Schrift an. Ist das wirklich so? Ist es gleichgültig, ob ich schreibe: „Dies ist ein Blindtext“ oder „Huardest gefburn“? Kjift – mitnichten! Ein Blindtext bietet mir wichtige Informationen. An ihm messe ich die Lesbarkeit einer Schrift, ihre Anmutung, wie harmonisch die Figuren zueinander stehen und prüfe, wie breit oder schmal sie läuft. Ein Blindtext sollte möglichst viele verschiedene Buchstaben enthalten und in der Originalsprache gesetzt sein. Er muss keinen Sinn ergeben, sollte aber lesbar sein. Fremdsprachige Texte wie „Lorem ipsum“ dienen nicht dem eigentlichen Zweck, da sie eine falsche Anmutung vermitteln.

4 Results and Discussion

5 Conclusion and Outlook

Some introducing words ...

5.1 Conclusion

What are the most relevant aspects of your thesis? Which important questions from your introduction could be answered?

5.2 Outlook and Future Directions

Given the results obtained in this thesis, which aspects need be improved? Which additional effects or phenomena should be studied?

Anhang A

Code Examples

A.1 AMPL

```
reset;  # all blue words are keywords in this language
        # they are defined in the file 01_Document_administration/
            f_CodeLanguageSpecifications.tex

model simulation.mod;
data simulation.dat;
include initial.dat;
option ipoptoptions "halt_on_ampl_error yes";

let e0_param := 4;

solve;
```

Code A.1: Code example for AMPL.

A.2 Matlab

```
clc
clear
close all

e0_param = 4;

j=0;
```

```
for i=1:e0_params % this loop is incredibly smart
    if 1==2
        j=j+1;
    else
        j=j-1;
    end
end
```

Code A.2: Code example for Matlab.

Anhang B

Examples of the longtable Environment

Especially in the appendix, it is common that long tables appear, which contain experimental or simulated data. For this purpose, the `longtable` environment can be used. The `\autoref` command to reference tables works for them as well (Tab. B.1).

Tab. B.1: This is a longtable, because it is a long table.

Ragged right Result A	Ragged left Result B	Justified Result C	Parbox Result D
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.

Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.

Tab. B.2: The caption of a long table on the first page.

Ragged right Result A	Ragged left Result B	Justified Result C	Parbox Result D
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.

Continued on next page

Tab. B.2 (continued).

Ragged right Result A	Ragged left Result B	Justified Result C	Parbox Result D
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.
Text.	Text.	Text.	Longer text to create line breaks.

Anhang C

Automatic Indenting in arara

In the following, the instructions on using `arara` for automatic indenting are shown for a Windows operating system. It is assumed that the instructions are similar on a Unix system, because `arara` is platform independent. However, this has not been verified, yet. In addition, we expect every person using this template to have installed TEXLive $\geq$ 2018 and the following instructions are only valid for these cases. If you *have* to use an older TEXLive version, please check earlier commits of this template for the necessary instructions and files.

4.0 (TEXLive $\geq$ 2018):

1. Add a user command for `arara` to Texmaker[1].

2. Add the command in Code C.1 to the beginning of the `main.tex` file (right before anything else). Note that the % before arara is *intentional* and necessary. This command executes the automatic file indenting for all files (and files in subfolders) that are stated within the square brackets as soon as `arara` is started. An example is given in Abb. C.1.

3. Execute `arara` (if you added it as the first user command, the shortcut Alt+Shift+F1 may be used).

4. Update your files by clicking on File $\rightarrow$ Reload all documents from file.

5. Your source code should now be nicely indented.

[1] https://tex.stackexchange.com/questions/107989/integration-of-arara-in-texmaker, January 2019

6. In case errors appear, `arara` always creates a backup with the file extension `.latexindentbackup`.

Note that `arara` 4.0 does not work with subdirectories by default.

```
% arara: indentsubdir: { overwrite : yes, files : [ folder/file1.tex,
    folder/file2.tex ] , settings: local, where: 00_Arara_and_Latexindent
    /localSettings.yaml }
```

Code C.1: Setting up `arara` for `latexindent` in Texmaker.

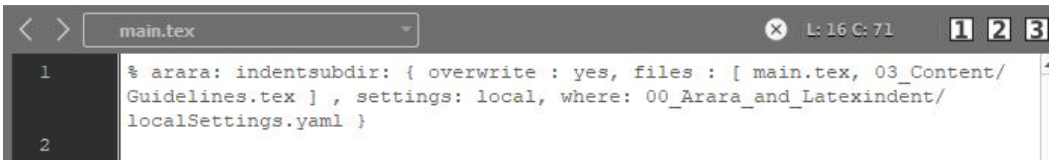

Abb. C.1: Directives for arara execution for automatic indenting. These commands must be added at the beginning of `main.tex`.

5.0 (TEXLive $\geq$ 2020):

As maintaining the code and keeping up-to-date with changes in `arara` is too cumbersome, these sections will not be updated with every new version of `arara`. Instead, the instructions above shall serve as starting point in newer versions of TEXLive.

Anhang D

Package Dependencies

Tab. D.1: List of all packages in this template. Packages without version number are part of the LaTeX distribution and are updated with every update of TeXLive itself.

Package name	Version	Reference
Document class		
KOMA script	3.48	https://ctan.org/pkg/koma-script
Document and encoding		
babel	25.13	https://ctan.org/pkg/babel?lang=de
calc	4.3b	https://ctan.org/pkg/calc?lang=de
datetime2	1.5.7	https://ctan.org/pkg/datetime2
fontenc	–	https://ctan.org/pkg/fontenc
ifthen	1.4.0	https://ctan.org/pkg/ifthen
microtype	3.2b	https://ctan.org/pkg/microtype
morewrites	–	https://ctan.org/pkg/morewrites?lang=de
pdfpages	0.6g	https://ctan.org/pkg/pdfpages?lang=de
scrlayer-scrpage	3.48	https://ctan.org/pkg/scrlayer-scrpage
textcomp	–	https://ctan.org/pkg/textcomp
todonotes	1.1.7	https://ctan.org/pkg/todonotes?lang=de
xparse	–	https://ctan.org/pkg/xparse
Tables		
array	–	https://ctan.org/pkg/array?lang=de
booktabs	1.61803398	https://ctan.org/pkg/booktabs

Continued on next page

Tab. D.1 (continued).

Package name	Version	Reference
collcell	0.6	https://ctan.org/pkg/collcell?lang=en
longtable	–	https://ctan.org/pkg/longtable
multirow	2.9	https://ctan.org/pkg/multirow
supertabular	4.2c	https://ctan.org/pkg/supertabular?lang=en
tabularx	–	https://ctan.org/pkg/tabularx
threeparttable	–	https://ctan.org/pkg/threeparttable?lang=de
threeparttablex	0.3	https://ctan.org/pkg/threeparttablex
Graphics		
graphicx	–	https://ctan.org/pkg/graphicx
overpic	2.1	https://ctan.org/pkg/overpic
wrapfig	3.6	https://ctan.org/pkg/wrapfig2
Fonts, math, and symbols		
amsmath	–	https://ctan.org/pkg/amsmath
amssymb	–	
amsthm	–	https://ctan.org/pkg/amsthm
cancel	2.2	https://ctan.org/pkg/cancel
chemfig	1.66	https://ctan.org/pkg/chemfig
chemmacros	6.2a	https://ctan.org/pkg/chemmacros?lang=de
courier	–	https://ctan.org/pkg/courier
helvet	–	https://ctan.org/pkg/helvet?lang=de
icomma	–	https://ctan.org/pkg/icomma
mathtools	1.31	https://ctan.org/pkg/mathtools
nicefrac	–	https://ctan.org/pkg/nicefrac
optidef	3.1	https://ctan.org/pkg/optidef
upgreek	2.0	https://ctan.org/pkg/upgreek
Units		
siunitx	3.4.14	https://ctan.org/pkg/siunitx
Text		
algorithm2e	5.2	https://ctan.org/pkg/algorithm2e
blindtext	2.0	https://ctan.org/pkg/blindtext
caption	–	https://ctan.org/pkg/caption

Continued on next page

Tab. D.1 (continued).

Package name	Version	Reference
`enumitem`	3.11	https://ctan.org/pkg/enumitem
`footnote`	1.13	https://ctan.org/pkg/footnote
`mdframed`	1.9b	https://ctan.org/pkg/mdframed
`nowidow`	1.0	https://ctan.org/pkg/nowidow
`placeins`	2.2	https://ctan.org/pkg/placeins
`setspace`	6.7b	https://ctan.org/pkg/setspace
`subcaption`	1.6	https://ctan.org/pkg/subcaption
`xcolor`	3.02	https://ctan.org/pkg/xcolor
References		
`biblatex`	3.21	https://ctan.org/pkg/biblatex
`csquotes`	5.2o	https://ctan.org/pkg/csquotes
Lists of Symbols and Abbreviations		
`acro`	3.8	https://ctan.org/pkg/acro?lang=de
`nomencl`	5.6	https://ctan.org/pkg/nomencl?lang=de
Index		
`imakeidx`	1.3e	https://ctan.org/pkg/imakeidx?lang=de
`Code`		
`listings`	1.10c	https://ctan.org/pkg/listings
`URLs`		
`xurl`	0.10	https://ctan.org/pkg/xurl?lang=de
Hyperref and pdfx		
`hyperref`	7.01o	https://ctan.org/pkg/hyperref
`pdfx`	1.6.5f	https://ctan.org/pkg/pdfx

Anhang E

Auto-completion

Texmaker (and propably many other editors) offer the possibility to define additional commands for automatic completion. This means they are suggested when you type a command. They can be edited under User → Customize Completion. The commands, which are assumed to be used on a regular basis in a thesis, are stated in Tab. E.1. You can simply copy each line and add it to your Texmaker. This takes approximately five minutes and saves you a lot of time when you actually write something, especially units.

Tab. E.1: List of recommended auto-complete commands in Texmaker.

Command	Explanation
`\ac{@}`	Acronym in text
`\ampere`	A unit
`\Autoref{#label#}`	Autoref with capitalized first letter
`\bar`	bar unit
`\begin{algorithm}`	new algorithm
`\begin{definition}`	new definition
`\begin{lemmaenv}`	new lemma
`\begin{longtable}{@}`	new long table
`\begin{mdframed}`	new frame
`\begin{overpic}[@]{@}`	new frame
`\begin{remarkenv}`	new remark
`\begin{tablenotes}`	table notes in three part table

Continued on next page

Tab. E.1 (continued).

Command	Explanation
\begin{theoremenv}	new theorem
\begin{threeparttable}	new three part table
\bottomrule	bottom rule in tabulars
\celsius	°C unit
\ch{@}	new chemical formula
\cubic	for cubed unit
\enquote{@}	new quote in current language
\gram	g unit
\joule	J unit
\kelvin	K unit
\kilo	for kilo in units
\mega	for mega in units
\metre	m unit
\midrule	mid rule in tabulars
\milli	for milli in units
\missingfigure[@]{@}	new missing figure with options
\missingfigure{@}	new missing figure without options
\mole	mol unit
\myfigure[@][@]{@}[@]{@}[@]	new figure
\nomenclature{@}{@}{@}{@}	new symbol
\num{@}	new number
\parencite[@]{#bib#}	new paren cite with options
\parencite{#bib#}	new paren cite without options
\pascal	Pa unit
\pder[@][@]{@}	partial derivative
\per	division command in units
\qty{@}{@}	new number with unit
\qtyrange{@}{@}{@}	new range for units
\roundbrack{@}	round brackets around argument
\squared	for squared unit
\textcite[@]{#bib#}	new text cite with option

Continued on next page

Tab. E.1 (continued).

Command	Explanation
`\textcite{#bib#}`	new text cite without option
`\todo[@]{@}`	new todo with option
`\todo{@}`	new todo without option
`\toprule`	top rule in tabulars
`\tothe{@}`	for power in units
`\unit{@}`	new unit
`\verb`	for verbat output
`\volt`	V unit
`\watt`	W unit

Anhang F

Large Figures

This appendix contains two examples of how to include a large figure, e.g., a P&I diagram, into the thesis when it is desirable to have it in DIN A3.

F.1 Include as Figure

In this case, the page format is changed to DIN A3 and the figure is included as a float (see Abb. F.1).

F.2 Include as Page

In another approach, the page format is changed to DIN A3 and the figure is included as PDF to cover the whole page. The disadvantage of this approach is having no caption to reference the figure in the text. This may be resolved with a reference to the page, here: page 31.

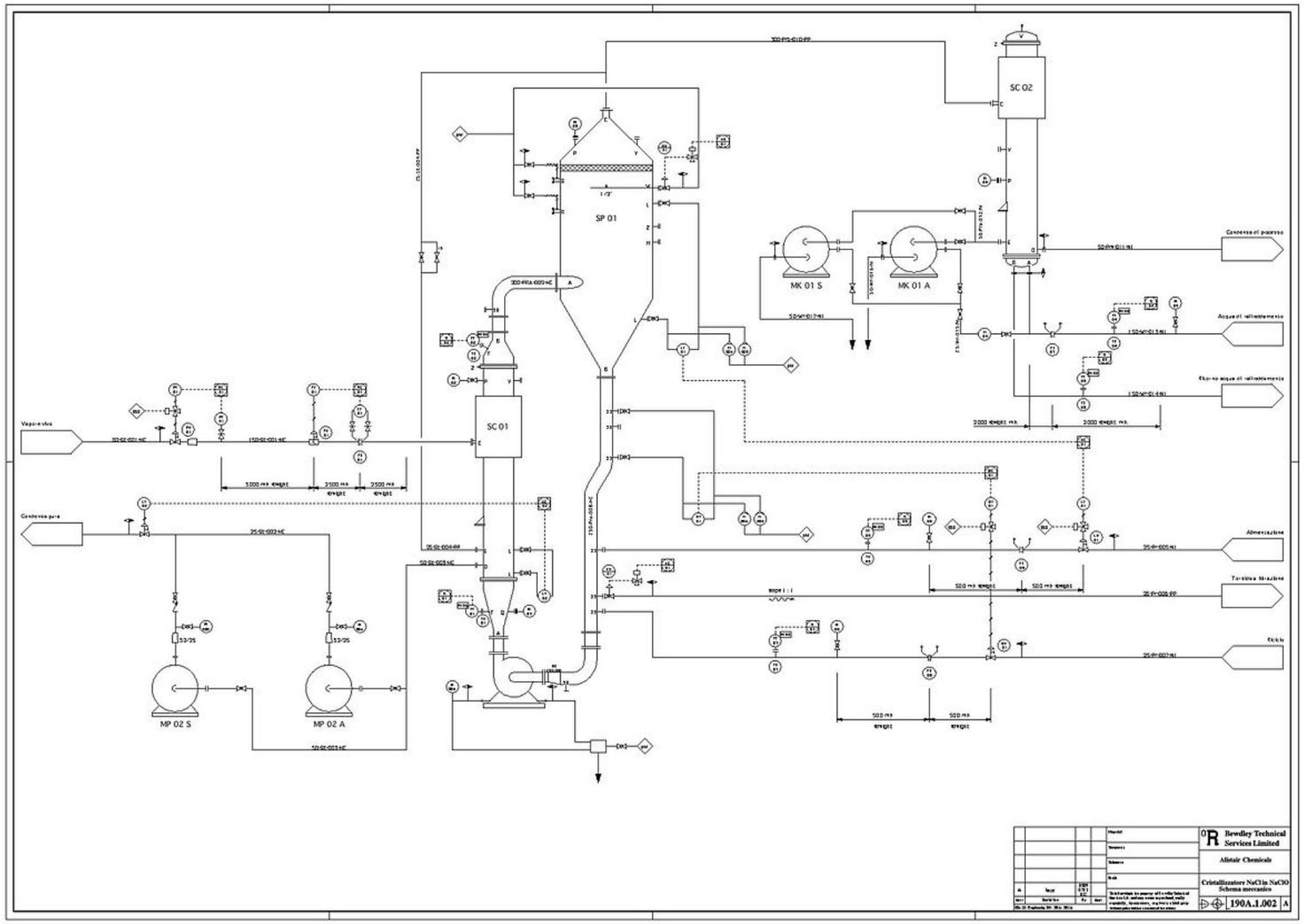

Abb. F.1: Example of a large figure for DIN A3; taken from Wikipedia.

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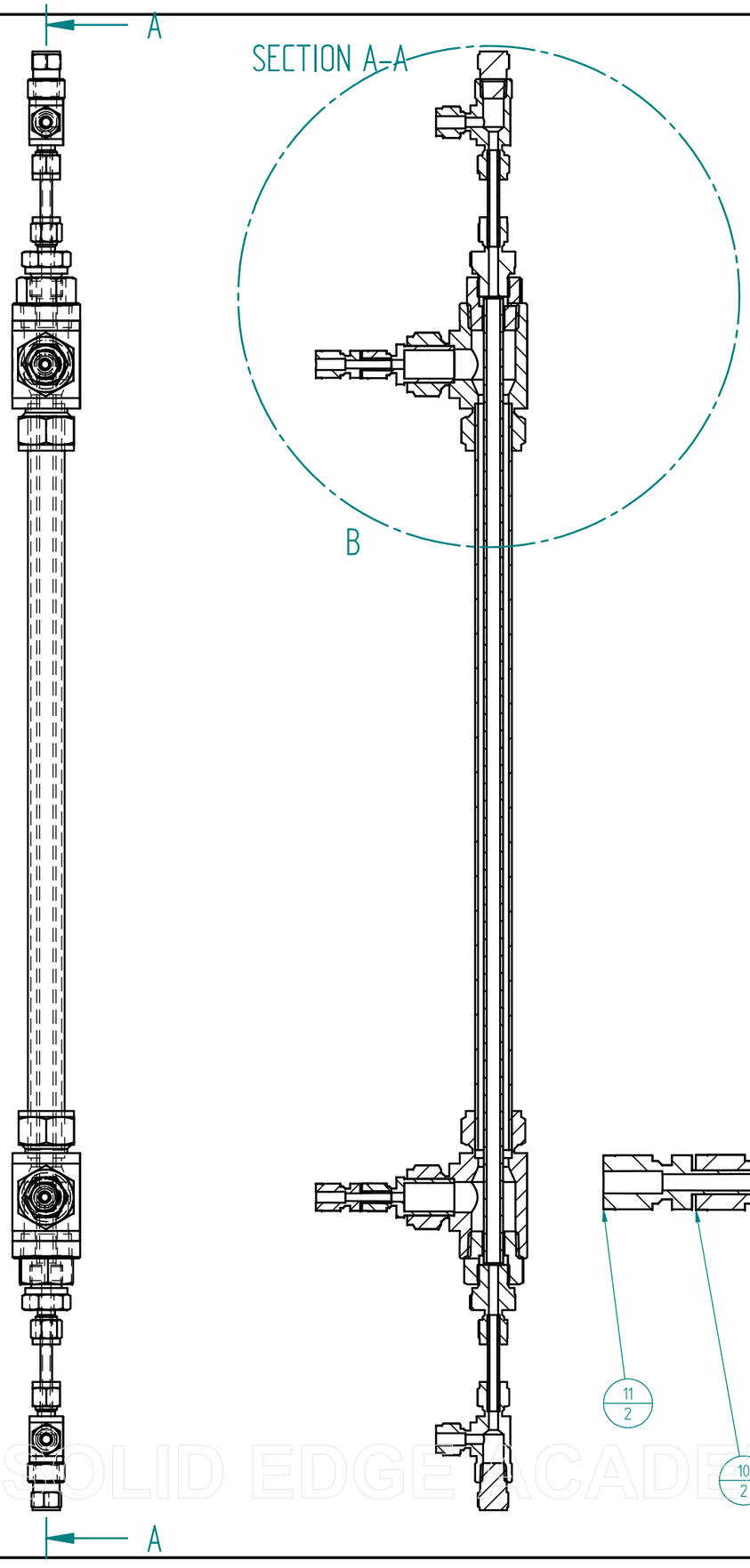
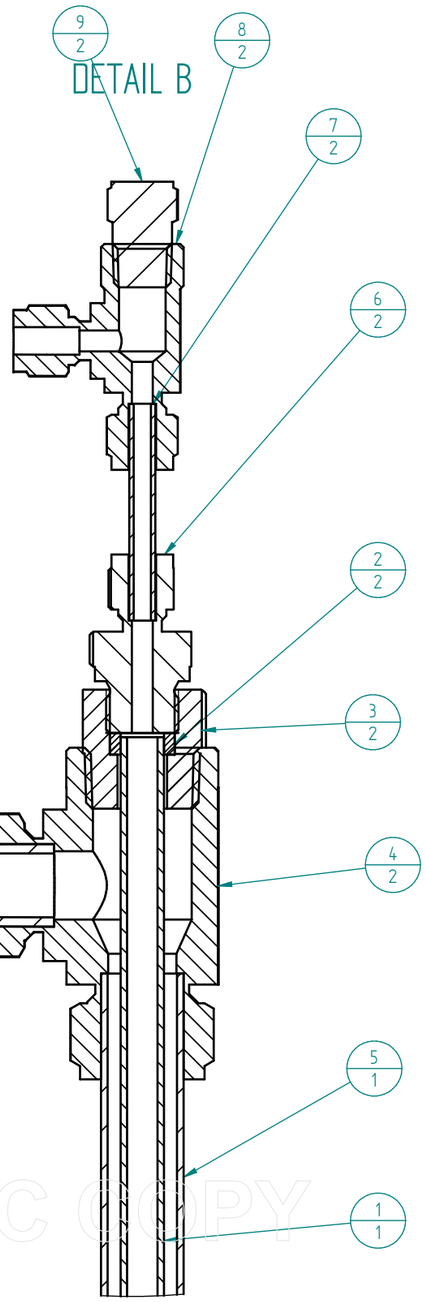
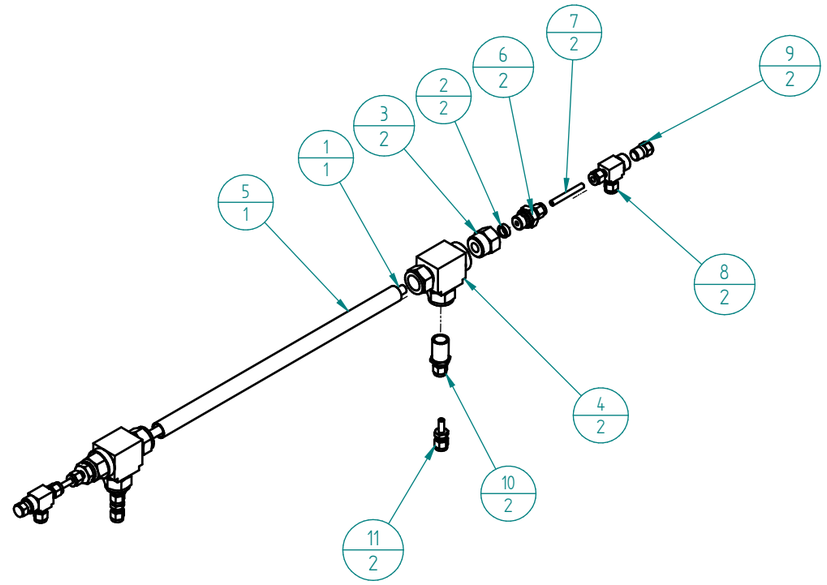
REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







Item Number	File Name	Autor	Quantity
1	membrana	k.jankowska	1
2	gasket	k.jankowska	2
3	SS_12_RB_4_21442 modif	k.jankowska	2
4	SS_1210_3TFT_20142	k.jankowska	2
5	module	k.jankowska	1
6	SS_400_1_6RS_21459	k.jankowska	2
7	50x6mm pipe	k.jankowska	2
8	SS_400_3_4TFT_20284	k.jankowska	2
9	SS_4_P_20270	k.jankowska	2
10	SS_400_R_12_21958	k.jankowska	2
11	SS_6M0_R_4_20250	Stary Ale Jary	2

	NAME	DATE
DRAWN	k.jankowska	11/20/16
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

Solid Edge

TITLE

SIZE A2 | DWG NO | REV

FILE NAME: Asm module.dft

SCALE: | WEIGHT: | SHEET 1 OF 1

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Indexverzeichnis